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Journal of Financial Economics 75 (2005) 85–114
JOURNAL OF Financial ECONOMICS
www.elsevier.com/locate/econbase

The cross-section of expected corporate bond returns: Betas or characteristics? ☆

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Received 21 August 2001; accepted 4 September 2003

Available online 2 June 2004

Abstract

This paper finds that default betas are significantly related to the cross-section of average bond returns even after controlling for characteristics such as duration, ratings, and yield-to-maturity. Among characteristics, only yield-to-maturity is significantly related to average bond returns after controlling for default and term betas. The default and term factors are able to price the returns of beta-sorted portfolios better than they do the returns of yield-sorted portfolios. The magnitude of the ex ante Sharpe ratio generated by yield-sorted portfolios suggests non-risk-based explanations. Overall, given the elusive nature of systematic risk in empirical asset pricing, the central finding of our paper is that systematic risk matters for corporate bonds.

JEL classification: G12; G14

Keywords: Corporate bond returns; Asset pricing; Betas; Characteristics; Yields

☆ We thank participants at the 2001 Frank Batten Young Scholars Conference, Craig MacKinlay and especially an anonymous referee for helpful comments and suggestions.
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0304-405X/$ - see front matter
doi:10.1016/j.jfineco.2004.04.002

1. Introduction

One of the key predictions of modern finance is that expected returns on securities can be explained solely by their systematic risk (see Sharpe, 1964; Lintner, 1965; Mossin, 1966; Ross, 1976). Recent research (see Fama and French 1992, 1993) has shown, however, that beta, the risk measure nominated by the capital asset pricing model (CAPM), has almost no ability to explain the cross-section of stock returns. Instead, considerable evidence shows that individual firm characteristics such as firm size, book-to-market (B/M) ratios, and past stock returns are better predictors of the cross-sectional variation in stock returns.

These findings have created much controversy in the literature over whether individual firm characteristics or factor loadings are more relevant in explaining the cross-section of stock returns. Daniel and Titman (1997) argue that firm characteristics are more important than factor loadings in explaining the cross-section of average stock returns and suggest that characteristics may be proxies of market mispricing. In contrast, Davis et al. (2000) argue that firm characteristics such as size and B/M ratios are just proxies of factor loadings (betas) on priced risk factors.[1] Using a longer time period than Daniel and Titman, they conclude that factor loadings on size and B/M factors provide a better description of the cross-section of stock returns than the characteristics themselves.

In this paper, we provide a comprehensive study of the cross-section of corporate bond returns using a unique database of individual bond returns and evaluate how factor loadings and bond characteristics fare against one another in explaining this cross-section. Corporate bonds provide an attractive setting to study these issues because few studies examine the cross-section of corporate bond returns in the empirical asset pricing literature and because the risk factors are easier to identify. Existing empirical work on corporate bonds (see Fama and French, 1993) recommends a two-factor asset pricing model involving default and term factors to price corporate bonds.[2] Theoretically, the two-factor model can be justified by an Intertemporal Capital Asset Pricing Model (ICAPM) setting in which the two factors are candidate hedging portfolios that proxy for underlying default and term risks in the economy. The factor loadings (betas) with respect to these two factors then become appropriate measures of systematic risk.

A popular alternative approach is to use characteristics such as corporate bond ratings and duration as measures of default and term risk. Our objective is to understand how these different measures of risk (factor loadings and bond characteristics) fare against each other in explaining the cross-section of expected corporate bond returns. In particular, we want to explore whether default betas and term betas are able to explain average bond returns after controlling for the effects of

[1] The risk factors themselves are based on size and B/M effects.

[2] In a CAPM world, the market factor should be able to price all assets. Empirically, however, the market factor has almost no explanatory power for corporate bond returns in the presence of default and term factors (see also Fama and French, 1993). We find all our results are robust to including the market factor as a third factor.

bond ratings and duration. Conversely, we would like to examine whether default and term betas diminish the importance of characteristics in explaining expected bond returns.

Unlike the debate involving stocks, for bonds, both the factor loadings and firm characteristics have a clear risk interpretation. The difference between factor loadings and characteristics lies mainly on the type of risk they measure. While factor loadings are proxies of systematic risk, characteristics such as bond ratings and duration tend to measure total risk. Because betas are measured with noise, characteristics such as ratings and duration that consist of the most up-to-date information about corporate bonds could be better proxies of true unobservable betas than estimated betas themselves. Alternatively, characteristics, as suggested by Daniel and Titman (1997), could have information independent of the covariance structure of bond returns that helps explain expected bond returns. Our empirical tests are designed to examine the interaction between these different measures of risk in explaining the cross-section of corporate bond returns.

In assessing the role of betas and characteristics on expected bond returns, we follow two distinct empirical methodologies. The first methodology relies on the portfolio approach detailed in Daniel and Titman (1997). Along these lines, we form bivariate portfolios based on ratings and duration and then divide each ratings-duration portfolio into additional portfolios based on default or term betas. This enables us to examine the cross-sectional variation in bond returns related to betas but independent of characteristics. We also do the converse by forming bivariate portfolios based on default and term betas and examine the cross-sectional variation in bond returns related to characteristics but independent of betas. The second methodology relies on a variant of the Fama and MacBeth (1973) cross-sectional regression approach used by Brennan et al. (1998) and is used to examine the cross-sectional relationship between individual bond returns and betas/characteristics.

The key findings are as follows. First, bond ratings are significantly correlated with default betas, and term betas are significantly correlated with duration. This suggests that ratings and duration contain information about the systematic term risk and default risk, respectively, of a corporate bond. The key question is whether characteristics or betas are better at explaining expected bond returns. We find that default betas, and to a lesser extent term betas, are able to explain the cross-section of bond returns after controlling for characteristics such as duration and ratings. In contrast, ratings and duration are unable to explain average bond returns after controlling for default and term betas. This suggests that the cross-sectional relationship between these characteristics and bond returns arises mainly because ratings and duration are proxies of systematic default and term risk, respectively. However, our results reveal a significant positive relationship between yield-to-maturity and average bond returns even after controlling for default and term betas, suggesting that yield-to-maturity has information independent of betas in explaining corporate bond returns.

We then examine the ability of the default and term factors in pricing the returns of beta-sorted bond portfolios and yield-sorted portfolios. While the ex post factor regressions generate statistically significant nonzero intercepts for both default-beta-sorted and yield-sorted portfolios, the intercepts of the yield-sorted portfolios are four times larger in magnitude and much more significant.[3] The ex ante Sharpe ratio (see MacKinlay, 1995) of 1.37 generated by the yield-sorted portfolios is more than one-and-half times that of the default-beta-sorted portfolios and is large enough to suggest non-risk-based explanations (such as biases in empirical methodology, market frictions, or market inefficiencies) as a source of the apparent mispricing. In contrast, the ex ante Sharpe ratio of the default beta-sorted portfolios is consistent with omitted risk factors.

Our Fama and MacBeth cross-sectional tests show that the only variable that performs better than default beta in explaining average bond returns is a bond's yield-to-maturity. Nevertheless, default betas continue to explain average bond returns even after controlling for ratings, duration, and yield-to-maturity. Overall, given the elusive nature of systematic risk in empirical asset pricing, the central finding of our paper is that systematic risk matters for corporate bond returns.

The rest of the paper proceeds as follows. In Section 2, we describe the data and the model used to estimate factor loadings. In Section 3, we evaluate the cross-sectional relationship among betas, characteristics, and average bond returns using portfolio tests. In Section 4, we present results from cross-sectional Fama and MacBeth regressions involving individual bond returns, and in Section 5 we conclude.

2. Data and methodology

The corporate bond data used in this study are drawn from the Lehman Brothers Fixed Income Database (LBFI) and covers the period January 1973 to December 1996. The LBFI database contains month-end bid prices, ratings, yields, and other characteristics for thousands of publicly traded, nonconvertible corporate bonds and is currently the best corporate bond database available for academic studies. In addition, actual trader quotes for round lots of at least 500 bonds, instead of matrix prices, make up the majority of the bids. Hong and Warga (2000) find that the bid prices contained in the LBFI database correspond closely with reported transactions and are better, i.e., have significantly fewer price discrepancies from transaction data, than bid prices for bonds traded on the NYSE's Automated Bond System. Lehman Brothers uses the prices in the LBFI database to construct its widely followed corporate bond indices. Given that Lehman Brothers also trades these indices, there are strong incentives for accurate prices. For these reasons, the LBFI database appears to be the best data available for corporate bond research. However, it does suffer from some potential problems.

The first potential problem is the use of matrix prices. Matrix prices are set according to some algorithm based on the prices of bonds with similar characteristics. These are regarded as less reliable than actual dealer quotes even

[3] The intercepts of term-beta-sorted portfolios are not significantly different from zero, suggesting that the two-factor model is well specified in terms of pricing term beta risk.

though they could still contain relevant information. In general, we use the full sample that contains both dealer quotes and matrix prices to achieve the maximum power in our tests. However, our key results are qualitatively similar when using only the dealer quotes (not reported).

Second, all bonds have missing data on August 1975 and December 1984. In addition, some bonds have data missing on other dates between the first date they appear in the database and the last. Bonds with data missing on more than four dates including August 1975 and December 1984 are eliminated from the sample. Perhaps a more severe problem is that returns are calculated from month-end bid prices of a single market maker, not transaction prices. However, this can be addressed in several ways. We have excluded noncoupon bonds and short time-to-maturity bonds because liquidity might be low for these issues and thus could be more subject to pricing errors. Noninvestment grade debt is also excluded because Lehman Brothers did not begin publishing high yield indices until 1992. By value-weighting the monthly returns of all eligible bonds by the total market value of each bond, biases resulting from bad prices of particular bonds should also be significantly reduced. Value-weighting also ensures investability of the portfolio strategies described in the paper.

The final but less easily addressed issue is that some bonds leave the database for unknown reasons. While most bonds can be directly classified as matured, called, defaulted, or still outstanding, approximately 10% of the sample drops out of the database for unidentifiable reasons. This could potentially introduce a delisting bias into the results depending on what happened to those bonds and whether the delisting was known ex ante. However, the percentage of firms, which delist for unknown reasons, averages less than one per year. Throughout this study it will be assumed that for each bond the return on the last date listed in the database is the final return on the bond.

To be included in our sample in any month, each bond must be coupon bearing, have at least three years to maturity, and be rated as investment grade by either Standard & Poor's (S&P) or Moody's (bonds rated BBB- or higher by S&P and Baa3 or higher by Moody's) in the preceding month. The resulting sample contains on average 2,880 corporate bonds per year. Finally, to minimize any microstructure problems in the data, we leave a one-month gap between the portfolio formation month and the first month we start computing the future returns earned by the portfolio. Most issues are rated by both S&P and Moody's. We use the S&P rating if available and otherwise use the Moody's rating.

The monthly corporate bond return as of time τ+1, $r_{\tau+1}$, is computed as

$$r_{\tau+1} = \frac{(P_{\tau+1} + AI_{\tau+1}) + C_{\tau+1} - (P_\tau + AI_\tau)}{P_\tau + AI_\tau}, \tag{1}$$

where P_τ is the quoted price at time τ; AI_τ is accrued interest, which is just the coupon payment scaled by the ratio of days since the last payment date to the days between last payment and next payment; and $C_{\tau+1}$ is the semiannual coupon payment (if any) at time $\tau + 1$.

2.1. Factor model for corporate bonds

Following Fama and French (1993), we consider two common risk factors for corporate bonds. One source of common risk for corporate bonds arises from unexpected changes in the term structure of interest rates. The other source of common risk arises from changes in default risk in response to changing economic conditions. Theoretically, the two-factor model can be justified by an ICAPM setting in which the two factors are candidate hedging portfolios that proxy for underlying default and term risks in the economy. We do not include the market factor in our factor model because empirically the market factor has almost no explanatory power for corporate bond returns in the presence of default and term risk factors. Adding the market factor to our factor model does not change any of our findings and only adds noise to the regressions. Therefore, to be parsimonious, we leave out the market factor.

We use *TERM*, defined as the difference in the monthly long-term government bond return (from Ibbotson Associates) and one month T-bill returns (from the Center for Research in Security Prices, CRSP), as a proxy for the term risk, and *DEF*, defined as the difference between the monthly return on a value-weighted market portfolio of all investment-grade corporate bonds (AAA to BBB) with at least ten years to maturity and the monthly long-term government bond return, as a proxy for the default risk. In Section 3.3, we examine the robustness of our empirical findings using an alternate default factor defined as the difference between the monthly return on a value-weighted market portfolio of all BBB corporate bonds with at least ten years to maturity and the monthly long-term government bond return.

Panel A of Table 1 provides summary statistics on the bond market factor portfolios. The average risk premium for the default factor (*DEF*) is 0.04% per month, while the average risk premium for the term factor (*TERM*) is 0.20% per month. The default premium of 0.04% is low compared with the standard deviation of 1.20%. This suggests that we cannot reliably reject the null hypothesis that the default premium is zero. However, the magnitude of default premium is comparable to the difference in average returns of 0.07% per month across BBB bonds and AAA bonds (see Table 2). Thus, default betas could be a significant determinant of the cross-sectional variation in bond returns (which is small compared with the cross-sectional variation in stock returns).

While the average return differences are comparable, the difference in returns across ratings portfolios could still appear large relative to the average monthly return on the *DEF* portfolio. However, the *DEF* portfolio consists of bonds with more than ten years to maturity, while the ratings portfolios cons consist of bonds with more than three years to maturity. Analysis shows that the spread between BBB and AAA is smaller for longer time-to-maturity bonds. Also, the spread between AAA/AA bonds and the long-term government bond is close to zero. Finally, while the full sample is not particularly skewed toward the highest-quality bonds (see Table 2, Panel A), those bonds tend to have longer time to maturity than do the lower-rated bonds. As a result, the sample of bonds in the corporate bond portfolio

Table 1

Summary statistics on the bond market factor portfolios

Monthly summary statistics for the two-factor portfolios, *DEF* and *TERM*, are shown in Panel A. The default factor (*DEF*) is defined as the difference between the value-weighted return on all investment grade bonds with atleast ten years to maturity and the return on the long-term government bond series from Center for Research in Security Prices. The term factor (*TERM*) is the difference between long-term government bond return and the one-month T-Bill return. Monthly excess returns are measured relative to the one-month T-Bill return. All corporate bond returns are from the Lehman Brothers Fixed Income Database. To be included in a corporate bond portfolio each bond must have at least three years to maturity. All statistics are based on monthly returns from January 1973 through December 1996. In Panel B, time-series regressions of the four investment grade ratings-based bond portfolios on the two factors are estimated over the sample period. Estimates of the ex post portfolio *DEF* (β_d) and *TERM* (β_t) betas are shown along with their associated t-statistics in paranthesis. The Gibbons et al. (1989) F-test is a test of the joint significance of the four intercept terms. Panel C reports time-series averages of cross-sectional correlations computed each month from January 1978 to December 1996 among time-to-maturity of the bond, duration, bond rating, average yield, and pre-ranking default and term betas. Rating is an integer representation of each bond's rating with 0 being assigned to AAA and 9 assigned to BBB-. Pre-ranking default and term betas for each bond, β_d and β_t, are calculated from rolling five-year regressions on *DEF* and *TERM*.

	Mean (%)	Standard deviation (%)	Minimum (%)	Maximum (%)	Autocorrelation		
					Lag 1	Lag 2	Lag 12
Panel A: summary statistics							
DEF	0.04	1.20	−5.37	5.48	−0.17	−0.05	−0.00
TERM	0.20	3.18	−9.37	13.95	0.10	−0.02	−0.01
Factor correlation	−0.43						

Panel B: time-series portfolio Level factor regression

	α	β_d	β_t	R_2
AAA	−0.01	0.82	0.92	0.98
	(−0.60)	(28.67)	(72.45)	
AA	−0.02	0.87	0.90	0.99
	(−1.46)	(44.50)	(109.17)	
A	−0.00	0.96	0.88	0.99
	(−0.26)	(38.69)	(109.51)	
BBB	0.04	1.08	0.88	0.93
	(0.97)	(15.69)	(46.56)	

Gibbons, Ross, and Shanken F-test:

F-statistic	0.781
p-value	0.538

Panel C: correlations among explanatory variables

	β_d	β_t	Maturity	Duration	Rating	Yield
β_d	1					
β_t	0.48	1				
Maturity	0.19	0.52	1			
Duration	0.17	0.64	0.87	1		
Rating	0.33	−0.03	−0.11	−0.21	1	
Yield	0.22	0.08	0.45	0.21	0.39	1

Table 2

Monthly excess returns of univariate portfolios based on betas and characteristics

Each month bonds are sorted into portfolios based on four different risk measures: bond rating, duration, pre-ranking *DEF* beta, and pre-ranking *TERM* beta (Panels A through D, respectively). Betas are estimated over rolling five-year periods for each bond. Time-series averages of several portfolio characteristics are reported: default and term betas, maturity in years, bond rating, post-formation average one-month excess returns, post-formation one-month returns on portfolios matched by bond rating and duration quintiles, and the yield-to-maturity. Difference in average monthly excess between the high and low portfolios and the corresponding *t*-statistics are also reported. All monthly portfolio returns are value-weighted based on the market value of the bond at the end of the previous month. There are 228 monthly observations.

	AAA	AA	A	BBB	Diff	*t*(diff)
Panel A: Rating						
N	210	787	1226	674		
β_d	0.72	0.81	0.98	1.26		
β_t	0.96	0.95	0.94	0.95		
Maturity	18.79	16.42	15.23	14.64		
Duration	7.29	6.79	6.43	6.15		
Rating	2.00	4.20	6.93	9.89		
Return	0.26	0.27	0.27	0.33	0.07	(1.31)
Duration adjusted return	−0.02	−0.01	−0.00	0.04	0.06	(1.51)
Yield	9.75	9.92	10.16	10.75		

Panel B: Duration

	Low				High	Diff	*t*(diff)
N	579	580	580	580	579		
β_d	0.73	1.00	1.05	1.07	0.93		
β_t	0.70	0.87	0.97	1.03	1.08		
Maturity	5.23	10.39	14.60	18.53	24.83		
Duration	3.50	5.33	6.43	7.54	8.73		
Rating	6.46	7.01	6.73	6.41	5.07		
Return	0.24	0.29	0.30	0.31	0.28	0.04	(0.37)
Rating adjusted return	0.00	0.01	0.00	0.01	−0.01	−0.01	(−0.67)
Yield	9.97	10.18	10.21	10.30	10.13		
Panel C: β_d							
N	579	580	580	580	579		
β_d	0.40	0.76	0.95	1.15	1.65		
β_t	0.77	0.93	0.97	1.00	1.09		
Maturity	14.04	16.69	16.81	16.50	16.53		
Duration	6.00	6.65	6.83	6.85	6.77		
Rating	5.39	5.41	5.87	6.59	7.95		
Return	0.21	0.25	0.28	0.31	0.35	0.13	(2.54)
Duration/rating adjusted return	−0.02	−0.02	−0.00	0.01	0.05	0.07	(3.37)
Yield	10.05	10.00	10.10	10.21	10.48		
Panel D: β_t							
N	579	580	580	580	579		
β_d	0.60	0.85	0.99	1.03	1.24		
β_t	0.60	0.85	0.97	1.06	1.21		
Maturity	9.46	13.09	16.46	19.09	20.26		

Table 2 (*continued*)

	Low				High	Diff	t(diff)
Duration	4.65	5.76	6.67	7.45	7.94		
Rating	6.43	6.30	6.12	5.92	6.16		
Return	0.22	0.24	0.28	0.30	0.33	0.11	(1.00)
Duration/rating adjusted return	−0.03	−0.02	−0.00	0.01	0.04	0.07	(1.66)
Yield	10.26	10.04	10.09	10.13	10.20		

used to compute *DEF* consists of relatively more high-quality bonds than does the overall sample.

The two-factor model involving default and term factors is:

$$r - r_f = \alpha + \beta_\mathrm{d}\, DEF + \beta_\mathrm{t}\, TERM + u, \tag{2}$$

where $r - r_f$ represents excess returns on corporate bonds; β_d and β_t represent the default beta and the term beta, respectively; α is the intercept; and u is the error term. We use the two-factor model in Eq. (2) to estimate pre-ranking default and term betas for each corporate bond in our sample. Specifically, at the beginning of each month, we estimate the two-factor model for each corporate bond that meets our screening criteria. The regressions are estimated using prior 60 months' returns, though individual bonds are included if they have at least 24 return observations before the test month. Because we require five years of prior data to estimate betas, our empirical tests use data from 1978 to 1996 even through the overall sample starts in 1973.

Panel B of Table 1 provides the results of factor regressions involving the different ratings portfolios. The results show that the two-factor model explains 93% to 99% of the time variation in corporate bond returns, BBB bonds (as expected) have higher default betas than AAA bonds, and the alphas from the two-factor model are not significantly different from zero. We use the Gibbons, Ross, and Shanken (GRS 1989) statistic (θ) to test the null hypothesis that the two-factor model produces regression intercepts on the four ratings-based bond portfolios (AAA, AA, A, and BBB) that are all equal to zero. The θ-statistic is given by

$$\theta = [(T - N - K)/N]\left[1 + \mu'\Omega^{-1}\mu\right]^{-1}\alpha'\Sigma^{-1}\alpha, \tag{3}$$

where T is the number of time-series observations; N is the number of assets, portfolios, or intercepts included in the test; K is the number of factor portfolios in the regression, α is the $(N \times 1)$ column vector of regression intercepts; Σ is the maximum likelihood estimator of the $(N \times N)$ variance–covariance matrix of the residuals from the N time-series factor regressions; μ is the $(K \times 1)$ column vector of average factor portfolio excess returns; and Ω is the maximum likelihood estimator of the $(K \times K)$ variance–covariance matrix of the factor portfolio excess returns. The statistic has a $F_{(N,T-N-K)}$ distribution under the null hypothesis that the intercepts are zero, assuming normality of all variables.

The results in Panel B of Table 1 show that the GRS θ-statistic is 0.781 with a p-value of only 0.54, which suggests that the null of zero intercepts cannot be rejected for the four rating-based bond portfolios. This, in turn, suggests that the two-factor model is fairly well specified in explaining the returns of ratings-based bond portfolios. We examine the issue of how well the two-factor model prices portfolios based on default and term betas and other characteristics in Section 3.

2.2. Bond risk characteristics

We use the following characteristics widely used as measures of corporate bond risk: corporate bond ratings and duration. Ratings are proxies of a bond's default risk, and duration is a proxy of term or maturity risk of a bond.

Corporate bond ratings are issued by credit rating agencies such as Moody's and Standard & Poor's based on fundamental analysis (analysis of financial ratios with regard to profitability, liquidity, leverage, etc.; management competence; growth opportunities; industry; and competitive advantages and disadvantages) of the firm. They group bonds into various risk classes that are meant to convey the credit rating agencies' estimate of the probabilities of default or delayed payments for an individual bond as well as the recovery rate in case of default. Grouping bonds into broad risk categories ignores the differences between bonds within each group. Nevertheless, these ratings are widely used because of their simplicity.

The Macaulay duration is a popular measure of term or maturity risk of a bond. We use the modified duration, namely the Macaulay duration divided by one plus the yield to maturity, as our proxy of term risk and compare modified duration with term beta in their ability to explain the cross-section of corporate bond returns. Henceforth, we use the terms *duration* and *modified duration* interchangeably.

2.3. Common variation among betas and characteristics

Panel C of Table 1 reports the time-series averages of cross-sectional Spearman correlations among betas and characteristics. The correlation between default betas and bond ratings is 0.33, which suggests that bond ratings and pre-ranking default betas likely share important information about systematic default risk. Similarly, the correlation between duration (maturity) and pre-ranking term beta is 0.64 (0.52), suggesting that the two variables share significant common information about systematic term risk. Panel C also shows significant positive correlations between bond yields and default betas (0.22), between yields and duration (of 0.45), and between yields and ratings (of 0.39), suggesting that yields (not surprisingly) capture information about all these variables. It is unclear, however, how betas and characteristics would fare against each other in explaining the cross-section of expected bond returns. We examine this issue in detail in the following sections.

Two other numbers worth noting in Panel C are the correlations between pre-ranking default and term betas and between ratings and duration. The positive correlation of 0.48 between the pre-ranking default and term betas could be the result of common measurement error in estimation because both come from the same factor model estimation. Empirically, the positive correlation suggests we need to generate variations in each independent of the other. We do that through independent sorts in Section 3.2. The negative correlation of −0.21 between ratings and duration is simply a result of the fact that lower-rated bonds tend to be of shorter duration because lenders are unwilling to lend for longer durations to firms with higher default risk.

3. Betas vs. characteristics in explaining corporate bond returns

We now conduct a series of empirical tests to determine how betas and characteristics fare in explaining the cross-section of corporate bond returns. Specifically, we examine the relation between the various risk characteristics and bond returns using portfolios based on univariate and multivariate sorts of the data. The univariate sorts provide a benchmark in terms of the univariate effects of each risk variable on expected bond returns; the multivariate sorts allow us to examine the relation between a given risk variable (say default beta) and expected bond returns while controlling for the influence of other risk variables. In Section 4, we conduct Fama and MacBeth cross-sectional regression tests using individual bond returns, which allow us to control for the effects of more than one risk variable.

3.1. Univariate portfolio results based on default beta, term beta, ratings, and duration

Table 2 reports the average monthly excess returns and yields earned by portfolios based on univariate sorts of betas and characteristics. The portfolios are formed as follows. At the beginning of each month during our sample period, we sort all outstanding bonds by the variable of interest (rating, duration, default beta, and term beta) and divide them into five portfolios with approximately the same number of bonds in each portfolio (on average 580 bonds in each portfolio except those involving ratings that fall into 4 portfolios—AAA/AA/A/BBB—and contain unequal number of firms in each ratings portfolio). We compute the value-weighted average excess return (in excess of one month T-bill return) earned by each portfolio over the next month and then report the time-series average of these monthly excess returns. As noted in Section 2, all returns are value-weighted based on the market value of the bond as of the sorting date. In addition, we also compute value-weighted averages of default and term betas, ratings, duration, and time-to-maturity.

We report raw excess returns as well as returns adjusted for duration or rating to control for risk. The adjusted returns are computed by subtracting from each bond's return, the return on a benchmark portfolio based on duration, rating, or duration and rating. For portfolios based on ratings, we adjust only for duration; for portfolios based on duration, we adjust only for rating; and for the rest, we adjust for both duration and rating. The benchmark portfolios involve five duration portfolios, four rating portfolios (AAA/AA/A/BBB), and 20 duration/rating portfolios. The duration/rating portfolios are created by first sorting bonds into four ratings portfolios, and then by sorting each rating portfolio into five duration portfolios. A benchmark portfolio is simply the portfolio to which a given bond belongs.

Panel A reports the relationship between average bond returns and ratings. The results show that low-grade bonds (BBB) earn 0.07% (0.06% for duration-adjusted returns) more than high-grade bonds (AAA) per month. Both return measures increase monotonically across the ratings portfolios. The differences, however, are only marginally significant (t-statistics of 1.31 for raw returns and 1.51 for duration-adjusted returns). The annualized yields on BBB bonds (10.75%) exceed the yields on AAA bonds (9.75%) by 1%. The table also shows, not surprisingly, that BBB bonds have higher default betas. Overall, the findings in Panel A, in general, confirm our priors that low-grade bonds are riskier than high-grade bonds and, therefore, should earn higher returns. In Panel B, we find that duration is not significantly related to average bond returns. The return differential between high duration bonds and low duration bonds is a statistically insignificant 0.04% per month (−0.01% when adjusted for rating). Overall, the univariate results suggest that the relationship between risk characteristics and corporate bond returns is weak.

Panels C and D report the returns earned by bond portfolios formed on the basis of default and term betas. The results in Panel C show that default beta is significantly related to the cross-section of bond returns. The high default beta portfolio earns a statistically significant (t-statistic of 2.54) 0.13% more than the low default beta portfolio per month. The duration and rating adjusted return differential is 0.07% per month but with a higher t-statistic of 3.37. In addition, there is a monotonic increase in both return measures across the default beta portfolios. The yield differential between high and low default beta portfolios is 0.43% per year, which is not as high as the return differential.

The results in Panel D provide mixed evidence on the relationship between term betas and expected bond returns. While the return differential of 0.11% per month (0.07% adjusted for ratings and duration) between the high term beta portfolio and the low term beta portfolio is almost as large as the premium of 0.13% observed for default beta portfolios, it is not statistically significant (t-statistics are 1.00 and 1.66 for raw returns and the ratings/duration adjusted returns, respectively). However, both return measures do show monotonic increases moving across the term beta portfolios. On the one hand, while not conclusive, the results do appear stronger than the findings on duration. On the other hand, no discernible relationship exists between yields and term betas.

In sum, the univariate evidence suggests that default betas and term betas are better determinants of average bond returns than ratings and duration. Still, the univariate results in Table 2 are confounded by the significant correlations among betas and characteristics. Therefore, we turn to examining returns of portfolios based on multiple sorts aimed at controlling for the effects of characteristics or betas. This approach allows us to evaluate whether default betas can explain the cross-sectional.

3.2. Returns of beta portfolios controlling for ratings and duration

Table 3 reports average monthly excess returns earned by default beta and term beta portfolios formed as follows. Each month, we sort all bonds independently into

Table 3
Monthly excess returns of portfolios sorted by rating, duration, and default or term beta
Each month bonds are independently sorted into three ratings portfolios [(1) AAA/AA, (2) A, and (3) BBB] and three duration portfolios. Nine portfolios are created at the intersection of the rating and duration portfolios. Within each of these portfolios, three portfolios are created based on either pre-ranking default beta (Panel A) or term beta (Panel B). The pre-ranking betas are estimated based on a time-based regression of excess bond return on the default and the term factor. The time-series average monthly excess return (in percent) of each portfolio is reported along with the difference in average return between the high beta and the low beta portfolio. The *t*-statistic is a simple *t*-test of differences. All monthly portfolio returns are value-weighted based on the market value of the bond at the end of the previous month. There are 228 monthly observations.

Characteristic portfolio		β_d				
Rating	Duration	1	2	3	Diff	*t*(diff)
Panel A: pre-ranking default beta						
1	1	0.219	0.199	0.220	0.002	(0.05)
1	2	0.266	0.272	0.303	0.038	(1.18)
1	3	0.242	0.280	0.315	0.073	(2.05)
2	1	0.213	0.214	0.256	0.043	(1.19)
2	2	0.263	0.297	0.350	0.087	(2.81)
2	3	0.236	0.289	0.316	0.080	(2.37)
3	1	0.280	0.314	0.378	0.098	(1.97)
3	2	0.284	0.308	0.371	0.088	(1.81)
3	3	0.201	0.242	0.305	0.104	(1.56)
Average		0.245	0.268	0.313	0.068	(2.73)

Panel B: pre-ranking term beta

Characteristic portfolio		β_t				
Rating	Duration	1	2	3	Diff	*t*(diff)
1	1	0.197	0.207	0.235	0.038	(0.62)
1	2	0.252	0.275	0.307	0.055	(1.06)
1	3	0.236	0.275	0.307	0.071	(1.21)
2	1	0.215	0.217	0.259	0.045	(0.70)
2	2	0.270	0.291	0.352	0.082	(1.59)
2	3	0.230	0.296	0.315	0.085	(1.42)
3	1	0.282	0.322	0.387	0.105	(1.23)
3	2	0.271	0.336	0.355	0.085	(1.25)
3	3	0.176	0.268	0.316	0.140	(1.62)
Average		0.237	0.276	0.315	0.078	(1.51)

three ratings portfolios (1 is high quality, 3 is low quality) and three duration portfolios (1 is low duration, 3 is high duration). Thus, nine portfolios are created at the intersection of rating and duration portfolios. Each of these rating-duration portfolios are then divided into three portfolios based on either pre-ranking default betas or term betas. This portfolio formation procedure is analogous to the one used by Daniel and Titman (1997) and is intended to generate variation in default or term betas independent of the variation in ratings and duration. As shown in Table 4, this sorting procedure generates sufficient variation in ex post default and term betas, suggesting pre-ranking betas are good proxies of post-ranking betas. The goal of this exercise is to determine whether there is cross-sectional variation in average bond returns related to default or term betas unrelated to the variation in characteristics.

Panel A of Table 3 reports the average excess returns of rating-duration-default beta portfolios. Each row provides the average excess returns of low (1), medium (2), and high (3) default beta portfolios, and the average return on a zero-investment portfolio that is long high default beta portfolio and short low default beta portfolio (see column entitled "Diff"). There are nine zero-investment portfolios, one for each rating-duration portfolio. All nine zero-investment portfolios earn positive returns ranging from 0.002% a month to 0.104% a month. Out of the nine t-statistics (testing the null that the difference is zero), two are significant at the 1% level, three at the 5% level, and one at the 10% level (all one-sided tests). The row entitled "average" provides the equal-weighted average return across all nine rating-duration portfolios. The average difference is 0.068% per month with a highly significant t-statistic of 2.73. Overall, the evidence suggests a significant positive relationship between average corporate bond returns and default betas that is independent of characteristics.

Panel B reports the average returns of rating-duration-term beta portfolios. Each row now provides the average returns of term beta portfolios. As in the case of default beta portfolios, all nine zero-investment portfolios (high term beta minus low term beta portfolio) earn positive returns ranging from a low of 0.038% to a high of 0.14%. Also, there is a monotonic increase in returns with term betas in each of the nine rows. The average across the nine portfolios is 0.078%, which is higher than the average for default beta portfolios in Panel A. The statistical significance of these findings, however, is weaker. Only three out of nine t-statistics are significant at even the 10% level (all one-sided tests). The rest are insignificant. The average return is also significant only at the 10% level. Thus, while the magnitude of the average returns is comparable to those of the default beta portfolios, the statistical significance is weaker, confirming the pattern observed in Table 2. Nevertheless, the results do suggest a positive relationship between term betas and average bond returns, controlling for ratings and duration.

Overall, the results in Table 3 indicate that default betas and, to a lesser extent, term betas are important determinants of the cross-sectional variation in average bond returns. We now turn to formally testing the role of characteristics and betas in explaining the cross-section of bond returns.

3.3. Ex post factor regressions involving default beta portfolios

Table 4 reports results from factor regressions involving the post-formation excess returns of the 27 ranking-duration-default beta portfolios. Panel A provides the intercepts, ex post default and term betas and the corresponding t-statistics for the 27

Table 4
Results from factor regressions involving post-formation excess returns of portfolios sorted by rating, duration, and default beta
Each month bonds are independently sorted into three ratings portfolios [(1) AAA/AA, (2) A, and (3) BBB] and three modified duration portfolios. Nine portfolios are created at the intersection of the rating and duration portfolios, and within each of these portfolios, three portfolios are created based on default betas (1 is low, three is high). This table presents the results from regressions of these portfolio excess returns on the default (*DEF*) and the term factor (*TERM*):

$$r_\tau - r_{f\tau} = \alpha + \beta_d\, DEF_\tau + \beta_t\, TERM_\tau + u_\tau.$$

Panel A provides the results for individual portfolios. Panel B provides the results for zero-investment portfolios that long high default beta portfolio and short low default beta portfolio. "Average" represents the equal-weighted average alphas and betas of individual default beta portfolios or zero-investment portfolios (Panel B) across all bivariate rating-duration portfolios. Panel C reports results using an alternate default factor defined as the return on a value-weighted portfolio BBB bonds with at least ten years to maturity minus the return on long-term government bonds. The Gibbons et al. (1989) *F*-test (with 9 degrees of freedom in the numerator and 217 degrees of freedom in the denominator) is a test of the null that the nine intercept terms are equal to zero. All monthly portfolio returns are value-weighted based on the market value of the bond at the end of the previous month. There are 228 monthly observations.

Characteristic portfolio		Pre-ranking default beta portfolio					
Rating	Duration	1	2	3	1	2	3
		α			$t(\alpha)$		
Panel A: factor regression results for individual portfolios							
1	1	0.059	0.017	0.010	1.45	0.46	0.26
1	2	0.008	−0.009	0.015	0.24	−0.38	0.56
1	3	−0.065	−0.037	0.002	−2.03	−1.43	0.07
2	1	−0.006	0.010	0.038	1.08	0.26	0.90
2	2	−0.009	0.014	0.059	−0.30	0.56	2.00
2	3	−0.063	−0.025	0.005	−2.92	−1.17	0.20
3	1	0.092	0.084	0.146	2.08	1.45	2.34
3	2	−0.006	0.001	0.070	−0.12	0.01	1.25
3	3	−0.094	−0.080	−0.028	−1.90	−1.35	−0.50
Average		−0.004	−0.003	0.035	−0.18	−0.13	1.46
		β_d			$t(\beta_d)$		
1	1	0.565	0.648	0.776	9.23	10.98	13.11
1	2	0.883	0.973	1.026	21.80	35.42	32.14
1	3	0.886	0.953	0.974	20.79	25.48	22.93
2	1	0.662	0.796	0.860	11.24	13.54	13.16
2	2	1.003	0.999	1.089	30.55	35.94	24.32
2	3	0.961	1.027	1.066	30.66	31.87	23.55
3	1	0.787	1.016	1.112	13.10	9.09	11.82
3	2	1.187	1.218	1.204	17.90	22.09	15.93
3	3	1.116	1.160	1.233	12.95	15.44	15.99
Average		0.894	0.977	1.038	27.25	34.32	29.24
		β_t			$t(\beta_t)$		
1	1	0.526	0.598	0.687	17.77	24.19	23.54
1	2	0.853	0.931	0.947	44.19	66.33	58.96
1	3	1.038	1.070	1.051	78.95	100.06	86.85

Table 4 (*continued*)

			β_t			$t(\beta_t)$		
2	1	0.555	0.662	0.705	21.47	25.45	25.99	
2	2	0.887	0.932	0.948	65.16	87.91	65.35	
2	3	0.997	1.045	1.030	68.19	107.94	56.64	
3	1	0.601	0.729	0.722	20.05	18.37	21.02	
3	2	0.931	0.995	0.973	35.38	45.13	39.40	
3	3	0.961	1.056	1.086	19.33	38.13	40.64	
Average		0.817	0.891	0.906	64.80	70.03	70.36	

Panel B: regression results for high default beta minus low default beta portfolio

Rating	Duration	α	β_d	β_t	$t(\alpha)$	$t(\beta_d)$	$t(\beta_t)$	Adj. R^2
0	0	−0.049	0.211	0.162	−2.15	8.99	14.80	0.65
0	1	0.007	0.143	0.094	0.28	3.97	6.64	0.30
0	2	0.067	0.088	0.012	1.84	1.47	0.77	0.01
1	0	−0.004	0.198	0.150	−0.19	6.95	14.83	0.62
1	1	0.068	0.086	0.061	2.26	1.96	3.90	0.13
1	2	0.068	0.105	0.033	1.99	1.88	2.19	0.04
2	0	0.054	0.326	0.121	1.23	4.60	4.05	0.23
2	1	0.076	0.017	0.042	1.64	0.27	1.81	0.03
2	2	0.067	0.116	0.125	1.15	1.48	2.45	0.13
Average		0.039	0.143	0.089	2.06	5.86	10.00	0.44

Gibbons, Ross, and Shanken *F*-Test
p-value 0.016

Panel C: regression results for high default beta minus low default beta portfolio based on alternate default factor using the BBB portfolio

1	1	−0.052	0.162	0.160	−2.27	7.97	15.07	0.642
1	2	0.006	0.107	0.092	0.21	3.22	6.08	0.292
1	3	0.061	0.102	0.019	1.70	2.37	1.23	0.039
2	1	−0.009	0.169	0.153	−0.43	7.51	15.83	0.636
2	2	0.064	0.084	0.064	2.14	2.14	4.05	0.143
2	3	0.062	0.114	0.039	1.86	2.66	2.69	0.065
3	1	0.040	0.320	0.134	0.97	6.74	5.14	0.309
3	2	0.074	0.023	0.044	1.61	0.40	1.79	0.025
3	3	0.059	0.134	0.134	1.02	2.31	2.83	0.138
Average		0.034	0.135	0.093	1.89	6.69	10.80	0.490

Gibbons, Ross, and Shanken *F*-Test
p-value 0.029

portfolios. The results show that high pre-ranking default beta portfolios have high post-ranking default betas. There is a monotonic increase in post-ranking betas in seven of the nine portfolio groups moving from low to high pre-ranking default beta portfolio. This suggests that pre-formation default betas are reasonably good predictors of post-formation default betas.

Of more interest to us are the intercepts of these portfolios. If the characteristics model involving ratings and duration is correct, i.e., average bond returns are determined by variation in characteristics instead of default betas, then the expected bond returns should be constant across the various pre-ranking default beta portfolios. However, because the ex post default betas increase from the low default beta portfolio to the high default beta portfolio, the intercept on the low default beta portfolio should be positive and the intercept on the high default beta portfolio should be negative. Consequently, the zero-investment portfolio that is long high default beta and short low default beta should also have a negative intercept.

The results in Panel A of Table 4 indicate just the opposite. Of the nine intercepts for the low default beta portfolio only four are positive and only one of them significantly. The average intercept across all nine portfolios is, in fact, negative. Among the high default beta portfolios, eight of the nine intercepts are positive and the average intercept, not surprisingly, is also positive. Panel B reports a formal test of the difference in intercepts between high and low default beta portfolio. If the characteristics model is correct, the differences should be significantly negative. The results in Panel B show that seven of the nine intercepts are positive, not negative; the average intercept is also positive and significant at the 5% level. The GRS F-test also rejects the null that the intercepts are jointly zero across the nine portfolios. Thus, the results in Table 5 reject the characteristics model involving duration and ratings for explaining the expected returns on corporate bonds.

Do these results support the factor model specified in Eq. (2)? If the factor model in Eq. (2) is correct, then the intercepts for the various default beta portfolios should be zero and not correlated with the default beta. Our findings show, instead, that the factor model leaves unexplained roughly half of the mean return difference (of 6.8 basis points as shown in Panel A of Table 3) between the high and the low default beta portfolio. The intercepts are nonzero and increase with default betas, suggesting that while the characteristics model is rejected in favor of the factor model, the particular factor model we use may not be well specified in terms of explaining all of the returns of the default beta portfolios.

One possible reason for these findings is that the average premium on the DEF factor is only 4 basis points per month, while the difference between high default beta and low default beta portfolios is 13 basis points per month (Panel C of Table 2). Therefore, we consider an alternate default factor defined as the difference between the monthly return on a value-weighted market portfolio of all BBB corporate bonds with at least ten years to maturity and the monthly long-term government bond return. This alternate default factor has an average premium of about 9 basis points per month, which is twice that of the original. However, the correlation between the alternate default factor and the original default factor is 93%, suggesting that both factors capture mostly similar time variation.

The results using the alternate default factor for the default beta portfolios are presented in Panel C of Table 4. The pre-ranking betas are still based on the original default factor, but we use the alternate default factor to estimate ex post regressions. In this way, we compare the pricing of the same portfolios across two different factor models. The average intercept falls from 3.9 basis points in Panel B to 3.4 basis points in Panel C, and the t-statistic falls from 2.06 to a marginally significant 1.89. The alternate default factor marginally improves the pricing performance, but the

Table 5

Results from factor regressions involving post-formation excess returns of portfolios sorted by rating, duration, and term beta

Each month bonds are independently sorted into three ratings portfolios [(1) AAA/AA, (2) A, and (3) BBB] and three modified duration portfolios. Nine portfolios are created at the intersection of the rating and duration portfolios, and within each of these portfolios, 3 portfolios are created based on pre-ranking term betas (1 is low, three is high). This table presents the results from regressions of these portfolio excess returns on the default (*DEF*) and the term factor (*TERM*):

$$r_\tau - r_{f\tau} = \alpha + \beta_{\mathrm{d}}\, DEF_\tau + \beta_{\mathrm{t}}\, TERM_\tau + u_\tau.$$

Panel A provides the results of individual portfolios. Panel B provides the results for zero-investment portfolios that long high term beta portfolio and short low term beta portfolios. "Average" represents the equal-weighted average alphas and betas of individual term beta portfolios or zero-investment portfolios (Panel B) across all bivariate rating-duration portfolios. The Gibbons et al. (1989) *F*-test (with 9 degrees of freedom in the numerator and 217 degrees of freedom in the denominator) is a test of the null that the nine intercept terms are equal to zero. All monthly portfolio returns are value-weighted based on the market value of the bond at the end of the previous month. There are 228 monthly observations.

Characteristic portfolio		Pre-ranking term beta portfolio					
Rating	Duration	1	2	3	1	2	3
		α			$t(\alpha)$		
Panel A: Factor regression results for individual portfolios							
1	1	0.058	0.023	0.011	1.46	0.59	0.27
1	2	0.006	−0.007	0.012	0.16	−0.27	0.44
1	3	−0.053	−0.046	−0.023	−1.70	−1.87	−0.77
2	1	−0.006	0.012	0.020	1.61	0.31	0.46
2	2	0.016	0.005	0.047	0.49	0.20	1.74
2	3	−0.047	−0.026	−0.012	−1.72	−1.25	−0.41
3	1	0.118	0.102	0.121	2.82	2.01	1.60
3	2	−0.001	0.030	0.033	−0.02	0.58	0.58
3	3	−0.107	−0.064	−0.029	−1.79	−1.18	−0.52
Average		0.006	0.003	0.020	0.23	0.16	0.79
		β_{d}			$t(\beta_{\mathrm{d}})$		
1	1	0.527	0.638	0.769	8.21	11.02	14.39
1	2	0.907	0.968	0.982	22.70	32.65	23.52
1	3	0.997	1.011	0.889	29.07	25.18	20.46
2	1	0.608	0.799	0.903	10.07	13.14	14.59
2	2	0.987	1.029	1.070	24.53	34.22	27.68
2	3	1.024	1.077	1.009	32.93	38.82	19.69
3	1	0.738	0.960	1.214	11.48	13.55	8.54
3	2	1.198	1.178	1.233	15.86	18.25	17.32
3	3	1.109	1.243	1.209	12.10	15.13	15.73
Average		0.899	0.989	1.031	26.72	38.08	23.82
		β_{t}			$t(\beta_{\mathrm{t}})$		
1	1	0.452	0.609	0.743	16.88	21.91	27.19
1	2	0.806	0.934	0.979	35.34	62.37	69.64
1	3	0.955	1.075	1.128	63.59	102.42	88.06
2	1	0.489	0.663	0.782	18.94	25.02	29.74
2	2	0.824	0.938	1.008	46.51	86.89	85.96

Table 5 (*continued*)

		β_t			$t(\beta_t)$			
2	3	0.909	1.071	1.098	54.71	98.37	67.75	
3	1	0.519	0.697	0.839	19.17	23.70	18.90	
3	2	0.862	0.993	1.050	30.75	43.73	40.01	
3	3	0.916	1.084	1.136	17.49	32.10	40.20	
	Average	0.748	0.896	0.974	55.16	70.26	68.93	
Panel B: regression results for high term beta minus low term beta portfolio								
Rating	Duration	α	β_d	β_t	$t(\alpha)$	$t(\beta_d)$	$t(\beta_t)$	Adj. R^2
1	1	−0.047	0.242	0.291	−1.98	7.78	24.94	0.86
1	2	0.007	0.076	0.172	0.17	1.47	7.76	0.47
1	3	0.030	−0.108	0.174	0.73	−2.04	8.56	0.55
2	1	−0.044	0.296	0.293	−1.48	8.58	21.48	0.79
2	2	0.030	0.083	0.184	0.86	1.64	9.93	0.55
2	3	0.036	−0.014	0.189	0.83	−0.24	8.51	0.51
3	1	0.003	0.476	0.319	0.05	4.15	9.07	0.49
3	2	0.034	0.035	0.188	0.62	0.47	7.64	0.36
3	3	0.078	0.101	0.221	1.15	0.94	3.43	0.28
	Average	0.014	0.132	0.226	0.59	3.79	18.31	0.79
Gibbons, Ross, and Shanken F-Test								
p-value	0.494							

increase in premium is not large enough to completely explain the intercept given the observed difference in ex post default betas.

One additional problem could be that even though we form portfolios every month, we could not be adequately controlling for time variation in betas. By using conditioning information in the beta estimation, we could be able to achieve better pricing. To examine this possibility, we estimate the following conditional version of the factor model (see Shanken, 1990; Fama and French, 1997):

$$r - r_f = \alpha + (\beta_{d1} + \beta_{d2}\, Rating) \times DEF + (\beta_{t1} + \beta_{t2}\, Duration) \times TERM + u.$$

In this regression, default and term betas vary with the bond's ratings and duration. Ratings and duration are measured one month prior to the month in which the excess return and the default and term factors are measured. We find that the conditional factor model results (not reported) are not appreciably different from the unconditional factor model results in Panels B and C of Table 4. The average intercept is significantly positive and the GRS F-test rejects the null of zero slopes at the 1% level.

3.4. Ex post factor regressions involving term beta portfolios

Table 5 reports results from (original) two-factor regressions involving the post-formation excess returns of the 27 ranking-duration-term beta portfolios. Panel A provides the intercepts, ex post default and term betas and the corresponding t-statistics for the 27 portfolios. The results show a monotonic increase in post-ranking term betas moving from the low term beta portfolio to the high term beta portfolio. The average return across zero-investment portfolios (high term beta minus low term beta) in Panel B is a statistically insignificant 0.014% per month. Also, the GRS F-test cannot reject the null hypothesis that the intercepts are jointly zero. In sum, the evidence suggests that the two-factor model is reasonably well specified in terms of pricing the term risk.

3.5. Returns of ratings or duration portfolios controlling for default and term betas

In Table 6, we examine whether characteristics-based portfolios are related to average bond returns, once we control for default and term betas. We first form three portfolios based on default betas and three portfolios based on term betas through independent sorts. The intersection of the two sorts gives nine default beta-term beta portfolios. We then divide each default beta-term beta portfolio into three portfolios based on ratings or duration.

Panel A of Table 6 presents the results for rating portfolios. These results confirm the univariate findings in Table 2 that the relationship between ratings and average bond returns is not very strong. Focusing on the difference between the low rating (portfolio 3) and the high rating portfolio (portfolio 1), we find that while the differences are uniformly positive, only two out of the nine t-statistics are significant. Accordingly, the average difference of 0.045% per month across all nine beta portfolios is only marginally significant.

Panel B of Table 6 presents the duration portfolio results. Controlling for differences in default and term betas, all the high duration portfolios (portfolio 3) earn lower returns than the corresponding low duration portfolios (portfolio 1). The differences, however, are not statistically significant. In sum, while betas are significantly related to average bond returns controlling for ratings and duration, ratings and duration are not related to average bond returns controlling for default and term betas.

3.6. Yield-to-maturity and average bond returns

The key finding thus far is that betas fare better than characteristics such as ratings and duration in explaining average bond returns. We have not examined, however, the one characteristic that is most likely to be related to average bond returns; a bond's own yield-to-maturity, which is analogous to the book-to-market ratio of a stock. In the time-series, yield variables have been shown to be excellent predictors of aggregate bond returns (See Fama and Bliss, 1987; Campbell and Shiller, 1991; Campbell, 1995; Cochrane and Piazzesi, 2002). In the cross-section, too, high yields must predict high bond returns unless higher default rates among high-yield bonds fully offset the higher yields. More substantively, the yield variable is likely to be a catch-all proxy for information about default and term risk, call provisions, and other bond covenants not captured by the default beta, differences in liquidity,

Table 6

Monthly excess returns of portfolios sorted by pre-ranking default beta, term beta, and characteristics

Each month bonds are independently sorted into three pre-ranking term beta portfolios. Nine portfolios are created at the intersection of the default and term beta portfolios. Within each of these portfolios, three portfolios are created based on either rating (Panel A, 1 is low risk and three is high risk), duration (Panel B), or yield-to-maturity (Panel C). The pre-ranking betas are estimated based on a time-series average monthly excess return (in percent) of each portfolio is reported along with the difference in average return between the high rating or duration portfolio and the low rating or duration portfolio. The t-statistic is a simple t-test of differences. All monthly portfolio returns are value-weighted based on the market value of the bond at the end of the previous month. There are 228 monthly observations.

Factor portfolio		Rating portfolio				
β_d	β_t	1	2	3	Diff	t(diff)
Panel A: Ratings						
1	1	0.183	0.241	0.255	0.071	(2.38)
1	2	0.227	0.244	0.249	0.022	(0.57)
1	3	0.309	0.264	0.314	0.055	(1.23)
2	1	0.202	0.233	0.328	0.126	(2.96)
2	2	0.253	0.360	0.279	0.026	(0.76)
2	3	0.295	0.302	0.319	0.023	(0.61)
3	1	0.254	0.354	0.259	0.005	(0.08)
3	2	0.307	0.335	0.359	0.052	(1.03)
3	3	0.341	0.293	0.377	0.036	(0.64)
Average		0.259	0.274	0.304	0.045	(1.49)

Panel B: Duration

Factor portfolio		Duration portfolio				
β_d	β_t	1	2	3	Diff	t(diff)
1	1	0.208	0.219	0.206	−0.003	(−0.03)
1	2	0.258	0.245	0.232	−0.026	(−0.41)
1	3	0.317	0.258	0.262	−0.056	(−0.98)
2	1	0.246	0.284	0.233	−0.013	(−0.19)
2	2	0.277	0.272	0.258	−0.020	(−0.43)
2	3	0.332	0.295	0.289	−0.043	(−0.94)
3	1	0.271	0.339	0.244	−0.027	(−0.36)
3	2	0.346	0.326	0.313	−0.032	(−0.57)
3	3	0.385	0.350	0.330	−0.055	(−0.88)
Average		0.293	0.288	0.263	−0.030	(−0.62)

Panel C: yield-to-maturity

Factor portfolio		Yield-to-maturity portfolio				
β_d	β_t	1	2	3	Diff	t(diff)
1	1	0.082	0.200	0.325	0.243	(5.60)
1	2	0.143	0.235	0.315	0.172	(3.29)

Table 6 (*continued*)

Factor portfolio		Yield-to-maturity portfolio				
β_d	β_t	1	2	3	Diff	t(diff)
1	3	0.200	0.267	0.353	0.153	(3.23)
2	1	0.121	0.236	0.341	0.220	(4.45)
2	2	0.181	0.270	0.332	0.152	(3.96)
2	3	0.233	0.288	0.361	0.128	(3.30)
3	1	0.091	0.298	0.385	0.294	(4.14)
3	2	0.207	0.302	0.437	0.230	(4.58)
3	3	0.243	0.330	0.458	0.215	(4.16)
Average		0.167	0.270	0.368	0.201	(5.83)

mispricing, and any omitted sources of risk beside the default and term risk. As a result, one would expect the yield-to-maturity to be a significant predictor of average bond returns.

Our empirical tests confirm the yield-to-maturity to be a strong predictor of average bond returns. Panel C of Table 6 reports average excess returns of portfolios formed on the basis of yield-to-maturity controlling for the variation in default and term betas.[4] It is important to control for default beta because of the significant positive correlation between yields and default betas (see Panel C of Table 1). To achieve this, we first form nine portfolios based on independent sorts of pre-ranking default and term betas and then we divide each default beta-term beta portfolio into three portfolios based on the yield-to-maturity. Focusing on the return differential between the high-yield (3) and the low-yield portfolio (1), the results show that the mean difference is in the range of 0.128% to 0.294%. Each of the nine differences is strongly significant at the 1% level and so is the average difference of 0.201%.

Table 7 reports results from factor regressions involving the post-formation excess returns of the 27 default beta-term beta-yield portfolios. To conserve space, we present results only for the nine high-yield minus low-yield zero-investment portfolios. Panel A presents results using the original factor model in Eq. (1), and Panel B presents results using the alternate BBB default factor discussed in Section 3.3. The results show that both factor models do a poor job of explaining the mean returns of yield portfolios even though high-yield portfolios tend to have high default betas (the spread in ex post default betas between high-yield and low-yield portfolios is about 0.2). In both panels, each of the nine zero-investment portfolios have economically and statistically significant positive intercepts, suggesting that high-yield portfolios continue to earn higher returns even after controlling for the factor

[4] For comparison, we have also computed the excess returns of quintile portfolios based on univariate sorts of yield-to-maturity. The results show that average bond returns increase monotonically with yield-to-maturity. The high yield portfolio earns 0.29% per month (t-stat of 5.24) more than the low yield portfolio. The duration and rating adjusted return differential is 0.18% per month (t-stat of 4.65).

Table 7

Results from factor regressions involving post-formation excess returns of portfolios sorted by default beta, and yield-to-maturity

Each month bonds are independently sorted into three pre-ranking default beta portfolios and three pre-ranking term portfolios. Nine portfolios are created at the intersection of the pre-ranking default and term beta portfolios, and within each of these portfolios, three portfolios are created based on yield-to-maturity (1 is low, three is high). This table presents the results from regressions of these portfolio-excess returns on the default factor (*DEF*) and the term factor (*TERM*):

$$r_\tau - r_{f\tau} = \alpha + \beta_d\, DEF_\tau + \beta_t\, TERM_\tau + u_\tau.$$

The alternate default factor is defined as the difference between value-weighted return on all BBB bonds with at least ten years to maturity and the return on the long-term government bond series from the Center for Research in Security Prices. Panel A provides the results for zero-investment portfolios that long high yield portfolio and short low yield portfolio based on the original default factor, and Panel B presents results based on the alternate BBB default factor. ''Average'' represents the equal-weighted average alphas and betas of zero-investment portfolios across all bivariate default beta-term beta portfolios. The Gibbons et al. (1989) *F*-test (with 9 degrees of freedom in the numerator and 217 degrees of freedom in the denominator) is a test of the null that the nine intercept terms are equal to zero. All monthly portfolio returns are value-weighted based on the market value of the bond at the end of the previous month. There are 228 monthly observations.

β_d	β_t	α	β_d	β_t	$t(\alpha)$	$t(\beta_d)$	$t(\beta_t)$	Adj. R^2
Panel A: regression results for portfolios that are long high yield and short low yield								
1	1	0.245	0.076	−0.018	5.46	1.16	−0.67	0.03
1	2	0.139	0.233	0.094	2.86	3.45	3.55	0.11
1	3	0.148	0.138	−0.004	3.18	2.71	−0.20	0.04
2	1	0.205	0.205	0.028	4.26	2.81	1.10	0.06
2	2	0.136	0.157	0.035	3.71	3.35	2.08	0.06
2	3	0.128	0.046	−0.006	3.38	1.03	−0.30	0.00
3	1	0.270	0.254	0.055	3.94	2.92	1.68	0.04
3	2	0.209	0.191	0.049	4.33	2.75	2.28	0.05
3	3	0.200	0.200	0.030	3.83	2.78	1.14	0.05
Average		0.187	0.167	0.029	5.69	3.66	1.90	0.08
Gibbons, Ross, and Shanken *F*-Test								
p-value	0.001							

Panel B: regression results for portfolios that are long high yield and short low yield based on alternate default factor using the BBB portfolio

β_d	β_t	α	β_d	β_t	$t(\alpha)$	$t(\beta_d)$	$t(\beta_t)$	Adj. R^2
1	1	0.236	0.114	−0.006	5.27	2.08	−0.22	0.06
1	2	0.129	0.229	0.103	2.69	4.31	4.02	0.15
1	3	0.135	0.191	0.014	2.97	4.96	0.72	0.10
2	1	0.199	0.176	0.031	4.08	3.08	1.23	0.07
2	2	0.124	0.200	0.052	3.48	4.92	2.84	0.15
2	3	0.119	0.103	0.008	3.16	3.11	0.40	0.04
3	1	0.252	0.303	0.077	3.81	4.14	2.34	0.10
3	2	0.188	0.287	0.079	4.24	4.99	3.69	0.19
Average		0.173	0.215	0.047	5.61	5.85	3.08	0.22
Gibbons, Ross, and Shanken *F*-Test								
p-value	0.001							

risks. In Panels B and C, the individual intercepts range from 12 to 24 basis points per month, and the average intercept ranges from 17 to 19 basis points per month. For comparison, these averages are about four to five times the average intercepts reported for the default beta portfolios in Panels B and C of Table 4. Not surprisingly, the *t*-statistic corresponding to the average intercept is a highly significant 5.61.

3.7. Ex ante maximum Sharpe measure

Are the nonzero intercepts in Table 7 (for the nine yield-sorted zero-investment portfolios) and Table 4 (for the nine default beta-sorted zero-investment portfolios) the result of omitted risk factors or nonrisk alternatives such as data snooping biases, market frictions, and market inefficiencies? To answer this question, we compute the ex ante maximum Sharpe ratio measure for the optimal orthogonal portfolio recommended by MacKinlay (1995). The ex ante Sharpe measure corrects for the bias introduced in the ex post Sharpe ratio by searching among N assets to find the maximum value. The optimal orthogonal portfolio is a portfolio of N assets that is orthogonal to the factor portfolios and can be combined with the factor portfolios to form the tangency portfolio. By definition, therefore, the Sharpe ratio of the orthogonal portfolio is the same as the Sharpe ratio computed from factor model intercepts and residual variance-covariance matrix. Because we are interested in the magnitude of the intercepts, we focus our attention on the Sharpe ratio of the optimal orthogonal portfolio. The magnitude of these Sharpe ratios can give a sense of whether the nonzero intercepts are consistent with missing risk factors or nonrisk-based alternatives.

Table 8 reports ex ante annualized Sharpe ratios and monthly squared Sharpe ratios for the yield- and default beta-sorted portfolios (based on the original factor model). The results show that the annualized Sharpe ratios (monthly squared Sharpe ratios) are a high 1.37 (0.1560) for yield-sorted portfolios and a moderate 0.79 (0.0523) for default beta-sorted portfolios. MacKinlay argues that in perfect capital markets a reasonable value for the annualized Sharpe measure of the tangency portfolio is 0.6. We use 0.6 as our benchmark and formally test if the ex ante Sharpe ratios are significantly above 0.6 using the GRS θ-statistic given in Eq. (2). Under the null in which the intercepts are expected to generate an annualized Sharpe ratio of 0.6 (or a monthly squared Sharpe ratio of 0.03), θ is distributed noncentral F with $N = 9$ degrees of freedom in the numerator and $T - N - K = 217$ degrees of freedom in the denominator. The noncentrality parameter is given by

$$\lambda = T\left[1 + \mu'\Omega^{-1}\mu\right]^{-1}\alpha'\Sigma^{-1}\alpha, \tag{4}$$

where all the parameters in Eq. (4) are defined as in Eq. (3) and the quadratic $\alpha'\Sigma^{-1}\alpha$ is the monthly squared Sharpe ratio set equal to 0.03. The results in Table 8 show that the ex ante Sharpe ratio of the yield-sorted portfolios is significantly greater than 0.6 at the 5% level. The ex ante Sharpe ratio of the default-beta sorted portfolios, however, is statistically indistinguishable from 0.6. These results suggest that nonrisk-based alternatives are a more likely explanation for the mispricing in

Table 8
Ex ante maximum Sharpe ratios of the optimal orthogonal portfolio involving yield-sortd and default beta-sorted portfolios
This table reports annualized ex ante Sharpe ratios (S_h) and ex ante monthly squared Sharpe ratios (s_h^2) corresponding to the nonzero intercepts of the yield-sorted and default beta-sorted corporated bond portfolios in Tables 4 and 7. σ (s_h^2) is a consistent estimator of the standard error of the monthly squared Sharpe ratio (see MacKinlay, 1995). T is the number of monthly observations equal to 228, N is the number or yield- or defualt beta-sorted zero-investment portfolios equal to 9, and K is the number of factors (default and term factor) equal to 2. θ is a test statistic distributed noncentral F with 9 degrees of freedom in the numerator and 217 ($T-N-K=217$) degrees of freedom in the denominator under the null hypothesis that the annualized ex ante Sharpe ratio corresponding to nonzero intercepts is equal to 0.6. λ is the noncentrality parameter of the noncentral F-distribution. The noncentral F p-value is the upper tail probability level corresponding to the test statistic θ. The Z-statistic is a test statistic distributed standard normal computed under the null that the annualized ex ante Sharpe ratio is equal to 0.6. It is equal to the estimated monthly squared Sharpe ratio minus its value under the null (square of annual Sharpe ratio divided by $12=0.6\times0.6/12=0.03$) divided by the monthly standard error. The p-value is the upper tail probability associated with the Z-statistic. The expressions for θ and λ are provided in Eqs. (3) and (4).

Portfolio sorting variable	Annualized ex ante Sharpe ratio S_h	Monthly ex ante squared Sharpe ratio, s_h^2	Monthly standard error, σ (s_h^2)	θ (H_0: $S_h=0.6$)	Non centrality parameter, λ	Non central F p-value	Z-statistic (H_0: $S_h=0.6$)	p-value
Yield	1.37	0.1560	0.0592	3.75	6.81	0.02	2.13	0.02
Default beta	0.79	0.0523	0.0370	1.26	6.81	0.73	0.60	0.27

yield-sorted portfolios, while omitted risk factors are a likely explanation for the mispricing in default beta-sorted portfolios.

As an additional check, we also compute Z-statistics (distributed asymptotically normal), defined as the monthly squared Sharpe ratio minus 0.03 divided by the estimated standard error of the squared Sharpe ratio (see MacKinlay (1995) for the expression). These findings confirm those based on θ statistics. Overall, the results in Table 8 indicate that the two-factor model used in this paper is fairly well specified in terms of pricing the average returns of the beta-sorted portfolios but not the yield-sorted portfolios.

4. Fama and MacBeth cross-sectional regression tests

In this section, we examine the role of characteristics and betas in explaining the cross-section of bond returns using the returns on individual corporate bonds as opposed to the portfolio approach used in Section 3. The portfolio approach tends to mask variation in betas and characteristics within portfolios that could be relevant for security returns. Empirical tests based on individual bond returns could therefore be more powerful.

We examine the relationship among betas, characteristics, and individual corporate bond returns using the Fama and MacBeth (1973) cross-sectional regression approach. The standard Fama and MacBeth regression for month τ with K factor loadings and M characteristics is specified as

$$r_{i\tau} - r_{f\tau} = a_\tau + \sum_{k=1}^{K} F_{k\tau}\beta_{ki\tau} + \sum_{m=1}^{M} \gamma_{m\tau} C_{mi\tau} + u_{i\tau}, \tag{5}$$

where $r_i - r_f$ is the excess return on the bond, β_{ki} is the factor loading/beta corresponding to risk factor F_{k}, and γ_m is the slope coefficient corresponding to characteristic C_{mi}. The regression in Eq. (5) is estimated each month with betas and characteristics as independent variables, and the time-series averages and t-statistics of the estimated slope coefficients are then used to examine pricing. Under the null hypothesis, that expected bond returns are a function only of default and term betas, the slope coefficients γ_m should be equal to zero.

Because betas are estimated with error, Brennan et al (1998) recommend the use of risk-adjusted returns in regression Eq. (5). The use of risk-adjusted returns of individual bonds avoids the measurement error problem that arises when using estimated betas as independent variables. The risk-adjusted returns for a given month τ are computed as follows. At the beginning of each month τ, for each corporate bond that has at least 24 monthly returns available over the prior 60 months, we estimate default and term betas using the two-factor model without the intercept term. We then compute risk-adjusted return for the subsequent month (month $\tau + 1$) using the estimated default and term betas and the month $\tau + 1$ excess bond returns and default and term factors:

$$r^{*}_{i\tau} = r_{i\tau} - r_{f\tau} - \hat{\beta}_{\mathrm{d}i}\, DEF_\tau + \hat{\beta}_{\mathrm{t}i}\, TERM_\tau, \tag{6}$$

where $r^*_{i\tau}$ is the risk-adjusted return, and $\hat{\beta}_{\mathrm{d}i}$ and $\hat{\beta}_{\mathrm{t}i}$ are the estimated default and term betas. Using these risk-adjusted returns we estimate the following Fama and MacBeth regression:

$$r^*_{i\tau} = a + \gamma_1\, Rating_{i\tau} + \gamma_2\, Duration_{i\tau} + u^*_{i\tau}. \tag{7}$$

This regression captures the measurement errors associated with the estimation of default and term betas in the regression error term, not in the independent variables. We estimate the regression in Eq. (7) each month and report the time-series averages of the slope coefficients and the corresponding t-statistics. We refer to these time-series averages as the raw estimators.

We also consider an alternate test that relies on the fact that the coefficients from the Fama and MacBeth regression are returns on portfolios that have a loading of one on the regressor in question, and zero on all other regressors. To purge these coefficients of possible influences from factor realizations, we regress the time-series of slope coefficients, $\hat{\gamma}_j$ on the default and term factors

$$\hat{\gamma}_{j\tau} = \alpha_j + \beta_{\mathrm{d}j}\, DEF_\tau + \beta_{\mathrm{t}\,j}\, TERM_\tau + u_{j\tau}, \tag{8}$$

The intercept from this regression, α_j, is the purged estimator, which can be used to test whether regressor j is related to average returns (see Black and Scholes, 1974; Brennan et al., 1998).

Table 9 reports the findings from Fama and MacBeth cross-sectional regressions involving individual bond returns.[5] We report several sets of findings. Panel A reports results on the relationship of ratings and duration with individual bond returns based on four estimators: raw estimators based on excess bond returns (raw, excess), purged estimators based on excess bond returns (purged, excess), raw estimators based on risk-adjusted returns (raw, risk-adjusted), and purged estimators based on risk-adjusted returns (purged, risk-adjusted). Panels B and C report only two estimators, raw and purged estimators based only on excess returns, because the independent variables in these regressions also include betas.

The results in Panel A confirm the weak relationship between ratings and average bond returns observed in empirical tests based on portfolio returns (see Tables 2 and 6). Of the four estimators reported in Panel A, only two are significant at the 5% level (based on a one-sided test). The results with respect to duration are also similar to the earlier findings, and the t-statistics are either insignificant or of only marginal significance.

Panel B examines how betas and characteristics fare against one another when included jointly in Fama and MacBeth regressions. We use post-ranking default and term betas (estimated from factor regressions involving ex post returns of default beta-term beta portfolios) in these regressions. The results show that the default beta is a significant determinant of the cross-section of bond returns. Both raw and purged Fama and MacBeth estimators corresponding to default beta are significant

[5] We have also run all of the regressions in Table 9 using firm-level bond portfolio returns. Firm-level returns are computed by forming a value-weighted portfolio of all eligible outstanding corporate bonds of the firm. The results are essentially the same.

Table 9
Fama and MacBeth regressions
This table presents results from cross-sectional Fama and MacBeth regressions involving individual bond returns. ''Raw'' refers to standard Fama and MacBeth estimators. ''Purged'' refers to Fama and MacBeth estimators obtained after purging time-series Fama and MacBeth slope coefficients of factor influences as described in Brennan et al. (1998) and in the text. ''Excess'' refers to excess bond returns; ''Risk adjusted'' refers to risk-adjusted returns as described in Brennan et al. (1998) and in text. β_d and β_t are post-ranking default and term betas. Panel A reports results using both betas and characteristics. Panel C also includes yield-to-maturity. The numbers in parantheses are simple Fama and MacBeth *t*-statistics or in the case of purged results the *t*-statistic associated with the intercept in purging regressions.

Dependent variable	Rating	Duration	β_d	β_t	Yield	Average R^2
Panel A: characteristics						
Raw, excess	0.011	0.020				0.16
	(1.72)	(0.72)				
Purged, excess	0.007	−0.020				
	(1.30)	(−1.75)				
Raw, risk-adjusted	0.010	−0.006				0.06
	(1.49)	(−0.41)				
Purged, risk-adjusted	0.012	−0.019				
	(1.90)	(−1.65)				
Panel B: betas and characteristics						
Dependent variable	Rating	Duration	β_d	β_t		Average R^2
Raw, excess	0.007	0.004	0.235	0.046		0.20
	(1.25)	(0.17)	(2.59)	(0.28)		
Purged, excess	0.005	−0.024	0.229	−0.109		
	(0.98)	(−1.75)	(2.73)	(−1.02)		
Panel C: betas, characteristics, and yield						
Dependent variable	Rating	Duration	β_d	β_t	Yield	Average R^2
Raw, excess	−0.015	−0.023	0.161	0.232	0.160	0.24
	(−2.56)	(−0.92)	(1.91)	(1.65)	(5.46)	
Purged, excess	−0.015	−0.054	0.170	0.095	0.147	
	(−2.51)	(-4.21)	(2.15)	(0.97)	(5.30)	

at the 1% level. The marginal significance of ratings observed in Panel A, however, disappears in the presence of default betas. This suggests that ratings are only a noisy proxy of the systematic default risk captured by post-ranking default betas. Both term beta and duration fare poorly in these regressions. The signs of their slope coefficients are positive based on raw estimators but negative based on purged estimators and neither of them is significant.

Finally, we include last month's yield-to-maturity as an explanatory variable in cross-sectional regressions that contain default betas, term betas, ratings, and duration. These results are provided in Panel C of Table 9. As expected, yields are positively related to average bond returns and the relationship is strongly significant. Default beta continues to remain significantly positive with t statistics of 1.91 and 2.15, respectively, for raw and purged estimators, and term beta becomes a bit more significant. Ratings, by contrast, now become significantly negative. Overall, the cross-sectional regressions confirm the earlier time-series findings based on portfolio returns that yield and default beta are significant predictors of the cross-section of bond returns.

5. Conclusions

In this paper, we examined the cross-sectional determinants of expected corporate bond returns. Specifically, we focused on examining the relationship among betas, characteristics, and expected bond returns. In particular, we wanted to address the debate on the importance of betas versus characteristics on expected returns in the context of corporate bond returns. Our results show that default betas are a more important determinant of expected bond returns than bond ratings, and the significance of default beta continues to hold even when controlling for yield-to-maturity. We also find that term betas fare better than duration in explaining average bond returns, although term betas are not as significant as default betas.

Our results also show that the default and term factors are able to price the average returns of beta-sorted portfolios better than they do the returns of yield-sorted portfolios. In addition, the mispricing in yield-sorted portfolios generates a large enough ex ante Sharpe ratio to suggest nonrisk-based explanations. In particular, our findings suggest high-yield bonds may be discounted too much relative to low-yield bonds. However, our results do unambiguously show that, as far as corporate bond returns are concerned, default and term betas are more important than characteristics such as ratings and duration. These findings add a significant new perspective to the existing betas versus characteristics debate in the asset pricing literature.

From a practical perspective, our findings suggest that a parsimonious empirical model containing two systematic risk variables, default beta and term beta, and the yield-to-maturity could be used to compute the cost of debt. The conventional approach is to rely on bond ratings and maturity or duration as a proxy of a bond's default and term risk. Our results show that default and term betas are more important.

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