Duration-Based Valuation of Corporate Bonds*

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Abstract

We decompose firm-level corporate bond and equity index returns into (1) duration-matched government bond returns and (2) the excess return over and above this duration-matched counterfactual, what we term duration-adjusted returns. Our decomposition provides markedly different return patterns and asset pricing model implications compared to previously employed excess return definitions (i.e., returns in excess of a short-duration fixed income instrument).

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1 Introduction

In the past five decades investors have witnessed a secular decline in discount rates (or expected returns) on a number of asset classes, including real bonds, nominal bonds and equities. This secular decline in rates has, ceteris paribus, led to large valuation windfalls, particularly for long-duration assets, such as long maturity bonds and equities. These ex post positive return realizations complicate the evaluation of asset pricing models that make predictions about ex ante expected returns. That is, in non-stationary environments, ex ante expectations and ex post realizations may not coincide.

This paper studies the cross-sectional asset pricing implications of the secular decline in interest rates using the corporate bond market as a laboratory. To correct for the effect of declining interest rate returns, we decompose individual corporate bond returns into duration-matched government returns and the excess return over and above this duration-matched counterfactual. This decomposition leads us to a number of novel findings on the drivers of corporate bond returns.

We begin by showing that the majority of returns earned by corporate bonds from 1997 to 2020 is due to falling interest rates rather than credit and liquidity risk premia. This is true for bonds across the rating spectrum, though declining rates have a larger impact on the returns of higher-rated bonds. This echoes the results on the stock and bond markets in Binsbergen (2020).

The failure to adjust returns for the duration-matched Treasury return plays an important role in the inability of the Capital Asset Pricing Model (CAPM) and other equity factor models to price corporate bonds. Bai, Bali, and Wen (2019) show that existing multi-factor equity and bond models are unable to price unadjusted bond portfolios sorted by their historical downside risk. Sorting by credit rating, we find similar evidence regarding the CAPM and these unadjusted corporate bond returns. It is worth noting that these findings contrast with the early literature on corporate bonds, which found no evidence of mispricing under the CAPM and similar models (e.g., Blume and Keim (1987), Fama and French (1993), Elton, Gruber, and Blake (1995)). However, the sample periods in these papers differ, with Bai et al. (2019) examining data from 2002 to 2016, while Blume and Keim (1987) study 1977 to 1986, Fama and French (1993) study 1963 to 1991, and Elton et al. (1995) study 1980 to 1992.

Although the CAPM is unable to explain variation in unadjusted corporate bond portfolio returns, it has significant explanatory power when applied to the duration-adjusted returns, which are driven by credit and liquidity risk rather than changes in the term structure of Treasury yields. The implication, which we support directly, is that the inability of the CAPM to price corporate bonds is due to the confounding effects of large ex post return realizations of long-term government debt, rather than an inability to price credit and liquidity risks. This could explain the different evidence on mispricing under the CAPM between Bai et al. (2019) and the early literature. Figure 1 shows that risk-free yields fluctuated over the samples covered in the early literature but did not exhibit a significant trend, whereas the recent period studied in Bai et al. (2019) and this paper is characterized by steadily declining risk-free rates. Thus, it is likely that duration plays a larger role recently than it did in earlier research.

We take the intuition from the decomposition of test asset returns to the factor returns, decomposing the equity index return into its duration-matched government bond return and dividend risk components to form a "duration-adjusted CAPM." This two-factor model based on equity returns improves significantly on the single-factor CAPM due to its ability to capture the two components of corporate bond returns. This model is similar in spirit to the TERM and DEF factors in Fama and French (1993), but has the benefit of nesting the CAPM because the factors sum to the market return. Finally, to assess the importance of market segmentation we construct a two-factor model based on the duration-matched Treasury return and duration-adjusted return components of the corporate bond market return, which we call the "duration-adjusted bond CAPM."

We compare the performance of the CAPM, the duration-adjusted CAPM, and the duration-adjusted bond CAPM to the Bai et al. (2019) model.[1] This model contains four factors including the corporate bond market return and downside risk, credit risk, and liquidity risk factors based on cross-sectional portfolio sorts. We find that the duration-adjusted CAPM has weaker explanatory power than the Bai et al. (2019), but it performs better at the extremes of the credit risk spectrum (i.e., AAA and CCC rated bonds). Despite having two fewer factors than the Bai et al. (2019) model, the duration-adjusted bond CAPM performs significantly better at explaining the time-series of corporate bond portfolio returns (adjusted R^2 increases from 60% to between 80% and 90%) and is similarly able to explain the cross-section of returns. This highlights the benefits of disentangling the effects of duration in asset pricing models.

Even the simple CAPM significantly outperforms the Bai et al. (2019) model when applied to the duration-adjusted corporate bond returns. The inclusion of corporate bond market returns in the Bai et al. (2019) model appears to give it better explanatory power for the duration-matched Treasury component and therefore the total (unadjusted) returns of corporate bonds. Given the additional degree of freedom in the duration-adjusted CAPM and the added benefit of information specific to the corporate bond market in the duration-adjusted bond CAPM, it is natural that these models perform even better at explaining the duration-adjusted corporate bond returns.

Our main analysis focuses on portfolios sorted by credit rating category, because this method of sorting has intuitive connections with both duration (longer for higher-rated bonds) and credit risk (higher for lower-rated bonds). However, we show that all of our results are robust to using portfolios sorted by bond size and maturity or by issuer industry.

This paper contributes to several strands of literature. Most directly, we build on the recent literature exploring the role of duration in driving equity returns in the time-series (Binsbergen, Hueskes, Koijen, and Vrugt (2013), Binsbergen (2020)) and the cross-section

[1]We focus on Bai et al. (2019) because it is the only published paper that applies standard equity factor models to corporate bond returns and for which the factor returns are publicly available. We are in the process of acquiring factor return data for the unpublished working papers listed below.

(Weber (2018), Gonçalves (2020), Gormsen and Lazarus (2020)). Our paper is unique in its focus on corporate bonds, which provide well defined cash flow streams that allow a clean computation of dividend-matched Treasury returns, instead of equity.

Our results on the ability of the CAPM and duration-adjusted CAPM to price corporate bonds are related to prior research on the integration of corporate debt and equity markets. This literature is mixed, with some papers finding evidence of market segmentation using within-firm evidence (e.g., Kwan (1996), Lewis (2019), Sandulescu (2020)) and market-level evidence (e.g., Lettau, Maggiori, and Weber (2014), Nozawa (2017), Collin-Dufresne, Junge, and Trolle (2021)), while others find evidence of market integration (e.g., Fama and French (1993), Chen, Collin-Dufresne, and Goldstein (2009), Culp, Nozawa, and Veronesi (2018)). We shed light on this issue by showing that the ability of linear equity factor models to price corporate bonds is significantly improved by making a simple duration adjustment to either the bonds and/or the factors. While this set of results could be viewed as supporting market integration, our finding that the duration-adjusted bond CAPM, based on corporate bond market returns, outperforms the equity-based models suggests there is a degree of segmentation.

Finally, we contribute to the relatively recent literature on corporate bond pricing. Early papers in this literature describe the risk exposures of corporate bonds (e.g., Blume, Keim, and Patel (1991), Fama and French (1993), Elton et al. (1995)) and the roles of default risk (Gebhardt, Hvidkjaer, and Swaminathan (2005)) and liquidity risk (Lin, Wang, and Wu (2011)) in driving returns. More recently, several papers have introduced multi-factor models based on bond characteristics and bond portfolio sorts (e.g., Israel, Palhares, and Richardson (2018), Bai et al. (2019), Bredendiek, Ottonello, and Valkanov (2019), He, Khorrami, and Song (2019), Kelly, Palhares, and Pruitt (2020), Bartram, Grinblatt, and Nozawa (2021), Elkamhi, Jo, and Nozawa (2021)). We show that simple two-factor models based on the duration-matched Treasury and risk components of equity or bond returns have significant explanatory power without adding more complex factors. In the sense that accounting for duration improves the fit of equity factor models, our paper is related to the findings on the shared term structure exposures of stocks and bonds in Fama and French (1993).

The remainder of the paper is organized as follows. Section 2 describes the data and the decomposition of corporate bond and equity index returns. Section 3 presents the asset pricing results. Section 4 concludes.

2 Data

We compute corporate bond returns using price quotes from Bank of America Merill Lynch (BAML). These data are available from 1997 to 2020 and form the basis for BAML's bond indices. Prior academic research using the BAML data includes Schaefer and Strebulaev (2008), Feldhutter and Schaefer (2018), and Schwert (2020). We restrict the sample to bonds that are denominated in U.S. dollars, senior unsecured in priority, and pay fixed, semi-annual coupon payments. Following the literature, we exclude bonds with less than one year to maturity. Finally, we exclude a small number of bonds with maturity over 30 years to avoid the need to extrapolate the Treasury yield curve for the bond return decomposition described below.

Our sample covers a large fraction of the U.S. corporate bond universe but is tilted towards larger and more liquid issues. Thus, it is worthwhile to establish that our data are representative of the overall market. First, we find that value-weighted portfolios of investment-grade and non-investment-grade bonds in our sample have correlations of 0.97 and 0.99, respectively, with the corresponding Bloomberg-Barclays indices.[2] Second, the Internet Appendix shows that our findings are robust to using the Trade Compliance and Reporting Engine (TRACE) Enhanced database, which contains historical transactions in the secondary market for corporate bonds. Our results are also robust to using the Wharton Research Data Services (WRDS) Bond Returns database, which provides returns based on

[2]Note that the Bloomberg-Barclays indices exclude bonds with more than 10 years to maturity, whereas our sample allows bonds with up to 30 years to maturity.

cleaning the Enhanced TRACE data with a proprietary algorithm.

In addition to the panel of corporate bond returns, our analysis requires data on factor returns and the term structure of risk-free rates. We obtain factor returns from Jennie Bai and Ken French's websites. To construct zero-coupon risk-free yields, we use the updated term structure data provided by the Federal Reserve following the approach in Gürkaynak, Sack, and Wright (2007). These data include parameters for the Svensson (1994) extension of the Nelson and Siegel (1987) model, estimated using the market prices of off-the-run Treasury notes and bonds.

2.1 Decomposition of Bond Returns

The return of a corporate bond is

$$r_{i,t} = \frac{P_{i,t} + AI_{i,t} + C_{i,t}}{P_{i,t-1} + AI_{i,t-1}} - 1, \tag{1}$$

where $P_{i,t}$ is the clean bid price of bond i at the end of period t, $AI_{i,t}$ is the accrued interest, and $C_{i,t}$ is the semi-annual coupon payment if period t is a coupon payment period.[3] We assume that bonds in default according to the Mergent Fixed Income Securities Database (FISD), or within 90 days of default and trading below a clean price of 40, are not making coupon payments (i.e., trading "flat"). This choice reflects the standard treatment of unsecured bonds in bankruptcy as well as the clawback of preference payments within 90 days of a Chapter 11 filing, and affects less than 0.2% of bond-month observations in our sample.

To provide some descriptive evidence on our sample, Table 1 presents statistics on the monthly returns of corporate bonds sorted into value-weighted portfolios by credit rating category. Interestingly, the arithmetic average returns are similar across rating categories,

[3]The quoted "clean" price of a bond is equal to the discounted value of the bond's future cash flows, also called the "all-in" price, minus the accrued interest over the fractional coupon period between the last payment and a trade's settlement date. In the U.S. corporate bond market, coupons are typically made on a semi-annual basis and accrued interest is computed under the 30/360 daycount convention, which assumes 30 days in each month (e.g., the number of days elapsed between February 10 and March 10 is 30 days).

with slightly lower returns for the B and CCC rated bonds. Consistent with their lower default risk, the standard deviation of returns is lower for bonds with better credit ratings. There are far more bonds in the BBB category than other rating categories and relatively few bonds in the AAA, AA, and CCC categories. Finally, duration is decreasing monotonically in credit quality, with higher-rated bonds having longer duration due to their longer maturities and lower coupon rates. In the Internet Appendix, we show that the duration of investment-grade bonds increases over our sample period, while the duration of non-investment-grade bonds decreases slightly.

One of this paper's innovations is to decompose the effects of duration and other factors on corporate bond returns. We construct the duration-matched Treasury return using the bond's promised cash flows and discount rates from the zero-coupon Treasury yield curve.[4] Define the synthetic risk-free price as

$$P_{i,t}^{Tsy} = \sum_{k=1}^{N} \frac{C_k}{(1 + y_{t,T_k})^{T_k}} + \frac{100}{(1 + y_{t,T_N})^{T_N}}, \tag{2}$$

where N is the number of coupon payments remaining, C_k is amount of the kth coupon, T_k is the time in years from t until the kth coupon, and y_{t,T_k} is the yield of a Treasury strip maturing in T_K years. The duration-matched Treasury return is the return on the synthetic risk-free price using the bond's actual coupon rate:

$$r_{i,t}^{Dur} = \frac{P_{i,t}^{Tsy} + C_{i,t}}{P_{i,t-1}^{Tsy}} - 1. \tag{3}$$

Note that the definition in equation (3) differs from equation (1) because the synthetic risk-free price defined in equation (2) is an all-in price inclusive of accrued interest, whereas the quoted price in the corporate bond data is a clean price that excludes accrued interest.

Finally, we take the difference between a bond's actual return and its synthetic risk-free

[4] This calculation ignores the presence of embedded options in the corporate bond indenture (e.g., the issuer's option to call the bond). Qualitatively, this results in an overstatement of a bond's duration and the role of interest rate changes in driving its returns.

return to isolate the return driven by factors other than shifts in the Treasury yield curve, which we call the duration-adjusted return:

$$r_{i,t}^{Risk} = r_{i,t} - r_{i,t}^{Dur}. \tag{4}$$

Figure 2 presents the decomposed returns of value-weighted portfolios of investment-grade and non-investment-grade bonds to illustrate the relative contributions of duration and risk to the overall return. Panel A shows that investment-grade bond returns are largely driven by the decline in long-term interest rates over the sample period – the average monthly return of 0.51% decomposes into a duration-matched Treasury return of 0.48% and a duration-adjusted return of 0.03%. Only since the financial crisis has risk provided a positive contribution to the overall return of investment-grade bonds. Panel B shows that intuitively, the duration-adjusted return plays a more prominent role in the overall performance of non-investment-grade bonds. The return breakdown is similar, with the average monthly return of 0.50% attributed to 0.42% from the duration-matched Treasury component and 0.08% from other risks, but the duration-adjusted return also contributes importantly to the downside. Due to default losses in the 2001 and 2007-2009 recessions, the total return of non-investment-grade bonds has only recently exceeded the duration-matched Treasury return.

For both investment-grade and non-investment-grade bonds, the duration-matched Treasury and duration-adjusted returns are negatively correlated with coefficients around -0.5. This correlation intuitively reflects the fact that credit spreads tend to rise when risk-free rates are falling and vice versa (Longstaff and Schwartz (1995)). The duration-matched Treasury return is positively correlated with total returns for investment-grade bonds (ρ = 0.57) but negatively correlated with total returns for non-investment-grade bonds (ρ = -0.17). Duration-adjusted returns are positively correlated with total returns for both categories, but the correlation coefficient is higher for non-investment-grade bonds ($\rho = 0.91$) than investment-grade bonds ($\rho = 0.43$).

2.2 Decomposition of Equity Index Returns

In addition to pricing the decomposed bond returns with existing factor models, we examine the ability of the CAPM to explain corporate bond returns when the effect of duration is stripped out of the equity market return. Due to the uncertain nature of equity dividends, in contrast to the fixed payments of corporate bonds, more structure is necessary to perform the equity index decomposition.

We follow Binsbergen (2020) and characterize the duration of the equity index using the concept of Macaulay duration (Dur). Macaulay duration is commonly computed as the weighted average time it takes for an asset to return the discounted cash flows to its owner:

$$\text{Dur}_t = \sum_{k=1}^{\infty} w_{t,k} k, \tag{5}$$

where $w_{t,k}$ is the weight that the present value of the kth cash flow has in the asset value.

To approximate the duration of the equity index, we apply equation (5) to the Gordon growth model. The Gordon growth formula expresses the value of the stock market as a function of the next period's dividend, denoted by D_{t+1}, the expected return on the index μ_s, and its expected dividend growth rate g:

$$S_t = \frac{D_{t+1}}{\mu_s - g}. \tag{6}$$

Under these assumptions, the present value of the kth dividend at time t, also called the dividend strip value, is given by:

$$\mathcal{P}_{t,k} = D_t \left(\frac{1+g}{1+\mu_s} \right)^k, \tag{7}$$

implying a weighting scheme equal to:

$$w_{t,k} = \left(\frac{\mu_s - g}{1+\mu_s} \right) \left(\frac{1+g}{1+\mu_s} \right)^{k-1}, \tag{8}$$

and a constant Macaulay duration equal to:

$$\text{Dur} = \sum_{k=1}^{\infty} w_{t,k} k = \sum_{k=1}^{\infty} \left(\left(\frac{\mu_s - g}{1+\mu} \right) \left(\frac{1+g}{1+\mu_s} \right)^{k-1} k \right) = \frac{1+\mu_s}{\mu_s - g}. \tag{9}$$

Equation (9) shows that the duration is bounded below by, and empirically close in value to, the inverse of the dividend yield $\mu_s - g$.

Based on these concepts, we can formally define the variables used in our study. Let $r_{s,t}$ denote the cum-dividend return on the equity index:

$$r_{s,t} = \frac{S_{t+1} + D_{t+1}}{S_t}, \tag{10}$$

where D_{t+1} is the cash dividend paid at time $t+1$ and S_t is the index price at time t.

The present value at time t of the expected dividend paid k periods from today is:

$$\mathcal{P}_{t,k} = \frac{E_t \left[D_{t+k} \right]}{\exp \left(k \left(y_{t,k} + \theta_{t,k} \right) \right)}, \tag{11}$$

where $y_{t,k}$ denotes the continuously compounded risk-free spot interest rate at time t for maturity k and $\theta_{t,k}$ denotes the normalized (by k) dividend risk term premium for a dividend of that maturity.[5].

According to the present-value relation, the value of the index today, S_t, is a portfolio that includes one unit of each dividend strip:

$$S_t = \sum_{k=1}^{\infty} \mathcal{P}_{t,k}. \tag{12}$$

Following the arguments above, the weighting scheme $w_{t,k}$ describes the weight that each dividend strip has in the index price:

$$w_{t,k} = \frac{\mathcal{P}_{t,k}}{S_t}. \tag{13}$$

[5]See Binsbergen et al. (2013) and Binsbergen (2020) for similar definitions.

The one-period return on a dividend strip with maturity k is given by:

$$r_{d,t+1,k} = \frac{\mathcal{P}_{t+1,k-1}}{\mathcal{P}_{t,k}} - 1 \quad \text{for } k > 1, \tag{14}$$

$$r_{d,t+1,k} = \frac{D_{t+1}}{\mathcal{P}_{t,k}} - 1 \qquad \text{for } k = 1, \tag{15}$$

and the one-period return on the k-period government bond is given by:

$$r_{b,t+1,k} = \frac{\exp\left(-(k-1)y_{t+1,k-1}\right)}{\exp\left(-ky_{t,k}\right)} - 1. \tag{16}$$

Because the return on the equity index is a weighted average of the returns on all its dividend strips, the return on holding the portfolio for one period can be written as the weighted average of the returns on the strips:

$$r_{s,t+1} = \sum_{k=1}^{\infty} w_{t,k} r_{d,t+1,k}, \tag{17}$$

where the weights are defined in equation (13).

The main object of interest is the equity index return in excess of its duration-matched government bond counterfactual. Define the duration-matched counterfactual as:

$$r_{Dur,t+1} = \sum_{k=1}^{\infty} w_{t,k} r_{b,t+1,k}. \tag{18}$$

Then the equity index return over and above the government bond counterpart is:

$$r_{Risk,t+1} = r_{s,t+1} - r_{Dur,t+1}. \tag{19}$$

Two inputs to this calculation are not obvious from the data. First, there is the weighting scheme $w_{t,k}$. As in Binsbergen (2020), we use a time-varying weighting scheme based on the Gordon growth model that uses the time t dividend yield of the equity index. In particular, we first compute the dividend yield as

$$dy_t = \frac{\sum_{i-11}^{i} D_i}{S_i}. \tag{20}$$

In each period, we then set

$$\mu_{s,t} - g_t = dy_t \tag{21}$$

and calculate the static Gordon growth implied weighting scheme as

$$w_{t,k} = \left(\frac{\mu_{s,t} - g_t}{1 + \mu_{s,t}}\right) \left(\frac{1 + g_t}{1 + \mu_{s,t}}\right)^{k-1}. \tag{22}$$

As the length of the holding period converges to 0 (i.e., going from annual to monthly to daily returns), this weighting scheme is only a function of dy_t, the difference between $\mu_{s,t}$ and g_t, and not of $\mu_{s,t}$ and g_t separately. Even with monthly compounding, the numerical errors are negligible.

Second, since government bond yields are not available at infinite horizons, the index decomposition requires a terminal period and a corresponding weight for the present value calculations. Following Binsbergen (2020), we use cutoff of 30 years and assign the residual weight to the terminal period. For instance, if 43% of the index value comes from cash flows paid in year 30 and beyond, then the 30-year Treasury strip receives a weight of 43% in the counterfactual portfolio.

Table 1 Panel B summarizes the return decomposition of the S&P 500 Index, which we use as a proxy for the equity market, as well as other factor series we use in in the subsequent analysis. Consistent with Binsbergen (2020), the duration-matched government bond return accounts for essentially all of the equity index return over the sample period. The duration-adjusted return, subtracting the duration-matched Treasury return from the total return, is negative on average but has higher variance than the duration-matched Treasury return. The total return has correlation coefficients of -0.31 with the duration-matched Treasury return and 0.85 with the duration-adjusted return, while the two components of the total return are negatively correlated with a coefficient of -0.76.

3 Results

3.1 Failure of Equity Factors to Price Corporate Bonds

As a starting point, we assess the ability of the Capital Asset Pricing Model (CAPM), originally derived by Sharpe (1964), to price corporate bonds. We focus on the CAPM because it is the simplest equity factor model and note that our qualitative conclusions are similar if additional equity market factors are added to the pricing model. This analysis uses bond portfolios sorted by credit rating, which were summarized in Table 1, because these have intuitive associations with credit risk and duration. In Section 3.3, we present results based on portfolios sorted by size and maturity or by industry.

Table 2 reports estimates of the following regression:

$$r_{i,t} - r_{f,t} = \alpha + \beta(r_{SP500,t} - r_{f,t}) + \varepsilon_{i,t}, \tag{23}$$

where the total return on the S&P 500 Index is the equity market return and the one-month Treasury bill rate is the risk-free return.

Panel A shows that the CAPM is unable to price corporate bonds, particularly in the investment-grade rating categories. The intercepts are statistically significant at the 5% level for every investment-grade portfolio and economically large, between 0.28% and 0.38% per month. Strikingly, the adjusted R^2 coefficient is less than 2% for bonds rated AAA, AA, and A, and only 12% for BBB-rated bonds. The model performs better for non-investment-grade bonds, with R^2 coefficients exceeding 35% and statistically insignificant intercepts for the B and CCC categories, consistent with them having more exposure to economic conditions. The Gibbons, Ross, and Shanken (1989) (GRS) test rejects the hypothesis that the intercepts are jointly zero at the 1% level of significance.

Panels B and C shed light on this finding by estimating the CAPM regressions for the duration-matched Treasury returns and duration-adjusted returns defined in equations (3) and (4), respectively. The CAPM is unable to price the duration-matched Treasury returns, with statistically significant intercepts across the rating spectrum and low R^2 coefficients. Similar to the total returns, the GRS test rejects the hypothesis that the intercepts are jointly zero.

However, the CAPM does not exhibit the same failure for the duration-adjusted returns, with statistically insignificant intercepts in all categories and a GRS test p-value of 0.65, failing to reject that the intercepts are jointly equal to zero. The adjusted R^2 coefficient exceeds 20% for every portfolio, showing substantial improvement for the investment-grade categories. Intuitively, the market beta coefficients are higher for lower-rated bonds with higher default risk.

Overall, the results in Table 2 suggest that the failure of equity factor models to price corporate bonds is largely due to their inability to price the duration-matched government bond returns. Indeed, the equity market return has substantial explanatory power for the duration-adjusted returns, which are driven by credit risk and liquidity.

3.2 Duration-Adjusted Capital Asset Pricing Model

The results in Table 2 suggest a natural extension of the CAPM into duration-matched Treasury and dividend risk components that should capture these distinct risks in the corporate bond portfolios. Using the equity index decomposition described in Section 2.2, define the duration-adjusted CAPM as:

$$r_{i,t} - r_{f,t} = \alpha + \beta_{Dur}(r_{Dur,t} - r_{f,t}) + \beta_{Risk}(r_{SP500,t} - r_{Dur,t}) + \varepsilon_{i,t}, \tag{24}$$

where $r_{Dur,t}$ is the return of the Treasury portfolio that matches the duration of the S&P 500 Index from Binsbergen (2020) and $r_{SP500,t} - r_{Dur,t}$ represents the equity index return in excess of the duration-driven return.

Table 3 presents estimates of the duration-adjusted CAPM for the corporate bond portfolio returns as well as their components. Panel A reveals a remarkable improvement in the ability to explain corporate bond returns, especially at the high end of the credit quality spectrum. The intercepts for investment-grade bonds are statistically insignificant and the R^2 coefficients are between 36% and 73%. The model's performance is less improved for the non-investment-grade bonds, but it continues to exhibit statistically insignificant intercepts. The GRS test fails to reject the hypothesis that the intercepts are jointly zero.

As before, Panels B and C use the bond return decomposition to show where the improvement comes from. Panel B shows that the duration-matched Treasury return for the equity market is able to price the duration-matched Treasury returns for corporate bonds, with R^2 coefficients between 70% and 89%. Panel C shows that the duration-adjusted CAPM explains a larger proportion of the duration-adjusted corporate bond returns than the CAPM, with increases in R^2 exceeding 7 percentage points (p.p.) across the rating spectrum.

The coefficient estimates in Table 3 exhibit intuitive patterns that shed light on the success of the duration-adjusted CAPM. Panel A shows that the loadings on the duration and equity risk factors are monotonically decreasing and increasing, respectively, as we move from the AAA-rated to the CCC-rated portfolios. Higher-rated bonds have higher exposure to the duration factor, consistent with their higher average duration (Table 1), and lower exposure to the equity risk factor, consistent with their lower default risk. Panels B and C provide further support, with the duration-driven bond returns having small and statistically insignificant equity risk loadings while the same applies to the duration loadings of the duration-adjusted returns.

3.3 Comparison with Existing Bond Pricing Factors

Prior research has argued that the failure of equity market factor models to price corporate bonds is justification for separate pricing models based on bond market risk factors. Along with the steady growth of the corporate bond market, this has led to a recent proliferation of factor models with the specific goal of pricing corporate bonds (e.g., Israel et al. (2018), Bai et al. (2019), Bredendiek et al. (2019), He et al. (2019), Kelly et al. (2020), Bartram et al. (2021), Elkamhi et al. (2021)).

To assess whether this is still the case when we split out the effects of duration, we compare the performance of the duration-adjusted CAPM to the corporate bond pricing model from Bai et al. (2019).[6] The Bai et al. (2019) model has four factors: the corporate bond market return, a downside risk factor, a credit risk factor, and a liquidity risk factor.

Table 4 Panel A presents the intercepts, *t*-statistics, and adjusted R^2 coefficients from regressions of corporate bond returns on the Bai et al. (2019) model, the CAPM, and the duration-adjusted CAPM. This table also considers a duration-adjusted bond market CAPM, which we describe below. As in the prior sections, we begin by using value-weighted portfolios sorted by credit rating category. The sample runs from July 2004 to December 2019 due to the availability of the Bai et al. (2019) factors.

Similar to the full sample results in Table 2, the CAPM has poor explanatory power, especially for the investment-grade bonds. The duration-adjusted CAPM represents a significant improvement, increasing the average adjusted R^2 from 22% to 51%. The regression intercepts are reduced to the extent that we cannot reject that they are jointly zero or equal to each other, which suggests that the duration-adjusted CAPM is able to price the cross-section of credit rating portfolios.

The Bai et al. (2019) model has strong explanatory power for the individual test portfolios, with adjusted R^2 coefficients exceeding 35% for all categories and averaging 62%. The

[6] We focus on the Bai et al. (2019) model because the paper is published and the authors made the factor returns publicly available. This is not the case for the other models cited above.

intercepts are economically small and statistically insignificant except for the BB category. The GRS test rejects the null hypothesis that the intercepts are jointly zero at the 5% level. We also modify the Gibbons et al. (1989) test to compare the intercepts to their mean, or each other, and find that this hypothesis is also rejected at the 5% level. While the Bai et al. (2019) has high explanatory power in the time-series for each portfolio, it is less able to explain the cross-section of credit rating portfolios.

Comparing the duration-adjusted CAPM to the Bai et al. (2019) model, there are interesting patterns across the credit rating portfolios. Although the Bai et al. (2019) model has higher average R^2 coefficients, it has the most explanatory power for the A and BBB portfolios that comprise most of the market (Table 1). The inclusion of the corporate bond market return may mechanically improve the performance of the Bai et al. (2019) model for these portfolios. In contrast, the duration-adjusted CAPM has more explanatory power for AAA and CCC rated bonds and similar performance for BB rated bonds, despite having two fewer factors and lacking information from the corporate bond market.

To assess the role of market segmentation, or the importance of including information specific to the corporate bond market in the model, we construct a duration-adjusted bond market CAPM in the same spirit as the duration-adjusted CAPM. Specifically, this is a two-factor model based on the value-weighted corporate bond market index return decomposed into its duration-matched Treasury and duration-adjusted components. This model has substantially more explanatory power for the time-series of corporate bond returns, with a minimum adjusted R^2 of 77% and an average of 90%. This represents a large improvement in model fit relative to the Bai et al. (2019) model, despite this model having only two factors instead of four, again highlighting the importance of splitting out the effects of duration. However, there are two portfolios with statistically significant intercepts (A and BB) and the GRS tests reject the hypotheses that the intercepts are equal to zero or to each other. Thus, the model appears to have slightly worse shortcomings than the Bai et al. (2019) model in the cross-section.

Panel B of Table 4 turns attention to the duration-adjusted corporate bond returns. In contrast to Panel A, we find that the Bai et al. (2019) has worse explanatory power than both the CAPM and the duration-adjusted CAPM, with an average adjusted R^2 that is 8 p.p. lower than the CAPM and 18 p.p. lower than the duration-adjusted CAPM. Moreover, the regression intercepts for the Bai et al. (2019) model are larger and more statistically significant than for the CAPM and duration-adjusted CAPM. The GRS test rejects the hypotheses that the intercepts are jointly zero or equal to each other under the Bai et al. (2019) model, while it fails to reject these hypotheses for the CAPM and the duration-adjusted CAPM. Thus, the Bai et al. (2019) model has worse performance than the CAPM in both the time-series and the cross-section for the duration-adjusted corporate bond returns.

Consistent with the intuition discussed above, the failure of the CAPM to price corporate bonds is due to the contribution of changes in government bond yields rather than credit and liquidity risks. This suggests that the success of the Bai et al. (2019) model in explaining the time-series of returns is due to its inclusion of a corporate bond market factor and not due to its ability to price credit risk, despite the authors' focus on default risk in the construction of the model. One practical implication of this finding is that duration-hedged investors may find the CAPM useful as a benchmark and may not benefit from using more complex models designed to price corporate bond returns.

3.4 Robustness to Alternative Test Portfolios

We consider two alternative sets of corporate bond portfolios to establish the robustness of our findings. Following Bai et al. (2019), we construct 25 portfolios double-sorted by size (i.e., face value) and maturity and 30 portfolios sorted by Fama and French (1997) industry definitions. To the extent that credit rating portfolios have an underlying factor structure, these alternative portfolios address the Lewellen, Nagel, and Shanken (2010) critique. For brevity, we present findings based on the size-maturity portfolios here and relegate the industry portfolio results to the Internet Appendix.

Tables 5 reports regression estimates for the 25 size-maturity portfolios in the same format as Table 4. Since the results are largely in line with Table 4, we focus on the key similarities and differences between these estimates and the prior results.

First, the duration-adjusted CAPM does not have as much explanatory power for the total returns (Panel A) on these portfolios as it did for the credit rating portfolios, with an average adjusted R^2 coefficients of 0.33. This is likely due to these portfolios containing a high share of BBB-rated bonds, similar to the rest of the market (Table 1), for which the duration-adjusted CAPM performs worse than the Bai et al. (2019) model (Table 4).

Second, the duration-adjusted corporate bond market CAPM continues to dominate the Bai et al. (2019) model in terms of explanatory power for total corporate bond returns, with average adjusted R^2 coefficient of 85% exceeding the corresponding figure for the Bai et al. (2019) model by 25 p.p.

Third, we continue to observe that the CAPM and its extensions outperform the Bai et al. (2019) model in explaining the duration-adjusted corporate bond returns. This again highlights that duration, rather than credit risk or illiquidity, is the reason that equity factor models are poorly suited to price corporate bonds.

To ease the interpretation of these estimates in a cross-sectional asset pricing context, Figure 3 plots the realized average returns of each size-maturity portfolio against the predicted returns from the four pricing models. Panel A focuses on total corporate bond returns and Panel B focuses on duration-adjusted returns.

Consistent with the evidence presented above, Figure 3 Panel A shows that decomposing the equity market return into its duration-matched Treasury and dividend risk components improves the ability of the CAPM to explain corporate bond returns. The Bai et al. (2019) model has a better fit than the duration-adjusted CAPM, as well as a slightly better fit than the duration-adjusted bond CAPM, likely due to its additional factors.

Moving on to the duration-adjusted returns, the fit of all models is significantly worse in the cross-section. The CAPM and Bai et al. (2019) model have a particularly weak relation between the model's prediction and the realized returns. The duration-adjusted CAPM based on equity market returns appears best suited to pick up cross-sectional variation in average returns, though it does not perform as well at capturing the level of returns, possibly due to the existence of a liquidity premium.

3.5 Out-of-Sample Test of Model Performance

As an out-of-sample test of each model's ability to predict the cross-section of corporate bond returns, we estimate Fama and MacBeth (1973) regressions of individual corporate bond returns on trailing factor betas. Specifically, for each bond-month observation we estimate a trailing beta against each factor over a trailing 36-month window, requiring at least 24 months of data to include the beta estimate in the sample. For the duration-adjusted CAPM and duration-adjusted bond CAPM, we estimate both the duration and risk betas in the same regression. We follow Bai et al. (2019) in estimating the corporate bond market beta on its own, then estimating the DRF, CRF, and LRF betas in separate regressions that include the corporate bond market return.

Table 6 presents estimates for corporate bond excess returns (Panel A) and duration-adjusted returns (Panel B). The main takeaway from both panels is that none of the factors have robust and statistically significant prices of risk, though the models have non-trivial explanatory power in the cross-section of corporate bond returns.[7] The duration-adjusted bond CAPM and the Bai et al. (2019) model have similar explanatory power in both panels, with the duration-adjusted CAPM just behind them.

[7]Our estimates of the factor prices of risk for the Bai et al. (2019) model differ substantially from what is reported in that paper. Whereas they report positive and significant prices of risk for all four factors, we find a positive and weakly significant price of risk for the market factor, a negative and weakly significant price of risk for the DRF factor, and statistically insignificant prices of risk for the CRF and LRF factors. After corresponding with the authors of the Bai et al. (2019) paper, we conclude that their Fama and MacBeth (1973) regression estimates are not robust to using dealer quote data or updates to the Enhanced TRACE data, despite following the procedures described in Bai et al. (2019).

4 Conclusion

In this paper we explore the importance of the secular decline in interest rates on the empirical evaluation of pricing models for corporate bonds. We find that decomposing realized corporate bond returns into the effect of the secular decline in risk-free interest rates (as measured by the duration-matched returns on government bonds) and the effects of credit risk and liquidity results in markedly different return patterns compared to previously employed excess return definitions. While the CAPM struggles to price investment-grade corporate bond returns, we find that it lines up quite well with duration-adjusted returns. Overall, our results contribute to the literature that argues for a more careful analysis of asset durations and their effects on ex post and ex ante return measures.

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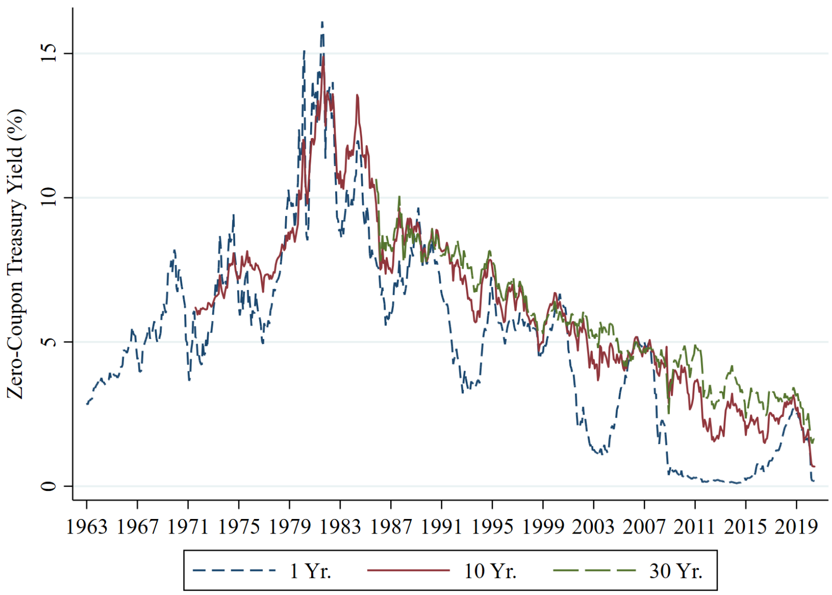
Figure 1: Time-Series of Zero-Coupon Treasury Yields

This figure illustrates the decline in long-term risk-free interest rates over our sample period. The plot contains the time-series of zero-coupon Treasury yields at maturities of one year, ten years, and 30 years. Zero-coupon yields are from the updated term structure data provided by the Federal Reserve following the approach in Gürkaynak et al. (2007). Panel A covers the period from January 1963 to June 2020, while Panel B focuses on the period from July 1997 to June 2020.

Panel A: January 1963 to June 2020



Panel B: July 1997 to June 2020

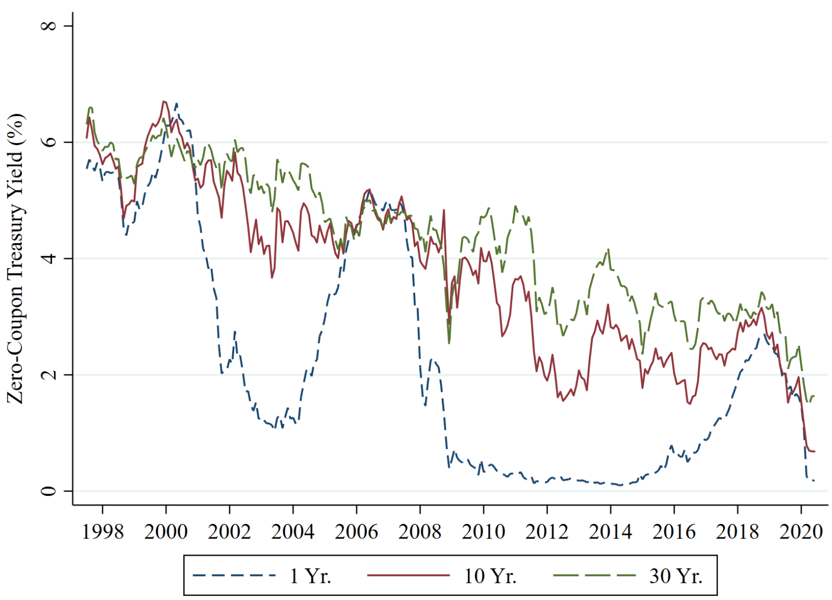


Figure 2: Cumulative Returns of Corporate Bond Portfolios

This figure presents the cumulative returns of corporate bond portfolios sorted by credit rating. For ease of exposition, bonds are sorted into investment-grade (BBB- and higher) and non-investment-grade (BB+ and lower) portfolios. Each line represents the market value weighted return of a bond portfolio. Bond Return is the realized portfolio return. Duration is the synthetic risk-free return computed by discounting bond cash flows using zero-coupon Treasury yields and substituting these values for observed prices. Risk is the difference between the realized and synthetic risk-free returns.

Panel A: Investment-Grade Bonds

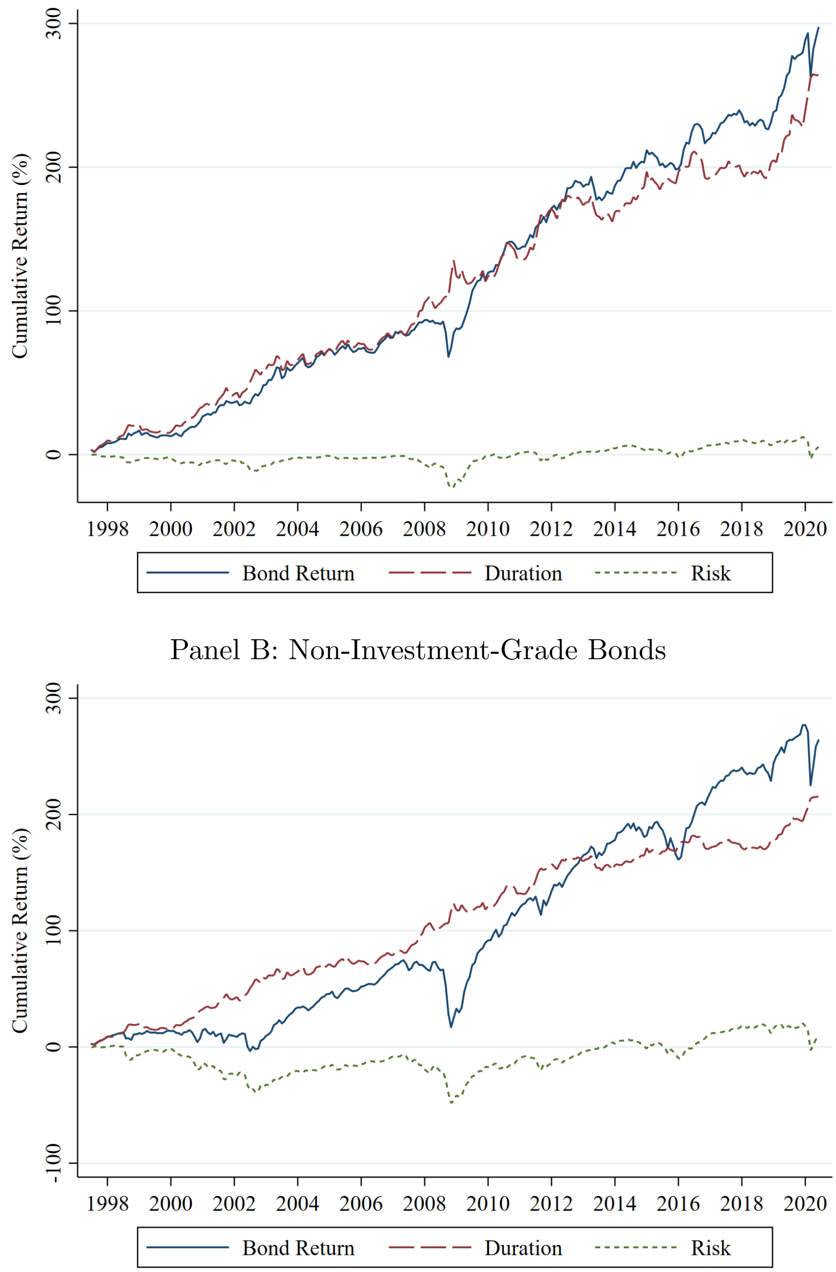
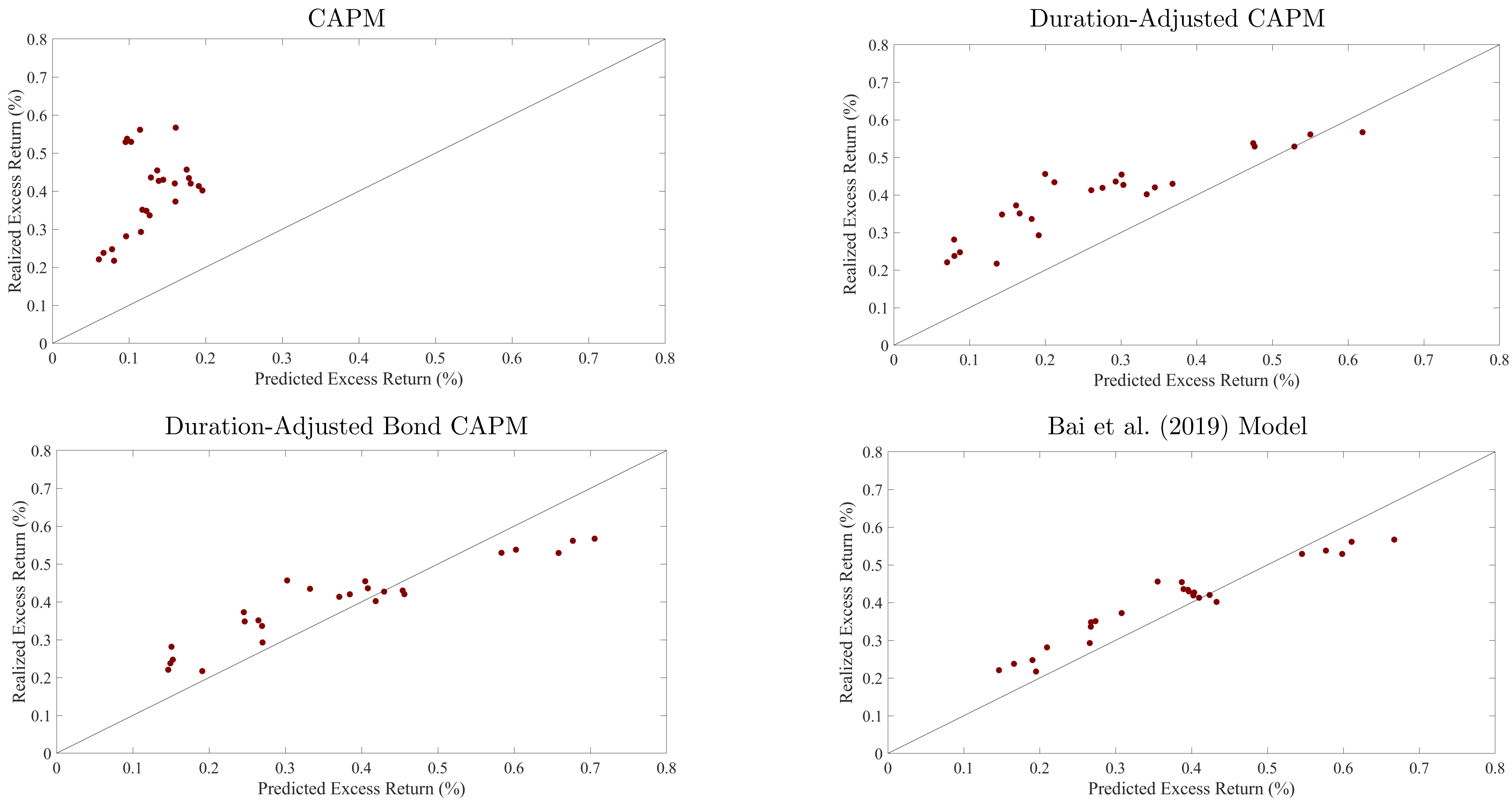


Figure 3: Visual Depiction of Model Performance

This figure depicts the model fit of the CAPM, the duration-adjusted CAPM, and the Bai et al. (2019) model for 25 portfolios double-sorted on size and maturity quintiles. Panel A is based on the excess returns of corporate bond portfolios and Panel B is based on duration-adjusted returns. In each plot, the y-axis is the sample average return for the portfolio and the x-axis is the predicted return based on the factor loadings and the sample average factor returns.

Panel A: Corporate Bond Returns



Panel B: Duration-Adjusted Returns

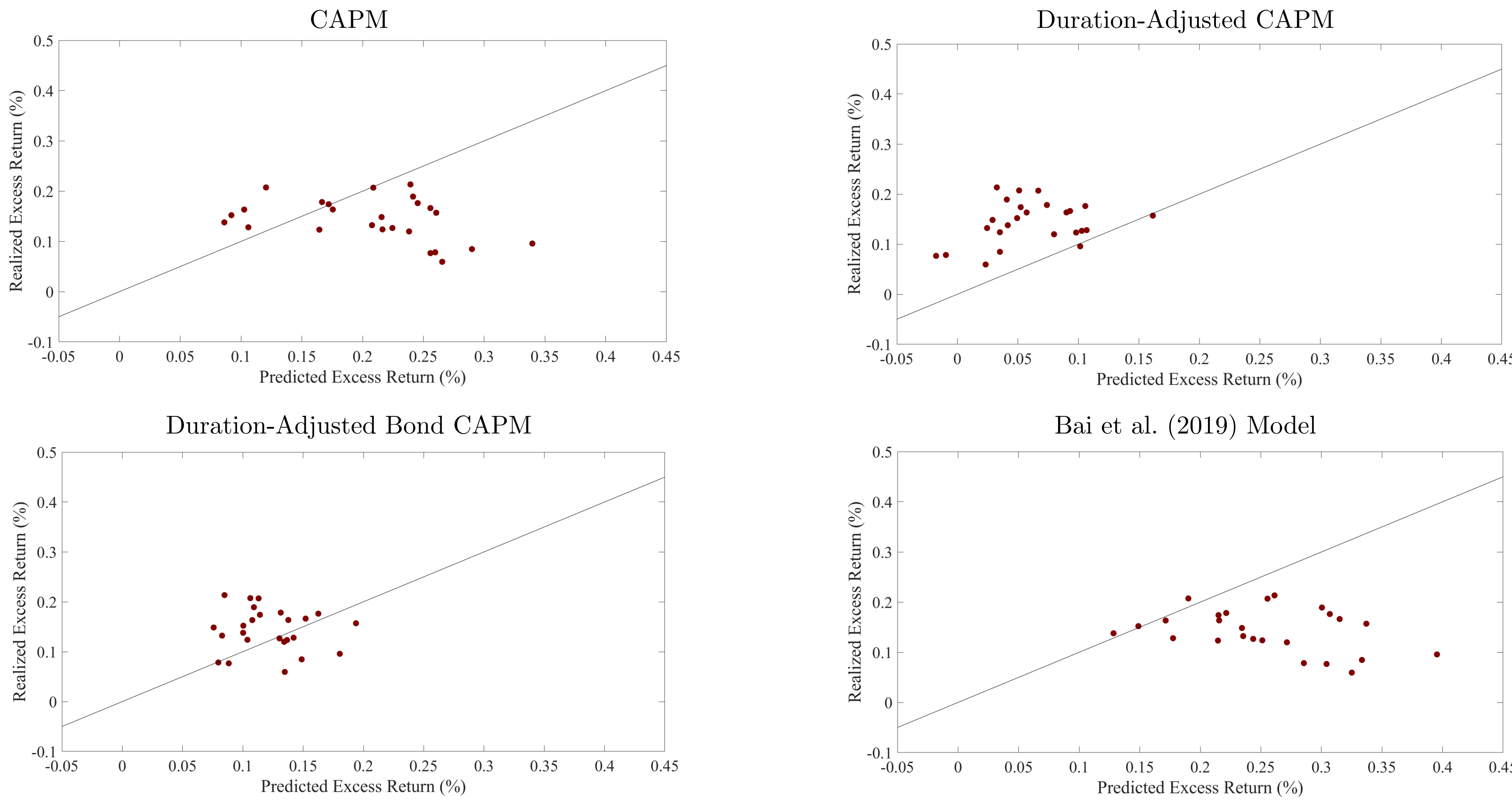


Table 1: Summary Statistics on Corporate Bond and Benchmark Returns

This table reports summary statistics on the corporate bond portfolio and factor benchmark returns. The sample consists of monthly observations from July 1997 to June 2020. Returns are reported in percentage terms. Panel A summarizes the value-weighted returns, duration, and number of bonds in portfolios sorted by credit rating. Panel B summarizes the returns of the benchmark portfolios used in our analysis. S&P 500 Duration and Risk are based on the decomposition in Binsbergen (2020). Corp. Bond Market, DRF, CRF, and LRF are the risk factors from Bai et al. (2019).

Panel A: Credit Rating Portfolios

	Mean	Std.Dev.	Min.	p10	p50	p90	Max.	Obs.
Value-Weighted Return:								
AAA	0.52	1.59	-5.97	-1.40	0.51	2.43	7.16	276
AA	0.50	1.42	-4.98	-1.26	0.56	2.12	7.54	276
A	0.50	1.53	-7.98	-1.22	0.58	2.19	7.66	276
BBB	0.53	1.77	-10.70	-1.10	0.53	2.47	6.18	276
BB	0.56	2.21	-14.40	-1.41	0.75	2.37	7.25	276
B	0.44	2.89	-14.60	-2.25	0.74	2.89	10.47	276
CCC	0.42	4.48	-23.22	-3.98	0.77	4.02	19.74	276
Value-Weighted Duration:								
AAA	8.04	0.92	5.84	6.90	8.02	9.29	10.20	276
AA	6.74	0.71	5.29	5.67	6.95	7.54	8.15	276
A	6.89	0.54	5.83	6.19	6.81	7.55	8.27	276
BBB	6.83	0.44	5.91	6.29	6.80	7.39	8.06	276
BB	5.38	0.31	4.59	5.06	5.39	5.78	6.40	276
B	4.86	0.36	3.71	4.38	4.90	5.29	5.57	276
CCC	4.33	0.47	3.06	3.69	4.32	4.98	5.36	276
Number of Bonds per Portfolio:								
AAA	35.2	18.6	12	15	31	64	76	276
AA	173.1	74.4	72	78	154.5	280	323	276
A	883.4	324.5	480	510	784.5	1,338	1,464	276
BBB	1,518.6	744.0	637	846	1,050.5	2,694	2,914	276
BB	474.7	184.0	164	227	421	729	768	276
B	408.3	142.6	122	193	401.5	583	626	276
CCC	151.3	72.9	13	34	170.5	256	283	276

Panel B: Benchmark Returns

	Mean	Std.Dev.	Min.	p10	p50	p90	Max.	Obs.
S&P 500	0.72	4.41	-16.70	-5.50	1.23	5.97	12.89	276
S&P 500 Duration	0.75	3.52	-10.43	-3.42	0.62	5.03	13.71	276
S&P 500 Risk	-0.03	6.44	-21.07	-8.98	0.26	7.43	14.82	276
Corp. Bond Market	0.34	1.31	-6.37	-0.89	0.41	1.69	7.57	186
Corp. Bond DRF	0.66	2.23	-7.43	-1.90	0.59	2.96	12.79	186
Corp. Bond CRF	0.36	1.81	-8.84	-1.57	0.25	2.22	8.19	186
Corp. Bond LRF	0.43	1.31	-2.63	-0.78	0.27	1.49	11.66	186
Treasury Bill	0.16	0.16	0.00	0.00	0.11	0.42	0.56	276

Table 2: CAPM Regressions of Corporate Bond Returns

This table presents regressions of the excess returns of corporate bond portfolios sorted by credit rating on the excess return of the S&P 500 Index:

$$r_{i,t} - r_{f,t} = \alpha + \beta(r_{SP500,t} - r_{f,t}) + \varepsilon_{i,t}$$

The sample consists of 276 monthly observations from July 1997 to June 2020. Value-weighted returns by credit rating are computed using bond-level quote data from Bank of America Merrill Lynch. Panel A uses excess corporate bond returns as the dependent variable, Panel B uses the duration-matched Treasury excess return from equation (3), and Panel C uses the duration-adjusted return from equation (4). Excess returns are computed by subtracting the one-month Treasury bill rate. t-statistics based on Newey and West (1987) standard errors with 12 lags are reported in brackets. GRS p-value is from the Gibbons et al. (1989) test.

Panel A: Corporate Bond Returns

Rating	AAA	AA	A	BBB	BB	B	CCC
β	-0.031	-0.001	0.045	0.143	0.301	0.412	0.622
	(-1.07)	(-0.04)	(1.21)	(3.15)	(6.53)	(7.41)	(6.07)
α	0.376	0.341	0.318	0.283	0.226	0.051	-0.092
	(3.96)	(3.87)	(3.29)	(2.49)	(1.98)	(0.35)	(-0.31)
Adj. R^2	0.004	-0.004	0.013	0.123	0.354	0.390	0.370
Mean α	0.215						
GRS p-value	0.003						

Panel B: Duration-Matched Treasury Returns

Rating	AAA	AA	A	BBB	BB	B	CCC
β	-0.121	-0.108	-0.111	-0.111	-0.090	-0.086	-0.076
	(-3.78)	(-3.73)	(-3.92)	(-3.74)	(-3.66)	(-3.90)	(-3.55)
α	0.407	0.372	0.378	0.391	0.332	0.301	0.262
	(4.05)	(4.26)	(4.33)	(4.33)	(4.44)	(4.41)	(3.86)
Adj. R^2	0.077	0.083	0.086	0.084	0.081	0.086	0.072
Mean α	0.349						
GRS p-value	< 0.001						

Panel C: Duration-Adjusted Returns

Rating	AAA	AA	A	BBB	BB	B	CCC
β	0.090	0.107	0.156	0.255	0.391	0.499	0.698
	(5.27)	(5.07)	(5.38)	(5.63)	(7.35)	(8.30)	(6.85)
α	-0.030	-0.030	-0.060	-0.108	-0.106	-0.250	-0.353
	(-0.62)	(-0.56)	(-0.89)	(-1.06)	(-0.90)	(-1.70)	(-1.19)
Adj. R^2	0.214	0.262	0.317	0.367	0.416	0.419	0.385
Mean α	-0.134						
GRS p-value	0.646						

Table 3: Duration-Adjusted CAPM Regressions of Corporate Bond Returns

This table presents time-series regressions of the excess returns of corporate bond portfolios sorted by credit rating on the duration-matched Treasury and dividend risk components of the S&P 500 Index excess return:

$$r_{i,t} - r_{f,t} = \alpha + \beta_{Dur}(r_{Dur,t} - r_{f,t}) + \beta_{Risk}(r_{SP500,t} - r_{Dur,t}) + \varepsilon_{i,t}$$

The sample consists of 276 monthly observations from July 1997 to June 2020. Value-weighted returns by credit rating are computed using bond-level quote data from Bank of America Merrill Lynch. Panel A uses excess corporate bond returns as the dependent variable, Panel B uses the duration-matched Treasury excess return from equation (3), and Panel C uses the duration-adjusted return from equation (4). Excess returns are computed by subtracting the one-month Treasury bill rate. t-statistics based on Newey and West (1987) standard errors with 12 lags are reported in brackets. GRS p-value is from the Gibbons et al. (1989) test.

Panel A: Corporate Bond Returns

Rating	AAA	AA	A	BBB	BB	B	CCC
β_{Dur}	0.470	0.416	0.442	0.464	0.384	0.403	0.464
	(15.41)	(11.18)	(10.35)	(7.47)	(5.59)	(5.12)	(4.21)
β_{Risk}	0.067	0.080	0.122	0.206	0.317	0.410	0.591
	(3.62)	(3.24)	(3.89)	(4.81)	(6.90)	(7.98)	(6.16)
α	0.084	0.098	0.086	0.096	0.178	0.056	0.000
	(1.26)	(1.36)	(0.95)	(0.78)	(1.36)	(0.39)	(0.00)
Adj. R^2	0.728	0.619	0.500	0.358	0.362	0.388	0.377
Mean α	0.085						
GRS p-value	0.212						

Panel B: Duration-Matched Treasury Returns

Rating	AAA	AA	A	BBB	BB	B	CCC
β_{Dur}	0.507	0.426	0.428	0.437	0.336	0.291	0.286
	(20.52)	(13.94)	(20.46)	(22.59)	(16.07)	(11.20)	(10.96)
β_{Risk}	0.002	-0.003	-0.006	-0.004	-0.007	-0.013	-0.006
	(0.15)	(-0.27)	(-0.51)	(-0.34)	(-0.54)	(-0.98)	(-0.42)
α	0.040	0.060	0.063	0.071	0.083	0.081	0.050
	(1.13)	(1.66)	(1.75)	(1.90)	(1.93)	(1.79)	(1.09)
Adj. R^2	0.887	0.872	0.873	0.871	0.782	0.722	0.702
Mean α	0.064						
GRS p-value	0.023						

Panel C: Duration-Adjusted Returns

Rating	AAA	AA	A	BBB	BB	B	CCC
β_{Dur}	-0.037	-0.010	0.014	0.027	0.047	0.112	0.178
	(-1.44)	(-0.35)	(0.38)	(0.42)	(0.64)	(1.32)	(1.57)
β_{Risk}	0.065	0.084	0.128	0.210	0.324	0.423	0.597
	(4.11)	(4.25)	(4.65)	(4.99)	(6.67)	(7.58)	(6.21)
α	0.044	0.038	0.023	0.025	0.095	-0.025	-0.050
	(0.86)	(0.68)	(0.32)	(0.23)	(0.80)	(-0.17)	(-0.17)
Adj. R^2	0.372	0.378	0.413	0.475	0.535	0.512	0.463
Mean α	0.021						
GRS p-value	0.461						

Table 4: Model Performance in the Time Series – Credit Rating Portfolios

This table presents time-series regressions of excess corporate bond returns on the CAPM, the duration-adjusted CAPM based on equity and bond market returns, and the pricing factors from Bai et al. (2019). The sample consists of 186 monthly observations from July 2004 to December 2019 due to the availability of the Bai et al. (2019) factors. The dependent variables in Panels A and B are based on the excess returns of corporate bond portfolios and the duration-adjusted returns, respectively. Value-weighted index returns by credit rating are computed using daily bond-level quote data from Bank of America Merrill Lynch. Excess returns are computed by subtracting the one-month Treasury bill rate. t-statistics are based on Newey and West (1987) standard errors with 12 lags. GRS p-values are from the Gibbons et al. (1989) test relative to null hypotheses of α equal to zero and the mean among the portfolios.

Panel A: Corporate Bond Returns

	CAPM			Decomposed CAPM			Decomposed Bond CAPM			Bai et al. (2019) Model		
	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2
AAA	0.379	3.37	0.007	0.069	0.95	0.715	0.002	0.08	0.908	0.099	1.50	0.629
AA	0.334	3.25	-0.005	0.061	0.74	0.630	-0.014	-0.68	0.921	0.071	1.15	0.739
A	0.308	2.63	0.014	0.064	0.55	0.478	-0.042	-2.42	0.961	0.036	0.78	0.806
BBB	0.282	2.01	0.128	0.100	0.62	0.341	-0.015	-0.60	0.962	-0.004	-0.13	0.764
BB	0.252	1.79	0.403	0.208	1.17	0.407	0.135	4.24	0.903	0.109	1.69	0.540
B	0.109	0.66	0.469	0.128	0.69	0.467	0.081	1.41	0.885	-0.044	-0.31	0.490
CCC	0.041	0.17	0.539	0.135	0.52	0.546	0.147	1.29	0.766	-0.199	-0.86	0.353
Mean	0.244	1.98	0.222	0.109	0.75	0.512	0.042	0.48	0.901	0.010	0.54	0.617
GRS p-value	0.009			0.218			0.029			0.036		
GRS p vs. Mean	0.357			0.404			< 0.001			0.043		

Panel B: Duration-Adjusted Returns

	CAPM			Decomposed CAPM			Decomposed Bond CAPM			Bai et al. (2019) Model		
	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2
AAA	-0.017	-0.31	0.192	0.059	0.94	0.326	0.020	0.79	0.686	-0.058	-1.51	0.239
AA	-0.030	-0.48	0.279	0.040	0.55	0.375	-0.007	-0.29	0.859	-0.066	-1.84	0.317
A	-0.055	-0.67	0.316	0.034	0.35	0.406	-0.035	-2.15	0.946	-0.104	-1.84	0.379
BBB	-0.094	-0.76	0.384	0.061	0.42	0.520	-0.017	-0.61	0.964	-0.154	-1.75	0.293
BB	-0.055	-0.39	0.463	0.148	0.91	0.574	0.122	4.50	0.936	-0.030	-0.24	0.287
B	-0.161	-0.93	0.483	0.066	0.38	0.579	0.067	0.98	0.916	-0.169	-0.82	0.319
CCC	-0.195	-0.75	0.536	0.100	0.39	0.612	0.153	1.32	0.810	-0.298	-1.04	0.265
Mean	-0.087	-0.61	0.379	0.073	0.56	0.484	0.043	0.65	0.874	-0.126	-1.29	0.300
GRS p-value	0.625			0.404			0.050			0.072		
GRS p vs. Mean	0.136			0.505			< 0.001			0.013		

Table 5: Model Performance in the Time Series – 25 Size-Maturity Portfolios

This table presents time-series regressions of excess corporate bond returns on the CAPM, the duration-adjusted CAPM based on equity and bond market returns, and the pricing factors from Bai et al. (2019). The dependent variables in Panels A and B are based on the excess returns of corporate bond portfolios and the duration-adjusted returns, respectively. Value-weighted index returns for portfolios double-sorted by size and maturity quintile are computed using quote data from Bank of America Merrill Lynch. t-statistics are based on Newey and West (1987) standard errors with 12 lags. GRS p-values are from the Gibbons et al. (1989) test relative to null hypotheses of α equal to zero and the mean among the portfolios.

Panel A: Corporate Bond Returns

	CAPM			Decomposed CAPM			Decomposed Bond CAPM			Bai et al. (2019) Model		
	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2
Small, Short Maturity	0.185	1.86	0.257	0.202	1.77	0.257	0.132	2.98	0.743	0.072	1.68	0.385
Small, Maturity 2	0.212	1.51	0.330	0.211	1.37	0.326	0.128	2.29	0.787	0.064	0.91	0.393
Small, Maturity 3	0.281	1.73	0.299	0.256	1.40	0.298	0.155	2.85	0.812	0.101	1.38	0.420
Small, Maturity 4	0.318	1.97	0.179	0.154	0.92	0.330	0.050	1.05	0.875	0.067	1.23	0.603
Small, Long Maturity	0.426	1.95	0.051	0.053	0.26	0.483	-0.055	-0.77	0.869	-0.016	-0.26	0.661
Size 2, Short Maturity	0.170	1.96	0.233	0.160	1.59	0.231	0.096	2.25	0.751	0.057	1.65	0.460
Size 2, Maturity 2	0.225	1.87	0.251	0.205	1.44	0.251	0.103	2.50	0.826	0.080	1.75	0.454
Size 2, Maturity 3	0.256	1.58	0.283	0.222	1.15	0.285	0.103	2.29	0.854	0.039	0.68	0.467
Size 2, Maturity 4	0.307	1.99	0.163	0.143	0.84	0.319	0.028	0.86	0.903	0.046	1.03	0.632
Size 2, Long Maturity	0.440	2.02	0.042	0.063	0.30	0.458	-0.066	-1.14	0.876	-0.039	-0.55	0.680
Size 3, Short Maturity	0.171	2.29	0.198	0.158	1.72	0.199	0.089	2.91	0.801	0.072	2.76	0.520
Size 3, Maturity 2	0.234	2.11	0.229	0.185	1.36	0.249	0.087	2.48	0.828	0.077	1.88	0.519
Size 3, Maturity 3	0.222	1.47	0.307	0.152	0.84	0.328	0.043	1.44	0.920	0.003	0.05	0.567
Size 3, Maturity 4	0.288	1.86	0.169	0.124	0.69	0.308	-0.002	-0.10	0.927	0.023	0.48	0.664
Size 3, Long Maturity	0.434	1.99	0.034	0.0001	0.00	0.504	-0.131	-2.21	0.892	-0.069	-0.91	0.715
Size 4, Short Maturity	0.160	2.24	0.167	0.150	1.67	0.165	0.075	2.35	0.771	0.074	2.67	0.478
Size 4, Maturity 2	0.209	1.97	0.276	0.154	1.21	0.303	0.068	2.20	0.886	0.069	1.75	0.575
Size 4, Maturity 3	0.239	1.64	0.295	0.143	0.81	0.341	0.037	1.36	0.955	0.017	0.39	0.655
Size 4, Maturity 4	0.261	1.76	0.208	0.075	0.46	0.372	-0.035	-1.77	0.958	-0.004	-0.09	0.715
Size 4, Long Maturity	0.447	2.21	0.048	0.011	0.06	0.496	-0.117	-2.01	0.895	-0.050	-0.60	0.770
Large, Short Maturity	0.137	1.96	0.154	0.081	1.10	0.194	0.026	0.96	0.607	0.022	1.07	0.649
Large, Maturity 2	0.177	1.79	0.249	0.101	0.85	0.310	0.023	0.78	0.886	0.027	0.77	0.726
Large, Maturity 3	0.206	1.45	0.302	0.068	0.43	0.388	-0.016	-0.66	0.932	-0.031	-0.61	0.738
Large, Maturity 4	0.285	2.15	0.180	0.062	0.44	0.435	-0.024	-0.84	0.939	0.033	0.85	0.824
Large, Long Maturity	0.406	2.02	0.086	-0.052	-0.29	0.513	-0.140	-1.95	0.853	-0.100	-1.54	0.867
Mean	0.268	1.89	0.200	0.123	0.93	0.334	0.026	0.80	0.854	0.025	0.74	0.605
GRS p-value	0.004			< 0.001			0.002			0.084		
GRS p vs. Mean	0.008			0.036			< 0.001			0.197		

Panel B: Duration-Adjusted Returns

	CAPM			Decomposed CAPM			Decomposed Bond CAPM			Bai et al. (2019) Model		
	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2	α	t-stat	Adj. R^2
Small, Short Maturity	0.083	0.80	0.312	0.152	1.35	0.368	0.099	2.27	0.804	0.011	0.16	0.302
Small, Maturity 2	-0.009	-0.06	0.401	0.134	0.91	0.508	0.092	1.53	0.860	-0.055	-0.44	0.261
Small, Maturity 3	-0.035	-0.22	0.377	0.176	1.05	0.544	0.129	2.41	0.882	-0.055	-0.38	0.226
Small, Maturity 4	-0.079	-0.61	0.385	0.116	0.83	0.565	0.074	1.98	0.900	-0.092	-0.71	0.228
Small, Long Maturity	-0.203	-1.13	0.355	0.085	0.46	0.600	0.001	0.02	0.914	-0.216	-1.43	0.247
Size 2, Short Maturity	0.057	0.68	0.325	0.103	1.08	0.359	0.053	1.75	0.828	-0.013	-0.28	0.355
Size 2, Maturity 2	-0.005	-0.04	0.374	0.118	0.90	0.481	0.058	1.74	0.914	-0.049	-0.54	0.292
Size 2, Maturity 3	-0.062	-0.40	0.371	0.144	0.82	0.524	0.080	2.10	0.904	-0.118	-0.97	0.261
Size 2, Maturity 4	-0.087	-0.70	0.382	0.104	0.72	0.567	0.051	1.71	0.918	-0.110	-0.99	0.228
Size 2, Long Maturity	-0.200	-1.11	0.332	0.093	0.47	0.576	-0.009	-0.15	0.909	-0.237	-1.77	0.245
Size 3, Short Maturity	0.057	0.76	0.303	0.099	1.14	0.337	0.050	1.91	0.871	-0.001	-0.03	0.407
Size 3, Maturity 2	0.004	0.04	0.382	0.099	0.79	0.450	0.044	1.36	0.908	-0.049	-0.62	0.325
Size 3, Maturity 3	-0.098	-0.69	0.419	0.070	0.42	0.520	0.015	0.44	0.947	-0.155	-1.27	0.305
Size 3, Maturity 4	-0.104	-0.81	0.371	0.086	0.55	0.535	0.022	0.89	0.946	-0.135	-1.24	0.247
Size 3, Long Maturity	-0.227	-1.30	0.352	0.035	0.18	0.545	-0.073	-1.69	0.937	-0.275	-2.16	0.267
Size 4, Short Maturity	0.047	0.67	0.280	0.092	1.10	0.319	0.035	1.31	0.855	0.005	0.13	0.367
Size 4, Maturity 2	-0.019	-0.18	0.424	0.069	0.60	0.482	0.024	0.72	0.940	-0.057	-0.67	0.330
Size 4, Maturity 3	-0.079	-0.58	0.436	0.067	0.42	0.522	0.014	0.67	0.970	-0.137	-1.24	0.330
Size 4, Maturity 4	-0.130	-1.12	0.443	0.037	0.27	0.567	-0.012	-0.77	0.968	-0.158	-1.42	0.259
Size 4, Long Maturity	-0.227	-1.31	0.364	0.048	0.25	0.548	-0.062	-1.05	0.934	-0.258	-2.10	0.260
Large, Short Maturity	0.018	0.25	0.247	0.017	0.23	0.243	-0.018	-0.54	0.647	-0.054	-1.05	0.538
Large, Maturity 2	-0.047	-0.51	0.429	0.021	0.20	0.469	-0.015	-0.70	0.939	-0.096	-1.27	0.434
Large, Maturity 3	-0.113	-0.88	0.457	-0.009	-0.06	0.497	-0.038	-1.37	0.933	-0.187	-1.51	0.381
Large, Maturity 4	-0.109	-1.07	0.471	0.022	0.19	0.561	-0.002	-0.05	0.942	-0.123	-1.27	0.295
Large, Long Maturity	-0.266	-1.53	0.407	-0.008	-0.04	0.538	-0.082	-1.23	0.913	-0.309	-2.11	0.292
Mean	-0.073	-0.44	0.376	0.079	0.59	0.489	0.021	0.61	0.899	-0.117	-1.01	0.307
GRS p-value	< 0.001			0.002			0.005			0.040		
GRS p vs. Mean	< 0.001			0.055			< 0.001			< 0.001		

Table 6: Model Performance in the Cross-Section – Fama-MacBeth Regressions

This table presents the results of Fama-MacBeth regressions of individual corporate bond excess returns on trailing factor betas. Panels A and B are based on the excess returns of individual corporate bonds and the duration-adjusted returns, respectively. Columns (1) to (4) are based on the CAPM, the duration-adjusted CAPM based on equity and bond market returns, and the Bai et al. (2019) four-factor model. Columns (5) to (7) combine each of the first three models with the Bai et al. (2019) model. Observations in the panel data set are at the bond-month level. Factor betas are estimated by regressing bond excess returns on factor returns over rolling 36-month windows ending in the month prior to current period, with a minimum of 24 months required to include the coefficient estimate in the sample. *t*-statistics are based on Newey and West (1987) standard errors with 12 lags.

Panel A: Corporate Bond Returns

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
β_{SP500}	0.098				0.445		
	(0.22)				(0.77)		
β_{EqDur}		0.221				0.007	
		(0.87)				(0.03)	
β_{EqRisk}		-0.055				0.595	
		(-0.09)				(0.74)	
β_{BndDur}			0.157				-0.301
			(1.35)				(-1.24)
$\beta_{BndRisk}$			0.048				0.251
			(0.26)				(0.89)
β_{Mkt}				0.148	0.028	-0.040	0.315
				(1.81)	(0.27)	(-0.30)	(1.10)
β_{DRF}				-0.274	-0.252	-0.300	0.125
				(-1.74)	(-1.95)	(-2.19)	(0.49)
β_{CRF}				-0.094	-0.230	-0.212	-0.294
				(-0.55)	(-1.03)	(-0.91)	(-1.30)
β_{LRF}				-0.016	-0.061	-0.031	0.044
				(-0.12)	(-0.52)	(-0.27)	(0.36)
α	0.393	0.279	0.234	0.280	0.278	0.270	0.227
	(3.49)	(2.71)	(2.93)	(2.97)	(2.59)	(2.49)	(2.83)
Adj. R^2	0.097	0.160	0.169	0.170	0.196	0.206	0.209
Time Periods	162	162	162	162	162	162	162
Bond-Month Obs.	454,358	454,358	454,358	454,358	454,358	454,358	454,358

Panel B: Duration-Adjusted Returns

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
β_{SP500}	0.057				0.504		
	(0.12)				(0.80)		
β_{EqDur}		0.112				-0.042	
		(0.34)				(-0.13)	
β_{EqRisk}		-0.001				0.740	
		(-0.00)				(0.83)	
β_{BndDur}			0.051				-0.296
			(0.36)				(-1.35)
$\beta_{BndRisk}$			0.046				0.230
			(0.25)				(0.88)
β_{Mkt}				0.029	-0.114	-0.172	0.178
				(0.40)	(-0.96)	(-1.13)	(0.85)
β_{DRF}				-0.276	-0.232	-0.296	0.136
				(-1.49)	(-1.56)	(-1.91)	(0.57)
β_{CRF}				-0.030	-0.210	-0.262	-0.258
				(-0.20)	(-1.00)	(-1.07)	(-1.27)
β_{LRF}				0.005	-0.035	-0.006	0.037
				(0.04)	(-0.37)	(-0.05)	(0.30)
α	0.124	0.095	0.117	0.121	0.113	0.121	0.113
	(1.56)	(1.60)	(1.90)	(1.28)	(1.60)	(1.76)	(1.86)
Adj. R^2	0.108	0.126	0.133	0.137	0.160	0.172	0.173
Time Periods	162	162	162	162	162	162	162
Bond-Month Obs.	454,358	454,358	454,358	454,358	454,358	454,358	454,358