# Corporate Credit Risk Changes: Common Factors and Firm-Level Fundamentals

**Doron Avramov***
Department of Finance
Robert H. Smith School of Business
University of Maryland
*davramov@rhsmith.umd.edu*
(301) 405-0400

**Gergana Jostova**
Department of Finance
School of Business
George Washington University
*jostova@gwu.edu*
(202) 994-7478

**Alexander Philipov**
Department of Finance
Kogod School of Business
American University
*philipov@american.edu*
(202) 415-4098

First Draft: June 14, 2003
Current Version: September 22, 2005

* This work has benefitted from comments and discussions with Jonathan Berk, Espen Eckbo, Robert Goldstein, Jean Helwege, Jing-Zhi Huang, Avner Kalay, Nikunj Kapadia, Nagpurnanand Prabhala, Suresh Sundaresan, and seminar participants at the 2005 AFA Meetings, the 2004 FMA meetings, and the 2004 Winter Finance Workshop. All remaining errors are ours.

# Corporate Credit Risk Changes: Common Factors and Firm-Level Fundamentals


**Abstract**

This paper provides new evidence on the empirical success of structural models in explaining corporate credit risk changes. A parsimonious set of common factors and firm-level fundamentals, inspired by structural models, explains more than 54% (67%) of the variation in credit spread changes for medium (low) grade bonds. No dominant latent factor is present in the unexplained variation. While our set of variables has lower explanatory power among high-grade bonds, it does capture most of the systematic variation of credit-spread changes in that category as well. It also subsumes the explanatory power of the Fama and French (1993) factors among all grade classes.

This paper assesses the success of structural models in empirical studies of *changes* in corporate credit spreads. Our focus is set on the change in the credit spread, not its level.[1] The difference in studying credit spreads vs. changes in credit spreads is equivalent to the difference in studying equity prices vs. equity expected returns. Indeed, there is a one-to-one correspondence between the spread level and the bond price, while the changes in credit spreads are directly associated with bond expected excess returns. As such, credit spread changes are the focus in bond pricing and, as it is the case with equity expected returns, they are the key to characterizing the risk-return tradeoff in corporate bond markets, fixed-income portfolio allocation, credit risk management, and credit derivative pricing.[2] So what drives credit spread changes? Early studies by Black and Scholes (1973) and Merton (1974) have given rise to "structural" models to explain corporate default risk, and have inspired firm-level and macro variables that potentially drive the changes in corporate credit spreads, such as volatility, leverage, and interest rates.[3]

Subsequently, several approaches have been used to evaluate the empirical success of structural models (e.g., Eom, Helwege, and Huang (2004) and Schaefer and Strebulaev (2004)). Here, we adopt the one that views structural models as empirically successful in corporate bond pricing if such models motivate variables that capture the variation in credit spread changes. Following this approach, Collin-Dufresne, Goldstein, and Martin (2001) recently find that structural model variables explain less than 25% of the total variation in credit spread changes. They also identify a strong latent factor, unrelated to structural model variables, that dominates the unexplained variation. These findings pose a serious challenge to the empirical validity of structural models in explaining corporate credit spread changes. Thus, should we dismiss, or at least discount, the importance of structural models in empirical studies of credit spread changes?

[1] Eom, Helwege, and Huang (2004) and Huang and Huang (2003) study credit spread levels and link the relative size of their credit risk component to the success of structural models. However, even a small credit risk component in the levels can account for most of the changes in credit spreads if the non-credit-risk component is less time-varying.

[2] Credit derivatives are one of the fastest growing segments in global over-the-counter derivatives markets, first appearing as over-the-counter contracts in 1991. The market has grown from $250 in 1997 to $1.2 trillion in 2001 and to $5 trillion in 2004. Source: *Credit Derivatives Report 2002*, British Bankers' Association, 2002.

[3] Structural models view equity and debt as options on the firm value. Default occurs when the firm value process reaches a default threshold. Later extensions of structural models include Anderson and Sundaresan (1996).

Not necessarily. Studying a large and diverse cross-section of 2,375 domestic corporate bonds over the 1990-2003 period, which covers the full spectrum of credit ratings (from AAA to D), we demonstrate that structural models are impressively successful in explaining credit spread changes in the middle and low-grade bond segments. Specifically, they explain more than 54% and even 67% of individual bond credit spread changes in these categories, respectively. In the highest-grade tercile the explanatory power is about 35%. Explanatory power differs across bond classes partly due to the different role played by firm-level fundamentals such as volatility, leverage, and growth opportunities. These variables are particularly important in the low-grade segment, but they play little role in the high-grade segment. Moreover, our common factors capture twice as much variation in the low-grade tercile relative to the highest-grade tercile.

Principal component analysis reveals no latent factor in the residual variation of low- and medium-grade bond portfolios and a strong latent factor in high-grade portfolios. However, analysis of *individual* bond regression residuals reveals virtually no common variation across any of the credit risk groups, providing solid evidence that structural models capture essentially all the systematic variation in individual bond credit spread changes for all credit risk classes.

We provide additional evidence that idiosyncratic volatility and the price-to-book ratio have a strong basis in empirical corporate bond pricing. Campbell and Taksler (2003) document a synchronous upward trend in aggregate idiosyncratic volatility and aggregate credit spread levels. Pastor and Veronesi (2003) show that the price-to-book ratio and idiosyncratic volatility are both driven by uncertainty about the firm's future profitability. Since future profitability affects default probability in a structural model framework, Pastor and Veronesi (2003) establish a theoretical link between credit spread levels (and potentially changes), idiosyncratic volatility, and the price-to-book ratio. We provide fresh empirical evidence on this link by showing that changes in idiosyncratic volatility and the price-to-book ratio, both at the aggregate and firm level, are economically and statistically significant in explaining both cross-sectional differences, as well as the time-series variation, in corporate credit spread changes. Our findings indicate that these variables should be considered along with more traditional ones in studies of credit risk changes at the individual bond level.

Our parsimonious set of variables subsumes the explanatory power of the Fama and French (1993) factors. These factors have traditionally been used in equity pricing. Recently, Elton, Gruber, Agrawal, and Mann (2001) document that these factors capture the systematic variation in credit spread changes. We find that the Fama-French factors are significant and explain about 26% of the variation in credit spread changes. Yet when added to our proposed set of structural model variables, the Fama-French factors lose significance and do not increase the overall explanatory power. This suggests that structural model factors capture the systematic risk in credit spread changes better than the Fama-French factors. Our empirical findings support the theoretical predictions of Gomes, Kogan, and Zhang (2003) who show, within a general equilibrium framework, that the size and value effects in expected asset returns are explained by accounting for growth opportunities, accomplished here by our structural variables.

It should be noted that our sample period, 1990 to 2003, has witnessed many central bank actions in response to major credit events.[4] For example, the early 1990s are characterized by Fed easing to bail out troubled commercial banks. The year 1997 is characterized by the Asian crisis, the year 1998 by the Russian default and the collapse of Long Term Capital Management, the year 2000 by the Treasury buybacks, and the period 2002-2003 by record defaults following the Telecom bubble burst. These credit events and the ensuing central bank actions could impact credit spreads. In particular, Fed easing could lead to tightening credit spreads, as is actually observed in the early 1990s. Likewise, the widening spreads in 2000-2001 are at least in part due to a shortage of Treasuries and the 'flight-to-quality.' To control for the extent of liquidity in the economy and its effect on credit spreads, we construct an indicator variable for the Fed easing and tightening cycles. We find that our set of results is robust to such liquidity considerations. In fact, the dummy variable is insignificant in the middle- and low-grade credit risk terciles. Among the high-grade bond tercile, expansionary (contractionary) Fed policy significantly reduces (increases) credit spreads. This reinforces previous evidence that investment-grade bonds provide close substitutes to Treasuries.

In summary, this paper provides vindication for structural models in explaining individual bond credit spread changes. First, structural model variables explain 67%, 54%, and 35% of the total variation in credit spread changes in low-, middle-, and high-

[4]We thank Suresh Sundaresan for pointing out this issue.

grade bonds, respectively. Second, these variables capture the explanatory power of the Fama-French factors, and the absence of a strong latent factor in the residual variation suggests no unexplained systematic variation. Third, firm-level variables, important drivers of credit spreads in a structural model framework, play an important role in explaining corporate credit spread changes, especially in the middle- and low-grade bond segments.

The remainder of the paper proceeds as follows. Section 1 describes the set of explanatory variables considered here and provides an economic appeal for their inclusion. Section 2 explains the data used in the empirical analysis. The results are discussed in section 3, and section 4 concludes.

# 1 Credit Spread Changes: Potential Determinants

Our determinants of credit spread changes are inspired by structural models of default risk. Structural models undertake the contingent claim approach, viewing equity and debt as options on the firm value. Under structural models, default occurs when the firm-value process hits a default threshold. These models imply that variables governing the firm-value process affect default probabilities and default recovery rates and thus ultimately drive credit spreads. Whether such models are empirically successful has long been an open question. True, one of the most popular and commercially successful systems for evaluating default risk, Moody's/KMV's expected default frequency (EDF) methodology, as well as their recent RiskCalc credit scoring system, are based on Merton's model.[5] Even so, the academic literature has been inconclusive regarding the performance of structural models. On the one hand, Jones, Mason, and Rosenfeld (1984) and Kim, Ramaswamy, and Sundaresan (1993) find that structural model variables explain only a small fraction of credit risk. Likewise, Collin-Dufresne, Goldstein, and Martin (2001) do not find structural models to be promising in motivating variables that adequately explain credit spread changes. On the other hand, Campbell and Taksler (2003) document strong co-movement between aggregate bond spreads and an aggregate measure of idiosyncratic volatility. This co-movement provides support for

[5] Source: Crosbie, Peter and Jeffrey R. Bohn, *Modeling Default Risk*, December 18, 2003. http://www.moodyskmv.com/research/defaultrisk.html

structural models because such models motivate firm volatility as a primary driver of a bond's default probability.

It should be noted that in this work we do not formally implement a structural model framework to evaluate model ability to fit prices or spreads. Instead, within a linear time-series regression specification, we assess the success of structural models in inspiring variables that are robust in explaining the movements in corporate credit spreads.

Structural model variables typically include economy-wide interest rates, term-structure slope, market return, market volatility, as well as firm-level leverage and volatility. Relative to previously studied variables, we incorporate firm-level and aggregate values of idiosyncratic volatility and growth prospects, as well as stock return momentum. The entire set of selected variables and the way they relate to the probability of default and the recovery rate conditional on default are described as follows:

**Idiosyncratic volatility.** The contingent-claim approach views debt as a combination of a risk-free loan and a short put option on the firm. Higher volatility increases the option value, thereby decreasing bond prices and increasing spreads. Intuitively, higher volatility increases the likelihood of hitting the default threshold. Structural models posit that firm value is driven by the firm's total volatility, which has previously been proxied by market volatility. We focus on the idiosyncratic volatility component following Campbell and Taksler (2003) who document a synchronous upward move in aggregate spreads and aggregate idiosyncratic volatility during 1990 to 2000. Furthermore, Campbell, Lettau, Malkiel, and Xu (2001) document that both idiosyncratic and total volatility have strongly moved upward in the past decade, while market volatility has remained constant over that period. Campbell and Taksler (2003)'s findings point to a link between idiosyncratic volatility and credit spread levels. Still Collin-Dufresne, Goldstein, and Martin (2001) point out that while some studies have been successful in explaining credit spread levels, little is known about the drivers of credit spread changes, which are the bond counterpart to equity excess returns. To investigate this further, we study the effect of changes in both aggregate and firm-level idiosyncratic volatility on credit spread changes.

**Stock return momentum.** Empirical research has extensively documented that the cross-section of equity returns is predictable based on past returns. Jegadeesh and Titman (1993) show that past winners continue to outperform past losers over the short-to-medium horizon, generating 'momentum' in stock prices. Thus higher momentum in equity returns implies higher future firm valuation, and could potentially imply lower probability of default and lower spreads.

**Growth opportunities.** Improving prospects of firm growth and profitability decrease the likelihood that the firm-value process hits the default threshold. We use the market-to-book ratio to proxy for future profitability following Pastor and Veronesi (2003) who provide theoretical proof and empirical evidence that the firm's market-to-book ratio increases with expected profitability. We study the effect of changes in both aggregate and firm-level market-to-book ratios on individual credit spread changes.

**Spot rate.** Longstaff and Schwartz (1995) argue that an increase in the spot rate increases the risk-neutral drift of the firm-value process and reduces the probability of the firm value falling below the default threshold. This spot-rate credit spread relation has been confirmed empirically in Longstaff and Schwartz (1995).

**Term-structure slope.** We consider two competing hypotheses of the directional impact of changes in the term-structure slope on credit spread changes. On the one hand, a steepening of the term-structure slope implies an increase in expected future spot rates (risk-neutral drift), thereby reducing credit spreads. In addition, Fama and French (1989) argue that an increase in the yield curve slope leads to an improving economy, improving recovery rates, and decreasing credit risk. On the other hand, the increase in expected future interest rates, implied by a steepening yield curve, may reduce the number of positive NPV projects available to the firm. This, in turn, leads to a lower firm valuation and an increase in spreads. The ultimate impact of changes in the term-structure slope on credit spread changes is thus an empirical question.

**Leverage.** Merton (1974) implies that high leverage should increase the probability of default, because it raises the default threshold. We use equity return as a measure of change in the firm's leverage, as in Collin-Dufresne, Goldstein, and Martin (2001). The use of this proxy is also justified by Welch (2004) who finds that when stock returns are accounted for, many other proxies used in the literature play a much lesser role in explaining changes in leverage.

**Market conditions.** Even with constant default probability, changes in credit spreads are affected by changes in expected recovery rates. Since the expected recovery rate is a function of the overall business climate (see, e.g., Altman and Kishore (1996)), an improving economy should drive credit spreads down. We use equity market returns to proxy for changes in business climate, as in Collin-Dufresne, Goldstein, and Martin (2001). Furthermore, Elton, Gruber, Agrawal, and Mann (2001) show that the credit spread compensates for exposure to aggregate risk factors, namely the Fama and French (1993) factors. For robustness and comparison, we study the predictive power of the Fama-French factors in the presence of our proposed set of structural model variables.

The goal of this paper is not to built an all-encompassing set of structural model variables, but rather to show that even a parsimonious set of variables inspired by these models can capture a substantial amount of the time-series variation in individual bond credit spread changes.

## 2 Data

We obtain bond and stock data from Datastream. The stock data is used to construct our firm-level variables, as described below. Our sample includes *all* US corporate bonds listed on Datastream, which satisfy a set of selection criteria commonly used in the corporate bond literature. Extracting all US corporate bonds from Datastream between September 1990 (the first available date for corporate bond spreads) and January 2003 yields 8,892 bond issues. The bond and equity datasets are then matched using the bond's unique identifier. This initial sample is subject to the following filtering criteria:

- We exclude bonds with no corresponding equity data in Datastream.
- We remove all bonds with equity or derivative features, such as callable, puttable, and convertible bonds, and bonds with warrants.
- We remove bonds with floating interest rates.
- For a bond to be in the sample, we require at least 25 consecutive monthly observations, as in Collin-Dufresne, Goldstein, and Martin (2001).
- We also remove all bonds for which the credit spread data appears to be problematic. For example, a problematic bond record may indicate a negative credit spread due to an incorrect Treasury yield curve assignment. In addition, credit spreads exceeding 13% are considered outliers and are thus removed.[6] Extreme spreads can be attributed either to data errors or to credit spread blow-ups.[7]

The filtered sample contains 2,375 fixed-rate straight US corporate bonds issued by 678 firms. The average number of monthly credit spread observations per bond is 47. It is important to note that our dataset addresses potential survivorship bias issues, as we have not excluded bonds that have gone bankrupt or that have expired.

Our database is similar in quality to data from Bloomberg and the Lehman Brothers (or Warga) database. In particular, analysis of a subset of bonds from the three data sources reveals a very close match in their prices. This is not surprising since these databases have the same data providers, i.e. the large institutional dealers in the bond market. Datastream does, however, cover a much larger cross-section of bonds. We verified that the size and liquidity (as measured by trading volume) of the part of our sample covered by other sources is similar to that of the part uncovered by other databases.

For all selected bonds, we extract all end-of-month credit spreads available in Datastream over the period September 1990 to January 2003. Credit spreads are

[6]We only remove the period over which the spread exceeds the limit, not the entire bond, to avoid introducing survivorship bias in the sample. The 13% figure reflects five standard deviations away from the mean.

[7]Credit blow-ups usually result from defaulted investment-grade credits, which are then relegated to junk-bond status. In this situation the credit spread can jump from a few hundred to tens of thousands basis points. The distressed high-grade companies are usually referred to as "fallen angels".

computed as the yield differential between the bond and the Treasury curve, taking into account maturity and compounding frequency:

$$Spread_{i,t} = Yield_{i,t} - Yield_{CURVE,t}, \tag{1}$$

where $Yield_{i,t}$ is the $t$-period yield on corporate bond $i$ and $Yield_{CURVE,t}$ is the yield on a $t$-period Treasury bond.

We also extract from Datastream issue-specific information, such as issue date, maturity date, time-to-maturity, duration, type of bond, embedded options, international identifier, and the corresponding equity-level information. This information is used for initial filtering and the formation of aggregate and firm-level variables.

Table 1 provides descriptive statistics for the entire sample of 2,375 corporate bonds and for the low, average, and high credit spread terciles. The average credit spread for our entire sample is 2.46%, ranging between zero and 12.99%. The standard deviation is 2.03%. Credit spread changes average three basis points per month, ranging between -10.02% and 11.81%, and having a standard deviation of 52 basis points.

Both credit spreads and credit spread changes display quite different characteristics across the three credit risk groups. For example, Table 1 illustrates a pronounced increase in the volatility of both credit spreads and credit spread changes as credit risk increases. Bonds in the low credit risk tercile have a credit spread standard deviation of 0.33%, while bonds in the high credit risk tercile have a 2.02% standard deviation. Moreover, the standard deviation of credit spread *changes* averages 0.17% in the low-risk tercile, while it is 0.77% in the high-risk tercile. The differences in the volatility of credit spread changes in the different risk groups are also underscored by the range of credit spread changes, which is much larger for the high-risk tercile. The mean credit spread change substantially differs across the credit risk groups. Low credit risk bonds have a mean credit spread change of zero, average credit risk bonds have a mean credit spread change of one basis point per month, while high credit risk bonds average six basis points credit spread increase per month. While our sample contains a variety of short- and long-term bonds, we do not observe a relationship between duration/time-to-maturity and credit risk. The average duration of the bonds in our sample is 5.16 years and the average time-to-maturity is 8.69 years. Note that the issue size and trading volume across the credit risk groups is also comparable.

In Table 1 and in part of the empirical analysis that follows, we form credit risk groups based on the bond's credit spread level. Ideally, one would form such groups using the bond rating. However, many bonds are not rated by any agency. Intuitively, a higher credit spread reflects a higher credit risk. To verify this, for the bonds having an S&P rating in Datastream, we compute the average credit rating for each of the credit risk groups.[8] The last two rows in Table 1 report, respectively, the numeric and alphabetic credit rating for the three credit spread groups. The average rating is A for the highest-grade tercile, BBB+ for the middle-grade tercile, and BB- for the lowest-grade tercile. This strong monotonic relationship between credit spread level and credit rating justifies our use of credit spread level as a proxy for credit rating. Our high credit risk group contains mostly high-yield bonds that have been excluded in previous studies of credit spread changes.

## 2.1 Firm-Level Variables

Firm-level variables are based on issuer equity data. Monthly stock returns and price-to-book ratios are obtained directly from Datastream. Following Brennan, Chordia, and Subrahmanyam (1998), we construct stock return momentum as the cumulative return over the two months ending at the beginning of the previous month. This variable excludes the preceding month's return to avoid spurious association between prior and current returns due to thin trading or/and bid-ask spread effects.[9] Monthly volatilities are calculated as the sum of squared daily returns over the trading days of the month. Firm-level idiosyncratic volatility is computed as the difference between monthly market volatility and monthly total firm-level volatility, as in Campbell, Lettau, Malkiel, and Xu (2001). Since our analysis focuses on the determinants of *changes* in corporate credit spreads, we use *changes* in volatility and price-to-book ratios.

[8] To compute the average rating, we first convert the alphabetic S&P rating into a numeric equivalent: AAA=1, AA+=2, AA=3, AA-=4, ..., D=25.

[9] For robustness, we also construct 6- and 12-month momentum variables as the cumulative return for months 4-6 and 7-12, respectively.

## 2.2 Aggregate Variables

Market-wide measures for aggregate idiosyncratic volatility, aggregate price-to-book ratio, and equity market return are calculated as equally-weighted averages across all 678 stocks in the sample. Spot rates are represented by the monthly series of two-, five-, ten-, and thirty-year Merrill Lynch Government bond yield indexes. We use one index at a time in our regressions, since changes in these indexes are highly correlated; correlations range between 0.73 and 0.95 (see Table 2). Changes in the five- and ten-year yield indexes exhibit the highest correlation with credit spread changes (-0.86). These changes are expected to be the most important drivers of credit spread changes as the average duration and time-to-maturity of the bonds in our sample are 5.16 and 8.69 years, respectively (see Table 1). The term-structure slope is measured as the yield differential between any two of the two-, five-, ten-, and thirty-year Merrill Lynch Government bond indexes. Except for equity market returns, we use changes, rather than levels, in the aggregate variables described above.

# 3 Results

## 3.1 Credit Spreads over the Period 1990-2003: An Overview

Figure 1 illustrates a significant upward trend in the average corporate credit spread over the past 13 years, and shows that the upward trend previously documented by Campbell and Taksler (2003) for the late 1990's extends beyond their sample period. A prominent spike in the spread levels is observed in 1998, during the major credit events of the Russian crisis and the follow-up collapse of Long Term Capital Management, as well as in 2002-2003, marking the record defaults of the Telecom bubble burst.

Figure 2 displays the time-series evolution of aggregate idiosyncratic volatility. The evolution of idiosyncratic volatility closely follows that of credit spreads with a strong upward trend and peaks around the Fall of 1998 and the end of 2002. This strong co-movement supports Campbell and Taksler (2003) who suggest that increasing corporate spreads may be driven by the increase in idiosyncratic volatility.

Figure 3 displays the time-series evolutions of the average credit spread and the five-year Treasury yield. Credit spreads exhibit a strong co-movement with interest rates, consistent with the theoretical predictions of structural default risk models. The two series display a correlation of -0.83. Table 2 shows that the correlation between the changes in these series is about the same (-0.86), suggesting that increases in interest rates significantly reduce the default probability of a typical firm.

## 3.2 Firm-Level Variables and the Cross-Section of Credit Spread Changes

We examine the power of firm-level fundamentals to explain cross-sectional differences in credit spread changes unexplained by common factors. Theoretically, structural models posit that default occurs when the firm-value process reaches some default threshold, suggesting that firm-level fundamentals should be a driving force behind changes in the probability of default. Empirically, support for firm-level variables is implied by Kwan (1996), who documents a strong firm-level relation between corporate yield and equity return. Since spreads are yields with a removed common interest-rate component, Kwan (1996)'s findings may suggest a robust relation between credit spreads and firm-level fundamentals. Nonetheless, previous work has primarily studied aggregate determinants of credit spread changes.

The cross-sectional analysis employs the methodology of Brennan, Chordia, and Subrahmanyam (1998).[10] For each bond in our sample, we run the time-series regression

$$\Delta S_{it} = \alpha_i + \boldsymbol{\beta}_i' \mathbf{F}_t + \epsilon_{it}, \tag{2}$$

where $\Delta S_{it}$ is bond $i$'s credit spread change from time $t$-1 to time $t$, $\mathbf{F}_t$ is a $K \times 1$ vector of common factors realized at time $t$, and $\boldsymbol{\beta}_i$ is the $K \times 1$ vector of factor sensitivities.

Then, for each month in our sample, we run the cross-sectional regression

$$\Delta S^*_{it} = a_t + \mathbf{b}_t' \mathbf{C}_{it} + e_{it}, \tag{3}$$

[10]This procedure is robust to the errors-in-variables bias arising when factor loadings, estimated in the first pass regression, are used as explanatory variables in the second pass regression.

where $\Delta S_{it}^* \equiv \Delta S_{it} - \widehat{\boldsymbol{\beta}}_i' \mathbf{F}_t = \widehat{\alpha}_i + \widehat{\epsilon}_{it}$, $\mathbf{C}_{it}$ is the vector of firm-level attributes, and $\widehat{\alpha}_i$, $\widehat{\boldsymbol{\beta}}_i$ and $\widehat{\epsilon}_{it}$ are the corresponding estimates from regression (2). Notice that $\Delta S_{it}^*$ is the credit spread change unexplained by common factors. The standard errors of $\mathbf{b}_t$ in (3), used to compute the $t$-ratios, are obtained from the time-series of monthly estimates, as in Fama and MacBeth (1973).

Table 3 reports the results from the cross-sectional regressions. Panel A describes the case where the three Fama and French (1993) factors are used to explain common variation. In Panel B, we replace the Fama-French factors by structural model factors, which include equity market returns and changes in the aggregate price-to-book ratio, aggregate idiosyncratic volatility, interest rates, and term-structure slopes.

The first row in panels A and B displays the results when all bonds are included in the analysis. Observe from Panel A that when the three Fama and French (1993) factors are used, firm-level leverage (proxied by stock returns) and momentum are significant in explaining cross-sectional differences in credit spread changes. In contrast, changes idiosyncratic volatility and growth prospects (the latter is proxied by the price-to-book ratio) are insignificant at conventional levels. In Panel B, when the structural model factors are used to explain common variation, changes in idiosyncratic volatility and price-to-book ratio are significant in explaining cross-sectional differences in credit spread changes at the 10% level.

We repeat the analysis excluding bonds with less than two years to maturity. Credit spreads on short maturity bonds could be less sensitive to evolving firm fundamentals. The results are reported in the second row of panels A and B in Table 3. Based on both panels, changes in idiosyncratic volatility are now strongly significant in explaining cross-sectional differences in credit spread changes. Variations in stock returns and momentum remain significant, whereas variations in price-to-book ratios become insignificant. The evidence shows the economic significance of firm-level fundamentals. For one, decreasing leverage (reflected by positive returns), positive momentum, and decreasing idiosyncratic volatility, are associated cross-sectionally with decreasing spreads. Specifically, Panel B (second row) shows that a firm with a one percent higher monthly return is expected to have a 12 basis points lower credit spread. Next, the coefficient on the momentum variable suggests that a one percent higher return over the past two months leads to eight basis points lower spreads. Finally, a 1% increase in monthly idiosyncratic volatility leads to 26 basis points higher spreads.

Overall, the analysis supports the importance of firm-level attributes, including those newly introduced here, in explaining the cross-section of credit spread changes left unexplained by common factors. This leads us to the next step in the analysis, where we examine the extent to which changes in firm-level fundamentals in conjunction with aggregate factors explain the time-series variation in credit spread changes.

## 3.3 Determinants of the Time-Series Variation of Credit Spread Changes

We start by examining the time-series explanatory power of common factors and firm-level attributes across all 2,375 corporate bonds in our sample. Throughout the time-series analysis, we run individual bond regressions, then average the estimated coefficients across all bonds and report the average values.

To assess the relative importance of each variable, we first present in Table 4 results from univariate regressions of credit spread changes on individual common factors (Panel A) and individual firm-level variables (Panel B). Panel A shows that credit spread changes are significantly affected by all structural model factors. Factor sensitivities are all strongly significant and have the theoretically expected sign.

Specifically, changes in spot rates seem to have the strongest impact on credit spread changes both in terms of significance and explanatory power. Consistent with the theoretical implications of risk-neutral contingent-claim pricing, increasing spot rates lead to decreasing credit spreads. Changes in 5-year spot rates alone explain 28.63% of the variation in individual credit spread changes. While the 2-, 10-, and 30-year spot rates have a similar degree of significance and explanatory power, the slight relative advantage of the 5-year rates may be due to the average bond duration of 5.16 years. Changes in the term-structure slope are also important determinants of corporate credit spread changes. Changes in the long-term slope have a strong positive impact on credit spread changes, consistent with the hypothesis that an increasing slope decreases the expected NPV of available projects, and thus reduces firm value and increases credit spreads. Changes between 30- and 10-year yields (30Y-10Y) explain 17.7% (t-statistic = 42.60) of individual spread changes. The highest explanatory power of this slope could be due to its correspondence to the period when the refinancing needs (and new projects decisions) of a typical firm occur. In contrast, an increase in the short-end of the term-structure slope (5Y-2Y) reduces credit spreads, consistent with the hypothesis that an increasing slope implies an improving economy, which leads to a credit risk decline.

Equity market return are the second strongest determinant of credit risk changes, explaining 18.25% (t-statistic = -36.26) of the variation. In line with the findings of Campbell and Taksler (2003), changes in aggregate idiosyncratic volatility have a strong positive impact on credit spread changes at the individual bond level (t-statistic = 32.25) and explain on average 6.47% of the time-series variation in credit spread changes. Next, an increase in the price-to-book (PB) ratio, indicating improving growth opportunities, reduces credit spreads. The PB ratio accounts on average for 3.21% (t-statistic = -34.88) of the variation in credit spread changes.

Panel B in Table 4 summarizes the relative importance of each firm-level characteristic. Each of the firm-level variables is significant and has the theoretically expected sign (the momentum variable is significant at the 10%). As posited by structural models, changes in firm leverage (proxied by stock returns) and firm-level idiosyncratic volatility are the most important drivers of credit spread changes. Positive stock returns (a decrease in leverage) tend to decrease spreads significantly (t-statistic = 22.17), while increases in stock volatility tend to increase them significantly (t-statistic = 26.44). Changes in firm leverage alone account for 15.45% of the variation in individual spread changes and changes in firm-level idiosyncratic volatility explain 13.20% of this variation. Bond spreads also respond to momentum in stock returns ($Adj.\text{-}R^2$ = 6.37%), but the t-statistic of -1.70 is significant only at the 10% level.[11] Finally, changes in the firm's growth opportunities (measured by the PB ratio) reduce spreads (t-statistic = -14.46) and explain about 7.29 % of the variation in credit risk changes.

Next, we analyze the joint explanatory power of all suggested variables in a series

[11] The momentum variable reported here is the cumulative return over months -3 and -2. We also tested momentum variables for longer lags, months -4 to -6 and months -7 to -12 (see Data section 2.2). These alternatives, not reported, do not improve significance.

of regressions of the type

$$\Delta Spread_{it} = \alpha_i + \boldsymbol{\beta}'_{1i}\mathbf{F}_t + \boldsymbol{\beta}'_{2i}\mathbf{C}_{it} + e_{it} \tag{4}$$

where $\mathbf{F}_t$ is the vector of common factors realized at time $t$, $\mathbf{C}_{it}$ is the vector of firm-level characteristics at time $t$, and $\boldsymbol{\beta}_{1i}$ and $\boldsymbol{\beta}_{2i}$ are the vectors of sensitivities.

Table 5 summarizes the results using five different specifications of regression (4) and provides a clear picture of the relative power of common and firm-level variables in explaining credit spread changes. Column $\mathcal{M}1$ presents the combined explanatory power of the five common factors - equity market return and changes in the aggregate price-to-book ratio, aggregate idiosyncratic volatility, 5-year spot rate, and the term-structure slope corresponding to the yield differential between 30- and 10-year Treasuries. These five common factors capture as much as 43.78% of the variation in credit spread changes. Changes in 5-year spot rates have the strongest impact on credit spread changes (t-statistic = -34.18), followed by changes in idiosyncratic volatility (t-statistic = 14.36). All aggregate variables, except for changes in the term-structure slope, are significant.

Column $\mathcal{M}2$ presents the combined explanatory power of firm-level stock return, momentum, and changes in idiosyncratic volatility and the price-to-book ratio. Lagged credit spread changes are included to control for potential autocorrelation. The firm-level attributes explain as much as 26.35% of the time-series variation of credit spread changes. All firm characteristics are significant and have the hypothesized sign, recording t-statistics that are higher than 7.72. Changes in idiosyncratic volatility and stock returns remain the most significant variables (t-statistics are 17.05 and -17.69, respectively). The results from the regressions based on firm characteristics attest to the importance of firm-level fundamentals in explaining the variation in corporate credit spread changes.

Next, we combine the aggregate and firm-level structural model variables to assess their joint explanatory power. Column $\mathcal{M}3$ shows that such variables capture as much as 53.44% of the variation in credit spread changes. The only firm characteristic that loses significance is the price-to-book ratio when the aggregate price-to-book ratio is included in the regression. Similarly, when the firm stock return is included, the market return loses significance. All remaining variables, however, are strongly significant in the all-inclusive regressions. The evidence suggests that the explained credit spread variation has both a systematic component, captured by common factors, and an idiosyncratic one, captured by firm-level variables. Indeed, later we will show that firm-level variables do not capture common variation and are purely idiosyncratic in nature.

Our parsimonious set of structural model determinants is then added to the Fama and French (1993) factors to explain the variation in corporate credit spread changes. The Fama-French factors have traditionally been used in equity pricing. Recently, Elton, Gruber, Agrawal, and Mann (2001) document that these factors capture the systematic variation in credit spreads. Indeed, column $\mathcal{M}4$ shows that the Fama-French factors have a negative and significant impact on credit spread changes, explaining altogether 25.93% of spread changes. Recall, our proposed determinants capture a much larger fraction of the time-series variation in credit spread changes. Moreover, including the Fama and French (1993) factors along with our common and firm-level variables (excluding equity market return because it is highly correlated with the market) increases the explanatory power from 53.44% to 54.72% (see Column $\mathcal{M}5$). Overall, the evidence suggests that our structural model factors capture essentially all the systematic variation in credit spread changes and subsume the explanatory power of the Fama-French factors. Note in Column $\mathcal{M}5$ that both MKT and HML lose significance in the presence of our suggested variables, and that the SMB flips sign.

To summarize, the time-series regression results provide strong empirical support for structural models. Common factors alone explain about 44% of the time variation in individual credit spread changes, while firm-level attributes alone explain 26%. Common factors and firm-level variables combined explain more than 53% of the variation in credit spread changes, a substantial improvement over previous findings.

## 3.4 Credit Spread Variation by Credit Risk Groups

The evidence thus far suggests that aggregate variables explain a substantial part of the variation in individual credit spread changes, much larger than previously documented.

The analysis also indicates a much larger role for firm fundamentals than previously suggested. We will show below that much of the sharp differences from related studies are attributable to the composition of bonds in our sample.

For the remainder of the analysis, the sample of 2,375 bonds is divided into three credit-risk terciles based on their credit spread level. The tercile bounds are calculated as the $33\frac{1}{3}$th and $66\frac{2}{3}$th credit spread percentiles based on all credit spread observations in the entire sample of 2,375 bonds. For a bond to be included in the low credit risk tercile, for example, all of its credit spread observations must lie within the lowest tercile bounds to allow running the individual bond regressions. A similar group attribution is used for the average and high credit risk terciles. This grouping procedure captures 405, 370, and 475 bonds in the low, average, and high credit risk groups, respectively. We re-run all five specifications of regression (4) for each of the credit risk groups separately. The five panels in Table 6 report the results.

Across all five regression specifications considered, the explained credit spread variation increases substantially as the bond credit risk increases (see last row of Panels A to E in Table 6). The level of significance of both common and firm-level variables also increases with credit risk. In particular, observe from Panel A in Table 6 that when only common factors are considered, the R-squared increases from 28.51% (low credit spread level) to 43.72% (average credit spread level) and to 53.67% (high credit spread level). The significance of aggregate idiosyncratic volatility appears to increase as the credit-risk increases (the t-statistic increases from 2.54 to 2.71 to 6.61), as prescribed by structural default risk models. The significance of changes in the aggregate price-to-book ratio, changes in interest rates, and equity market returns also increases with credit risk. The flip in sign of the term-structure change variable, in turn, indicates opposite effect on high-versus-low-grade bonds.

Panel B confirms that the explanatory power of firm-level attributes is more pronounced for the highest credit risk bonds. The R-squared increases from 18.56% to 28.37% moving from the low to the high credit risk group. Moreover, the significance of the firm characteristics is highest in the high-risk category, where all coefficients are strongly significant and with the theoretically motivated signs.

Panel C provides the most direct evidence for the differences between our results and previous results based on high-grade bonds. First, the time-series variation in credit spread changes explained by both common factors and firm-level attributes is substantially higher for low-versus-high grade bonds. In the low-risk category it is about half (34.96%) that in the high-risk category (67.14%). Second, firm-specific variables remain strongly significant when combined with common factors for the high-risk group, while they lose power in the low-risk group.

Focusing on high-grade bonds, Elton, Gruber, Agrawal, and Mann (2001) argue that corporate bonds have systematic risk, captured by the Fama and French (1993) factors. We extend this analysis by showing a stronger effect of the Fama and French (1993) factors on lower-grade bonds. Specifically, Panel D shows that the credit spread variation explained by the three factors increases from 14.27% to 17.35 and to 30.26% as we move up the credit risk groups. However, when augmented with the structural model variables proposed in this work (Panel E), SMB and HML lose significance in all but the highest-grade bond tercile. They also do not improve the explained variation beyond that of our factors. That is, the systematic risk is entirely captured by the five structural model factors.

To further assess the robustness of our results, we investigate the impact of liquidity, caused by the Federal Reserve expansionary or contractionary policy, on credit spread changes. Indeed, our sample period is characterized by Federal Reserve actions, such as raising and reducing the federal funds rate. These Fed actions could impact corporate bond liquidity. To incorporate the potential impact of Fed actions on credit spreads, we construct a dummy variable indicating Fed expansionary (dummy=1) and contractionary (dummy=0) cycles. The dates of Federal Reserve policy change that mark these periods are taken directly from the transcripts of the Federal Open Market Committee meetings available on the Federal Reserve Board website. The results are reported in Panel F. Our previous results remain unchanged, except for the Fama-French factors which lose significance now even in the high-grade segment. The adjusted R-squared remain almost unchanged (they even fall slightly) following the inclusion of the Fed cycle dummy, indicating that our results are robust to changes in liquidity induced by Federal Reserve intervention. More importantly, the Fed cycle dummy is only significant in the highest-grade tercile, where expansionary Fed policy reduces credit spreads and contractionary policy increases them.

Our findings so far indicate that structural models capture a substantial amount of the time-series variation in individual bond credit spread changes, especially in the middle- and low-grade bond segments. Still the strongest evidence against structural models provided in the literature is that there is a dominant latent factor, unrelated to structural models and equity markets, that captures 75% of the residual variation in individual bond credit spread changes. Next we investigate whether such large systematic factor is present in the residual variation of any segment of our bond sample after accounting for the structural model variables.

## 3.5 Analysis of the Unexplained Credit Spread Variation

We implement principal component [PC] analysis on credit spread changes, as well as on the residuals of the time-series regressions. These residuals reflect variation unexplained by structural models. The comparison between the two provides insights on the degree to which our variables have been successful in capturing the common variation in credit spread changes. The purpose of the PC analysis is to detect if significant unexplained systematic variation remains in the residuals, rather than establish the number of driving factors. That is why we only look at the first five components, and focus on the strength of the first factor. The 2,375 corporate bond credit spread and regression residual series are each assigned to one of 35 portfolios formed as the interaction of five credit spread and seven time-to-maturity categories. PC analysis is applied to portfolios rather than individual bonds because bonds expire or default, and are therefore not available for the entire sample period.

Figure 4 summarizes the principal component analysis based on the total variation in spread changes (first bar plot), as well as on the unexplained variation reflected by the regression residuals (second bar plot). The light-shaded bars in the first plot point to a strong common factor in the portfolio-aggregated credit spread changes, capturing 63% of their variation. The explanatory power of each subsequent principal component is significantly smaller. However, focusing on the residuals, the light-shaded bars in the second plot show that the first principal component accounts for less than 28% of their variation. The regression residuals are from the time-series regressions on our aggregate and firm-level variables (see Table 5, column $\mathcal{M}3$). Our PC analysis so far provides evidence that our parsimonious set of structural model variables capture a major portion of the common variation in credit spread changes. This evidence is apparently at odds with previous findings of a much stronger latent factor in the regression residuals. We find that this difference is primarily attributable to the larger number of portfolios used in our study, which is made possible by the larger number of bonds in our sample.

Specifically, portfolio grouping procedures may spuriously increase the importance of latent factors. For example, if we decrease the number of portfolios from 35 to 15, our PC analysis of regression residuals reveals that the first factor captures about 45% of the unexplained credit spread variation, compared to 28% when using 35 portfolios. To investigate this further, we regress the individual credit spread changes on each of the first five portfolio-based latent factors. We do the same for the individual residuals and the corresponding portfolio-based residual latent factors. We summarize the average R-squared in the dark-shaded bars overlayed in the two plots in Figure 4.[12] As with the portfolios, the dark-shaded bars on the first plot in Figure 4 reveal a prominent systematic factor in individual bond credit spread changes, capturing 30% of their common variation. Moreover, each of the third and fourth portfolio-based latent factors also captures more than 10% of the individual spread variation, suggesting that there is indeed substantial systematic variation in individual credit spread changes.[13] However, our set of structural model variables captures most of this systematic variation. Indeed, the dark-shaded bars in the second plot of Figure 4 show no significant portfolio-based latent factor in the residual variation of individual spread changes. Each of the first five latent factors captures less than 6% of the common variation in individual bond residuals.

Since the variation explained by structural models is much smaller in high grade bonds, we further investigate if there is remaining systematic variation in the high- and low-grade terciles separately. The two plots in Figure 5 summarize our analysis within the low and high credit risk terciles. Looking at the light-shaded bars on both plots in Figure 5, we demonstrate that there is a stronger latent factor in the unexplained

[12]Comparing the average R-squared from individual regressions on each factor is equivalent to comparing the weights of the eigenvalues from the PC analysis.

[13]Note that because the 35 portfolios span a different space than the 2,375 individual series, the first five principal components, constructed based on the portfolios, are not necessarily monotonically decreasing in their explanatory power of the individual series.

variation of the portfolio-aggregated residuals of high-grade bonds, capturing more than 50% of their common variation, while it is less than 30% in the high risk tercile. PC analysis is performed based on 15 portfolios because of the lower number of bonds within each credit risk group. Repeating the previous analysis with individual bond residuals reveals that most of this common variation is spurious and driven by portfolio grouping. Indeed, regressing the individual bond residuals on the latent factors shows that each factor explains less than 7% of the common variation in individual high-grade bond residuals and less than 4% in individual low-grade bond residuals.

These findings suggest that our parsimonious set of structural model variables successfully captures essentially all of the systematic variation in individual bond credit spread changes for bonds of all credit risk levels. While the explained variation is smaller in high-grade bonds, structural models are still successful in this credit group as they leave little systematic variation unexplained.

# 4 Conclusion

Using 2,375 corporate bonds over the 1990-2003 period, we document that structural models are successful in motivating variables that explain credit spread dynamics. A parsimonious set of aggregate and firm-level variables explains about more than 67%, 53%, and 35% of the total variation in credit spread changes of individual low-, middle-, and high-grade bonds, respectively. Principal component analysis of the individual bond regression residuals reveals that for all bond grades, structural models successfully capture the systematic variation in credit spread changes.

We also demonstrate that the Fama-French factors capture some of the systematic risk in credit spread changes. The explanatory power of the Fama-French factors seems to increase moving from high- to low-grade bonds. However, for each credit-risk category, the Fama-French factors lose significance when combined with our proposed set of determinants, suggesting that structural model factors better capture the systematic risk in credit spread changes than do the Fama-French factors.

We develop further evidence on the viability of structural models in empirical corporate bond pricing. Building on recent innovations in asset pricing, we identify idiosyncratic volatility and the price-to-book ratio to have a strong basis in a structural model framework. Both variables are economically and statistically significant in explaining cross sectional differences in corporate bonds, as well as in explaining the time-series variation in corporate credit spread changes. Hence, these variables should be considered along with more traditional ones in studies of bond-level credit risk.

These findings are robust to liquidity considerations. In particular, we show that changes in the overall bond market liquidity due to Federal Reserve tightening and easing cycles do not affect the documented support for structural models.

# References


Altman, Edward I., and Vellore Kishore, 1996, Almost Everything You Wanted to Know About Recoveries on Defaulted Bonds, *Financial Analysts Journal* 52(6), 57–64.

Anderson, Ronald W., and Suresh Sundaresan, 1996, Design and Valuation of Debt Contracts, *Review of Financial Studies* 9, 37–68.

Black, Fisher, and Myron S. Scholes, 1973, The Pricing of Options and Corporate Liabilities, *Journal of Political Economy* 81, 637–654.

Brennan, Michael J., Tarun Chordia, and Avanidhar Subrahmanyam, 1998, Alternative Factor Specifications, Security Characteristics, and the Cross-Secion of Expected Stock Returns, *Journal of Financial Economics* 49, 345–373.

Campbell, John Y., Martin Lettau, Burton G. Malkiel, and Yexiao Xu, 2001, Have Individual Stocks Become More Volatile? An Empirical Exploration of Idiosyncratic Risk, *Journal of Finance* 56(1), 1–43.

Campbell, John Y., and Glen B. Taksler, 2003, Equity Volatility and Corporate Bond Yields, *Journal of Finance* 58(6), 2321–2349.

Collin-Dufresne, Pierre, Robert S. Goldstein, and J. Spencer Martin, 2001, The Determinants of Credit Spread Changes, *Journal of Finance* 56(6), 2177–2207.

Eom, Young Ho, Jean Helwege, and Jing-Zhi Huang, 2004, Structural Models of Corporate Bond Pricing: An Empirical Analysis, *Review of Financial Studies* 17(2), 499–544.

Fama, Eugene F., and Kenneth R. French, 1989, Business Conditions and Expected Returns on Stocks and Bonds, *Journal of Financial Economics* 25, 23–49.

Fama, Eugene F., and Kenneth R. French, 1993, Common Risk Factors in the Returns on Stocks and Bonds, *Journal of Financial Economics* 33, 3–56.

Fama, Eugene F., and James D. MacBeth, 1973, Risk, Return, and Equilibrium: Empirical Tests, *Journal of Political Economy* 81, 607–636.

Gomes, Joao, Leonid Kogan, and Lu Zhang, 2003, Equilibrium Cross-Section of Returns, *Journal of Political Economy* 111(4), 693–732.

Huang, Jing-Zhi, and Ming Huang, 2003, How Much of the Corporate-Treasury Yield Spread is Due to Credit Risk?, Working Paper, Smeal College of Business, Penn State University.

Jegadeesh, Narasimhan, and Sheridan Titman, 1993, Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency, *Journal of Finance* 48(1), 35–91.

Jones, E. Philip, Scott P. Mason, and Eric Rosenfeld, 1984, Contingent Claims Analysis of Corporate Capital Structures: An Empirical Investigation, *Journal of Finance* 39, 611–625.

Kim, Joon, Krishna Ramaswamy, and Suresh Sundaresan, 1993, Does Default Risk in Coupons Affect the Valuation of Corporate Bonds? A Contingent Claims Model, *Financial Management* 22(3), 117–131.

Kwan, Simon H., 1996, Firm-Specific Information and The Correlation between Individual Stocks and Bonds, *Journal of Financial Economics* 40, 63–80.

Longstaff, Francis A., and Eduardo S. Schwartz, 1995, A Simple Approach to Valuing Risky Fixed and Floating Rate Debt, *Journal of Finance* 50, 789–821.

Merton, Robert C., 1974, On the Pricing of Corporate Debt: The Risk Structure of Interest Rates, *Journal of Finance* 29, 449–470.

Pastor, Lubos, and Pietro Veronesi, 2003, Stock Valuation and Learning about Profitability, *Journal of Finance* 58(5), 1749–1790.

Schaefer, Stephen M., and Ilya A. Strebulaev, 2004, Structural Models of Credit Risk are Useful: Evidence from Hedge Ratios on Corporate Bonds, Unpublished Paper, London Business School.

Welch, Ivo, 2004, Capital Structure and Stock Returns, *Journal of Political Economy* 112 (1), 106–131.

## Table 1
## Descriptive Statistics of Corporate Bond Sample

The table presents descriptive statistics for the 2,375 US corporate bonds included in our sample over the period September 1990 through January 2003. Bonds are also divided into three groups based on their credit spread level. The last three columns provide statistics per credit risk group. The credit spread is computed in Datastream as the bond's yield spread over the corresponding Treasury, $Spread_{it} = Yield_{it} - Yield_{CURVE,t}$. Trading volume data is not available for all bonds - the figures represent trading volume per bond per month when data is available. Credit ratings are also available for only some of the bonds. The last two rows report the average numeric and letter S&P rating (1=AAA,..., 8=BBB+,..., 17=CCC+,..., 25=D). S&P rating below (above) BBB is considered to be investment (non-investment) grade.

| Statistic | All Bonds | Groups Based on Credit Spread Level | | |
|---|---|---|---|---|
| | | Low | Average | High |
| Credit Spread (%) - mean | 2.46 | 0.80 | 1.88 | 4.69 |
| - median | 1.84 | 0.82 | 1.84 | 4.05 |
| - minimum | 0.00 | 0.00 | 1.32 | 2.63 |
| - maximum | 12.99 | 1.32 | 2.63 | 12.99 |
| - st. deviation | 2.03 | 0.33 | 0.37 | 2.02 |
| Credit Spread Changes (%) - mean | 0.03 | 0.00 | 0.01 | 0.06 |
| - median | 0.01 | 0.00 | 0.01 | 0.05 |
| - minimum | -10.02 | -1.09 | -1.25 | -8.76 |
| - maximum | 11.81 | 1.22 | 1.20 | 9.67 |
| - st. deviation | 0.52 | 0.17 | 0.23 | 0.77 |
| Duration (years) | 5.16 | 4.90 | 5.95 | 4.35 |
| Time-to-Maturity (years) | 8.69 | 8.20 | 10.44 | 7.19 |
| Issue size ($million) | 300 | 296 | 307 | 297 |
| Monthly trading volume ($million per issue) | 5.48 | 4.96 | 6.66 | 5.59 |
| S&P Rating - mean | 8.58 | 5.92 | 8.29 | 12.99 |
| - corresponding letter rating | BBB | A | BBB+ | BB- |

## Table 2
## Correlation between Credit Spread Changes and Treasury Yield Changes

The table presents correlations between changes in aggregate credit spreads and changes in treasury yields. The credit spread is computed in Datastream as the bond's yield differential with the corresponding Treasury. The credit spread index used here is computed as the equal-weighted average credit spread across all 2,375 US corporate bonds. The treasury yields are represented by the two-, five-, ten-, and thirty-year treasury yield indexes provided by Merrill Lynch. Correlations are calculated based on changes in end-of-month yield data from September 1990 to January 2003.

| Changes in | Changes in the Credit Spread Index | Changes in Treasury Yields | | |
|---|---|---|---|---|
| | | 2 Year | 5 Year | 10 Year |
| Credit Spread Index | 1 | | | |
| 2 Year Treasuries | -0.79 | 1 | | |
| 5 Year Treasuries | -0.86 | 0.95 | 1 | |
| 10 Year Treasuries | -0.86 | 0.86 | 0.95 | 1 |
| 30 Year Treasuries | -0.79 | 0.73 | 0.84 | 0.92 |

## Table 3
## Cross-Sectional Explanatory Power of Firm-Level Variables

The table reports the average coefficients and the corresponding $t$-ratios in the cross-sectional regressions of bond-level credit spread changes unexplained by common variation on firm-level attributes. Specifically, we first estimate factor sensitivities using the time-series regressions

$$\Delta S_{it} = \alpha_i + \boldsymbol{\beta}_i' \mathbf{F}_t + \epsilon_{it},$$

where $\Delta S_{it}$ is the change in credit spread from time $t$-1 to time $t$, $\mathbf{F}_t$ is a $3 \times 1$ vector of the Fama and French (1993) factors (Panel A) or a $5 \times 1$ vector the common structural model factors (listed in Table 5 column $\mathcal{M}1$) (Panel B) realized at time $t$, and $\beta_i$ is the vector of factor loadings. Next, we run cross-sectional regressions of spread changes unexplained by the common factors on firm-level characteristics

$$\Delta S_{it}^* = a_t + \mathbf{b}_t' \mathbf{C}_{it} + e_{it},$$

where $\Delta S_{it}^* \equiv \Delta S_{it} - \widehat{\boldsymbol{\beta}}_i' \mathbf{F}_t = \widehat{\alpha}_i + \widehat{\epsilon_{it}}$, $\widehat{\alpha}_i$ and $\widehat{\boldsymbol{\beta}}_i$ are the coefficients estimated form the time-series regressions, and $\mathbf{C}_{it}$ is the vector of firm attributes. Here is the list of attributes: *stock return* is the monthly equity return of the bond's issuing firm; *stock momentum* is the cumulative return over the two months ending at the beginning of the previous month; *idiosyncratic volatility* is the difference between the realized volatility of the stock's daily returns and the volatility of the market's daily returns over the month; and *price-to-book* is the ratio of the issuing firm's market price of equity divided by its book value. Reported are the coefficients from the cross-sectional regressions first including all bonds (first row) and then excluding bonds with less than two years to maturity (second row). The sample t-statistics are reported in parenthesis with 5% significance level presented in bold.

Panel A: $\mathbf{F_t}$ = Fama and French (1993) Factors

| $\Delta S_{it}^*$ | Stock Return | Stock Momentum | Change in Idiosyncratic Volatility | Change in Price-to-Book Ratio |
|---|---|---|---|---|
| All bonds | -0.11 | -0.09 | 13.62 | -0.01 |
| | (**-2.61**) | (**-2.53**) | (1.09) | (-0.70) |
| > 2 years to maturity | -0.13 | -0.09 | 26.32 | -0.01 |
| | (**-2.84**) | (**-2.43**) | (**2.01**) | (-0.29) |

Panel B: $\mathbf{F_t}$ = Common Factors Inspired by Structural Models of Default Risk

| $\Delta S_{it}^*$ | Stock Return | Stock Momentum | Change in Idiosyncratic Volatility | Change in Price-to-Book Ratio |
|---|---|---|---|---|
| All bonds | -0.15 | -0.09 | 23.21 | -0.03 |
| | (**-3.50**) | (**-2.55**) | (1.78) | (-1.77) |
| > 2 years to maturity | -0.12 | -0.08 | 25.71 | -0.02 |
| | (**-2.79**) | (**-2.44**) | (**2.16**) | (-1.03) |

## Table 4
## Explanatory Power of Individual Common Factors and Firm-Level Characteristics

Panel A presents the average slope coefficients, t-statistics, and adjusted R-squared of univariate time-series regressions of changes in credit spreads on single common factors

$$\Delta Spread_{it} = a_i + b_{ik}F_{kt} + e_{it}.$$

Panel B presents average slope coefficients, t-statistics, and adjusted R-squared, of time-series regressions of credit spread changes on firm-level characteristics

$$\Delta Spread_{it} = a_i + b_{ij}C_{ijt} + e_{it},$$

where $C_{ijt}$ denotes the $j$'th attribute of firm $i$ at time $t$: *stock return* is the monthly equity return of the bond's issuing firm; *stock momentum* is the cumulative return over the two months ending at the beginning of the previous month; *idiosyncratic volatility* is the difference between the realized volatility of the stock's daily returns and the volatility of the market's daily returns over the month; and *price-to-book* is the ratio of the issuing firm's market price of equity divided by its book value. T-statistics indicating 5% significance level are presented in bold. The sample period is September 1990 to January 2003.

Panel A: Common Factors

| Common Factor | $\overline{b_{ik}}$ | $Adj.\text{-}R^2$ |
|---|---|---|
| Equity Market Return | -3.22<br>(**-36.26**) | 18.25% |
| Change in Aggregate Price-to-Book Ratio | -0.89<br>(**-34.88**) | 3.21% |
| Change in Aggregate Idiosyncratic Volatility | 123.73<br>(**32.25**) | 6.47% |
| 2-year Government Rates (2Y) | -0.56<br>(**-45.30**) | 26.79% |
| 5-year Government Rates (5Y) | -0.54<br>(**-49.29**) | 28.63% |
| 10-year Government Rates (10Y) | -0.60<br>(**-50.52**) | 25.73% |
| 30-year Government Rates (30Y) | -0.52<br>(**-45.95**) | 15.82% |
| Term Structure Slope (5Y-2Y) | -0.26<br>(**-14.96**) | 1.74% |
| Term Structure Slope (10Y-2Y) | 0.30<br>(**17.58**) | 4.15% |
| Term Structure Slope (30Y-2Y) | 0.48<br>(**31.96**) | 11.49% |
| Term Structure Slope (30Y-10Y) | 1.22<br>(**42.60**) | 17.70% |

Panel B: Firm-Level Characteristics

| Firm-level Characteristic | $\overline{b_i}$ | $Adj.\text{-}R^2$ |
|---|---|---|
| Stock Return | -1.35<br>(**-22.17**) | 15.45% |
| Stock Momentum | -1.45<br>(-1.70) | 6.37% |
| Change in Idiosyncratic Volatility | 263.52<br>(**26.44**) | 13.20% |
| Change in Price-to-Book Ratio | -0.52<br>(**-14.46**) | 7.29% |

## Table 5
## Total Explained Variation in Credit Spread Changes

The table reports average regression coefficients, t-statistics, and adjusted R-squared, of time-series regressions of credit spread changes on select common factors and firm-level characteristics:

$$\Delta Spread_{it} = a_i + \boldsymbol{\beta}'_{1i}\mathbf{F_t} + \boldsymbol{\beta}'_{\mathbf{2i}}\mathbf{C_{it}} + \epsilon_{\mathbf{it}}.$$

- $\mathcal{M}1$: Regression on common factors, $\mathbf{F_t}$.
- $\mathcal{M}2$: Regression on firm-level characteristics, $\mathbf{C_{it}}$.
- $\mathcal{M}3$: Regression on common factors and firm-level characteristics.
- $\mathcal{M}4$: Regression on the market (MKT), size (SMB), and value (HML) factors.
- $\mathcal{M}5$: Regression on all variables.

T-statistics indicating 5% level of significance are presented in bold. The sample period is September 1990 to January 2003. NOTE: *Stock return* is the monthly equity return of the bond's issuing firm; *stock momentum* is the cumulative return over the two months ending at the beginning of the previous month; *idiosyncratic volatility* is the difference between the realized volatility of the stock's daily returns and the volatility of the market's daily returns over the month; and *price-to-book* is the ratio of the issuing firm's market price of equity divided by its book value.

| Variable | $\mathcal{M}1$ | $\mathcal{M}2$ | $\mathcal{M}3$ | $\mathcal{M}4$ | $\mathcal{M}5$ |
|---|---|---|---|---|---|
| COMMON FACTORS | | | | | |
| Equity Market Return | -0.66 | - | -0.05 | - | - |
| | (**-6.98**) | | (-0.59) | | |
| Change in Aggregate Price-to-Book Ratio | -0.10 | - | -0.07 | - | -0.11 |
| | (**-4.63**) | | (**-3.23**) | | (**-4.30**) |
| Change in Aggregate Idiosyncratic Volatility | 58.13 | - | 27.46 | - | 15.11 |
| | (**14.36**) | | (**6.24**) | | (**3.30**) |
| 5-year Government Rates (5Y) | -0.46 | - | -0.45 | - | -0.43 |
| | (**-34.18**) | | (**-33.70**) | | (**-29.75**) |
| Term Structure Slope (30Y-10Y) | 0.02 | - | -0.07 | - | 0.07 |
| | (0.70) | | (**-2.19**) | | (1.86) |
| MKT Factor | - | - | - | -0.02 | 0.00 |
| | | | | (**-27.62**) | (1.27) |
| SMB Factor | - | - | - | -0.01 | 0.00 |
| | | | | (**-19.77**) | (**4.14**) |
| HML Factor | - | - | - | -0.03 | 0.00 |
| | | | | (**-22.00**) | (1.93) |
| FIRM-LEVEL CHARACTERISTICS | | | | | |
| $\Delta Spread_{i,t-1}$ | - | -0.11 | -0.06 | - | -0.04 |
| | | (**-12.51**) | (**-7.95**) | | (**-4.80**) |
| $\Delta Spread_{i,t-2}$ | - | -0.06 | -0.03 | - | -0.05 |
| | | (**-8.68**) | (**-4.85**) | | (**-7.27**) |
| Stock Return | - | -0.77 | -0.30 | - | -0.25 |
| | | (**-17.69**) | (**-8.49**) | | (**-6.20**) |
| Stock Momentum | - | -0.28 | -0.26 | - | -0.18 |
| | | (**-10.36**) | (**-9.70**) | | (**-5.60**) |
| Change in Idiosyncratic Volatility | - | 129.15 | 49.83 | - | 84.05 |
| | | (**17.05**) | (**6.35**) | | (**9.51**) |
| Change in Price-to-Book Ratio | - | -0.18 | -0.01 | - | -0.07 |
| | | (**-7.72**) | (-0.27) | | (**-2.24**) |
| Adj.-$R^2$ | 43.78% | 26.35% | 53.44% | 25.93% | 54.72% |

## Table 6
## Explained Variation in Credit Spread Changes Across Credit Risk Groups

The table reports average regression coefficients, t-statistics, and adjusted R-squared, of time-series regressions of credit spread changes on select common factors and firm-level characteristics:

$$\Delta Spread_{it} = a_i + \boldsymbol{\beta}'_{1i}\mathbf{F_t} + \boldsymbol{\beta}'_{\mathbf{2i}}\mathbf{C_{it}} + \epsilon_{\mathbf{it}}.$$

PANEL A: Regression on common factors, $\mathbf{F_t}$.
PANEL B: Regression on firm-level characteristics, $\mathbf{C_{it}}$.
PANEL C: Regression on common factors and firm-level characteristics.
PANEL D: Regression on the market (MKT), size (SMB), and value (HML) factors.
PANEL E: Regression on all variables.

T-statistics indicating 5% level of significance are presented in bold. The sample period is September 1990 to January 2003. For a bond to be in a credit-risk group, its spread observations along the entire sample period must be within the tercile bounds calculated based on the entire bond sample.

### Panel A: Common Factors ($\mathcal{M}1$)

| Variable | Groups Based on Credit Spread Level | | |
|---|---|---|---|
| | Low | Average | High |
| Number of Bonds per Group | 405 | 370 | 475 |
| Equity Market Return | -0.15 | -0.10 | -1.37 |
| | (**-3.07**) | (-1.35) | (**-5.47**) |
| Change in Aggregate Price-to-Book Ratio | -0.04 | -0.07 | -0.28 |
| | (**-3.85**) | (**-3.67**) | (**-5.23**) |
| Change in Aggregate Idiosyncratic Volatility | 12.32 | 24.93 | 71.92 |
| | (**2.54**) | (**2.71**) | (**6.61**) |
| 5-year Government Rates (5Y) | -0.28 | -0.41 | -0.75 |
| | (**-20.10**) | (**-20.43**) | (**-21.91**) |
| Term Structure Slope (30Y-10Y) | -0.11 | -0.12 | 0.33 |
| | (**-4.17**) | (**-3.97**) | (**3.53**) |
| Adj.-$R^2$ | 28.51% | 43.72% | 53.67% |

### Panel B: Firm-Level Characteristics ($\mathcal{M}2$)

| Variable | Low | Average | High |
|---|---|---|---|
| $\Delta Spread_{i,t-1}$ | -0.27 | -0.09 | -0.06 |
| | (**-17.42**) | (**-4.18**) | (**-2.64**) |
| $\Delta Spread_{i,t-2}$ | -0.16 | -0.12 | -0.05 |
| | (**-12.19**) | (**-6.57**) | (**-2.69**) |
| Stock Return | 0.12 | -0.04 | -1.55 |
| | (**2.45**) | (-0.47) | (**-10.10**) |
| Stock Momentum | -0.01 | -0.15 | -0.33 |
| | (-0.34) | (**-3.27**) | (**-3.75**) |
| Change in Idiosyncratic Volatility | 28.55 | 126.49 | 183.07 |
| | (**2.83**) | (**5.80**) | (**7.33**) |
| Change in Price-to-Book Ratio | -0.06 | -0.10 | -0.46 |
| | (**-4.11**) | (**-2.29**) | (**-5.61**) |
| Adj.-$R^2$ | 18.56% | 18.29% | 28.37% |

**Table 6** (continued)
**Explained Variation in Credit Spread Changes**
**Across Credit Risk Groups**

PANEL C: COMMON FACTORS AND FIRM-LEVEL CHARACTERISTICS ($\mathcal{M}3$)

| Variable | Groups Based on Credit Spread Level | | |
|---|---|---|---|
| | Low | Average | High |
| Number of Bonds per Group | 405 | 370 | 475 |
| COMMON FACTORS | | | |
| Equity Market Return | -0.18 | 0.08 | -0.57 |
| | (**-2.51**) | (0.73) | (-1.84) |
| Change in Aggregate Price-to-Book Ratio | -0.06 | -0.06 | -0.13 |
| | (**-3.78**) | (-1.94) | (-1.41) |
| Change in Aggregate Idiosyncratic Volatility | 10.57 | 13.25 | 35.96 |
| | (**2.30**) | (1.65) | (**2.41**) |
| 5-year Government Rates (5Y) | -0.24 | -0.45 | -0.78 |
| | (**-15.63**) | (**-14.20**) | (**-21.49**) |
| Term Structure Slope (30Y-10Y) | -0.08 | -0.19 | 0.02 |
| | (**-2.63**) | (**-3.37**) | (0.14) |
| FIRM-LEVEL CHARACTERISTICS | | | |
| $\Delta Spread_{i,t-1}$ | -0.22 | -0.07 | -0.04 |
| | (**-14.99**) | (**-4.25**) | (**-2.60**) |
| $\Delta Spread_{i,t-2}$ | -0.11 | -0.10 | -0.04 |
| | (**-7.91**) | (**-7.06**) | (**-2.88**) |
| Stock Return | 0.04 | -0.08 | -0.48 |
| | (1.31) | (-1.52) | (**-4.38**) |
| Stock Momentum | -0.03 | -0.14 | -0.18 |
| | (-1.24) | (**-3.81**) | (**-2.57**) |
| Change in Idiosyncratic Volatility | 3.75 | 44.88 | 37.55 |
| | (0.35) | (**2.43**) | (**2.09**) |
| Change in Price-to-Book Ratio | -0.02 | -0.05 | -0.16 |
| | (-1.48) | (-1.65) | (**-2.06**) |
| Adj.-$R^2$ | 34.96% | 53.38% | 67.14% |

PANEL D: FAMA AND FRENCH (1993) FACTORS ($\mathcal{M}4$)

| Variable | Low | Average | High |
|---|---|---|---|
| MKT Factor | 0.00 | -0.00 | -0.04 |
| | (**2.74**) | (-0.42) | (**-18.24**) |
| SMB Factor | -0.01 | -0.01 | -0.02 |
| | (**-13.60**) | (**-16.00**) | (**-13.36**) |
| HML Factor | -0.00 | -0.01 | -0.05 |
| | (**-2.55**) | (**-5.33**) | (**-14.06**) |
| Adj.-$R^2$ | 14.27% | 17.35% | 30.26% |

**Table 6** (continued)
**Explained Variation in Credit Spread Changes**
**Across Credit Risk Groups**

Panel E: Common Factors and Firm-Level Characteristics
+ Fama and French (1993) Factors ($\mathcal{M}5$)

| Variable | Groups Based on Credit Spread Level | | |
|---|---|---|---|
| | Low | Average | High |
| Number of Bonds per Group | 405 | 370 | 475 |
| Common Factors | | | |
| Change in Aggregate Price-to-Book Ratio | -0.05 | -0.08 | -0.25 |
| | (**-2.69**) | (**-2.56**) | (**-2.52**) |
| Change in Aggregate Idiosyncratic Volatility | 10.75 | 8.36 | 34.61 |
| | (**2.35**) | (0.95) | (**2.24**) |
| 5-year Government Rates (5Y) | -0.23 | -0.44 | -0.74 |
| | (**-14.66**) | (**-13.23**) | (**-16.51**) |
| Term Structure Slope (30Y-10Y) | -0.06 | -0.13 | 0.10 |
| | (-1.65) | (-1.93) | (0.81) |
| MKT Factor | -0.00 | 0.00 | -0.01 |
| | (-0.03) | (0.60) | (**-2.14**) |
| SMB Factor | -0.00 | 0.00 | 0.00 |
| | (**-2.31**) | (0.22) | (0.51) |
| HML Factor | -0.00 | 0.00 | 0.00 |
| | (**-2.42**) | (**3.02**) | (0.61) |
| Firm-Level Characteristics | | | |
| $\Delta Spread_{i,t-1}$ | -0.21 | -0.06 | -0.04 |
| | (**-13.21**) | (**-3.22**) | (**-2.42**) |
| $\Delta Spread_{i,t-2}$ | -0.11 | -0.10 | -0.04 |
| | (**-7.98**) | (**-6.69**) | (**-2.57**) |
| Stock Return | 0.00 | -0.10 | -0.44 |
| | (0.00) | (-1.94) | (**-4.09**) |
| Stock Momentum | -0.01 | -0.12 | -0.23 |
| | (-0.32) | (**-3.15**) | (**-3.05**) |
| Change in Idiosyncratic Volatility | 8.37 | 34.81 | 35.06 |
| | (0.90) | (1.81) | (1.75) |
| Change in Price-to-Book Ratio | -0.04 | -0.08 | -0.13 |
| | (**-2.71**) | (**-2.30**) | (-1.62) |
| Adj.-$R^2$ | 35.89% | 54.83% | 67.51% |

## **Table 6** (continued)
## **Explained Variation in Credit Spread Changes Across Credit Risk Groups**

PANEL F: COMMON FACTORS AND FIRM-LEVEL CHARACTERISTICS + FAMA AND FRENCH (1993) FACTORS + Federal Reserve Cycle Dummy

The Fed Cycle Dummy indicates Fed expansionary (dummy=1) and contractionary (dummy=0) cycles. The dates of Federal Reserve policy change that mark these periods are taken directly from the transcripts of the Federal Open Market Committee meetings available on the Federal Reserve Board website.

| Variable | Groups Based on Credit Spread Level | | |
|---|---|---|---|
| | Low | Average | High |
| Number of Bonds per Group | 405 | 370 | 475 |
| COMMON FACTORS | | | |
| Change in Aggregate Price-to-Book Ratio | -0.05<br>**(-2.66)** | -0.07<br>**(-2.24)** | -0.24<br>**(-2.42)** |
| Change in Aggregate Idiosyncratic Volatility | 10.35<br>**(2.28)** | 12.68<br>(1.47) | 38.76<br>**(2.46)** |
| 5-year Government Rates (5Y) | -0.23<br>**(-14.17)** | -0.46<br>**(-13.35)** | -0.73<br>**(-16.19)** |
| Term Structure Slope (30Y-10Y) | -0.04<br>(-1.24) | -0.17<br>**(-2.64)** | 0.13<br>(1.05) |
| MKT Factor | 0.00<br>(0.17) | 0.00<br>(0.30) | -0.01<br>**(-2.41)** |
| SMB Factor | -0.00<br>(-1.93) | 0.00<br>(0.07) | 0.00<br>(0.65) |
| HML Factor | -0.00<br>(-1.83) | 0.00<br>**(3.26)** | 0.00<br>(0.50) |
| Fed Cycle Dummy (1=expansion) | -0.01<br>**(-4.70)** | -0.01<br>(-1.80) | 0.01<br>(1.60) |
| FIRM-LEVEL CHARACTERISTICS | | | |
| $\Delta Spread_{i,t-1}$ | -0.22<br>**(-13.67)** | -0.07<br>**(-3.65)** | -0.04<br>**(-2.52)** |
| $\Delta Spread_{i,t-2}$ | -0.12<br>**(-8.12)** | -0.10<br>**(-6.76)** | -0.04<br>**(-3.01)** |
| Stock Return | 0.00<br>(0.01) | -0.10<br>(-1.73) | -0.41<br>**(-3.75)** |
| Stock Momentum | -0.02<br>(-0.67) | -0.13<br>**(-3.24)** | -0.23<br>**(-2.98)** |
| Change in Idiosyncratic Volatility | 1.11<br>(0.12) | 27.81<br>(1.40) | 35.01<br>(1.76) |
| Change in Price-to-Book Ratio | -0.04<br>**(-2.34)** | -0.08<br>**(-2.15)** | -0.10<br>(-1.26) |
| Adj.-$R^2$ | 35.28% | 55.00% | 66.56% |

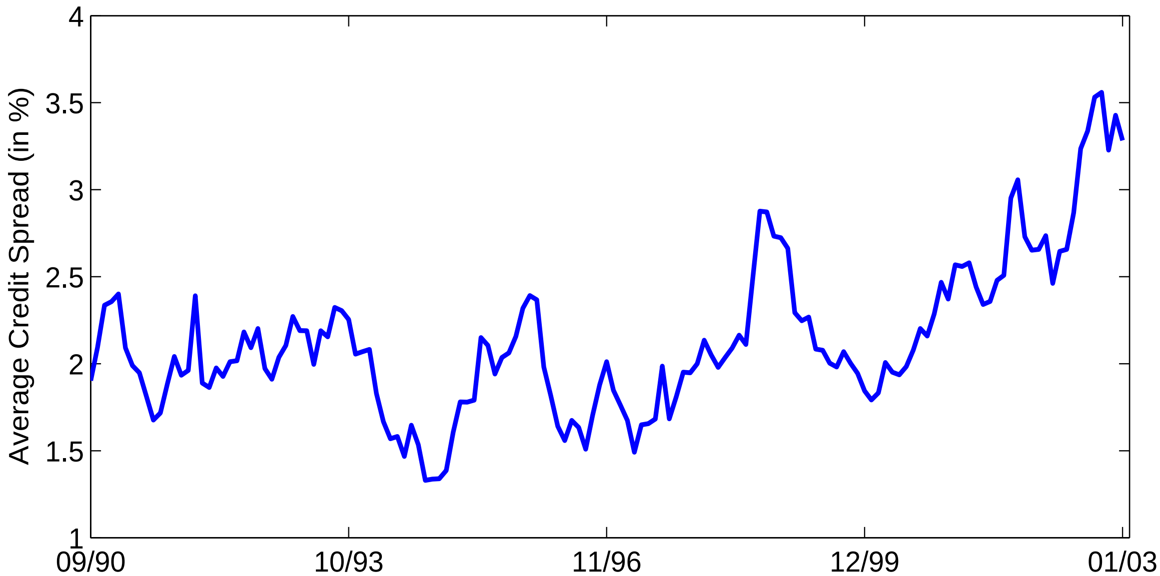


**Figure 1. History of Credit Spreads of US Corporate Bonds (in %).** The plot displays the equal-weighted average of credit spread level across 2,375 corporate bonds included in our sample. The credit spread is computed as the yield spread over the corresponding Treasury yield curve.

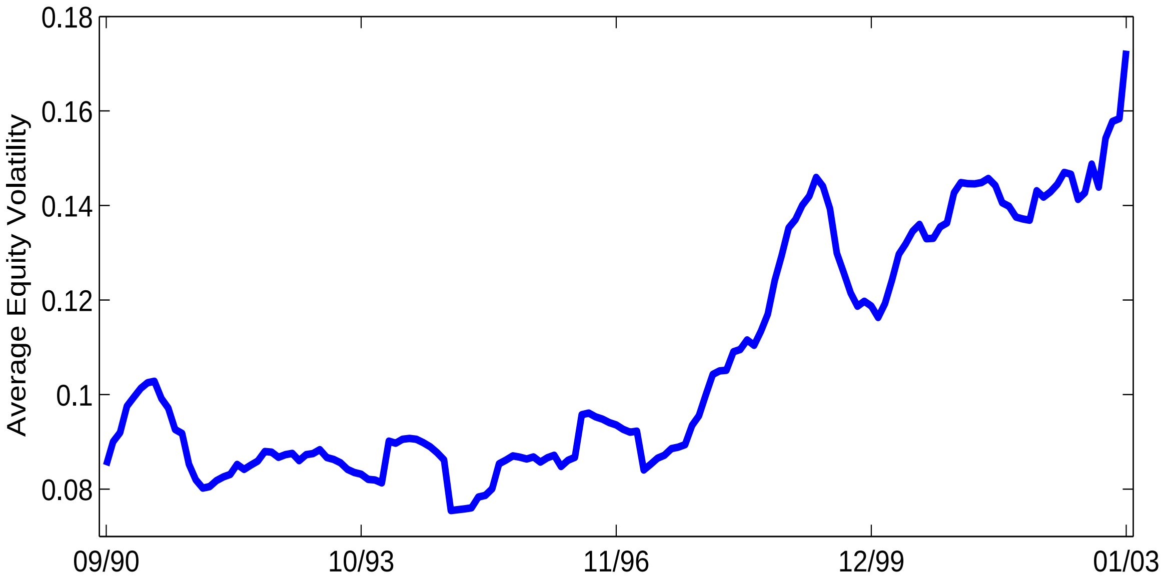


**Figure 2. History of Idiosyncratic Volatility.** The figure displays the 12-month moving average idiosyncratic volatility, equal weighted across the stocks corresponding to all bonds included in our sample. The volatility figures are annualized.

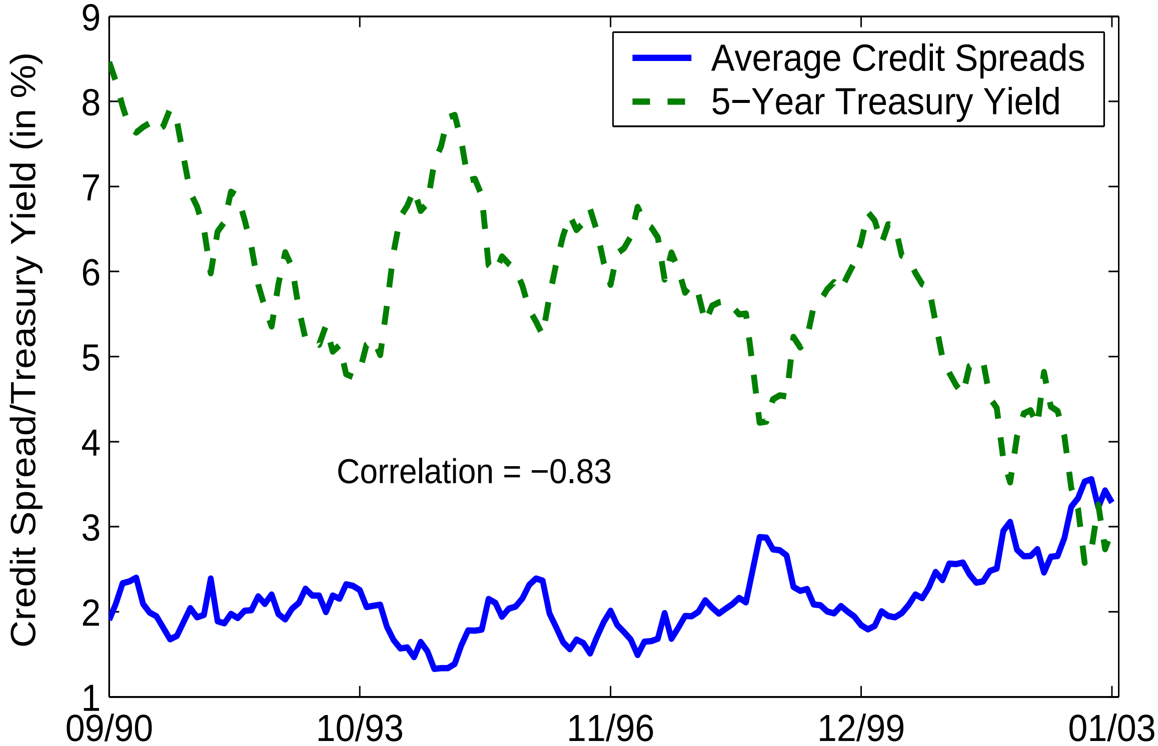


**Figure 3. Treasury Yields vs. Corporate Credit Spreads.** The figure compares the 5-Year treasury yield index from Merrill Lynch to the equal-weighted average credit spread of all 2,375 corporate bonds included in our sample.

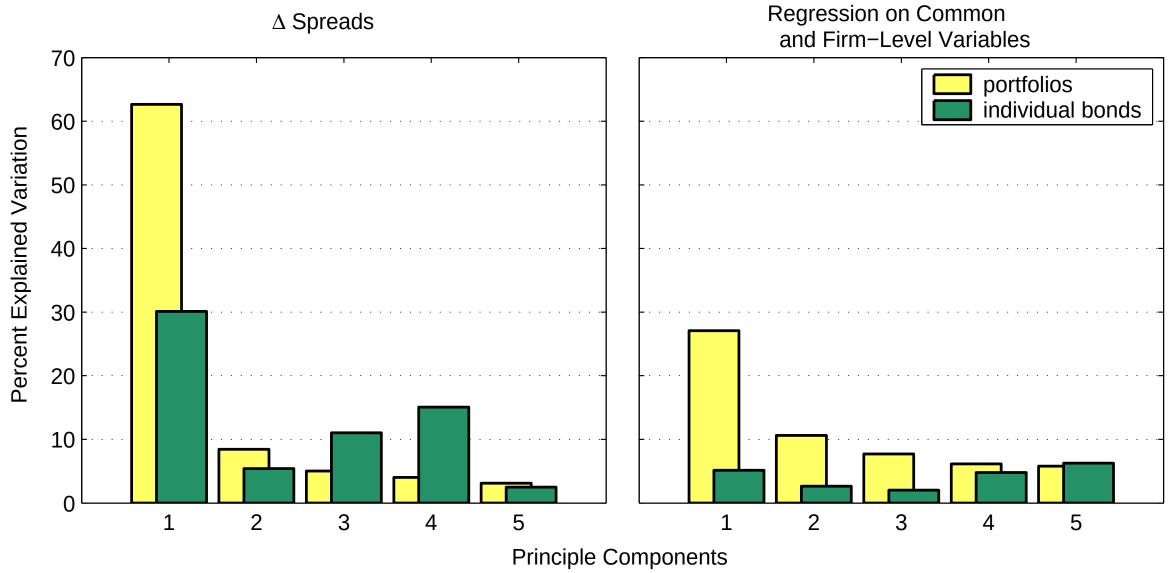


**Figure 4. Principal Component Analysis of Credit Spread Changes and Regression Residuals.** The first barplot presents results from principal component analysis of credit spread changes. Principal component analysis is based on 35 portfolios formed by grouping the entire sample of 2,375 US corporate bonds into 5 average spread and 7 life-to-maturity categories. The light bars represent the percentage of common variation in the 35 portfolios of credit spread changes explained by each of the first 5 principal components. The second barplot summarizes principal component analysis results based on the residuals from regressions of credit spread changes on common and firm-level variables described in Table 5 column $\mathcal{M}3$. The light bars represent the percentage of common variation in the 35 portfolios of regression residuals explained by each of the first 5 principal components. The darker bars in the first (second) plot represent the average R-squared from regressions of individual credit spread changes (individual regression residuals) on each of the portfolio-derived latent factors.

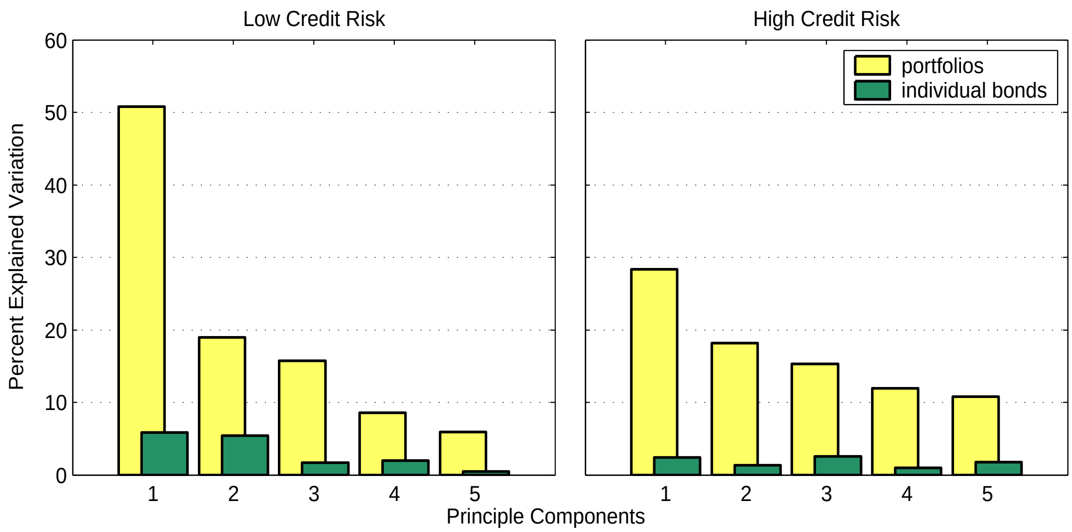


**Figure 5. Principal Component Analysis of Regression Residuals in the Low and High Credit Risk Groups.** The figure presents results from principal component analysis of residuals from time-series regressions of credit spread changes on common factors and firm-level variables described in Table 6 ($\mathcal{M}3$). The first plot presents PC analysis of residuals of low credit risk bonds (lowest tercile), while the second plot presents results from bonds with high credit risk (highest tercile). Since there are fewer bonds (405 in the low credit risk group and 475 in the high credit risk group) than that in Figure 4, principal component analysis is based on 15 portfolios formed based on 5 average spread and 3 life-to-maturity categories. The light bars represent the percentage of common variation in the portfolios of residuals explained by each of the first 5 principal components. The dark bars represent the average R-squared from regressions of individual residuals on each of the first five latent factors.