Explaining Credit Spread Changes: New Evidence from Option-Adjusted Bond Indexes

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This is an examination of the determinants of corporate bond credit spreads using both weekly and monthly option-adjusted spreads for nine Merrill Lynch corporate bond indexes from January 1997 through July 2002. The Russell 2000 index historical return volatility and the Conference Board composite leading and coincident economic indicators have significant power in explaining credit spread changes, especially for high-yield indexes. These three variables plus the interest rate level, the historical interest rate volatility, the yield curve slope, the Russell 2000 index return, and a high-minus-low factor together can explain more than 40% of credit spread changes for five bond indexes. These eight variables together can explain 67.68% and 60.82% of credit spread changes for the B and BB-rated indexes.

The analysis confirms that credit spread changes for high-yield bonds are more closely related to equity market factors and also provides evidence in favor of incorporating macroeconomic factors into credit risk models.

Assessing and managing credit risk of corporate bonds has been a major area of interest and concern to academics, practitioners, and regulators. See, for example, Caouette, Altman, and Narayanan [1998], Saunders and Allen [2002], and Duffie and Singleton [2003]. An important issue related to credit risk is the factors that affect credit yield spreads of corporate bonds.

Elton et al. [2001] find that expected default losses and state taxes are insufficient to explain corporate bond yield spreads, and default loss in fact can account for no more than 25% of the observed spreads. Collin-Dufresne, Goldstein, and Martin [2001] consider determinants of spreads within structural models of corporate bond pricing, and find that these variables can explain only a small portion of credit spread changes.[1] Campbell and Taksler [2003] document that idiosyncratic equity volatility can explain about one-third of the variation in yield spreads. All three studies use individual bond prices and focus on investment-grade bonds.

Brown [2001] examines the explanatory power of the ten-year Treasury yield, consumer confidence, the VIX, and a Treasury bond liquidity measure on credit spread changes in Salomon Brothers bond indexes. He finds that these variables can explain up to 32.79% of spread changes. Kao [2000] documents that the interest rate level and the yield curve slope, the implied volatility of over-the-counter interest rate options, and the Russell 2000 index return have significant explanatory power for changes in the credit spread index level.

We investigate possible determinants of credit spread changes using credit spread data from Merrill Lynch. We consider five sets of explanatory variables that characterize different aspects of credit risk: 1) realized default rates; 2) the interest rate level, slope of the term structure, and volatility; 3) equity market factors such as index return and volatility; 4) supply of and demand for liquidity from corporate bond mutual funds; and 5) macroeconomic indicators. We examine the explanatory power of these variables using option-adjusted credit spreads for nine Merrill Lynch corporate bond indexes from January 1997 through July 2002.

Our main findings are as follows. Among the variables not so far used in the literature, the Russell 2000 historical return volatility and the Conference Board leading and coincident indicator indexes have significant power to explain credit spread changes, especially for high-yield bond indexes. These three variables plus the interest rate level, the historical interest rate volatility, the yield curve slope, the Russell 2000 index return, and the Fama-French [1996] high-minus-low factor can explain more than 60% of credit spread changes for both BB and B-rated indexes.

These eight variables account for, respectively, 55.54%, 51.4%, and 41.58% of spread changes for the C-rated index, the BBB-A 15+ year index, and the BBB-A 1- to 10-year index. The explanatory power of these eight variables is around 30% for the other four Merrill Lynch bond series analyzed.

Our results confirm that credit spread changes for high-yield bonds are driven mainly by equity-related factors, consistent with predictions of structural models of corporate bond pricing. The results also suggest that, in addition to equity market variables and interest rate variables, macroeconomic factors may also have power to explain credit spread changes, at least at the aggregate level.

I. DATA

We first describe our credit spread data and provide some basic summary statistics on credit spread changes. We then discuss the explanatory variables used in our empirical analysis.

The Merrill Lynch Credit Spread Data

The credit spread data used in this study are weekly and monthly option-adjusted spreads (OAS) for nine Merrill Lynch corporate bond indexes from January 1997 through July 2002. These spreads are purged of the value of any embedded options, coupon effects, and index rebalancing effects. Use of the option-adjusted spread is important for empirical analysis of bond indexes.[2]

Each index is a market value-weighted average of credit spreads on individual bonds in a given maturity, industry, and credit rating portfolio. The sample includes six OAS series for investment-grade corporate bonds: AA-AAA and BBB-A rated series with maturities of 1-10 years, 10-15 years, and 15+ years. These indexes track the performance of U.S. dollar-denominated investment-grade public debt of industrial sector corporate issuers issued in the U.S. domestic bond market. The sample also includes three series for high-yield corporate bonds with ratings of BB, B, and C. We do not know the industry composition of the high-yield credit spread indexes.[3]

We use mainly monthly credit spread changes in this analysis because many of our explanatory variables are available only at monthly frequencies. We construct monthly credit spread changes from the corresponding daily credit spread series. The Merrill Lynch daily option-adjusted credit spread indexes start from December 31, 1996, and are rebalanced on the last calendar day of each month. To avoid potential bias due to index rebalancing, we use start-to-end month (excluding the rebalancing day) spread changes to construct our monthly series.

For example, consider the monthly spread change for January 1997. January 30, 1997 is the last observation in that month before index rebalancing on the 31st. The monthly credit spread change for January 1997 is then measured as the difference between the credit spread on January 30, 1997, and the spread on December 31, 1996. Under this method, monthly credit spread changes are measured on the same portfolio. Each monthly series consists of 67 observations from January 1997 through July 2002.

Exhibit 1 presents summary statistics on credit spread changes, denoted ΔCS, for all nine monthly credit spread series. Note that standard deviations of credit spread changes increase as ratings deteriorate and maturities lengthen, except for the AA-AAA rated 10-15-year index (which has higher standard deviation than the AA-AAA rated 15+ years index). Over the sample period, standard deviations of credit spread changes range from 5.07 to 12.21 basis points for the six investment-grade indexes and from 44.82 to 105.91 basis points for the three high-yield indexes.

The distribution of spread changes seems to have fatter tails than a normal distribution. Extreme movements in spread changes are observed in some months as indicated by the maximum, minimum, and 10th and 90th percentiles of the distribution of spread changes. Spread changes are also positively serially correlated, albeit insignificantly in most cases.

The last row of Exhibit 1 shows the average number of bonds included in a given index over the sample period. The Merrill Lynch bond indexes used here are generally

EXHIBIT 1

Summary Statistics for Monthly Changes in Option-Adjusted Credit Spread for Merrill Lynch Corporate Bond Indexes

ΔCS (bp)	AA-AAA 1-10 Yr	AA-AAA 10-15 Yr	AA-AAA 15+ Yr	BBB-A 1-10 Yr	BBB-A 10-15 Yr	BBB-A 15+ Yr	BB	B	C
Mean	-0.08	-1.13	-0.00	2.62	1.11	0.81	6.66	11.99	19.87
Std Dev.	5.07	10.46	6.57	11.47	12.09	12.21	44.82	63.29	105.91
Skewness	0.47	-1.26	-0.77	1.38	1.21	-0.25	1.82	0.59	0.56
Kurtosis	2.29	5.05	3.27	5.41	5.14	2.69	6.90	3.27	2.43
Max	16.62	23.35	15.85	48.98	53.77	37.03	195.26	229.20	384.47
90%	7.16	12.46	8.25	15.37	16.91	16.02	30.61	88.73	137.60
10%	-6.10	-12.87	-6.64	-7.89	-10.83	-12.28	-30.80	-37.58	-110.20
Min	-14.84	-47.54	-25.73	-30.77	-30.28	-41.24	-96.77	-169.76	-236.70
ρ	0.24	0.12	0.23	0.12	0.15	0.08	0.20	0.12	0.13
Issues	82	5	45	813	75	494	419	552	175

ΔCS denotes credit spread change in basis points. Parameter ρ represents first-order serial correlation coefficients. The average number of issues included in each index over the sample period is reported in the last row. Each credit spread series includes 67 monthly observations January 1997–July 2002.

constructed from a large group of bonds except for the AA-AAA rated 10-15-year index. The fact that the three high-yield indexes are each based on a large group of high-yield bonds is particularly important. Corporate bond databases available to academics such as the Lehman Fixed Income Database mainly cover investment-grade bonds.

Explanatory Variables

The credit spread on corporate bonds (without embedded options) is the extra yield offered to compensate investors for a variety of risks: 1) expected default loss—the risk that in the event of default, investors will not receive the full amount of the promised cash flow (directly related to the default probability of the firm and the recovery rate in the event of default); 2) credit risk premium, due to the uncertainty of default losses; and 3) liquidity and tax premiums, which result from the difference in liquidity and tax status of corporate bonds and Treasury bonds.

We focus on financial markets and macroeconomic variables that are related to different components of credit spreads. Specifically, we select sets of explanatory variables that characterize

1. The realized overall default rate in the U.S. corporate bond market.
2. The dynamics of the risk-free interest rate.
3. U.S. equity market factors such as return and volatility.
4. Liquidity indicators from corporate bond mutual funds.
5. State of the U.S. economy.

The first three sets of variables are our proxies for changes in aggregate default risk. The realized overall default rate is directly related to the expected default loss. Interest rate variables and equity return variables are explicit in structural pricing models for risky bonds.

The supply of and demand for liquidity from corporate bond mutual funds is intended to capture one aspect of the liquidity of the corporate bond market. The economic state variables are based on the perception that the default risk of corporate bonds is correlated with the aggregate economic activity.

Exhibit 2 summarizes the explanatory variables and the predicted sign of the correlation between these variables and credit spread changes.

Realized Default Rates. If historical default rates of corporate issuers predict future default risk in the corporate bond market, we would expect a close positive relationship between changes in realized default rates and changes in credit spreads. We use Moody's monthly trailing 12-month default rates for all corporate U.S. issuers as well as for speculative-grade U.S. issuers over our sample period. Because the effective date of the monthly default rate is on the first day of each month, we take the month t release to measure the month $t-1$ trailing 12-month default rates.

EXHIBIT 2

Description of Explanatory Variables

Variable	Description	Sign
Δdf_a	Changes in Moody's trailing 12-month default rates of all U.S. corporate issuers	+
Δdf_s	Changes in Moody's trailing 12-month default rates of U.S. corporate speculative-grade issuers	+
Δlevel	Changes in yield of Merrill Lynch Treasury Master Index	–
Δslope	Changes in yield of Merrill Lynch 15+ years Treasury Index minus yield of Merrill Lynch 1-3-year Treasury Index	–
$\Delta\sigma^r_{hv}$	Changes in historical volatility of Merrill Lynch Treasury Master Index yields	+
$\Delta\sigma^r_{iv}$	Changes in implied volatility of 30-year Treasury bond futures options traded on Chicago Board of Trade (CBOT)	+
rus	Russell 2000 index return	–
$\Delta\sigma^{rus}_{hv}$	Changes in historical volatility of Russell 2000 index return	+
$\Delta\sigma^{rus}_{iv}$	Changes in implied volatility of Russell 2000 index options	+
sp	S&P 500 index return	–
$\Delta\sigma^{sp}_{hv}$	Changes in historical volatility of S&P 500 index return	+
ΔVIX	Changes in CBOE VIX	+
SMB	Fama-French small-minus-big factor	–
HML	Fama-French high-minus-low factor	–
Δliquid	Changes in corporate bond mutual fund liquid assets as percentage of total net assets	+
ΔNCF	Changes in corporate bond mutual fund net new cash flow as percentage of total net assets	–
Δlead	Changes in Conference Board leading index	–
Δci	Changes in Conference Board coincident index	–
Δlg	Changes in Conference Board lagging index	+

Changes in trailing 12-month default rates for all corporate U.S. issuers, denoted $\Delta df_{a,t}$, are used in regression analysis of investment-grade index credit spread changes. Changes in the trailing 12-month default rate for corporate speculative-grade U.S. issuers, denoted $\Delta df_{s,t}$, are used in the regression analysis of high-yield index credit spreads.

Interest Rate Variables. Most empirical studies have used either changes in the short end (three-month) or changes in the long end (ten-year) of the Treasury yield curve as measures of changes in the general interest rate level. In fact, a Treasury yield index may be a more appropriate proxy for the level. We use the monthly changes in the Merrill Lynch Treasury Master Index yields, Δ*level*, as the measure of changes in the general interest rate. We use the difference between the Merrill Lynch 15+ year Treasury index yield and the 1- to 3-year yield as the measure of the yield curve slope. The change in the yield curve slope is denoted as Δ*slope*.

Interest rate volatility has been incorporated in some credit risk models (e.g., Longstaff and Schwartz [1995] and Das and Tufano [1996]). Higher interest rate volatility should be associated with wider credit spreads.

The literature on the empirical relationship of interest rate volatility and credit spread changes is relatively thin. Kao [2000] considers the implied volatility of the three-month OTC option on a ten-year rate, and documents that changes in this implied volatility play an important role in explaining monthly credit spread changes for both investment-grade and high-yield bond indexes from March 1991 through December 1998. The implied volatility of OTC interest rate options, however, is not easily available to investors and researchers.

We examine two alternative proxies for interest rate volatility that are based on accessible market data. The first one is the monthly change in the implied volatility of 30-year Treasury bond futures options traded on the Chicago Board of Trade (CBOT), denoted $\Delta\sigma^r_{iv,t}$ (observations only from January 1997 through August 2001). The second measure is the monthly change in the historical volatility of Merrill Lynch Treasury Master Index yields, denoted $\Delta\sigma^r_{hv,t}$. These two volatility measures are expected to capture anticipated and realized changes in interest rate volatility, respectively.

Equity Market Variables. Structural models of risky debt pricing indicate that higher asset and equity returns should be associated with narrowing credit spreads. Empirically, it may be interesting to find out which particular equity market index is most closely correlated with credit spread changes and thus most suitable for hedging. So far most studies have examined the S&P 500 index, which is dominated by large-cap stocks. Kao [2000] shows that credit spread changes are significantly related to returns of a small-cap stock index such as the Russell 2000 index. We consider both the S&P 500 index return (*sp*) and the Russell 2000 index return (*rus*).

Structural models also imply that credit spreads usually increase with equity return volatility. We consider two measures of equity market volatility: the option-implied volatility on the Russell 2000 index, and the historical volatility of the Russell 2000 index returns. The monthly changes of these two volatility series are denoted $\Delta\sigma^{rus}_{iv,t}$ and $\Delta\sigma^{rus}_{hv,t}$, respectively. For comparison, we also consider two other proxies for equity volatility: the CBOE volatility index (VIX, based on the implied volatility of the S&P 100 index options), and the S&P 500 historical return volatility denoted by σ^{sp}_{hv}. Historical volatility is estimated using daily returns of the 30 days prior.

Elton et al. [2001] show that the Fama-French [1996] three factors—the market, the small-minus-big (SMB), and the high-minus-low (HML)—are closely related to the portion of credit spreads that is not explained by expected default loss and taxes. Collin-Dufresne, Goldstein, and Martin [2001] also report that the SMB and HML factors are important determinants of credit spread changes of individual corporate bonds.

The intuition of this result is that the two factors might be closely correlated with changes in the credit risk premium component of credit spreads. We examine the incremental explanatory power of these two variables in the presence of equity index returns and equity index volatility.

Liquidity Indicators. Institutional investors are the major owners of corporate bonds. Fridson and Jonsson [1995] find that flows of capital into high-yield bond mutual funds, measured as a percentage of total assets, are negatively correlated with high-yield bond credit spreads, and that cash positions, as a percentage of fund assets, are positively correlated with high-yield credit spreads. They argue that these two variables strongly influence market liquidity, as cash flows into and out of bond mutual funds. Barnhill, Joutz, and Maxwell [2000] also find that mutual fund flows play a dominant role in explaining the yield on high-yield bond indexes.

We obtain monthly statistics of the aggregate dollar amount of total net assets, net new cash flow, and liquid assets for all corporate bond mutual funds and all high-yield mutual funds from June 1997 through July 2002. These statistics are released by the Investment Company Institute (ICI).

We then calculate the ratio of net new cash flow to total net assets and the ratio of liquid assets to total net assets for all corporate bond mutual funds and all high-yield mutual funds. The monthly changes in these two ratios are denoted as ΔNCF_t and $\Delta liquid_t$, respectively, and are expected to capture the liquidity risk in corporate bond markets. We use the series for all bond funds in analysis of the investment-grade credit spread indexes, and the series for all high-yield funds in analysis of high-yield credit spread indexes.

Macroeconomic Indicators. Empirical evidence indicates that credit spreads behave cyclically over time (see, e.g., Van Horne [2001]). During periods of economic downturn, credit spreads are expected to widen as investors become more risk-averse and firms have lower asset returns. Fridson and Jonsson [1995] find that an index of lagging economic indicators has significant impact on credit spread changes for high-yield bond indexes. Helwege and Kleiman [1997] find that the GDP growth rate and recession indicators are important in explaining the aggregate default rates of high-yield bonds. Jarrow and Turnbull [2000] also suggest that incorporating macroeconomic variables may improve a reduced-form model.

The Conference Board publishes composite indexes of leading, coincident, and lagging indicators as gauges of the state of the U.S. economy. The leading index is an average of ten leading indicators; the coincident index is an average of four coincident indicators; and the lagging index is an average of seven lagging indicators.[4] The leading indicator index indicates the future direction of aggregate economic activity. The coincident indicator index measures the current health of the economy. And the lagging indicator index usually reaches its cyclical peaks in the middle of a recession.

We use the month-to-month percentage changes in the three indicator indexes as measures of general economic conditions. The changes in these three economic indexes are denoted $\Delta lead_t$, Δci_t, and Δlg_t. Although the S&P 500 index and the yield curve slope are both common measures of economic conditions (in fact, both are components of the leading index), we believe that the leading index—an average of ten leading indicators—should be a better barometer of future economic conditions.[5] The correlation between $\Delta lead_t$ and $\Delta slope_t$ is indeed -0.32 over our sample period, even though the weight of the yield curve slope is 0.3274 in the leading index.

II. EMPIRICAL RESULTS

To compare the power of these factors to explain credit spread spreads, we run ordinary least squares regressions with each set of explanatory variables separately, and then examine the interaction of the variables.

Regression models with financial time series often are subject to errors that indicate serial correlation or heteroscedasticity of unknown form. A preliminary analysis reveals some degree of autocorrelation and non-normality in the regression errors of certain models. To correct for the potential bias due to these problems, we use the

EXHIBIT 3

Relation Between Changes in Credit Spreads and Changes in Realized Default Rates

	AA-AAA 1-10 Yr	AA-AAA 10-15 Yr	AA-AAA 15+ Yr	BBB-A 1-10 Yr	BBB-A 10-15 Yr	BBB-A 15+ Yr	BB	B	C
α	0.36	-0.44	0.57	3.12	2.35	1.49	8.97	16.72	27.21
	(0.46)	(0.28)	(0.66)	(1.66)	(1.21)	(0.87)	(1.13)	(1.84)	(1.72)
Δdf_t	-7.71	-12.26	-10.12	-8.70	-21.8	-12.01	-18.09	-36.95	-57.42
	(1.47)	(1.13)	(1.66)	(0.77)	(1.69)	(1.10)	(0.71)	(1.14)	(1.09)
Adj R^2	2.83%	1.05%	2.93%	-0.46%	4.58%	0.28%	-0.7%	1.53%	1.11%

In parentheses are absolute values of t-statistics, based on the Newey-West heteroscedasticity and autocorrelation-consistent covariance matrix estimator with three lags.

Newey-West [1987] heteroscedasticity and autocorrelation-consistent covariance matrix estimator to calculate the t-statistics. We also choose the optimal lag parameter using the Newey and West [1994] method.

Group-Level Regressions

Realized Default Rates. To examine the explanatory power of realized default rates, we estimate the regression model:

$$\Delta CS_t = \alpha + \beta \Delta df_t + \varepsilon_t \quad (1)$$

where Δdf_t represents changes in Moody's trailing 12-month default rates. We use default rates of all U.S. corporate issuers ($df_{a,t}$) in the analysis of the investment-grade credit spread series and default rates of U.S. speculative-grade issuers ($df_{s,t}$) in the analysis of the high-yield spread series.

The estimation results are reported in Exhibit 3. The coefficients on changes in realized default rate are all negative, which is counter-intuitive, but coefficients are statistically insignificant in most cases. The adjusted R^2 is below 5% in all the regressions. These results indicate that realized default rates incorporate little information on the future prospect of default risk. This reinforces the intuition that realized default rates are, by construction, lagging variables.

Interest Rate Variables. To capture the impact of interest rate dynamics on credit spreads, we consider the interest rate level, the yield curve slope, and the interest rate volatility. First, we use historical volatility as a proxy for interest rate volatility and estimate the model:

$$\Delta CS_t = \alpha + \beta_1 \Delta level_t + \beta_2 \Delta slope_t + \beta_3 \Delta \sigma^r_{hv,t} + \varepsilon_t \quad (2)$$

The estimation results using data from January 1997 through July 2002 are presented in Panel A of Exhibit 4. The interest rate variables can account for only a small portion of the credit spread changes for the investment-grade indexes. The adjusted R^2 ranges from 1.29% for the BBB-A 10- to 15-year series to 15.81% for the AA-AAA 10- to 15-year series. The signs of the coefficients on the interest rate variables are consistent with intuition. High interest rates and steep yield curves are usually associated with an expanding economy and low credit spreads. Higher interest rate volatility is usually associated with wider credit spreads. Nonetheless, the impacts of changes in the yield curve slope and changes in historical interest rate volatility are largely insignificant as indicated by their *t*-values.

The same set of interest rate variables performs much better for the high-yield credit spread series. Adjusted R^2s are, respectively, 32.84%, 34.08%, and 25.21% for the BB-, B-, and C-rated series. The coefficients on the interest rate level are significantly negative at the 1% level for the three series. The coefficients on the yield curve slope are positive but insignificant for the three high-yield series. The coefficients on the historical interest rate volatility are also all positive and have a *t*-value slightly below the 10% critical value.

Next, we use option-implied interest rate volatility as a proxy for interest rate volatility and estimate the model:

$$\Delta CS_t = \alpha + \beta_1 \Delta level_t + \beta_2 \Delta slope_t + \beta_3 \Delta \sigma^r_{iv,t} + \varepsilon_t \quad (3)$$

The implied volatility is forward-looking and expected to have a higher correlation with credit spreads than the historical volatility does. In our estimation, we use the implied volatility of 30-year Treasury bond futures options traded on the CBOT over the period January 1997 through August 2001 (after which the data on the implied volatility are not available).

Estimation results, reported in Panel B of Exhibit 4, actually show that the implied interest rate volatility has less impact than the historical yield volatility. This con-

EXHIBIT 4

Relation Between Changes in Credit Spreads and Interest Rate Variables

Panel A: OLS Regressions with Historical Interest Rate Volatility

	AA-AAA 1-10 Yr	AA-AAA 10-15 Yr	AA-AAA 15+ Yr	BBB-A 1-10 Yr	BBB-A 10-15 Yr	BBB-A 15+ Yr	BB	B	C
α	-0.01	-0.01	0.02	2.03	1.14	0.62	2.37	5.98	9.95
	(0.03)	(0.01)	(0.02)	(1.66)	(0.83)	(0.48)	(0.57)	(1.07)	(0.92)
$\Delta level_t$	-7.14	-0.19	-9.83	-21.92	-14.18	-22.4	-112.6	-157.3	-204.6
	(2.20)	(0.03)	(1.68)	(2.65)	(1.57)	(2.18)	(4.34)	(4.44)	(3.34)
$\Delta slope_t$	-6.37	-24.47	-6.77	-2.42	-10.05	-11.53	16.41	22.49	72.84
	(1.45)	(2.76)	(1.06)	(0.21)	(0.89)	(0.87)	(0.46)	(0.38)	(0.82)
$\Delta\sigma^r_{hv,t}$	1.24	-0.27	-0.01	3.09	0.9	3.25	11.79	20.02	31.91
	(1.35)	(0.16)	(0.00)	(1.38)	(0.39)	(1.36)	(1.38)	(1.63)	(1.52)
Adj R^2	7.16%	15.81%	4.99%	15.47%	1.29%	12.13%	32.84%	34.08%	25.21%

Panel B: OLS Regressions with CBOT Option-Implied Interest Rate Volatility

	AA-AAA 1-10 Yr	AA-AAA 10-15 Yr	AA-AAA 15+ Yr	BBB-A 1-10 Yr	BBB-A 10-15 Yr	BBB-A 15+ Yr	BB	B	C
α	-0.09	-0.2	0.33	1.49	0.26	0.72	1.19	6.86	12.58
	(0.14)	(0.18)	(0.37)	(1.14)	(0.21)	(0.55)	(0.39)	(1.17)	(1.16)
$\Delta level_t$	-2.85	13.34	-0.73	-8.9	3.48	-6.69	-65.12	-116.17	-123.05
	(0.81)	(2.18)	(0.15)	(1.23)	(0.50)	(0.75)	(3.11)	(2.98)	(1.81)
$\Delta slope_t$	-9.84	-35.53	-7.6	-16.27	-27.28	-22.96	-39.12	-24.59	-4.15
	(1.83)	(4.26)	(0.99)	(1.45)	(2.86)	(1.65)	(1.43)	(0.35)	(0.04)
$\Delta\sigma^r_{iv,t}$	0.5	-1.30	0.24	0.47	0.45	0.96	3.32	8.45	19.34
	(0.60)	(1.07)	(0.21)	(0.37)	(0.28)	(0.56)	(0.68)	(0.92)	(1.40)
Adj R^2	6.50%	38.57%	-1.30%	4.26%	19.21%	7.50%	20.77%	14.30%	6.10%

Panel A: 67 monthly observations January 1997– July 2002; Panel B: 56 monthly observations January 1997–August 2001. In parentheses are the absolute values of t-statistics, based on the Newey-West heteroscedasticity and autocorrelation-consistent covariance matrix estimator with three lags.

clusion still holds when we reestimate Equation (2) over the shorter January 1997 through August 2001 period.

Kao [2000] documents that implied interest rate volatility (from the OTC three-month option on a ten-year yield) has a strong impact on credit spreads over the March 1991–December 1998 period. The difference between our result and his may reflect a time-varying relationship between interest rate volatility and credit spreads. Or, it may be due to the way the implied interest rate volatility from the CBOT is computed.

The implied volatility is based on the price of the nearby interest rate future options traded on the CBOT. When one contract expires, the new nearby contract is selected to derive the implied interest rate volatility series. The switch of contract may bring significant noise into the derived implied volatility series.

So far the interest rate level and the yield curve slope have been estimated using the Merrill Treasury Master Index yields. Alternatively, constant-maturity Treasury (CMT) yields can be used for the estimation.

In analysis not tabulated here, we tried using the CMT ten-year yield to estimate the level and the difference between the ten-year yield and the two-year yield to estimate the slope. The regression adjusted R^2 is below 11% for all three high-yield credit spread series over the whole sample period. That is, the term structure variables based on the CMT yields are much less correlated with credit spread changes for the Merrill corporate bond indexes than those based on the Merrill Treasury indexes. As a result, we use only the Merrill Treasury Master Index yields to estimate the term structure variables in this analysis.

Overall, the interest rate variables considered here can explain a small portion of credit spread changes for the investment-grade series, but do a much better job for the high-yield series.

Equity Market Variables. To capture the impact of the equity market on credit spreads, we consider variables such as the equity index return, the index return volatility, and the

EXHIBIT 5

Relation Between Credit Spread Changes and Russell 2000 Index Variables

	AA-AAA 1-10 Yr	AA-AAA 10-15 Yr	AA-AAA 15+ Yr	BBB-A 1-10 Yr	BBB-A 10-15 Yr	BBB-A 15+ Yr	BB	B	C
α	-0.06	-0.85	0.03	2.69	1.24	0.99	7.04	12.61	20.2
	(0.11)	(0.69)	(0.04)	(2.34)	(0.90)	(0.93)	(1.62)	(2.49)	(2.15)
rus_t	-0.26	-0.65	-0.32	-0.72	-0.79	-0.98	-3.25	-4.92	-6.61
	(2.43)	(2.41)	(2.26)	(3.51)	(2.95)	(3.79)	(3.77)	(3.92)	(3.26)
$\Delta\sigma^{rus}_{hv,t}$	0.17	-0.18	0.18	0.43	0.32	0.34	1.71	2.55	4.69
	(2.33)	(0.89)	(2.38)	(3.06)	(1.88)	(2.56)	(3.11)	(2.78)	(2.60)
Adj R^2	23.76%	9.27%	17.98%	33.67%	26.9%	38.25%	41.12%	47.09%	39.66%

67 monthly observations January 1997–July 2002. In parentheses are the absolute values of t-statistics, based on the Newey-West heteroscedasticity and autocorrelation-consistent covariance matrix estimator with three lags.

Fama and French [1996] factors in the analysis that follows.

First, we estimate the model:

$$\Delta CS_t = \alpha + \beta_1 rus_t + \beta_2 \sigma^{rus}_{hv,t} + \varepsilon_t \tag{4}$$

where rus_t and $\sigma^{rus}_{hv,t}$ denote the Russell 2000 index return and the index historical return volatility, respectively. Using the implied volatility from options on the Russell 2000 would yield similar results. We use the historical volatility here due to concern of a high correlation between the index return and the implied volatility.

Estimation results, reported in Exhibit 5, indicate that the Russell 2000 variables can explain a significant portion of credit spread changes for both investment-grade and high-yield series over the sample period. The adjusted R^2 ranges from 9.27% for the AA-AAA 10- to 15-year series to 38.25% for the BBB-A 15+ year series for the investment-grade indexes. Adjusted R^2s are 41.12%, 47.09%, and 39.66% for the BB-, B-, and C-rated portfolios. The coefficient on the equity volatility is positive and significant at the 10% level for all the portfolios except the AA-AAA 10- to 15-year series.

In analysis not tabulated here, we also estimate Equation(4) using S&P 500 index variables. The results are similar. Namely, a higher equity market index return will reduce credit spreads, and a higher equity volatility will significantly widen credit spreads. The adjusted R^2 with the Russell 2000 index variables is at least 10% higher than with the S&P 500 index variables for most of the nine credit spread series analyzed.

Next, we add the Fama and French [1996] factors to the regression model in (4). Given the close correlation between the Russell index variables and credit spread changes that is shown in Exhibit 5, other determinants of the equity market risk premium, such as the Fama and French SMB and HML factors, may also closely covary with credit spreads.

Elton et al. [2001] document that the SMB and HML factors explain a significant portion of credit spreads in their sample of investment-grade bonds from 1987 through 1996 in the Lehman Fixed Income Database. Vassalou and Xing [2002] also find that the SMB and HML factors incorporate some default-related information.

In analysis not tabulated here, we find that the three Fama-French factors have roughly the same amount of explanatory power for credit spread changes as the Russell index return and volatility variables. In fact, the correlation of the Fama-French market and SMB factors with the Russell index return is over 0.68 during our sample period (although, the correlation of the Russell index return with the HML factor is -0.42 over the sample period).

As a result, we estimate the model:

$$\Delta CS_t = \alpha + \beta_1 rus_t + \beta_2 \sigma^{rus}_{hv,t} + \beta_3 \text{HML}_t + \varepsilon_t \tag{5}$$

The estimated results are reported in Exhibit 6. The HML factor is more closely related to credit spread changes for the high-yield portfolios and only marginally related to those for the investment-grade portfolios. Adjusted R^2s are 47.93%, 54.94%, and 49.45% for the BB-, B-, and C-rated portfolios, respectively. The estimated coefficient on the HML is significant at the 1% level for all three high-yield portfolios but is insignificant for all the investment-grade portfolios except the BBB-A one- to ten- year portfolio. The findings here reinforce the notion that credit spread changes for high-yield bonds are more

EXHIBIT 6
Regression Analysis with Russell 2000 Index Variables and Fama-French [1996] HML Factor

	AA-AAA 1-10 Yr	AA-AAA 10-15 Yr	AA-AAA 15+ Yr	BBB-A 1-10 Yr	BBB-A 10-15 Yr	BBB-A 15+ Yr	BB	B	C
α	-0.03	-0.83	0.09	2.77	1.28	1.08	7.46	13.23	21.36
	(0.05)	(0.68)	(0.12)	(2.39)	(0.94)	(1.04)	(1.76)	(2.56)	(2.40)
rus_t	-0.34	-0.69	-0.45	-0.89	-0.88	-1.18	-4.17	-6.31	-9.19
	(2.44)	(2.54)	(2.79)	(3.44)	(2.71)	(4.19)	(3.92)	(4.69)	(4.57)
$\Delta\sigma^{rus}_{hv,t}$	0.17	-0.17	0.18	0.43	0.33	0.35	1.73	2.57	4.72
	(2.25)	(0.88)	(2.21)	(2.98)	(1.84)	(2.46)	(3.46)	(3.01)	(2.77)
HML_t	-0.21	-0.09	-0.32	-0.43	-0.22	-0.51	-2.37	-3.55	-6.6
	(1.39)	(0.32)	(1.48)	(1.73)	(0.61)	(1.43)	(3.19)	(3.40)	(4.98)
Adj R^2	27.13%	8.06%	23.18%	36.54%	26.67%	42.14%	47.93%	54.94%	49.45%

67 monthly observations January 1997–July 2002. In parentheses are the absolute values of t-statistics, based on the Newey-West heteroscedasticity and autocorrelation-consistent covariance matrix estimator with three lags.

EXHIBIT 7
Relation Between Credit Spread Changes and Supply of Demand for Liquidity from Corporate Bond Mutual Funds

	AA-AAA 1-10 Yr	AA-AAA 10-15 Yr	AA-AAA 15+ Yr	BBB-A 1-10 Yr	BBB-A 10-15 Yr	BBB-A 15+ Yr	BB	B	C
α	0.06	-1.12	0.03	3.01	1.42	0.96	7.5	13.56	21.82
	(0.08)	(0.79)	(0.03)	(1.81)	(0.77)	(0.55)	(1.27)	(1.85)	(1.79)
$\Delta liquid_t$	0.52	2.96	0.65	1.7	2.08	2.87	6.59	9.53	15.8
	(0.40)	(0.84)	(0.47)	(0.65)	(0.70)	(0.97)	(1.28)	(1.01)	(0.92)
ΔNCF_t	-2.4	1.2	-1.31	-4.31	-3.51	-3.82	-11.27	-21.17	-37.09
	(1.86)	(0.62)	(0.97)	(1.22)	(1.14)	(1.09)	(2.54)	(3.30)	(3.72)
Adj R^2	1.85%	-1.6%	-2.28%	0.35%	-0.71%	0.29%	4.47%	10.15%	11.31%

61 monthly observations July 1997–July 2002. In parentheses are the absolute values of t-statistics, based on the Newey-West heteroscedasticity and autocorrelation-consistent covariance matrix estimator with three lags.

closely related to equity market factors.

In summary, about 30% of credit spread changes for investment-grade portfolios and about 50% of those for high-yield portfolios over our sample period are associated with returns, the return volatility, and the Fama-French HML factor in the equity market.

Liquidity Indicators. To examine the impact of buying and selling pressure from corporate bond mutual funds on credit spreads, we consider the regression model:

$$\Delta CS_t = \alpha + \beta_1 \Delta liquid_t + \beta_2 NCF_t + \varepsilon_t \qquad (6)$$

The estimation results, reported in Exhibit 7, indicate that, as expected, the coefficient on the liquid asset ratio is positive for all the credit spread series, and the coefficient on the net cash flow ratio is negative for all the spread series (except the AA-AAA 15+ year portfolio). The adjusted R^2, however, is below 2% for all the investment-grade series. The two ratios have some explanatory power for the high-yield series as adjusted R^2s are 4.47%, 10.15%, and 11.31% for the BB-, B-, and C-rated indexes.

Notice that the coefficient on the net cash flow ratio is also significant for the high-yield indexes. In a word, consistent with Fridson and Jonsson [1995], the results here show that the net cash flow (to high-yield mutual funds) ratio has a significant negative correlation with credit spread changes for the high-yield portfolios.

Macroeconomic Indicators. To study the relation between macroeconomic indicators and credit spreads, we run the regression:

$$\Delta CS_t = \alpha + \beta_1 \Delta lead_t + \beta_2 \Delta ci_t + \beta_3 \Delta \lg_t + \varepsilon_t \qquad (7)$$

Estimation results are reported in Exhibit 8. The adjusted R^2 is over 20% for three credit spread series with a maximum of 27% for the BBB-A rated 15+ year index. As expected, increases in the leading index lead to narrowing credit spreads. But surprisingly, the coincident

EXHIBIT 8

Relation Between Credit Spread Changes and Macroeconomic Indicators

	AA-AAA 1-10 Yr	AA-AAA 10-15 Yr	AA-AAA 15+ Yr	BBB-A 1-10 Yr	BBB-A 10-15 Yr	BBB-A 15+ Yr	BB	B	C
α	-0.72	-2.24	-1.21	3.59	0.2	0.08	7.38	16.82	26.75
	(0.77)	(1.68)	(1.02)	(1.41)	(0.09)	(0.03)	(0.82)	(1.27)	(1.21)
$\Delta lead_t$	-4.64	0.93	-7.08	-14.43	-13.36	-18.99	-65.22	-93.99	-121.3
	(2.35)	(0.29)	(2.62)	(3.46)	(2.57)	(4.88)	(3.15)	(4.10)	(3.11)
Δci_t	6.88	4.83	11.77	6.36	15.28	18.7	47.79	49.29	59.32
	(2.16)	(0.91)	(2.69)	(0.81)	(2.32)	(2.50)	(1.51)	(1.06)	(0.76)
Δlg_t	0.49	2.44	0.41	0.06	-3.43	-0.97	-6.63	-2.55	23.12
	(0.25)	(0.62)	(0.22)	(0.01)	(0.92)	(0.28)	(0.37)	(0.10)	(0.55)
Adj R^2	11.48%	-1.9%	19.34%	15.08%	10.37%	27%	20.32%	22.24%	14.48%

67 monthly observations January 1997–July 2002. In parentheses are the absolute values of t-statistics, based on the Newey-West heteroscedasticity and autocorrelation-consistent covariance matrix estimator with three lags.

index, which measures the current health of the economy, has positive coefficients that are significant at the 5% level for four of nine credit spread series. The sign on the lagged index is mixed, and is insignificant in all cases.

Given the significance of macroeconomic indicator indexes in explaining credit spreads, it may be interesting to investigate the explanatory power of individual macroeconomic indicators. In analysis not tabulated here, we examined the relation between credit spread changes and the four individual macroeconomic indicators: the growth rate of money supply (M2), the inflation expectation from the University of Michigan's Survey Research Center, the industrial production index growth rate, and the unemployment rate. M2 has a standardized factor of 0.3034 in the leading index, and industrial production has a standardized factor of 0.1292 in the coincident index.

The explanatory power of the individual macroeconomic indicators is generally very weak. This seems to justify the construction of the indicator indexes, which are intended to effectively smooth out part of the noise in the individual indicator series and produce a better gauge of the whole economy. The regression coefficient on the industrial production growth rate is positive in all cases, although mostly insignificant.

Thus one plausible explanation for the positive sign on the coincident index is that the real productivity of the economy has been growing over the past few years, but so too has been the volatility of the market. (The correlation between the industrial growth rate and changes in the CBOE VIX level is 0.26 over the sample period.)

Combined Regressions

Our results so far indicate that credit spread movements can largely be explained by interest rate dynamics, equity market returns and volatility, and the general state of the economy. Realized default rates and the supply/demand pressures from corporate bond mutual funds are not closely related to credit spread changes. We now examine how well these three sets of variables together can explain credit spread changes:

$$\Delta CS_t = \alpha + \beta_1 \Delta level_t + \beta_2 \Delta slope_t + \beta_3 \sigma^{r}_{hv,t} + \beta_4 rus_t + \beta_5 \sigma^{rus}_{hv,t} + \beta_6 \text{HML}_t + \beta_7 \Delta lead_t + \beta_8 \Delta ci_t + \varepsilon_t \quad (8)$$

The overall explanatory power of these variables is quite strong, as shown in Panel A of Exhibit 9. The adjusted R^2 is 67.68% for the B-rated index and 60.82% for the BB-rated index. It reaches 55.54%, 51.4%, and 41.58% for the C-rated, BBB-A 15+ year, and BBB-A one- to ten-year portfolios, respectively. The adjusted R^2 is around 30% for the remaining four of the nine credit spread series analyzed here.

Notice that the overall explanatory power of the three sets of variables is a notable improvement over that in other studies that use spread changes for corporate bond portfolios. More important, our findings confirm that credit spread changes for high-yield indexes are closely related to equity market factors. These results provide some support for the structural models of credit risk.

To summarize, the Russell 2000 index return, its historical volatility, and the Conference Board leading index are the most significant explanatory variables in the combined regression.

Robustness Tests

To examine how stable the empirical relations estimated with the whole sample are, we split the monthly sample in the middle and reestimate the regression model in Equation (8) for separate subsamples. The estimation results are reported in Panels B and C of Exhibit 9.

The overall explanatory power of the independent variables is fairly stable through the two subsample periods for the high-yield portfolios, but the adjusted R^2 is much higher in the later than the earlier subsample for most investment-grade portfolios. As indicated by the t-values shown in the exhibit, the main reason for this sharp increase is that equity market variables and the leading economic indicator are much more significant in the second half of the sample.

To examine the stability of the regression coefficients, we perform a Chow test. The test results (not shown) indicate that the null hypothesis that the two coefficient vectors are the same is rejected at the 5% significance level only for the AA-AAA 15+ year portfolio. This implies that the regression model of credit spreads given in Equation (8) is fairly stable over our entire sample period.

Next, we examine the sensitivity of the results to the

EXHIBIT 9
OLS Regression Analysis with Interest Rate, Equity Market, and Macroeconomic Variables

Panel A: 1997.1–2002.7 Sample Period (N = 67)

	AA-AAA 1-10 Yr	AA-AAA 10-15 Yr	AA-AAA 15+ Yr	BBB-A 1-10 Yr	BBB-A 10-15 Yr	BBB-A 15+ Yr	BB	B	C
α	0.18	2.51	-0.54	4.72	2.68	2.15	3.83	14.71	16.96
	(0.27)	(1.57)	(0.53)	(2.17)	(1.94)	(1.53)	(0.86)	(1.66)	(0.92)
$\Delta level_t$	-1.69	4.86	-1.03	-9.46	0.03	-3.89	-60.57	-79.82	-83.05
	(0.72)	(0.77)	(0.33)	(1.67)	(0.01)	(0.7)	(4.38)	(3.68)	(1.84)
$\Delta slope_t$	-6.03	-30.09	-2.91	-8.15	-12.04	-10.93	25.08	15.68	79.62
	(1.49)	(2.89)	(0.63)	(0.69)	(1.31)	(1.16)	(0.83)	(0.38)	(1.05)
$\Delta\sigma^{r}_{hv,t}$	-0.00	-1.33	-1.79	0.29	-2.3	-0.42	0.79	3.6	5.53
	(0.00)	(0.81)	(1.63)	(0.2)	(1.55)	(0.26)	(0.15)	(0.44)	(0.42)
rus_t	-0.27	-0.8	-0.34	-0.74	-0.78	-0.95	-3.23	-5.15	-7.79
	(1.93)	(3.81)	(2.23)	(3.58)	(2.67)	(3.83)	(4.69)	(3.57)	(4.16)
$\Delta\sigma^{rus}_{hv,t}$	0.18	0.03	0.21	0.41	0.4	0.34	1.27	1.99	3.73
	(2.27)	(0.21)	(2.48)	(2.63)	(2.45)	(2.6)	(2.55)	(2.71)	(2.46)
HML_t	-0.16	-0.18	-0.23	-0.37	-0.17	-0.38	-1.74	-2.88	-5.79
	(1.10)	(0.84)	(1.17)	(1.4)	(0.5)	(1.21)	(3.03)	(2.45)	(3.33)
$\Delta lead_t$	-2.42	-0.1	-5.22	-6.4	-7.98	-11.98	-20.83	-31.58	-37.64
	(1.77)	(0.04)	(2.16)	(2.15)	(2.33)	(4.36)	(2.4)	(2.62)	(1.34)
Δci_t	1.85	-9.33	7.71	-4.71	1.83	5.54	18.96	0.21	19.73
	(0.71)	(1.49)	(2)	(0.69)	(0.36)	(1.12)	(0.9)	(0.01)	(0.31)
Adj R^2	28.96%	28.89%	32.94%	41.58%	29.47%	51.4%	60.82%	67.68%	55.54%

Panel B: 1997.1–1999.9 Sample Period (N = 33)

	AA-AAA 1-10 Yr	AA-AAA 10-15 Yr	AA-AAA 15+ Yr	BBB-A 1-10 Yr	BBB-A 10-15 Yr	BBB-A 15+ Yr	BB	B	C
α	3.07	6.99	3.84	-1.45	-2.79	-1.11	-5.08	-8.84	-29.41
	(1.71)	(1.54)	(1.59)	(0.50)	(0.65)	(0.34)	(1.13)	(0.8)	(1.35)
$\Delta level_t$	-1.45	7.49	1.66	-1.32	7.48	3.69	-45.89	-64.98	-68.61
	(0.46)	(0.92)	(0.39)	(0.27)	(1.24)	(0.67)	(2.75)	(2.03)	(1.13)
$\Delta slope_t$	3.86	-39.46	17.25	10.98	-4.16	18.79	39.71	86.70	195.03
	(0.68)	(1.67)	(2.22)	(1.12)	(0.40)	(1.90)	(1.75)	(1.76)	(1.95)
$\Delta\sigma^{r}_{hv,t}$	2.63	4.49	1.35	1.41	-3.33	-0.97	-0.87	3.36	2.24
	(1.93)	(0.98)	(0.62)	(0.60)	(1.02)	(0.32)	(0.19)	(0.40)	(0.16)
rus_t	-0.15	-0.83	-0.27	-0.10	0.06	-0.22	-0.75	-1.43	-4.07
	(1.01)	(1.60)	(1.68)	(0.37)	(0.16)	(0.76)	(1.26)	(1.16)	(2.03)
$\Delta\sigma^{rus}_{hv,t}$	-0.1	-0.50	-0.01	0.11	0.31	0.29	1.05	2.57	3.52
	(0.70)	(1.87)	(0.04)	(0.48)	(0.72)	(0.77)	(2.15)	(2.7)	(2.36)
HML_t	-0.03	0.36	0.67	-0.01	0.44	0.55	0.31	-0.32	-4.75
	(0.13)	(1.02)	(2.45)	(0.05)	(1.64)	(1.98)	(0.46)	(0.23)	(2.24)
$\Delta lead_t$	-3.07	0.37	-1.18	-4.32	-4.55	-3.69	-8.29	-28.85	-56.97
	(1.44)	(0.05)	(0.36)	(1.29)	(0.72)	(0.75)	(0.87)	(1.47)	(1.6)
Δci_t	-5.83	-24.89	-6.53	10.69	11.22	8.27	27.52	63.81	159.46
	(1.10)	(1.41)	(0.97)	(1.14)	(0.77)	(0.87)	(1.77)	(1.70)	(2.1)
Adj R^2	2.98%	32.04%	33.38%	0.5%	-2.21%	33.14%	63.23%	64.14%	56.16%

EXHIBIT 9 (continued)

OLS Regression Analysis with Interest Rate, Equity Market, and Macroeconomic Variables

Panel C: 1999.10—2002.7 Sample Period (N = 34)

	AA-AAA 1-10 Yr	AA-AAA 10-15 Yr	AA-AAA 15+ Yr	BBB-A 1-10 Yr	BBB-A 10-15 Yr	BBB-A 15+ Yr	BB	B	C
α	0.34	2.49	0.20	6.20	4.26	4.33	-7.48	27.7	36.12
	(0.42)	(1.20)	(0.20)	(2.31)	(2.55)	(3.00)	(1.08)	(2.91)	(1.53)
$\Delta level_t$	-0.41	4.19	-3.87	-10.50	4.41	-2.04	-35.86	-6.96	0.81
	(0.08)	(0.28)	(0.65)	(0.74)	(0.28)	(0.18)	(0.97)	(0.15)	(0.01)
$\Delta slope_t$	-7.96	-24.01	-10.09	-14.48	-11.17	-20.35	33.99	2.13	49.26
	(1.64)	(2.97)	(2.83)	(0.94)	(0.84)	(2.32)	(0.75)	(0.05)	(0.51)
$\Delta\sigma^r_{hv,t}$	-0.47	-3.20	-2.75	0.52	-2.57	-1.01	-0.99	-7.35	-6.64
	(0.53)	(2.11)	(2.32)	(0.21)	(1.28)	(0.44)	(0.10)	(0.59)	(0.28)
rus_t	-0.48	-0.84	-0.46	-1.09	-1.30	-1.40	-5.04	-8.55	-11.42
	(2.69)	(2.66)	(0.21)	(3.42)	(3.00)	(5.69)	(6.47)	(9.32)	(3.84)
$\Delta\sigma^{rus}_{hv,t}$	0.25	0.20	0.21	0.58	0.48	0.36	1.45	1.95	4.03
	(2.74)	(1.42)	(2.37)	(2.79)	(3.04)	(2.80)	(2.04)	(2.13)	(1.81)
HML_t	-0.24	-0.32	-0.44	-0.55	-0.47	-0.71	-2.82	-5.29	-8.18
	(1.58)	(1.22)	(2.12)	(2.16)	(1.44)	(2.67)	(4.86)	(4.70)	(3.28)
$\Delta lead_t$	-1.17	0.11	-4.93	-5.76	-7.25	-13.15	-21.05	-38.12	-40.36
	(0.62)	(0.02)	(1.95)	(1.00)	(1.32)	(3.58)	(2.09)	(3.07)	(0.81)
Δci_t	-0.35	-7.37	-0.04	-9.15	3.20	-2.15	20.08	-46.08	-34.85
	(0.07)	(1.09)	(0.01)	(0.96)	(0.32)	(0.31)	(0.40)	(1.04)	(0.36)
Adj R^2	45.18%	34.15%	50.22%	52.35%	39.63%	64.11%	63.58%	75.45%	52.38%

Panel A: 67 monthly observations January 1997–July 2002; Panel B: 33 monthly observations January 1997–September 1999; Panel C: 34 monthly observations October 1999–July 2002. In parentheses are the absolute values of t-statistics, based on the Newey-West heteroscedasticity and autocorrelation-consistent covariance estimator with three lags.

frequency of data used in regression by analyzing weekly changes of credit spreads. Since weekly data are not available on the Fama-French HML factor and the Conference Board leading indicators, we estimate the regression model:

$$\Delta CS_t = \alpha + \beta_1 \Delta level_t + \beta_2 \Delta slope_t + \beta_3 \sigma^r_{hv,t} + \beta_4 rus_t + \beta_5 \sigma^{rus}_{hv,t} + \varepsilon_t \qquad (9)$$

To construct weekly data, we select the Tuesday observation of each week to avoid any possible weekend effect. When a Tuesday observation is missing, we use the Wednesday observation. (There is only one Monday observation, in the week of the September 11, 2001, event.) The final sample includes a total of 295 observations, one for each week for the period from December 31, 1996, through August 30, 2002. (Note that credit spread changes over the weeks that include a rebalancing day may be affected by rebalancing.)

The interest rate historical volatility and the Russell 2000 historical return volatility are estimated using the daily data over the past one month. (We also used two alternative volatility estimates: the three-month historical volatility and the RiskMetrics™ volatility with an exponentially weighted moving average over the prior three months. Regression results are robust to the alternative measures of historical volatility and are not shown here for reasons of space.)

Results from the regression model (9), reported in Exhibit 10, show that the interest rate and the equity market factors perform much better in explaining credit spread changes for the high-yield portfolios than for the investment-grade portfolios. More specifically, the adjusted R^2 is below 20% for all the investment-grade series but is 28.91%, 42.19%, and 23.22% for the three high-yield series.

We should note that potential problems due to market microstructure and index rebalancing effects are more severe with more frequent data, and thus may result in a lower adjusted R^2. Nonetheless, as Exhibit 10 shows, the interest rate factors and the Russell 2000 return and its volatility are still significant in most of the regressions with weekly data.

Finally, we repeat the analysis using daily option-adjusted credit spreads from S&P from December 31, 1998, through July 31, 2002. The S&P provides two such series within the U.S. industrial sector: the U.S. industrial investment-grade credit spread index, and the U.S. industrial speculative-grade credit spread index. The inception date of the two indexes is December 31, 1998. Composite market prices used to calculate the option-adjusted spread are based on the average bid and ask prices from a number of sources including brokers and dealers. Whenever there is a change in the index issue, the index level is adjusted by a divisor. This mitigates the potential effect due to index rebalancing.[6]

We reestimate Equation (9) with weekly data and Equation (8) with monthly data, and report results in Exhibit 11. The interest rate and equity market factors can explain 31.2% of spread changes for the S&P investment-grade series and 62.41% of spread changes for the high-yield series with the weekly sample. Results from Equation (8) using the monthly sample show that adjusted R^2s are 63.37% and 72.95% for the investment-grade and the high-yield series, respectively.

To summarize, our robustness analysis provides evidence that the interest rate and equity market factors are important determinants of credit spread changes for high-yield portfolios even at weekly frequencies. The interest rate, equity market, and economic indicator factors can also explain much of the spread changes for the S&P credit spread portfolios.

III. CONCLUSIONS

We analyze determinants of corporate bond credit spreads using Merrill Lynch option-adjusted credit spread data from January 1997 through July 2002, focusing on Moody's realized default rates, the historical volatility of interest rates, the Russell 2000 historical return volatility, and the Conference Board indexes of leading, coincident, and lagging indicators. Among these variables, the Russell 2000 historical return volatility and the Conference Board composite leading and coincident indicators have a significant impact on the contemporaneous changes in credit spreads, especially for high-yield corporate bonds.

These three variables plus the historical volatility of interest rates, the interest rate level, the yield curve slope, the Russell 2000 index return, and the Fama-French [1996] high-minus-low factor can explain more than 40% of credit spread changes for five of nine Merrill Lynch credit spread series analyzed. These eight variables can explain 67.68% and 60.82% of credit spread changes for the B- and BB-rated portfolios, respectively.

Overall, we find that credit spread changes for high-yield bonds are more closely related to interest rate and equity market factors. This finding is confirmed with both monthly and weekly credit spread data and also with credit spread data from S&P.

Our findings are important for both pricing and managing credit risk. First, from a pricing perspective, we provide evidence that credit risk models may need to take into account the impact of macroeconomic variables on credit spreads. From a risk management perspective, small-cap equity indexes such as the Russell 2000 index may be used in hedging the equity component of corporate bond credit spreads. These considerations may call for a hedging strategy based on the interest rate, the equity market return and volatility, and macroeconomic variables.

EXHIBIT 10
OLS Regression Analysis Using Weekly Credit Spread Changes

	AA-AAA 1-10 Yr	AA-AAA 10-15 Yr	AA-AAA 15+ Yr	BBB-A 1-10 Yr	BBB-A 10-15 Yr	BBB-A 15+ Yr	BB	B	C
α	0.12	0.21	0.16	0.44	0.57	0.36	0.90	0.7	1.68
	(0.74)	(0.73)	(0.74)	(1.53)	(1.66)	(1.19)	(1.13)	(0.49)	(0.52)
$\Delta level_t$	-0.76	7.30	-1.74	-7.52	-4.56	-7.77	-55.03	-113.57	-165.21
	(0.47)	(1.96)	(0.74)	(3.27)	(1.36)	(2.80)	(6.79)	(8.96)	(4.99)
$\Delta slope_t$	0.29	-8.80	-0.61	1.29	-5.97	-1.91	5.77	26.03	59.31
	(0.09)	(1.95)	(0.19)	(0.26)	(1.33)	(0.40)	(0.33)	(1.20)	(1.85)
$\Delta\sigma^{r}_{hv,t}$	0.68	0.27	0.72	1.26	0.56	1.22	2.33	5.89	-1.74
	(1.40)	(0.23)	(1.07)	(1.84)	(0.68)	(1.37)	(0.80)	(1.94)	(0.26)
rus_t	-0.17	-0.51	-0.21	-0.3	-0.46	-0.39	-1.10	-1.81	-0.31
	(1.42)	(2.78)	(1.43)	(1.95)	(2.54)	(2.00)	(3.13)	(3.29)	(0.30)
$\Delta\sigma^{rus}_{hv,t}$	0.17	0.20	0.12	0.35	0.38	0.42	0.97	2.27	5.11
	(2.37)	(1.33)	(1.38)	(2.81)	(2.20)	(3.21)	(3.20)	(4.41)	(3.19)
Adj R^2	7.1%	6.37%	4.47%	15.92%	9.85%	17.19%	28.91%	42.19%	23.22%

295 weekly observations January 1997–July 2002. In parentheses are the absolute values of t-statistics, based on the Newey-West heteroscedasticity and autocorrelation-consistent covariance matrix estimator with five lags.

EXHIBIT 11

OLS Regression Analysis Using S&P Credit Spread Data

Panel A. Using Weekly Credit Spread Changes for S&P Indexes (N = 186)

	Investment-Grade	High-Yield
α	0.37	2.95
	(1.03)	(1.92)
$\Delta level_t$	-16.27	-149.32
	(4.00)	(10.05)
$\Delta slope_t$	0.33	-16.28
	(0.05)	(0.82)
$\Delta\sigma^r_{hv,t}$	0.84	3.08
	(0.96)	(0.96)
rus_t	-0.49	-1.55
	(2.97)	(2.98)
$\Delta\sigma^{rus}_{hv,t}$	0.26	2.91
	(1.74)	(4.00)
Adj R^2	29.25%	60.45%

Panel B: Using Monthly Credit Spread Changes for S&P Indexes (N = 43)

	Investment-Grade	High-Yield
α	4.46	20.94
	(3.20)	(1.94)
$\Delta level_t$	-16.55	-94.38
	(1.56)	(2.22)
$\Delta slope_t$	-15.2	6.82
	(1.59)	(0.16)
$\Delta\sigma^r_{hv,t}$	0.41	-4.53
	(0.16)	(0.37)
rus_t	-1.18	-6.3
	(5.48)	(6.70)
$\Delta\sigma^{rus}_{hv,t}$	0.2	2.44
	(1.46)	(2.85)
HML_t	-0.5	-3.83
	(2.12)	(3.88)
$\Delta lead_t$	-12.62	-46.3
	(3.32)	(2.49)
Δci_t	-0.29	-6.49
	(0.05)	(0.15)
Adj R^2	63.37%	72.95%

Sample period is December 31, 1998–July 31, 2002.
Panel A: 186 weekly observations; Panel B: 43 monthly observations.
In parentheses are the absolute values of t-statistics, based on the Newey-West heteroscedasticity and autocorrelation-consistent covariance matrix estimator with four lags for the weekly series and with three lags for the monthly series.

ENDNOTES

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[1]See, for example, Merton [1974], Geske [1977], Kim, Ramaswamy, and Sundaresan [1993], Longstaff and Schwartz [1995], Leland and Toft [1996], and Collin-Dufresne and Goldstein [2001]. Examples of reduced-form models, which use a different approach, include Jarrow and Turnbull [1995], Das and Tufano [1996], Jarrow, Lando, and Turnbull [1997], Madan and Unal [1998], and Duffie and Singleton [1999].

[2]Duffee [1998], for instance, demonstrates how the callability of corporate bonds and the coupon effects will strongly influence the relationship between Treasury term structure changes and corporate credit spread changes.

[3]For detailed discussion of the various Merrill Lynch bond indexes, see "Merrill Lynch Bond Index Rules and Definitions" [2000].

[4]Detailed information about the three indexes is available at www.tcb-indicators.org.

[5]The yield curve slope in the leading index is defined as the difference between the ten-year Treasury bond rate and the federal funds rate.

[6]More detailed information is available in *S&P Credit Indices: Overview and Methodology* [1999].

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