Interest Rates and Credit Spread Dynamics

Robert Neal, Douglas Rolph, Brice Dupoyet, and Xiaoquan Jiang

Robert Neal
is an associate professor of finance at Indiana University in Indianapolis, IN.
skyking@indiana.edu

Douglas Rolph
is a senior lecturer at Nanyang Business School at Nanyang Technological University in Singapore.
drolph@ntu.edu.sg

Brice Dupoyet
is an associate professor of finance at the College of Business at Florida International University in Miami, FL.
dupoyetb@fiu.edu

Xiaoquan Jiang
is an associate professor of finance and Knight Ridder Research Fellow at the College of Business at Florida International University in Miami, FL.
jiangx@fiu.edu

This article revisits the relationship between callable credit spreads and interest rates. The authors use cointegration to model the time series of corporate and government bond rates and draw inference about how credit spreads evolve after a shock to government rates using a bootstrapped standard error methodology. They find little evidence that unexpected changes to government rates lead to a significant change in future credit spreads. These results hold for both large positive and negative shocks, as well as after conditioning on the prevailing interest rate environment.

Credit spreads are negatively correlated with interest rates through the impact of changes in interest rates on the credit conditions of corporations. Most theoretical studies consider these correlations in the context of risk-neutral valuation models of corporate debt and focus on the effect that interest rates have on the growth in firm value. These models specify how firm value evolves over time and assume that default is triggered when the firm value falls below some default threshold. The default threshold is a function of the amount of debt outstanding.[1] Because the (risk-neutral) growth of the firm increases with the instantaneous risk-free rate, the likelihood that the firm value falls below the default threshold decreases and the credit risk premium declines. This effect induces a negative correlation between credit spreads and interest rates.

A number of empirical studies provide evidence of a strong negative relationship between changes in credit spreads and interest rates. The negative correlation between interest rates and credit spreads persists after controlling for firm- and market-level determinants of default risk (Longstaff and Schwartz [1995], Collin-Dufresne et al. [2001], Avramov et al. [2007], Campbell and Taksler [2003]). Although the general consensus in the literature points to a negative link between credit spreads and government rates, the call feature of corporate debt has the potential to induce a source of common variation in credit spreads and interest rates that is unrelated to default risk (Jacoby et al. [2009]). For callable bonds, higher interest rates imply a lower chance that the issuer will exercise the call option. Thus, bondholders will accept a lower yield for these call provisions, which will result in an overall decrease in the bond yield spread. Although the negative relationship between credit spreads and interest rates weakens for non-callable bonds, there remains a statistically significant decrease in credit spreads for several months following a positive shock to short-term government rates (Duffee [1998]).

A common approach in the literature is to regress contemporaneous credit spreads or changes in credit spreads on contemporaneous levels or changes in Treasury rates. Interest rates and credit spreads, however, have a high degree of persistence. The error term of the regression is thus autocorrelated, correlated with the independent variable (interest rates), and contains information about contemporaneous interest rates. The estimates of the regression coefficients can then be inefficient and the significance tests on the estimated coefficients invalid, as shown in Granger and Newbold [1974]. Our approach is to let the data be our guide by explicitly incorporating the influence of persistence through the modeling of the joint evolution of corporate and government interest rates using a cointegration framework.

We revisit the relationship between credit spreads and interest rates using an improved methodology that combines cointegration with bootstrapped standard errors. Two variables are cointegrated when both are driven by the same unit root process. If corporate rates can be modeled as the sum of the nonstationary Treasury rate and a risk premium, it is clear that both the Treasury and the corporate rates share a common process. Because the two rates are driven by the same stochastic trend, they cannot evolve independently, and the levels of the variables will be linked together.[2]

Using the cointegration estimates, we examine how credit spreads evolve after an unexpected change in government rates by taking advantage of the generalized impulse response function (GIRF) methodology (Koop et al. [1996]). This econometric technique uses bootstrapped standard errors to infer how credit spreads evolve after a shock to government rates. In contrast, many previous empirical studies rely on an assumed distribution of the residuals. Thus, our approach provides a more robust testing framework and accounts for possible fat tails of the empirical distribution of residuals.

Additionally, this approach allows the path of credit spreads to depend on recent levels and changes in government rates. Numerous studies document that government rates and credit spreads contain information about the current and future state of the macroeconomy.[3] However, most previous studies focus on the unconditional relationship between credit spreads and government rates. Our approach conditions on current interest rates and allows for asymmetric responses to positive and negative interest rate shocks.

We find no statistically significant change in credit spreads after large shocks to either short-term or long-term Treasury yields, either contemporaneously or up to three years after a shock. The results hold for shocks to short, intermediate, and long maturity government rates and credit spreads constructed with intermediate and long maturity corporate bond indexes. These findings contrast with earlier empirical studies that found yields and spreads to be negatively correlated. Our results suggest that how interest rates evolve over time matters for our understanding of the relationship between interest rate shocks and credit spreads.

Our results are interesting for several reasons. First, cointegration has implications for models of pricing corporate debt and credit derivatives. Cointegration supports the intuition that corporate and Treasury rates are closely linked and cannot evolve in arbitrary ways. This linkage, however, is not captured in the parameterization of reduced-form bond pricing models, structural models, and credit spread option pricing models. The omission is important because Duan and Pliska [2004] showed that, under reasonable conditions, ignoring cointegration will significantly bias the calculated price of spread options. Second, our finding that higher Treasury rates do not have a statistically significant impact on credit spreads has implications for models that analyze credit spread dynamics. For example, the comparative statics of the capital structure models of Leland and Toft [1996] and Collin-Dufresne and Goldstein [2001] and the bond pricing models of Longstaff and Schwartz [1995], Kim et al. [1993], and Merton [1974] all predict that higher rates will lower credit spreads. Our results suggest that there is little empirical support for this relationship.

DATA AND SUMMARY STATISTICS

We obtain monthly corporate bond yields from the Lehman Brothers U.S. Corporate Index and monthly constant-maturity government rates from the Federal Reserve's H.15 release. The Lehman Brothers U.S. Corporate database begins in 1973, and our study thus spans from February 1973 to December 2007. The Lehman Brothers Corporate Indices include all publicly traded U.S. corporate debentures and secured notes that meet prescribed maturity, liquidity, and quality guidelines. Securities with calls, puts, and sinking fund provisions are included. We consider the effects of interest rate shocks on the credit spreads for bond indexes that differ by credit rating (Aaa, Aa, A, and Baa) and maturity (below 10 years for intermediate maturity bonds, and above 10 years for long maturity bonds).

Summary Statistics

Exhibit 1 contains summary statistics for corporate rates, Treasury rates, changes in corporate rates, and changes in Treasury rates for both long-term and intermediate-term maturities. Over the 1973–2007 period, the 10-year government rate averaged 7.59%, while long-term corporate rates ranged between 8.52% and 9.62%. During the same period, the three-year government rate averaged 7.07%, while intermediate-term corporate rates ranged between 7.81% and 8.99%. The mean monthly changes in rates are close to zero for all series.

Panel A of Exhibit 2 presents autocorrelation coefficients for both levels and changes of the 10-year Treasury and long-term corporate rates, while Panel B covers the 3-year Treasury and intermediate-term corporate rates. For long-term corporate rates levels, the autocorrelation coefficients for the first four lags exceed 0.95, while for intermediate-term rates, the autocorrelation coefficients for the first four lags exceed 0.93, with highly statistically significant (unreported) Box–Ljung Q-Statistics. Correlations in *changes* range from −0.13 to 0.16, and again there is strong statistical significance for all lags. Exhibit 3 reports the augmented Dickey–Fuller and Phillips–Perron unit root tests. Using between one and six lags, these two tests fail to reject at the 5% level the presence of a unit root for both long-term and intermediate-term corporate and government rates. In addition, the Dickey–Fuller and Phillips–Perron tests for the first differences (not reported) are significant at the 1% level, a result consistent with the previously obtained correlations in changes. Thus, the levels of the interest rates appear nonstationary while the changes appear stationary. Overall, these results are consistent with the conclusions of a number of studies on unit roots in nominal interest rates.[4]

EXHIBIT 1
Descriptive Statistics

Variables	Mean	Std. Dev.	Percentile (10%)	Percentile (90%)
Panel A: Lehman Long-Term Bond Series and 10-Year Treasury Rates				
Lehman AAA Long	8.52	2.33	5.83	12.21
Lehman AA Long	8.75	2.43	5.89	12.52
Lehman A Long	9.03	2.47	6.21	12.83
Lehman BAA Long	9.62	2.61	6.65	13.46
10-Year Treasury	7.59	2.61	4.50	11.67
Δ Lehman AAA Long	–0.004	0.339	–0.340	0.360
Δ Lehman AA Long	–0.003	0.331	–0.340	0.340
Δ Lehman A Long	–0.003	0.342	–0.350	0.350
Δ Lehman BAA Long	–0.003	0.372	–0.380	0.390
Δ 10-Year Treasury	–0.006	0.372	–0.390	0.410
Panel B: Lehman Intermediate-Term Bond Series and 3-Year Treasury Rates				
Lehman AAA Intermediate	7.81	2.69	4.62	11.58
Lehman AA Intermediate	8.01	2.81	4.86	11.89
Lehman A Intermediate	8.33	2.83	5.21	12.29
Lehman BAA Intermediate	8.99	2.90	5.71	13.02
3-Year Treasury	7.07	2.92	3.70	11.13
Δ Lehman AAA Intermediate	–0.005	0.401	–0.401	0.420
Δ Lehman AA Intermediate	–0.004	0.401	–0.410	0.370
Δ Lehman A Intermediate	–0.003	0.403	–0.390	0.390
Δ Lehman BAA Intermediate	–0.003	0.417	–0.410	0.460
Δ 3-Year Treasury	–0.009	0.482	–0.500	0.500

Notes: The statistics are based on monthly data from February 1973 to December 2007. In Panel A, the AAA, AA, A, and BAA series are Lehman Brothers Long-Term Corporate Yields and the 10-year Treasury series is a constant maturity series from the Board of Governors. In Panel B, the AAA, AA, A, and BAA series are Lehman Brothers Intermediate-Term Corporate Yields and the 3-year Treasury series is a constant maturity series from the Board of Governors.

EXHIBIT 2
Sample Autocorrelations

Variables	Autocorrelation Coefficients in Level						Autocorrelation Coefficients in Changes					
	n = 1	n = 2	n = 3	n = 4	n = 5	n = 6	n = 1	n = 2	n = 3	n = 4	n = 5	n = 6
Panel A: Lehman Long–Term Bond Series and 10-Year Treasury Rates												
Lehman Aaa Long	0.99	0.97	0.96	0.95	0.94	0.93	0.07	–0.05	–0.05	–0.09	0.09	0.05
Lehman Aa Long	0.99	0.98	0.96	0.95	0.94	0.93	0.12	–0.08	–0.01	–0.07	0.08	0.05
Lehman A Long	0.99	0.98	0.96	0.95	0.94	0.93	0.10	–0.06	0.01	–0.11	0.07	0.03
Lehman Baa Long	0.99	0.97	0.96	0.95	0.93	0.92	0.11	–0.04	–0.01	–0.05	0.07	0.02
10-Year Treasury	0.99	0.97	0.96	0.95	0.94	0.92	0.13	–0.07	–0.06	–0.01	0.03	0.03
Panel B: Lehman Intermediate–Term Bond Series and 3-Year Treasury Rates												
Lehman Aaa Intermediate	0.99	0.97	0.96	0.94	0.93	0.92	0.14	–0.06	–0.06	–0.07	0.10	–0.04
Lehman Aa Intermediate	0.99	0.97	0.96	0.95	0.94	0.93	0.13	–0.05	–0.04	–0.09	0.10	–0.04
Lehman A Intermediate	0.99	0.97	0.96	0.95	0.94	0.92	0.11	0.01	0.00	–0.13	0.09	–0.07
Lehman Baa Intermediate	0.99	0.97	0.96	0.94	0.93	0.92	0.15	0.03	–0.02	–0.11	0.01	–0.08
3-Year Treasury	0.98	0.96	0.95	0.93	0.92	0.91	0.16	–0.10	–0.09	–0.05	0.05	–0.01

Note: Levels and changes autocorrelation estimates are based on monthly data from 1973:2 to 2007:12.

EXHIBIT 3
Unit Root Tests for Levels of Interest Rates

Variables	Dickey–Fuller						Phillips–Perron					
	n = 1	n = 2	n = 3	n = 4	n = 5	n = 6	n = 1	n = 2	n = 3	n = 4	n = 5	n = 6
Panel A: Lehman Long-Term Bond Series and 10-Year Treasury Rates												
Lehman AAA Long	–1.40	–1.30	–1.23	–1.08	–1.22	–1.24	–1.34	–1.33	–1.31	–1.27	–1.27	–1.28
	(0.58)	(0.63)	(0.66)	(0.72)	(0.66)	(0.65)	(0.61)	(0.61)	(0.62)	(0.64)	(0.65)	(0.64)
Lehman AA Long	–1.47	–1.30	–1.32	–1.19	–1.33	–1.32	–1.35	–1.35	–1.34	–1.32	–1.32	–1.34
	(0.55)	(0.63)	(0.62)	(0.68)	(0.61)	(0.62)	(0.61)	(0.61)	(0.61)	(0.62)	(0.62)	(0.61)
Lehman A Long	–1.44	–1.31	–1.35	–1.16	–1.31	–1.26	–1.35	–1.35	–1.35	–1.32	–1.32	–1.33
	(0.56)	(0.62)	(0.61)	(0.69)	(0.63)	(0.65)	(0.61)	(0.61)	(0.61)	(0.62)	(0.62)	(0.62)
Lehman BAA Long	–1.49	–1.39	–1.39	–1.29	–1.41	–1.37	–1.39	–1.40	–1.40	–1.39	–1.40	–1.41
	(0.54)	(0.59)	(0.59)	(0.63)	(0.58)	(0.60)	(0.59)	(0.58)	(0.58)	(0.59)	(0.58)	(0.58)
10-Year Treasury	–1.39	–1.24	–1.16	–1.17	–1.19	–1.23	–1.27	–1.27	–1.25	–1.23	–1.24	–1.24
	(0.59)	(0.66)	(0.69)	(0.69)	(0.68)	(0.66)	(0.64)	(0.64)	(0.65)	(0.66)	(0.66)	(0.66)
Panel B: Lehman Intermediate-Term Bond Series and 3-Year Treasury Rates												
Lehman AAA Intermediate	–1.61	–1.45	–1.38	–1.27	–1.46	–1.28	–1.47	–1.47	–1.45	–1.42	–1.43	–1.43
	(0.48)	(0.56)	(0.59)	(0.64)	(0.55)	(0.64)	(0.55)	(0.55)	(0.55)	(0.57)	(0.57)	(0.57)
Lehman AA Intermediate	–1.54	–1.42	–1.39	–1.24	–1.42	–1.26	–1.42	–1.43	–1.42	–1.39	–1.40	–1.40
	(0.51)	(0.57)	(0.59)	(0.66)	(0.57)	(0.65)	(0.57)	(0.57)	(0.57)	(0.59)	(0.58)	(0.58)
Lehman A Intermediate	–1.52	–1.50	–1.51	–1.27	–1.46	–1.26	–1.42	–1.45	–1.47	–1.44	–1.45	–1.44
	(0.53)	(0.53)	(0.53)	(0.64)	(0.55)	(0.65)	(0.57)	(0.56)	(0.55)	(0.56)	(0.56)	(0.56)
Lehman BAA Intermediate	–1.61	–1.61	–1.57	–1.36	–1.43	–1.25	–1.46	–1.51	–1.53	–1.52	–1.51	–1.48
	(0.48)	(0.48)	(0.50)	(0.60)	(0.57)	(0.65)	(0.55)	(0.53)	(0.52)	(0.53)	(0.53)	(0.54)
3-Year Treasury	–1.76	–1.51	–1.40	–1.33	–1.43	–1.34	–1.57	–1.57	–1.53	–1.48	–1.47	–1.46
	(0.40)	(0.53)	(0.58)	(0.62)	(0.57)	(0.61)	(0.50)	(0.50)	(0.52)	(0.54)	(0.55)	(0.55)

Notes: The estimates are based on monthly data from February 1973 to December 2007. The null hypothesis for the Dickey–Fuller and the Phillips–Perron tests is that the series contains a unit root. The percentage p-values (in parentheses) are approximate asymptotic p-values calculated using the method described in MacKinnon [1991].

COINTEGRATION AND THE UNCONDITIONAL RELATIONSHIP BETWEEN CORPORATE AND TREASURY RATES

The Cointegration Model

In this section, we provide a cointegration framework to analyze the relationship between corporate and Treasury bond yields. Cointegration is based on the idea that whereas a set of variables are individually nonstationary, a linear combination of the variables might be stationary due to a long-run statistical relationship linking the cointegrated variables together. Cointegration also implies that the short-term movements of the variables will be affected by the lagged deviation from the long-run relationship between the variables, inducing mean reversion around the long-run relationship. An alternative view of cointegration is that two variables are cointegrated when both are driven by the same unit root process. If corporate rates can be modeled as the sum of the nonstationary Treasury rate and a risk premium, it is clear that both the Treasury and the corporate rates share a common process. Because the two rates are driven by the same stochastic trend, they cannot evolve independently and the levels of the variables will be linked together.[5]

Assuming stationarity in the changes, the short-term dynamics of two cointegrated variables X_{1t} and X_{2t} can be captured in the following error-correction model:

$$\Delta X_{1,t} = a_{10} + \gamma_1(X_{1,t-1} - \lambda X_{2,t-1}) + \sum_{i=1}^{p} a_{i,11}\Delta X_{1,t-i} + \sum_{i=1}^{p} a_{i,12}\Delta X_{2,t-i} + \varepsilon_{1,t} \quad (1)$$

$$\Delta X_{2,t} = a_{20} + \gamma_2(X_{1,t-1} - \lambda X_{2,t-1}) + \sum_{i=1}^{p} a_{i,21}\Delta X_{1,t-i} + \sum_{i=1}^{p} a_{i,22}\Delta X_{2,t-i} + \varepsilon_{2,t} \quad (2)$$

In this model, ε_{1t} and ε_{2t} represent two i. i. d. error terms, the cointegration vector is said to be $(1,-\lambda)$, and the linear combination $X_{1,t} - \lambda X_{2,t}$ is stationary. The economic interpretation of $X_{1,t} - \lambda X_{2,t}$ is that it represents the deviation from the long-run relationship between X_1 and X_2. This deviation affects the short-term dynamics, with the error-correction coefficients γ_1 and γ_2 describing how quickly X_1 and X_2 respond to the deviation. It is well known that the presence of cointegration between X_1 and X_2 causes the time series behavior of X to differ from that of a conventional vector autoregression.[6]

Equations (1) and (2) can also be written in matrix form as

$$\Delta X_t = A_0 + \Pi X_{t-1} + A_1\Delta X_{t-1} + \cdots + A_k\Delta X_{t-p} + \varepsilon_t \quad (3)$$

where A_0 is a (1×2) vector of intercepts and $A_1 \ldots A_k$ are (2×2) matrixes of coefficients on lagged ΔX.[7] The important characteristic distinguishing cointegration models from VAR models is whether $\Pi = 0$. If this restriction holds, then ΔX_t can be represented by a conventional VAR in differences. If the rank of Π exceeds zero, however, the elements of Π are non-zero. We test for cointegration by estimating the rank of Π using Johansen [1988]'s likelihood ratio tests, namely, the maximal eigenvalue test and the trace statistic test.

Vector Error-Correction Model Estimates

The first set of trace statistics in Exhibit 4 examines whether long-term corporate rates (Panel A) and intermediate-term rates (Panel B) share a common unit root with the corresponding government rates. All tests are statistically significant at the 5% level. Thus, we reject the null hypothesis that corporate and government yields are not cointegrated in favor of the alternative hypothesis that there is at least one cointegrating vector. The second trace statistics, however, do not support the existence of two cointegrating vectors for either the intermediate-term bond series or the long-term bond series as one cannot reject the null hypothesis of one cointegrating vector or less for any of the series. The results for all series are based on using two lags of the levels of interest rates, with the lag length determined by the Schwartz criterion.

Exhibit 5 reports the estimated cointegrating vectors, with λ ranging from 1.1054 to 1.2508 for long maturity bonds, and from 1.0852 to 1.2480 for intermediate maturities. The *p*-values for both panels are less than 1%. The results in Exhibit 5 have two interesting implications. First, because all λ values exceed 1, a 1% increase in Treasury rates ultimately generates increases in corporate rates of more than 1%. Thus, as interest

Exhibit 4
Cointegration Results

Variables	Maximum Rank	Trace Statistic	5% Critical Value
Panel A: Lehman Long-Term Bond Series and 10-Year Treasury Rates			
Lehman AAA Long	0	18.35	12.53
	1	0.46	3.84
Lehman AA Long	0	16.03	12.53
	1	0.44	3.84
Lehman A Long	0	15.79	12.53
	1	0.44	3.84
Lehman BAA Long	0	14.98	12.530
	1	0.47	3.84
Panel B: Lehman Intermediate-Term Bond Series and 3-Year Treasury Rates			
Lehman AAA Intermediate	0	33.71	12.53
	1	0.64	3.84
Lehman AA Intermediate	0	34.63	12.53
	1	0.61	3.84
Lehman A Intermediate	0	33.09	12.53
	1	0.67	3.84
Lehman BAA Intermediate	0	24.52	12.530
	1	0.71	3.84

Notes: The estimates are based on monthly data from February 1973 to December 2007. This exhibit uses Johansen's [1988] maximum likelihood method to estimate the rank of Π for the corporate and government rates in the two-variable regression.

Exhibit 5
Estimates of Cointegrating Vectors

Variables	Coefficient	Estimate	P-Value
Panel A: Lehman Long-Term Bond Series and 10-Year Treasury Rates			
Lehman AAA Long	1	1	.
	λ	1.1054	0.00
Lehman AA Long	1	1	.
	λ	1.1381	0.00
Lehman A Long	1	1	.
	λ	1.1741	0.00
Lehman BAA Long	1	1	.
	λ	1.2508	0.00
Panel B: Lehman Intermediate-Term Bond Series and 3-Year Treasury Rates			
Lehman AAA Intermediate	1	1	.
	λ	1.0852	0.00
Lehman AA Intermediate	1	1	.
	λ	1.1159	0.00
Lehman A Intermediate	1	1	.
	λ	1.1599	0.00
Lehman BAA Intermediate	1	1	.
	λ	1.2480	0.00

Notes: The estimates are based on monthly data from February 1973 to December 2007. This exhibit reports estimates of λ in the cointegrating vector $(1, -\lambda)$ for the corporate and government rates using Johansen's [1988] maximum likelihood method. The Johansen normalization restrictions are imposed, and we report the coefficient estimates as well as the respective P-values.

rates rise, credit spreads will eventually widen. Second, the lower-quality bonds exhibit a greater long-run sensitivity to interest rate movements than do higher quality bonds. This is inconsistent with a commonly held view that increased credit risk will make corporate bonds less interest rate sensitive.

An alternative way to interpret the cointegrating relationship is to estimate the error-correction regressions found in Equations (1) and (2). Cointegration implies that the coefficient on the error-correction term will be negative and significant, with the size of the coefficient measuring the sensitivity of corporate rates to the error-correction term. The negative sign indicates that credit spreads subsequently adjust to restore the long-run equilibrium when a deviation occurs. Using the estimated cointegrating vectors from Exhibit 5, Exhibit 6 provides estimates of the error-correction model. The error-correction coefficients are significantly negative, ranging from −0.0653 to −0.0511 and from −0.1042 to −0.0619 for long and intermediate maturities respectively.

GIRF AND THE CONDITIONAL RELATIONSHIP BETWEEN CREDIT SPREADS AND TREASURY RATES

The previous section's results describe the unconditional relationship between credit spreads and Treasury rates. However, conditioning on the current interest rate environment may illuminate how credit spreads evolve following positive and negative shocks to government rates. For example, when the economy is in recession and government rates are relatively low, a positive shock to government rates may convey different information about future business conditions and credit risk than if the shock occurred during an expansion, when rates are relatively high.

In order to examine the conditional relationship between corporate spreads and interest rates, we use the estimates from the second-stage regression in Exhibit 6 to implement the generalized impulse response function (GIRF) methodology of Koop et al. [1996]. When using traditional impulse response functions, the history of the process or the sequence of observations as well as the signs, sizes, and correlations of the shocks occurring between

Exhibit 6

Estimates of the Error-Correction Model

Panel A: Lehman Long-Term Bond Series and 10-Year Treasury Rates

Dependent Variables	Independent Variables: Error-Correction	$\Delta X_{1,t-1}$	$\Delta X_{2,t-1} = \Delta$ 10-Year Treasury$_{t-1}$
$\Delta X_{1,t} = \Delta$ Lehman AAA Long$_t$	–0.0653	–0.1262	0.6038
	(0.0166)	(0.0354)	(0.0356)
$\Delta X_{1,t} = \Delta$ Lehman AA Long$_t$	–0.0578	–0.0971	0.6103
	(0.0159)	(0.0348)	(0.0343)
$\Delta X_{1,t} = \Delta$ Lehman A Long$_t$	–0.0545	–0.1206	0.5931
	(0.0155)	(0.0376)	(0.0374)
$\Delta X_{1,t} = \Delta$ Lehman BAA Long$_t$	–0.0511	–0.0809	0.612
	(0.0143)	(0.0384)	(0.0410)

Panel B: Lehman Intermediate-Term Bond Series and 3-Year Treasury Rates

Dependent Variables	Independent Variables: Error-Correction	$\Delta X_{1,t-1}$	$\Delta X_{2,t-1} = \Delta$ 3-Year Treasury$_{t-1}$
$\Delta X_{1,t} = \Delta$ Lehman AAA Intermediate$_t$	–0.1042	–0.0702	0.5674
	(0.0189)	(0.0303)	(0.0306)
$\Delta X_{1,t} = \Delta$ Lehman AA Intermediate$_t$	–0.1027	–0.0765	0.5599
	(0.0185)	(0.0309)	(0.0309)
$\Delta X_{1,t} = \Delta$ Lehman A Intermediate$_t$	–0.0892	–0.1192	0.5211
	(0.0166)	(0.0355)	(0.0334)
$\Delta X_{1,t} = \Delta$ Lehman BAA Intermediate$_t$	–0.0619	–0.0319	0.5111
	(0.0131)	(0.0372)	(0.0348)

Notes: This exhibit reports estimates from Equation (1) along with standard errors in parentheses for the bivariate error-correction system of Equations (1) and (2) in the one-lag difference case. The error-correction terms are estimated using Johansen's [1988] maximum likelihood method. X1 represents the corporate rate, and X2 represents the government rate.

the initial shock and the impulse horizon can produce misleading estimates, as demonstrated by Pesaran and Potter [1997]. The GIRF approach, however, corrects for these issues and allows for asymmetric responses to positive and negative interest rate shocks.

In the GIRF framework, the residuals observed from the VEC model are bootstrapped and the standard errors reflect the empirical (not assumed) residual distribution. Separating the GIRF functions into positive and negative shocks—with possibly different implications regarding the business conditions and their relationship to credit risk—potentially increases the power of the test to reject the null hypothesis of no response. Additionally, traditional impulse response functions' standard errors rely on a ceteris paribus argument that neglects the effect of the prevailing interest rate environment. In contrast, GIRF functions construct forecasts for each period during the sample using the most recent interest rates and then average over the resulting forecast. Thus, there is more variability in the forecasted path of future credit spreads. The higher variability leads to wider and more realistic standard errors and helps guard against erroneously concluding shocks to government rates have a statistically significant impact on credit spreads.

GIRF Methodology

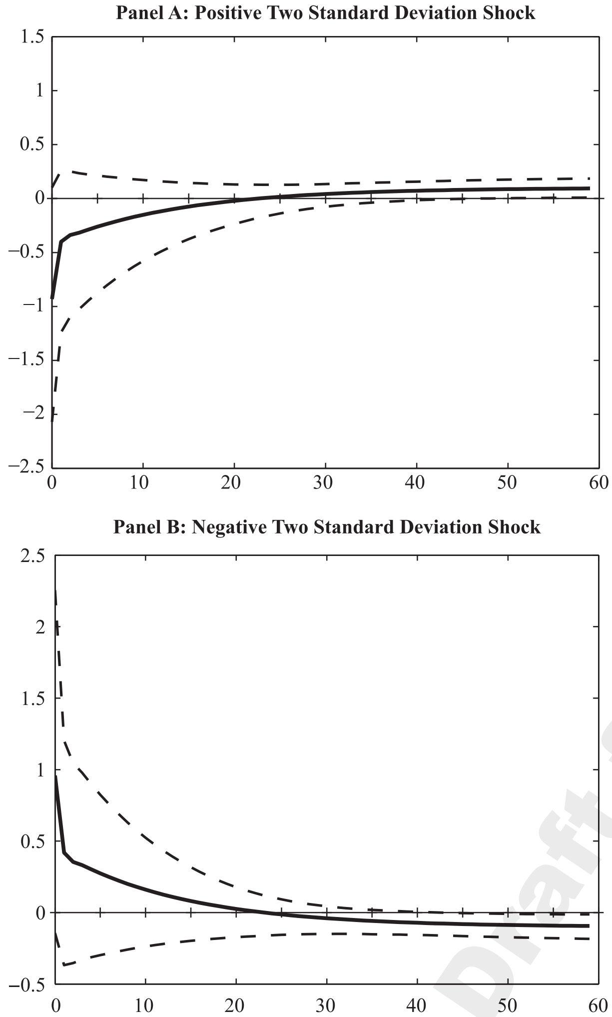
The generalized impulse response functions are defined as the difference in month $t+i$ between the conditional expectation of the corporate bond spread (corporate yield – Treasury yield) following a shock to Treasury yields exceeding two standard deviations at month t and the conditional expectation across all possible shocks to Treasury yields. Both expectations condition on interest rates at $t-1$. The response function describes what might happen to credit spreads in the months following a shock to government rates after controlling for the influence of lagged government and corporate rates.

The GIRF equations can be written as follows:

$$GIRF(n,\varepsilon_{g,t},\Omega_{t-1}) = E(y_{t+n}\,|\,\Omega_{t-1},\varepsilon_{g,t} > 2\sigma_{\varepsilon}) - E(y_{t+n}\,|\,\Omega_{t-1}) \quad \text{when } \varepsilon_{g,t} > 0 \tag{5}$$

Exhibit 7

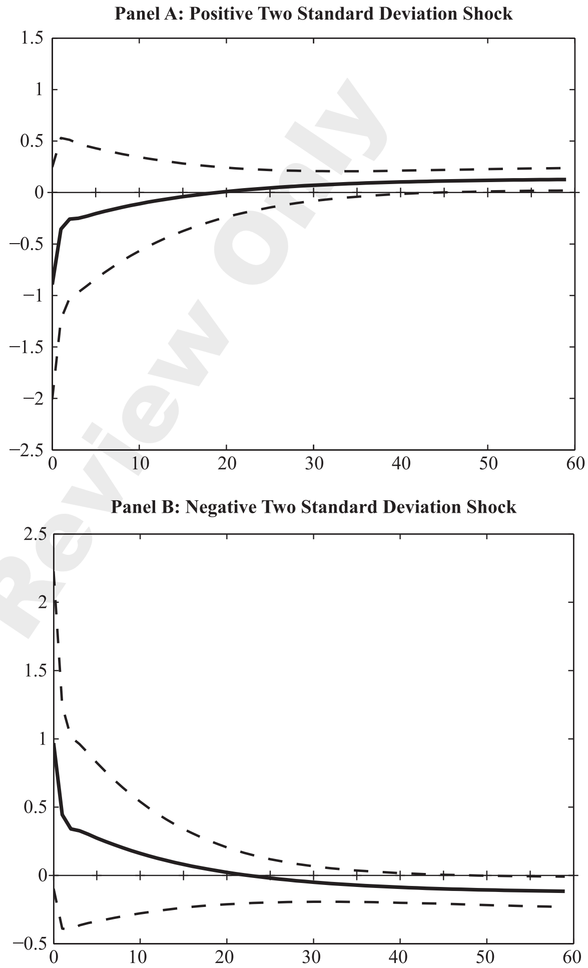
Response of Lehman AAA Long Spread to Shock in 10-Year Treasury Rate



Notes: The graphs are obtained by constructing GIRFs that capture both the short-term dynamics and the long-run relationship between corporate and Treasury rates. The GIRFs are defined as the difference in month t + i between the conditional expectation of the corporate bond spread (corporate yield – Treasury yield) following a large shock to Treasury yields at month t and the conditional expectation across all possible shocks to Treasury yields. Both expectations condition on interest rates at t – 1. The solid line represents the average response of credit spreads, while the dashed lines show the 2.5th and 97.5th percentiles of the GIRF functions.

Exhibit 8

Response of Lehman AA Long Spread to Shock in 10-Year Treasury Rate



Note: See Notes to Exhibit 7.

and as

$$GIRF(n,\varepsilon_{g,t},\Omega_{t-1}) = E(y_{t+n} \mid \Omega_{t-1}, |\varepsilon_{g,t}| > 2\sigma_\varepsilon) - E(y_{t+n} \mid \Omega_{t-1}) \quad \text{when } \varepsilon_{g,t} < 0 \tag{6}$$

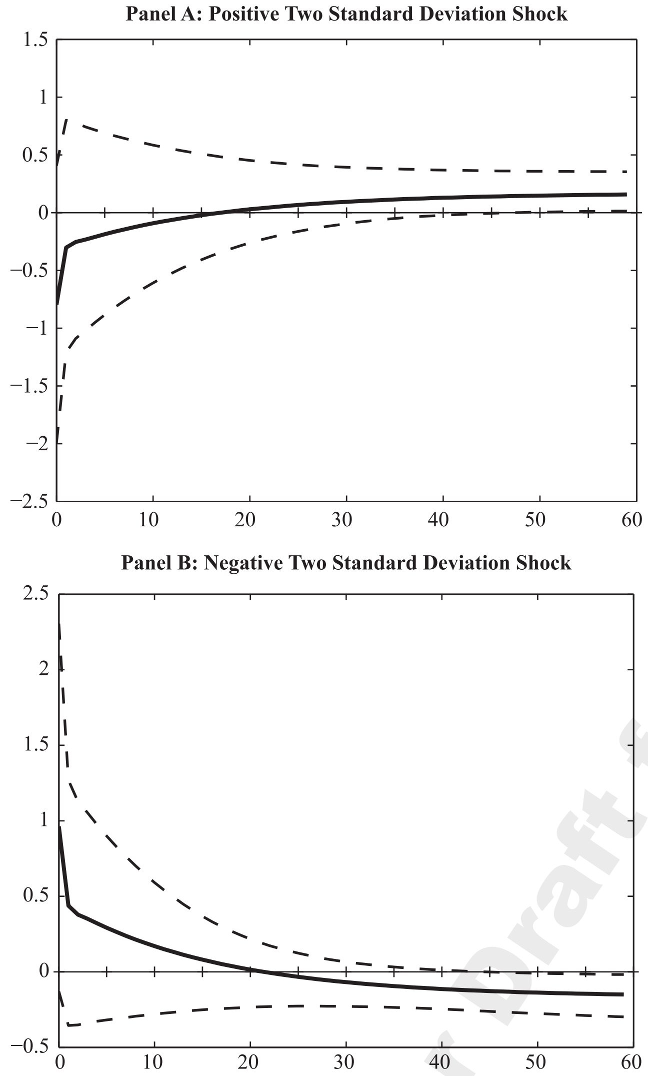
where y_{t+n} is the corporate credit spread at time $t+n$, Ω_{t-1} is the time $t-1$ information set used to produce forecasts of y_{t+n}, $\varepsilon_{g,t} > 2\sigma_\varepsilon$ represents a positive shock exceeding two standard errors, and $|\varepsilon_{g,t}| > 2\sigma_\varepsilon$ represents a negative shock exceeding two standard errors.

To explain the GIRF procedure, we use a model which includes one corporate bond rate and one government bond rate, where

$$X_t = \begin{bmatrix} X_{1t} \\ X_{2t} \end{bmatrix} = \begin{bmatrix} \text{corporate rate at } t \\ \text{government rate at } t \end{bmatrix},$$

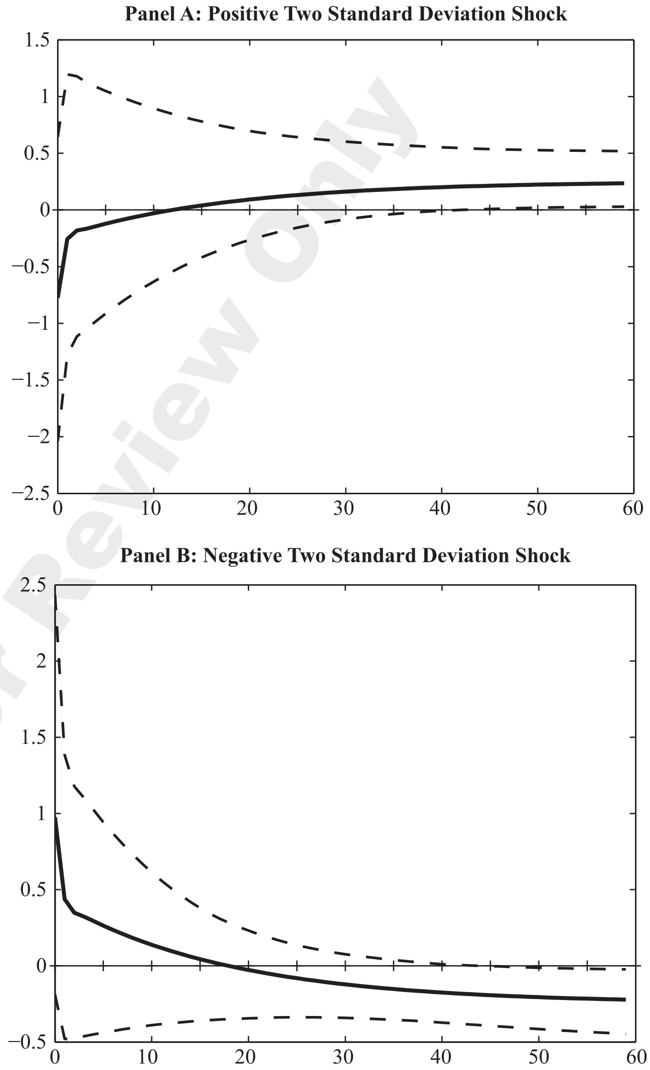
$$\Lambda = \begin{bmatrix} 1 & -\lambda \end{bmatrix} \tag{7}$$

EXHIBIT 9
Response of Lehman A Long Spread to Shock in 10-Year Treasury Rate



Note: See Notes to Exhibit 7.

EXHIBIT 10
Response of Lehman BAA Long Spread to Shock in 10-Year Treasury Rate



Note: See Notes to Exhibit 7.

$$\text{and} \quad A_2 = \begin{bmatrix} \gamma_1 \\ \gamma_2 \end{bmatrix} \quad \text{so that} \quad \Pi = A_2\Lambda \tag{8}$$

Models that include government rates are generalizations of the two-variable case.

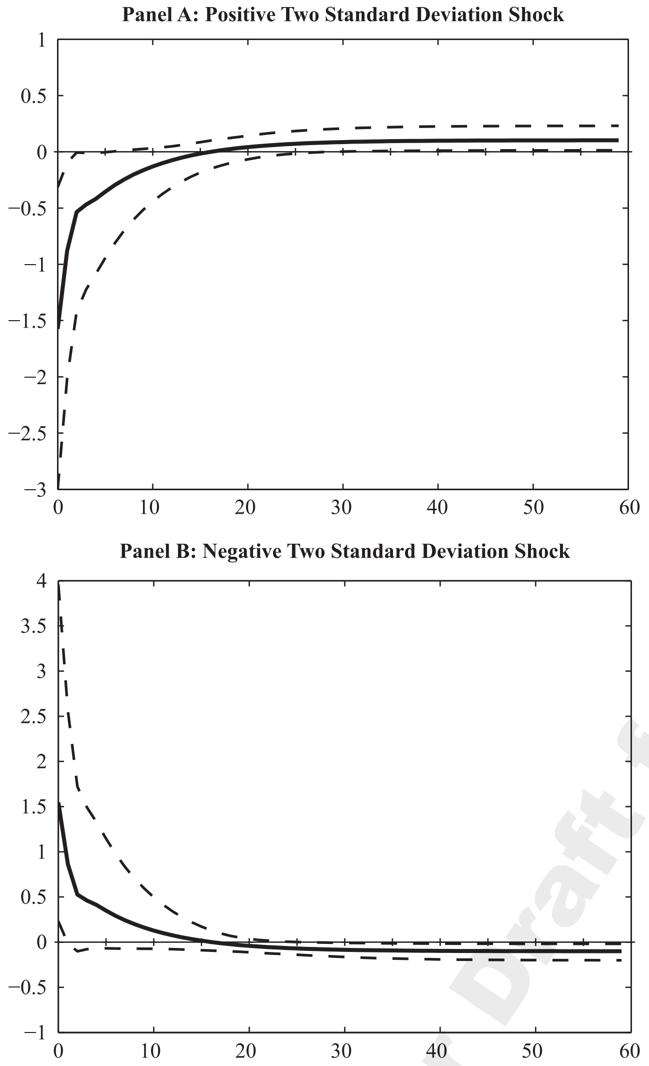
1. Retrieve the fitted/realized residuals from the vector error-correction model for each month t using actual data. In (2×2) matrix and (2×1) vector notation, for month t, use real data at month $t-1$ and month $t-2$ and compute

$$\Delta X_t^{\text{forecasted}} = A_1 \Delta X_{t-1} + A_2 \Lambda\ X_{t-1} \quad \text{where} \quad \Delta X_{t-1} = X_{t-1} - X_{t-2} \tag{9}$$

in order to retrieve the (2×1) fitted residual vector $\varepsilon_t = \Delta X_t - \Delta X_t^{\text{forecasted}}$

Exhibit 11

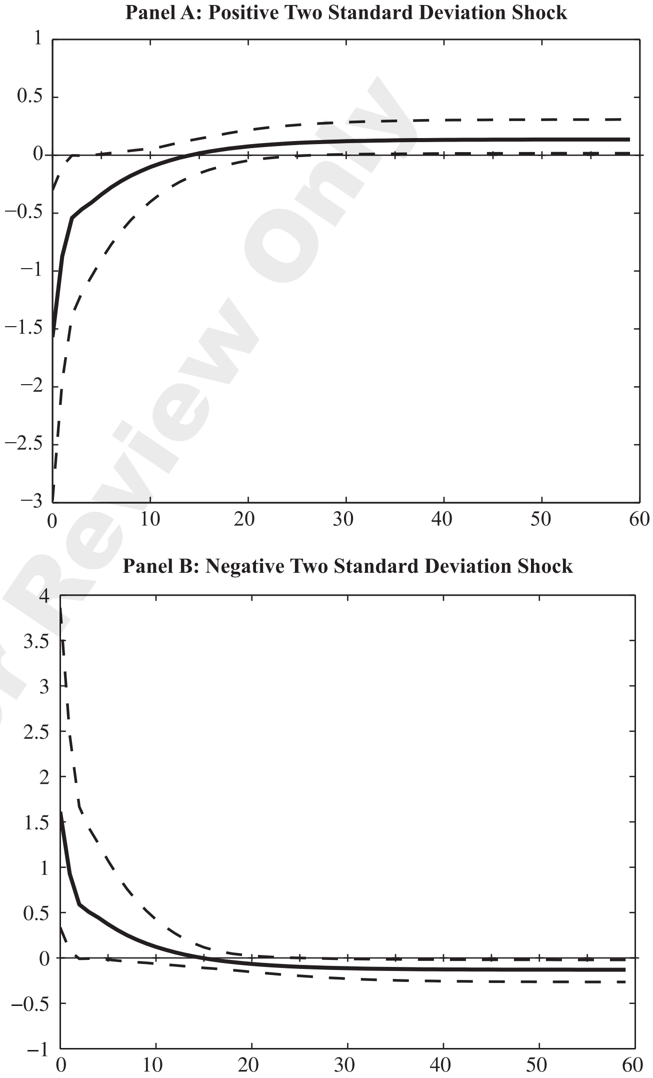
Response of Lehman AAA Intermediate Spread to Shock in Three-Year Treasury Rate



Note: See Notes to Exhibit 7.

Exhibit 12

Response of Lehman AA Intermediate Spread to Shock in Three-Year Treasury Rate



Note: See Notes to Exhibit 7.

2. For each month t, calculate "future" interest rates at month $t + n$ (for $n = 0,1,\ldots N$) by bootstrapping the model residuals obtained in step 1.

- For month t, use real data at month $t-1$ and month $t-2$ as well as residual ε_t, and compute

$$\Delta X_t^{\text{unconditional forecast}} = A_1 \Delta X_{t-1} + A_2 \Lambda\ X_{t-1} + \varepsilon_t \quad (10)$$

and obtain

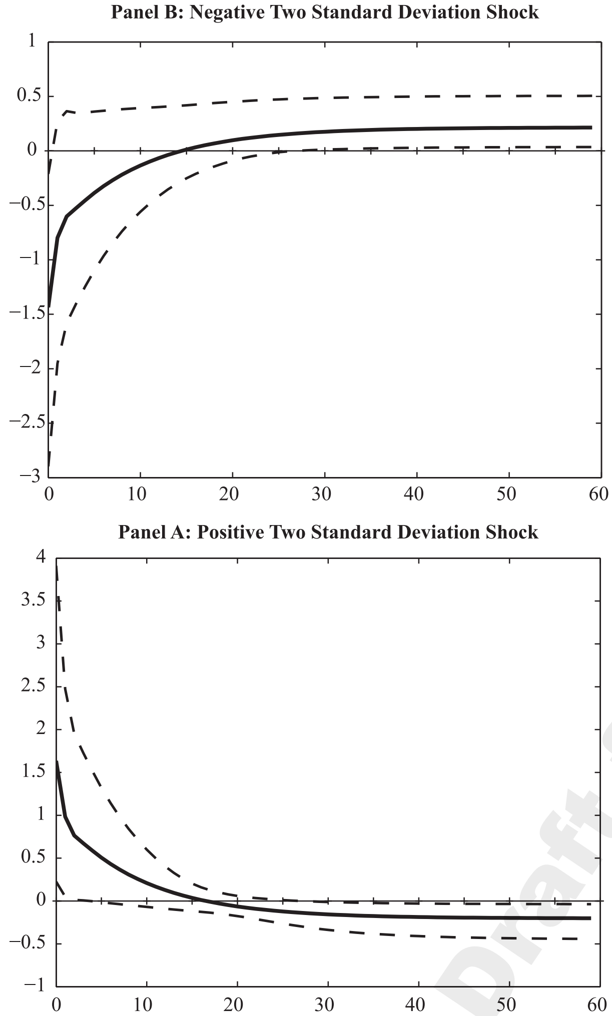
$$X_t^{\text{unconditional forecast}} = X_{t-1} + \Delta X_t^{\text{unconditional forecast}} \quad (11)$$

- For month $t+1$, use $X_t^{\text{unconditional forecast}}$, real data at month $t-1$ and residual ε_{t+1}, and compute

$$\Delta X_{t+1}^{\text{unconditional forecast}} = A_1 (X_t^{\text{unconditional forecast}} - X_{t-1}) + A_2 \Lambda\ X_t^{\text{unconditional forecast}} + \varepsilon_{t+1} \quad (12)$$

and obtain

EXHIBIT 13
Response of Lehman A Intermediate Spread to Shock in Three-Year Treasury Rate



Note: See Notes to Exhibit 7.

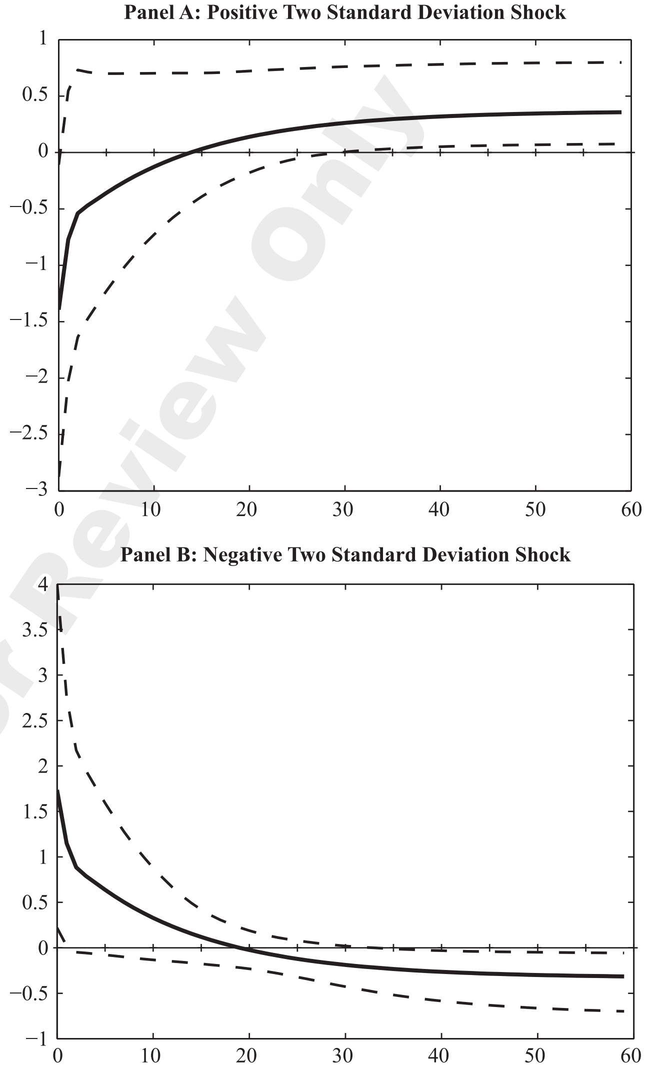
$$X_{t+1}^{\text{unconditional forecast}} = X_{t}^{\text{unconditional forecast}} + \Delta X_{t+1}^{\text{unconditional forecast}} \tag{13}$$

- For month $t + n$, $n > 1$, use $X_{t+n-1}^{\text{unconditional forecast}}$, $X_{t+n-2}^{\text{unconditional forecast}}$ and residual ε_{t+n}, and compute

$$\Delta X_{t+n}^{\text{unconditional forecast}} = A_1(X_{t+n-1}^{\text{unconditional forecast}} - X_{t+n-2}^{\text{unconditional forecast}}) + A_2\Lambda\, X_{t+n-1}^{\text{unconditional forecast}} + \varepsilon_{t+n} \tag{14}$$

and obtain

EXHIBIT 14
Response of Lehman BAA Intermediate Spread to Shock in Three-Year Treasury Rate



Note: See Notes to Exhibit 7.

$$X_{t+n}^{\text{unconditional forecast}} = X_{t+n-1}^{\text{unconditional forecast}} + \Delta X_{t+n}^{\text{unconditional forecast}} \tag{15}$$

These forecasted interest rates are used to calculate the unconditional expectation of interest rate spreads.

3. For each month t, calculate "future" interest rates at time $t + n$ for $n = 0,1,\ldots N$ by imposing that the value of the first residual at time t be larger than two standard deviations (for positive shocks).

The remaining residual series is kept exactly the same as in step 2. The only difference between step 2 and step 3 is that in step 3 the first residual is drawn from the subset of residuals that are larger than two times the residuals' standard deviation.

4. Record the corporate spread for both the unconditional and the conditional simulation separately, and repeat steps 2 and 3 for the chosen number of simulations (1,000 in this case).
5. For a given number of steps ahead *n*, calculate the differences between these 1,000 simulated conditional and unconditional spreads and calculate their means, lower bounds, and upper bounds (2.5% and 97.5%, respectively).
6. For each number of steps ahead *n*, compute averages of the means, lower bounds, and upper bounds across all *t* (months).

The Conditional Relationship between Credit Spreads and Treasury Rates

Exhibits 7 through 10 plot the response of long-term credit spreads to a two standard deviation shock in the 10-year Treasury rate. The exhibits plot the average response of credit spreads, as well as the 2.5th and 97.5th percentiles of the GIRF functions. In order to examine the long-run response, we plot the path of credit spreads for the five years that follow both a positive and a negative shock to the government rate. Although most empirical studies focus on the response of interest rates after a shock of one standard deviation, we focus on larger, two standard deviation shocks to government rates. Using such large shocks increases the power to reject the null hypothesis of no response to credit spreads following interest rate shocks.

As can been seen in the exhibits, there is no statistically significant short-term reaction of spreads to either positive or negative shocks to long maturity government rates. After a large positive (negative) shock, the credit spread decreases (increases) initially but subsequently reverts to near pre-shock levels. However, this temporary average deviation from initial levels is generally not statistically significantly different from zero, as shown by the width of the confidence bounds. In addition, across credit ratings, there is little difference in the response of credit spreads to interest rate shocks.

Exhibits 11 through 14 plot the response of intermediate-term corporate spreads to a two standard deviation shock in the three-year Treasury rate, and as in the long-term rate cases, the short-run response of credit spreads to interest rate shocks are generally not statistically significantly different from zero, as shown by the width of the confidence bounds. For completeness, we also estimate (unreported) generalized impulse responses that include one-year government rates and find marginal significant response of intermediate maturity credit spreads. When the same impulse response analysis uses shocks that exceed one standard deviation, as is common in the empirical literature, we find no statistically significant relationship between shocks and future intermediate maturity credit spreads.

As a final robustness check, we also estimate a VECM that incorporates both short (three-month) and intermediate (three-year) government rates, and we again find no significant relationship between credit spreads and shocks to government rates, regardless of the maturity of the corporate bonds.

CONCLUSION

In contrast to existing studies, we find little evidence that unexpected changes to government rates lead to a significant change in future credit spreads. This empirical result holds for credit spreads constructed using bonds of differing maturities and credit ratings and is robust to shocks to both short and long maturity government bonds. This is in contrast to the existing literature, in which researchers have found that credit spreads and changes in rates are negatively correlated.

Our approach removes many of the restrictive assumptions found in the existing empirical literature. We use a vector error-correction methodology that allows for interest rates to be cointegrated, thus precluding corporate and government rates from evolving in arbitrary, opposite directions over time. We also incorporate the empirical distribution of residuals when constructing the confidence intervals, thus allowing for potential fat tails in the distribution of interest rate shocks. Finally, our results condition on the prevailing interest rate environment, which may be viewed as a proxy for economic conditions. The absence of a meaningful relationship between interest rates and credit spreads provides empirical evidence against the dynamic process for credit spreads assumed in existing structural models for pricing corporate bonds.

ENDNOTES

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[1]See Black and Cox [1976], Leland [1994], Collin-Dufresne and Goldstein [2001], Eom et al. [2004], Schaefer and Strebulaev [2008], and Ericsson et al. [2009].

[2]Although cointegration is intuitively appealing, it assumes that the underlying variables are nonstationary. We impose the assumption of unit root processes not because we believe that interest rates can exhibit unbounded variation, but because it provides the distribution theory that best represents the finite sample properties of our data. Our view is consistent with that of Granger and Swanson [1996] and Phillips [1998], who showed that nonstationary distribution models provide superior inference for both unit root and near unit root processes.

[3]For instance, see Fama and French [1989], Chan-Lau and Ivaschenko [2001, 2002], Davies [2008], and Mueller [2009].

[4]See Rose [1988], Stock and Watson [1988], Hall et al. [1992], Bradley and Lumpkin [1992], Konishi et al. [1993], and Enders and Granger [1998] for short-term rates; Mehra [1994] and Campbell and Shiller [1987] for long-term rates.

[5]Although cointegration is intuitively appealing, it assumes that the underlying variables are nonstationary. We impose the assumption of unit root processes not because we believe that interest rates can exhibit unbounded variation, but because it provides the distribution theory that best represents the finite sample properties of our data. Our view is consistent with Granger and Swanson [1996] and Phillips [1998] who showed that nonstationary distribution models provide superior inference for both unit root and near-unit root processes.

[6]An attractive feature of the cointegration framework is that it allows one to distinguish between short-run and long-run behavior. We estimate the models with a two-stage procedure that first identifies the cointegration vector, and then includes the vector in a second-stage regression of changes in corporate rates on changes in Treasury rates.

[7]For purposes of comparing across models, we fix the number of lags for changes in rates to one, which implies that there are two lags in the levels. We also consider other forms as a robustness check where we select variable lags with Akaike's information criterion, and our results remain the same.

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