A New Take on the Relationship between Interest Rates and Credit Spreads

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Abstract

We revisit the link between interest rates and corporate bond credit spreads by applying Rigobon's (2003) heteroskedasticity identification methodology to their interconnected dynamics through a bivariate VAR system. This novel approach allows us to account for endogeneity issues and to use this framework to test the various possible explanations for the credit spread – interest rate relation that have been proposed by the literature over the years. This innovative methodology allows us to conclude that credit spreads do indeed respond negatively to interest rates, yet that this negative relation is surprisingly robust to macroeconomic shocks, interest rates characteristics, different volatility regimes, and bond ratings. We also find the magnitude of the negative relation to be larger for high-yield bonds than for investment-grade bonds. Additionally, we are also able to rule out business cycles, the option-like feature of callable bonds proposed by Duffee (1998), as well as the term spread as the main drivers of the negative nature of the relationship.

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The relation between interest rates and credit spreads has been a subject of debate since Merton's (1974) proposed structural model for corporate bond valuation. Identifying the response of credit spreads to changes in interest rates is a challenging task for two main reasons. One issue is that credit spreads and interest rates endogenously react to one another. For instance, credit spreads often react to a change in expected inflation and the supply of credit, which are themselves associated with a change in interest rate. Meanwhile, Federal Reserve policy makers may react to credit spread shocks - due to liquidity, inflation, risk, or growth concerns for instance – by taking actions that result in a change in interest rates. The observed credit spreads and interest rates are therefore simultaneously determined by the interaction of the two schedules.

The second issue is that of the confounding factors problem. The co-movements of interest rates and credit spreads are likely influenced by a certain set of macroeconomic common shocks or preference shifting, rendering the disentangling of the two a challenge. All in all, these two issues complicate the studying of the response of credit spreads to interest rate changes and might also explain the conflicting findings found in the literature. Merton's structural model hinges on the proposition that debt can be viewed as a contingent claim on the underlying firm value; when interest rates are raised, under risk-neutral valuation the expected future value of the firm's assets increases, leading to a lower probability of default and thus to lower corporate credit spreads. Subsequent research at times validates Merton's prediction of a negative relation between interest rates and credit spreads. Kim, Ramaswarmy and Sundaresan (1993) develop a contingent-claims model with stochastic interest rates, obtaining a negative relationship between interest rates and corporate spreads for all bond maturities. Extending the Black and Cox (1976) model by incorporating default and interest risks, Longstaff and Schwartz (1995) also find that credit spreads are negatively related to interest rates, with their closed-form corporate debt valuation framework attributing the negative relation to both an asset-value factor and an interest-rate factor. Other studies confirming the result include Longstaff and Schwartz (1995), Collin-Dufresne Goldstein and Martin (2001), Campbell and Taksler (2003), Blanco et al. (2005), Avramov, Jostova and Philipov (2007), and Ericsson and Oviedo (2009).

Duffee (1998), however, argues that the callability feature plays an important role in the inverse relation between interest rates and credit spreads. The rationale is the fact that when interest rates increase, callable bonds are less likely to be called and their credit spreads should therefore see a decrease relative to their levels prior to the interest rate rise. Furthermore, Jacoby, Liao, and Batten (2007) find the negative relation between interest rates and credit spreads severely weakened once callable bonds are excluded from the sample. Others such as Neal, Rolph, Dupoyet and Jiang (2015) find a negligible relationship after conditioning on interest rates and market conditions.

Lastly, some research supports the idea that an increase in the risk-free rate induces a widening of credit spreads. The positive relation is predicted under certain conditions by models such as the dynamic optimal capital structure model of Leland and Toft (1996) and Goldstein, Ju and Leland (2001). The positive relationship is also supported by Bevan and Garzarelli (2000) as well as Davies (2008) who conclude that an increase in interest rates induces a positive change in credit spreads in both the short run and the long run, casting additional doubt as to the sign of the relation.

The subject has some important portfolio and risk management implications. If credit spreads do indeed shrink when interest rates rise, as Merton (1974) or Longstaff and Schwartz (1995) predict, the changes in corporate bond yields of a given maturity will depend on the magnitude of the credit spreads changes. If, on the other hand, the arguments put forward by Neal et al. (2015) are confirmed, in an instance of rising interest rates, corporate bonds negative percentage changes in price should be of about the same magnitude as those of Treasury bonds of equivalent duration. Finally, if, as Leland and Toft (1996) and others suggest, there is a positive relation between interest rates and credit spreads, corporate bonds yields should increase more than Treasury rates of similar duration, implying that corporate bonds negative percentage changes in price should be of greater magnitude than those of Treasury bonds of equivalent duration. We detail the various possible aforementioned scenarios in the Appendix.

We tackle the endogeneity problem by applying Rigobon's (2003) "identification through heteroskedasticity" method to the possibly bidirectional interest rate - credit spread relationship. This approach allows parameter identification through the shifting of the variance of the shocks, dealing with the endogeneity issue when other identification methods would otherwise not be appropriate. Applied in this setting, the identification through heteroskedasticity method delivers consistent and robust estimates of the credit spreads' reaction to interest rates. We find a negative response of credit spreads to interest rates, as implied by Merton (1974) structural model. The negative relation is of economic and statistical significance, robust to common shocks, interest rates characteristics, different volatility regimes, callability features, term spread, and bond credit ratings. We also find that the magnitude of the negative relation is larger for high-yield bonds than for investment-grade bonds, a sensible result since riskier bonds are in general more sensitive to a changing economic environment.

Finally, we reexamine several existing explanations for the negative relation. First, we show that the negative relationship remains statistically significant even when the methodology is applied to a bond index devoid of any callability features, supporting King's (2002) argument that callable bonds are not necessarily largely responsible for the negative relation between interest rates and credit spreads and that the effect persists even when they are removed from the sample. Collin-Dufresne et al. (2001) argue that business climate change is a significant determinant of credit spreads. Superficially, the negative relationship might be due to investors' perception of economic growth and risk related to business cycles. During a period of economic expansion, interest rates generally gradually rise, and as the economic environment continues to improve, corporate risk largely goes down and corporate bond default risk premiums tend to decrease, thus lowering credit spreads. Conversely, during a period of economic contraction, interest rates are likely gradually decreased by the Federal Reserve, and as the economic environment keeps worsening, corporate risk goes up and corporate bond default risk premiums generally tend to rise, increasing credit spreads. We further test this intuition by using a two-step procedure. Interest rate and credit spread changes are first made orthogonal to changes in various macroeconomic variables and business cycle effects and are then run through the identification through heteroskedasticity procedure. Our results confirm with high statistical significance that, even when macroeconomic variables and business cycles are excluded from interest rates and credit spreads, a similar negative relationship remains.

This paper casts a fresh eye on the debate over the interest rates - credit spreads relation and contributes to the literature in several ways. First, to the best of our knowledge, this is the first paper to address the endogeneity problem found in the dynamics between credit spreads and interest rates. Second, contrary to the findings of Jacoby et al. (2007), we show the negative relation to be economically and statistically significant and robust for all bond indices, even though the reaction of credit spreads to interest rate changes is indeed slightly lower when callable bonds are excluded from the sample. Our empirical results are in fact consistent with Duffee (1998) and King (2002) in the sense that the negative relation between credit spreads and interest rates is slightly weaker for a bond index without options. However, the fact that the negative relation persists to some extent indicates that the callability feature embedded in callable bonds is alone not able to explain the negative relation.[1] Finally, we examine the business cycle explanation for the negative relationship between interest rates and credit spreads by testing whether the negative relation survives after the macroeconomic variables and business cycle effects are removed, and show that the negative relationship subsists.

The remainder of this paper is organized as follows. Section I introduces the methodology used to identify the parameters through heteroskedasticity and the data employed in the study. Section II describes the different models estimated and the corresponding empirical estimates of the relationship between interest rates and credit spreads. Section III explores the validity of two additional possible explanations for the negative relation, and section IV concludes.

[1] King (2002) estimates that the call option value only makes up about two percent of the par value of the average callable bond.

I. Methodology and data

In this section, we describe the methodology and data used in our empirical tests. The technique used in these different exercises follows Rigobon's (2003) method of identification through heteroskedasticity, a procedure that allows one to account for endogeneity issues and properly capture the interaction between interest rates and credit spreads.

A. Methodology

When empirically estimating the relation between credit spreads and interest rates, one faces an identification challenge since both credit spreads and interest rates are endogenous variables. We address this concern by applying the heteroskedasticity identification method developed by Rigobon (2003). The fundamental idea behind identification through heteroskedasticity is that with structural parameters remaining stable across different regimes, variances of structural shocks in the regimes provide additional restrictions, leading to the identification of the system. The key assumption is that the variances of structural shocks in regimes cannot change proportionally. In order to apply this method successfully, one must therefore ensure that the structural shocks exhibit some non-proportional heteroskedasticity. We first consider a simple bivariate VAR model without common shocks, and subsequently take various macroeconomic common shocks into account as well.

We first establish a structural bivariate VAR system to capture the interaction between interest rates and credit spreads:

$$CS_t = \alpha TB_t + \sum_{k=1}^{n} \xi_k TB_{t-k} + \sum_{k=1}^{n} \theta_k CS_{t-k} + \upsilon_t \tag{1}$$

$$TB_t = \beta CS_t + \sum_{k=1}^{n} \kappa_k CS_{t-k} + \sum_{k=1}^{n} \lambda_k TB_{t-k} + \mu_t \tag{2}$$

where TB_t and CS_t designate the Treasury Bill rates and Corporate Bond credit spreads respectively, and where υ_t and μ_t are the structural shocks for credit spreads and interest rates. The index *k* represents the number of lag terms, α stands for the impact of interest rates on credit spreads, and β represents the interest rate sensitivity to credit spreads. The contemporaneous reaction of credit spreads to interest rates, α, is the parameter in which we are most interested.

It is however well known that these coefficients cannot be estimated directly due to the endogeneity of the regressors. The usual approach to get around an endogeneity issue is to impose an instrumental variable or additional parameter restriction (for instance, an exclusion restriction, a sign restriction, or a long-run restriction). In this case, however, it is challenging to find an instrumental variable affecting only interest rates and not credit spreads, for the simple reason that both interest rates and credit spreads are both influenced by a set of common macroeconomic factors. No economic or finance theory can help impose additional restrictions in this case. In order to deal with these endogeneity issues, one must therefore resort to an alternative identification technique. The heteroskedasticity in the residuals of interest rates and credit spreads is used here to identify the α and β parameters.

If we insert $\mathrm{TB_t}$ in (2) into (1) and $\mathrm{CS_t}$ in (1) into (2), respectively, we obtain the reduced-form equations (3) and (4):

$$CS_t = \frac{1}{1-\alpha\beta}[\sum_{k=1}^{n} (\alpha\lambda_k + \xi_k) TB_{t-k} + \sum_{k=1}^{n} (\alpha\kappa_k + \theta_k) CS_{t-k} + (\alpha\mu_t + \upsilon_t)] \tag{3}$$

$$TB_t = \frac{1}{1-\alpha\beta}[\sum_{k=1}^{n}(\beta\xi_k + \lambda_k)TB_{t-k} + \sum_{k=1}^{n}(\beta\theta_k + \kappa_k)CS_{t-k} + (\mu_t + \beta\upsilon_t)] \tag{4}$$

where $\frac{1}{1-\alpha\beta}(\alpha\mu_t + \upsilon_t)$ and $\frac{1}{1-\alpha\beta}(\mu_t + \beta\upsilon_t)$ are the residuals of the reduced-form equations (3) and (4).

Based on the reduced-form VAR system, we can estimate the variance-covariance matrix of equations (3) and (4) determined by:

$$\Omega = \frac{1}{(1-\alpha\beta)^2}\begin{pmatrix} \sigma_\upsilon^2 + \alpha^2\sigma_\mu^2 & \beta\sigma_\upsilon^2 + \alpha\sigma_\mu^2 \\ & \beta^2\sigma_\upsilon^2 + \sigma_\mu^2 \end{pmatrix} \tag{5}$$

The variance-covariance matrix offers three equations, while there are four parameters to be estimated: $\alpha, \beta, \sigma_\upsilon^2, \text{and } \sigma_\mu^2$. The system is clearly under-justified and at least one additional equation is required to identify the system. We consider two regimes based on the different variance characteristics of the two structural shocks μ_t and υ_t. However, it is necessary to assume that the α and β parameters remain stable across the different regimes and that the structural shocks are not correlated. For each regime, we have:

$$\Omega_i = \begin{pmatrix} \Omega_{11,i} & \Omega_{12,i} \\ & \Omega_{22,i} \end{pmatrix} = \frac{1}{(1-\alpha\beta)^2}\begin{pmatrix} \sigma_{\upsilon,i}^2 + \alpha^2\sigma_{\mu,i}^2 & \beta\sigma_{\upsilon,i}^2 + \alpha\sigma_{\mu,i}^2 \\ & \beta^2\sigma_{\upsilon,i}^2 + \sigma_{\mu,i}^2 \end{pmatrix} \tag{6}$$

where each regime is represented by i = {1,2}

There are six equations provided by the variance-covariance matrices in the two regimes and six unknown parameters: $\alpha, \beta, \sigma_{\upsilon,1}^2, \sigma_{\upsilon,2}^2, \ \sigma_{\mu,1}^2, \text{and } \sigma_{\mu,2}^2$. If the six equations are independent, then the parameters are just-identified. Solving from matrix (6), $\alpha \text{ and } \beta$ must satisfy:

$$\alpha = \frac{\Omega_{12,i} - \beta\Omega_{11,i}}{\Omega_{22,i} - \beta\Omega_{12,i}} \tag{7}$$

where i= {1,2}

The β parameter can then be solved from the following equation:

$$(\Omega_{11,1}\Omega_{12,2} - \Omega_{12,1}\Omega_{11,2})\beta^2 - (\Omega_{11,1}\Omega_{22,2} - \Omega_{22,1}\Omega_{11,2})\beta + (\Omega_{12,1}\Omega_{22,2} - \Omega_{22,1}\Omega_{12,2}) = 0. \tag{8}$$

Rigobon (2003) shows that the α and β parameters can be consistently estimated from the variance-covariance matrices of the two regimes.[2] It is worth noting that consistency can be still achieved under some misspecification of the heteroskedasticity.[3] In this paper, we estimate these parameters using Hansen's (1982) Generalized Method of Moments (GMM). To address potential small-sample bias concerns, we additionally implement a bootstrapping procedure and report the bootstrapped p-values for each estimate. The bootstrapping procedure involves simulating historical data for the variables and then using these simulated time series to generate the parameters distributions through the same estimation method applied to actual historical data. Our bootstrapping procedure consists of the following four steps. First, we begin by estimating the VAR system described in equations (3) and (4) and store the reduced-form residuals for resampling. Then the parameter α and β are estimated by GMM using the identification through heteroskedasticity method. Second, we randomly draw from the stored residuals in each regime and generate two bootstrapped time series $\widehat{\mathrm{CS}}_\mathrm{t}$ and $\widehat{\mathrm{TB}}_\mathrm{t}$ in the reduced-form VAR system. In the third step, using the bootstrapped series $\widehat{\mathrm{CS}}_\mathrm{t}$ and $\widehat{\mathrm{TB}}_\mathrm{t}$, we re-estimate the α and β parameters via the identification through heteroskedasticity procedure.

[2] See proposition 1 in Rigobon (2003, pp. 780).
[3] See proposition 3 and 4 in Rigobon (2003, pp.783-784).

The fourth step involves repeating steps 2 and 3 one thousand times and storing the bootstrapped parameter estimate α for each iteration. Finally, the bootstrapped p-values of the α parameter are reported.

Interest rates time series are known to exhibit fairly long up and down swing patterns. Figure 1 shows that the variations in interest rates are largely upward before 1981 and largely downward after 1981. Figure 1 also already hints graphically at the inverse nature of the relationship between interest rates and credit spreads, particularly during recessions. This pattern suggests that interest rates have both a slow mean-reverting component[4] and a more rapid (business-cycle-length) mean-reverting element. In order to capture the slow mean-reverting effect, we follow Fama (2006) and consider three approaches. The first approach is to add a dummy variable D in the VAR system in equations (1) and (2). The dummy variable D is equal to one for data before August 1981 (when interest rates peak), and zero otherwise. This interest rate dummy variable enables us to distinguish between upward and downward periods, and the equations become:

$$CS_t = \alpha TB_t + \sum_{k=1}^{n} \xi_k TB_{t-k} + \sum_{k=1}^{n} \theta_k CS_{t-k} + \phi_1 D_t + v_t \tag{9}$$

$$TB_t = \beta CS_t + \sum_{k=1}^{n} \kappa_k CS_{t-k} + \sum_{k=1}^{n} \lambda_k TB_{t-k} + \psi_1 D_t + \mu_t \tag{10}$$

The second approach is to decompose interest rates into a long-term expected value (K_t) measured as a five-year moving average of interest rates, and a local mean-reverting component (X_t), measured as the difference between current interest rates (TB_t) and the long-term mean-

[4] There are slightly differing opinions on the slow mean reversion of interest rates. Duffee (2002) interprets the slow mean reversion of interest rates as a result of a near-permanent shock, while Fama (2006) argues that it is due to a permanent shock.

reverting level (K_t). Adding X_t into the VAR system allows us to take into account the local mean-reverting effect, yielding the following system:

$$CS_t = \alpha TB_t + \sum_{k=1}^{n} \xi_k TB_{t-k} + \sum_{k=1}^{n} \theta_k CS_{t-k} + \phi_2 X_t + \upsilon_t \qquad (11)$$

$$TB_t = \beta CS_t + \sum_{k=1}^{n} \kappa_k CS_{t-k} + \sum_{k=1}^{n} \lambda_k TB_{t-k} + \psi_2 X_t + \mu_t \qquad (12)$$

The third approach is to combine the first two. Including a dummy variable and a local mean-reverting component yields the following equations:

$$CS_t = \alpha TB_t + \sum_{k=1}^{n} \xi_k TB_{t-k} + \sum_{k=1}^{n} \theta_k CS_{t-k} + \phi_1 D_t + \phi_2 X_t + \upsilon_t \qquad (13)$$

$$TB_t = \beta CS_t + \sum_{k=1}^{n} \kappa_k CS_{t-k} + \sum_{k=1}^{n} \lambda_k TB_{t-k} + \psi_1 D_t + \psi_2 X_t + \mu_t \qquad (14)$$

In the above bivariate VAR model we assume that the structural shocks are orthogonal, implying that the structural VAR system does not allow common shocks. Rigobon (2003) demonstrates that in a bivariate VAR setting with unobservable common shocks, heteroskedasticity alone will not be sufficient to achieve identification. Additionally, failing to take these common shocks into account may lead to spurious estimations. We therefore proceed to achieve identification through heteroskedasticity and the use of additional observable common shocks, since many studies in the literature have shown that macroeconomic variables affect both interest rates and credit spreads (Altman, Brady, Resti, and Sironi (2005), Ang and Piazzesi (2003), Langstaff and Schwartz (1995) and Wu and Zhang

(2008) to name a few). We select inflation, unemployment rate, economic growth, personal income, consumer expenditure, and stock market excess returns as the main common shocks.

B. Data

We obtain monthly yields on Barclay bond indices from Datastream and 3-month Treasury bill rates, 5-year Treasury bond yield and 10-year Treasury bond yield from the Saint Louis Federal Reserve, with the corporate bond investment-grade index spanning from 1973.1 to 2014.12 and the corporate bond high-yield index spanning from 1987.1 to 2014.12. In order to test whether the callability feature of bonds might be responsible for the negative relation between interest rates and credit spreads, we also use the Bank of America - Merrill Lynch Aggregate Corporate Bond Index and the Corporate Bond Index that specifically excludes Yankee and optionable bonds, with data spanning from 1995.1 to 2014.12. Although some studies sometimes focus on individual corporate bond yields in order to explore the cross-sectional dimensions of credit spreads, we follow another branch of the literature (for instance Longstaff and Schwartz (1995), Morris, Neal and Rolph (1998), Davies (2008), Jacoby, Liao and Batten (2009) or Neal, Rolph, Dupoyet and Jiang (2015)) and use bond indices because Rigobon's (2003) heteroskedasticity identification method is not a cross-sectional approach and requires long times series of data that would otherwise not be available with individual bonds.

The Consumer Price Index (CPI), Unemployment Rate (UER), Industrial Productivity Index (IPI), Personal Disposable Income (PDI) and Personal Consumer Expenditure (PCE) are obtained from the Saint Louis Federal Reserve. The UER, IPI, PDI, and PCE are monthly percentage changes of the respective variables. Inflation (INF) is the CPI monthly percentage change. Stock market excess returns (RMRF) are the value-weighted returns on all NYSE, AMEX, and NASDAQ stocks (from CRSP) minus the one-month Treasury bill rate. Macroeconomic common shocks are measured as residuals of AR(1) processes fitted to each macroeconomic variable.

Insert Table [I]

II. Relationship between interest rates and credit spreads

A. Properties of interest rates and credit spreads

Table I summarizes the monthly statistics for Treasury rates, credit spreads for investment-grade and high-yield bonds, inflation rates, CRSP value-weighted market excess returns, the Unemployment Rate, Industrial Productivity Index, Personal Disposable Income, Personal Consumer Expenditure, and in some cases their respective first differences or percentage changes. Treasury bill rates exhibit a wide spectrum of levels, ranging from 0.01% to 16.3%, with their first differences indicating fairly gradual monthly changes averaging about -0.01% per month, extending from -4.62% (an extreme outlier in May of 1980) to 2.61%. The Treasury bill rate is highly persistent; its first-order autoregressive AR(1) coefficient is 0.992. The different measures of credit spreads with different interest rates and different corporate bond rates also exhibit a substantial degree of persistence; the AR(1) coefficients range from 0.914 to 0.969. Monthly average inflation is about one third of a percent with a fairly tight range, while monthly stock market excess returns - although on average close to half a percent - experience a very large array of values ranging from -23% to 16%.

We then test for the presence of a unit root in both the interest rates and credit spreads time series. Table II reports the results for the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests with a constant and a trend. The null hypothesis of a unit root is weakly rejected at the 10 percent significance level for Treasury rates in both ADF and PP tests. For investment-grade credit spreads, the hypothesis of unit root is rejected at the 1 percent significance in both ADF and PP tests. For high-yield credit spreads, the ADF test tends to reject the unit root hypothesis while the PP test does not. Overall, the unit root tests yield mixed results. It is well known that standard unit root tests can lack power (a type II error), and while the results in Table II do not indeed provide a definite conclusion, they generally do tend to reject the unit root hypothesis. Since a non-stationary process implies an explosive volatility structure over time, Joutz, Mansi and Maxwell (2001) argue that interest rates and credit spread cannot plausibly be non-stationary over long periods of time. Facing a similar issue on the time-series properties of book-to-market ratios, Vuolteenaho (2000) states "I am forced to base the stationarity assumption more on economic intuition than on the clear-cut rejection of unit root tests." However, simulations in Granger and Newbold (1974) also show that statistically significant results and high R^2 values can be obtained when two unrelated but highly persistent time series are regressed on one another, indicating that failing to take their persistence into account could lead to spurious conclusions. Granger and Newbold (1974) suggest that the rule should rather be to work with both levels and changes, and to subsequently interpret the combined results. Following Granger and Newbold (1974), we therefore use both levels and changes of interest rates and credit spreads in our estimations. The results with levels and changes are similar. In the interest of space, we report the results pertaining to the changes in interest rates and credit spreads and leave the results with levels available upon request.

Insert Table [II]

B. Relation between changes in interest rates and credit spreads: The base model

We begin with the base model without common shocks. The first step is to estimate the residual vector $[(\alpha\mu_t + \upsilon_t)/(1-\alpha\beta), (\mu_t + \beta\upsilon_t)/(1-\alpha\beta)]'$ of the reduced-form bivariate VAR model in equations (3) and (4). Using the Bayesian Information Criterion, we identify a number of three lags as optimal for the investment-grade bond VAR, and a number of two lags for the high-yield bond VAR. The heteroskedasticity identification approach is motivated by the different variances of the residual vectors under different regimes. The key element in the identification process is to divide the sample into different regimes. Volatility regimes can be split in a variety of ways, all appropriate as long as the ratio of the variance of interest rate shocks in regime one ($\Omega_{11,1}$) to the variance of interest rate shocks in regime two ($\Omega_{11,2}$) remains different from the ratio of the covariance between interest rate shocks and credit spreads shocks in regime one ($\Omega_{12,1}$) to the covariance between interest rate shocks and credit spreads shocks ($\Omega_{12,2}$) in regime two. One implication is that if interest rate shocks become more volatile, the reaction of credit spreads to those interest rates will have a larger effect on the covariance between interest rates and credit spreads.

We define regimes according to the size and direction of the variance of the residuals in the reduced-form model, with the different regimes affecting the coefficients in distinct ways. Interest rates and credit spreads are in regime I when both shocks are above one standard deviation over the mean. Interest rates and credit spreads are in regime II when both shocks are below one standard deviation under the mean. Finally, interest rates and credit spreads are in regime III when both shocks are within one standard deviation of the mean. Regimes I and II both capture high volatility regions of the distribution, with regime I pertaining to the upper tail and regime II to the lower tail of the distribution, while regime III captures the lower volatility region of the distribution. There are therefore two possible subsets associated with these three regimes, denoted from here on as [regime I&III] and [regime II&III]. Adopting this regime segregation method allows the capturing of the asymmetric effects of shocks on the interest rate-credit spread relation. Additionally, the different standard deviations of interest rates and credit spreads provide favorable conditions for an estimation through heteroskedasticity since the variances of interest rate shocks and credit spread shocks are not proportional. If the identification through heteroskedasticity approach performs well, results from an estimation based on Regime I&III should be very similar to those of an estimation based on Regime II&III. The estimates from these two subsets are shown in Table III.

Insert Table [III]

Table III reports results associated with the four models estimated on the investment-grade corporate bond index and the two models estimated on the high-yield bond index using changes in interest rates and credit spreads. We do not implement the dummy variable for high-yield bonds (Panel B) since our sample for the high-yield bond index starts in September of 1981 only. Table III shows that interest rates have a significant impact on credit spreads for both investment-grade and high-yield bonds. In Panel A, for investment-grade bonds, under Regime I&III the estimated α (credit spreads' reaction to interest rates) is -0.950 with a t-statistic of -9.716 and a bootstrapped p-value of 0.000 in the base model, -0.944 with a t-statistic of -9.461 and a bootstrapped p-value of 0.001 when adding the dummy variable to the base model, -0.935 with a t-statistic of -9.168 and a bootstrapped p-value of 0.001 when adding the local mean-reverting variable to the base model, and -0.934 with a t-statistic of -9.158 and a bootstrapped p-value of 0.001 when adding both the dummy and the local mean-reverting variables to the base model. These results appear to confirm a significantly negative relation between credit spreads and interest rates, including when the time-series behavior of interest rates is being taken into account. Under Regime II&III, our results show that the estimates are quantitatively similar to the estimates obtained under Regime I&III, suggesting the identification through heteroscedasticity approach is robust.

In Panel B, for high-yield bonds under Regime A, credit spreads' reaction to interest rates is -2.498 with a t-statistic of -3.865 and a bootstrapped p-value of 0.015 in the base model, and -2.649 with a t-statistic of -3.729 and a bootstrapped p-value of 0.025 when including the local mean-reverting variable to the base model. The relation is again similar under Regime II&III, suggesting that the estimation is valid and robust to both types of bonds and volatility regimes.

It is also worth noting that high-yield bond credit spreads additionally display a higher sensitivity to interest rates than investment-grade bond credit spreads do, a result consistent with the ubiquitous risk-return tradeoff and with Ericsson and Oviedo (2009).

As a robustness check, we also perform all estimations using levels of interest rates and credit spreads. When using levels instead of their changes, we continue to observe a robust negative reaction of credit spreads on interest rates in all cases, with estimated parameters statistically significant at the 1% level.

C. Relation between changes in interest rates and credit spreads, with common shocks and business cycle dummy

In the bivariate structural VAR model, we assume the structural shocks to be orthogonal to interest rates and credit spreads. However, confounding macroeconomic factors can have a simultaneous influence on both interest rates and credit spreads. In this subsection, we relax the orthogonality assumption by taking a set of common shocks M_t and a business cycle dummy BC_t into account and once again empirically estimate the impact of interest rates on credit spreads. For this exercise, we select the following macroeconomic variables: the Inflation Rate (INF), Unemployment Rate (UER), Industrial Productivity Index (IPI), Personal Disposable Income (PDI), Personal Consumer Expenditures (PCE), and Excess Stock Market Returns (RMRF). The common shocks are measured by the residuals of an AR (1) model fitted to each macroeconomic variable. The business cycle dummy is equal to one for recession periods and to zero for expansionary periods according to NBER business cycle dates. For comparison purposes, we adopt the same regime segregation approach as in the previous section, and present results in Table IV.

Insert Table [IV]

Table IV shows that the negative relation between interest rates and credit spreads still holds when accounting for common macroeconomic shocks and the effect of business cycles. In Panel A, for investment-grade bonds, under Regime I&III the estimated α (credit spreads' reaction to interest rates) is -0.979 with a t-statistic of -12.075 and a bootstrapped p-value of 0.000 with the macroeconomic variables added to the base model, -0.973 with a t-statistic of -11.715 and a bootstrapped p-value of 0.000 when adding the business cycle dummy variable to the base model, -0.992 with a t-statistic of -12.221 and a bootstrapped p-value of 0.000 when adding both the business cycle dummy and the macroeconomic variables to the base model.

In Panel B, for high-yield bonds, under Regime I&III, the credit spreads' reaction to interest rates is -2.990 with a t-statistic of -4.046 and a bootstrapped p-value of 0.012 when the macroeconomic shock are added into the base model and -2.800 with a t-statistic of -3.259 and a bootstrapped p-value of 0.031 when including business the cycle dummy variable to the base model, -3.163 with a t-statistic of -4.141 and a bootstrapped p-value of 0.009 when adding both the business cycle dummy and the macroeconomic variables to the base model. Finally, just like in Table III, the results under Regime II&III suggest that the relation between credit spreads and interest rates is quantitatively similar to the relation estimated under Regime I&III. The presence of common macroeconomic shocks and the effect of business cycles thus do not appear to significantly affect the relation between interest spreads and credit spreads.

III. Explanations for the negative relation, reexamined

A. The callability feature

Given the economic and statistically significant negative relation between credit spreads and interest rates, we next begin to investigate its possible drivers. Duffee (1998) reports that the negative relation between interest rates and credit spreads is weakened when the callability option is excluded from the corporate bond pool, and argues that the callability feature is a non-negligible concern in the negative relation due to the fact that corporate bond indices usually contain a large portion of callable bonds. Jacoby, Liao and Batten (2007) use a Canadian bond index devoid of any callability characteristics and find no significant relation between interest rates and corporate bond credit spreads. Our additional findings that the impact of interest rates on high-yield bond credit spreads is two to three times larger than on investment-grade bond credit spreads seems consistent with the fact that callable bonds make up less than 1% of the investment-grade bonds pool while they make up about 70% of the high-yield bonds pool (see Aneiro, 2014). Our conclusions thus at first appear to be in line with the results in Jacoby, Liao and Batten (2007). However, King [2002] finds that the call option value constitutes only around 2 percent of the par value of the average callable bond, implying that given the small contribution of the callability feature to the bond value, it would seem unlikely that this aspect of the bond would alone be responsible for the negative correlation between credit spreads and interest rates.

To further explore whether the callability embedded in bond index might be a possible explanation for the large sensitivity of credit spreads to interest rates, we conduct estimations and tests on both the Bank of America - Merrill Lynch aggregate corporate bond index and the aggregate corporate bond index that excludes Yankee and optionable bonds, and compare the results. The sample of Bank of America – Merrill Lynch data extends from January 1995 to December 2014. We adopt the same regime separation methodology as in the previous sections, and report the results in Table V.

Insert Table [V]

Table V shows that, when using a corporate bond index that excludes Yankee and optionable bonds, credit spreads still respond negatively to interest rates. Under Regime I&III, the reaction of credit spreads to interest rates for the aggregate corporate bond index (with options) is -1.941 with a bootstrapped p-value of 0.139, while the reaction of credit spreads to interest rates for the aggregate corporate bond index that excludes Yankee bonds and optionable bonds is -1.921 with a bootstrapped p-value of 0.105. Under Regime B, the results are quantitatively similar, with all estimates statistically significant at the 1% level. Our findings are thus consistent with King's (2002) since the difference between option-embedded and option-free bonds is minimal: the α parameter percentage difference between the corporate bond index with and without callable bonds is actually across regimes an average value of 2 percent. We can therefore conclude that a possible callability feature would not appear to affect the relation between credit spreads and interest rates much.

B. Business cycles

Now that the callability of corporate bonds has been excluded as a possible culprit for the negative response of credit spreads to interest rates, we reexamine an alternative explanation and focus on the negative relation between interest rates and credit spreads from a business cycles point of view. Davies (2008) uses a regime-switching model to capture business cycle transitions and shows that the negative relationship exists independently across different inflationary environments. Delianedis and Geske (2001) conclude that credit risk and credit spreads are not primarily attributable to default and recovery risk but are mainly due to tax, liquidity, and market risk factors. Wu and Zhang (2008) identify fundamental risk dimensions such as inflation, real output growth, and financial market volatility; they show that positive shocks to real output growth increase Treasury yields but narrow credit spreads at low credit-rating classes, thereby generating negative correlations between interest rates and credit spreads. Nielsen (2012) develops a structural credit-risk model that includes both business cycles and jump risk to show how the interaction between these two factors can explain business cycles variation in short- and medium-term credit spreads. In another attempt to link credit spreads to business cycles, Gilchrist and Zakrajsek (2012) decompose the credit spread into an expected default component and an excess bond premium, and show that an increase in the latter causes a contraction in the credit supply and a deterioration of macroeconomic conditions. Lastly, Barnea and Menashe (2014) extend Gilchrist and Zakrajsek (2012)'s work by applying their methodology to the banking sector and reach similar conclusions.

In a recession, the Federal Reserve usually gradually decreases the federal funds rate as an attempt to stimulate investments (until things turn around). Simultaneously, the worsening of the economy increases the risk of a firm through several mechanisms. From an operational point of view, sales conditions in a recession get worse due to the lower demand for consumption, and uncertainty increases. From a financial point of view, the poor economic environment makes it more difficult for the firm to obtain external financing and raises financing costs. Therefore, the increase in the firm's risk leads to a widening of the firm's corporate bonds' credit spreads. Consequently, when interest rates are decreasing, one can on average expect credit spreads to be on the rise. Conversely, in a period of economic expansion, the Federal Reserve tends to gradually increase the federal funds rate as a way of keeping inflation under control and preventing the economy from overheating. At the same time, this economic growth progressively leads to a decrease in the firm's risk both from an operational point of view (higher sales and lower uncertainty) and through decreased financing risk and costs, ultimately resulting in a narrowing of its corporate bonds' credit spreads. Therefore, when interest rates are increasing, one should on average expect credit spreads to be on the decline.

We first use the business cycle dates reported by the National Bureau of Economic Research (NBER) to investigate the general directions of interest rates and credit spreads during contraction and expansion periods. We report the average changes in interest rates and credit spreads for the overall sample, as well as for separate periods of contractions and expansions for investment-grade and high-yield bonds in Table VI.

Insert Table [VI]

In the full sample, for both investment-grade and high-yield bonds, average changes in interest rates and credit spreads are not statistically significantly different from zero. However, during periods of economic contractions, the average change in interest rates is statistically significantly negative and the average change in credit spreads is statistically significantly positive. Conversely, during periods of economic expansion, the average change in interest rates is positive and the average change in credit spreads is negative. For investment-grade bonds, all results are statistically significant at the 5% level. For high-yield bonds, although the signs of the estimated coefficients are in line with our business cycle proposition, the 5% significance level is not met. This might be explained by the fact that a junk bond already displaying a high credit spread will most likely not see its credit spread increase tremendously even in recessionary periods since its credit premium is already high. Conversely, the same high-yield bond will not see its credit spread decrease tremendously even during expansionary periods since the firm remains a somewhat default-prone one in general.

Overall, the results found in Table VI appear to support the idea that the negative relationship between interest rates and credit spreads could simply be due to their timing with respect to business cycles. However, mere synchronicity does not necessarily indicate that business cycles actually cause the negative relation. We further investigate whether the negative relationship originates from the business climate using a two-step approach that considers both macroeconomic variables and NBER business cycle dates. In a first step, we regress changes in credit spreads and interest rates on a set of macroeconomic variables and a business cycle dummy as described by the following two equations:

$$\Delta CS_t = const. + b_1 M_t + b_2 BC_t + \varepsilon_{cs} \tag{15}$$

$$\Delta TB_t = const. + b_1 M_t + b_2 BC_t + \varepsilon_{tb} \tag{16}$$

where M_t represents the six macroeconomic variables previously defined and where BC_t is a business cycle dummy equal to one or zero for recession and expansion periods.

Equations (15) and (16) are run alternatively with only the macroeconomic variables, only the business cycle dummy, or both. From these we are then able to back out two sets of residuals ε_{cs} and ε_{tb} that can now be seen as interest rate and credit spread changes devoid of macroeconomic interferences, business cycles effects, or both. In a second step, we estimate the contemporaneous relation between ε_{cs} and ε_{tb} by means of the identification through heteroskedasticity methodology. In a nutshell, equations (1) through (8) are revisited where ΔCS_t and ΔTB_t are now replaced with ε_{cs} and ε_{tb}. For comparison purposes, we adopt the same regime segregation approach as in the previous sections, and present results in Table VII.

Insert Table [VII]

Focusing on regime I&III, when the six macroeconomic variables are used in equations (15) and (16) alone, for investment-grade bonds (Panel A) the estimated α (credit spreads' reaction to interest rates) is -1.007 with a t-statistic of -13.045 and a bootstrapped p-value of 0.000, while for high-yield bonds (Panel B) the estimated α is -2.928 with a t-statistic of -4.022 and a bootstrapped p-value of 0.012. With only the business cycle dummy present in equations (15) and (16), the estimated α for investment-grade bonds is -0.942 with a t-statistic of -12.923 and a bootstrapped p-value of 0.000, while for high-yield bonds it is -2.835 with a t-statistic of -3.130 and a bootstrapped p-value of 0.034. Finally, when macroeconomic variables and business cycle effects are all removed, the negative response of credit spreads to interest rates does not vary much. For investment-grade bonds the estimated α is -0.994 with a t-statistic of -13.090 and a bootstrapped p-value of 0.002, while for high-yield bonds the credit spreads' reaction to interest rates is -3.153 with a t-statistic of -4.159 and a bootstrapped p-value of 0.006. Additionally, just like in Table III, the results under Regime II&III suggest that the relation between credit spreads and interest rates is quantitatively similar to the relation estimated under Regime I&III. These findings thus lead us to conclude that common macroeconomic shocks and business cycles are not the main drivers of the negative relation between interest spreads and credit spreads.

C. Term structure of interest rates

In the above analysis, following the existing literature, we constructed credit spreads as the difference between corporate bond indices yields and three-month Treasury bill rates. However, the measure of credit spreads clearly contains a term spread and it could consequently be reasonably argued that the negative relation found above could be due to the reaction of the term spread to interest rates. We therefore run a robustness test using the 5-year treasury constant maturity rate and the 10-year treasury constant maturity rate in the construction of the credit spread.[5] This exercise additionally helps us understand the potentially different reactions of credit spreads to changes in interest rates of different maturities. We thus construct the two credit spreads series as:

CS_IG/HY_5Y = IG/HY Corporate Bond Yield – 5-year Treasury Bond Yield

CS_IG/HY_10Y = IG/HY Corporate Bond Yield – 10-year Treasury Bond Yield

Table VIII and table IX report results associated with the four models estimated on the investment-grade corporate bond index and the two models estimated on the high-yield bond index with credit spreads computed using 5-year and 10-year Treasury bond yields. The negative relation between credit spreads and interest rates is robust when we control for the term spread. The two estimates are similar and help us reaffirm the negative relationship between interest rates and credit spreads.

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[5] We do not use 20-year and 30-year treasury bond rates because of discontinuities in the data. The department of Treasury states that "Treasury discontinued the 20-year constant maturity series at the end of calendar year 1986 and reinstated that series on October 1, 1993. As a result, there are no 20-year rates available for the time period January 1, 1987 through September 30, 1993." It also states that "30-year Treasury constant maturity series was discontinued on February 18, 2002 and reintroduced on February 9, 2006".

Insert Table [VIII] [IX]

Taking business cycle and macroeconomics variables into consideration, we estimate the reaction of credit spread to changes in interest rates using the same method. Table X and table XI show that the negative relation between interest rates and credit spreads using 5-year and 10-year Treasury bond yields still holds when accounting for common macroeconomic shocks and the effect of business cycles.

Insert Table [X] [XI]

To rule out the fact that the callability feature embedded in bond indices might be a possible explanation for the large sensitivity of credit spreads to interest rates, we also conduct an analysis on the Bank of America - Merrill Lynch aggregate corporate bond index and the aggregate corporate bond index that excludes Yankee and optionable bonds, using both the 5-year Treasury bond yield and the 10-year Treasury bond yield. Table XII and Table XIII report results similar to those found in Table V.

Insert Table [XII] [XIII]

Lastly, to examine whether macroeconomic variables and/or business cycle contribute to the negative relation, we also estimate the contemporaneous relation between shocks ε_{cs} and ε_{tb} that are independent of macroeconomic variables and/or business cycles, as we did in Table VII. The results are reported in Table XIV and Table XV. As with the results reported in Table VII, we find that even when macroeconomic variables and business cycles are accounted for, the negative relation between credit spreads and interest rates persists.

Insert Table [XIV] [XV]

IV. Conclusion

The relationship between interest rates and credit spreads is of paramount importance to portfolio and risk managers since both the size and the direction of credit spreads' reactions to changes in Treasury yields determine the sign and magnitude of subsequent corporate bond price movements. In this paper we reexamine the relation between government rates and corporate credit spreads by applying Rigobon's (2003) method of identification through heteroskedasticity to the issue. We find significant and robust evidence of a negative reaction of credit spreads to interest rates, in line with Merton's (1974) structural model predictions. We also show that our results are robust to a variety of factors related to the time-series properties of interest rates such as the presence of permanent (or near-permanent) shocks and their low speed of mean reversion, varying volatility regimes, different corporate bond ratings, and various macroeconomic variables affecting the economy as a whole.

Additionally, by testing the relation using a corporate bond index devoid of callable bonds, we are also able to rule out the callability feature of corporate bonds as the main factor behind the negative correlation between Treasury rates and corporate credit spreads. We additionally show that although business cycles at first appear to be the likely culprit for the relation, macroeconomic and business conditions are in fact ruled out as a possible explanation. Lastly, the term spread does not change the negative relation either. Overall, we empirically demonstrate that the response of credit spreads to interest rates remains statistically significantly negative even when the effects of business cycles and a set of macroeconomic variables are removed from the credit spreads and Treasury yields time series.

Appendix

The price of a bond B yielding a rate y and paying n coupons C_i at various times t_i can be expressed with continuous compounding as

$$B = \sum_{i=1}^{n} c_i e^{-yt_i} \tag{A1}$$

The corresponding duration D of the bond is

$$D = \sum_{i=1}^{n} t_i \frac{c_i e^{-yt_i}}{B} \tag{A2}$$

If we express the bond yield y as the sum of the risk-free rate r and a credit spread $cs(r)$, the bond price can instead be written as

$$B = \sum_{i=1}^{n} c_i e^{-(r+cs(r))t_i} \tag{A3}$$

Differentiating the bond price with respect to the risk-free rate r rather than to the yield y gives

$$\frac{dB}{dr} = -\sum_{i=1}^{n} c_i t_i \left(1 + \frac{d[cs(r)]}{dr}\right) e^{-yt_i} \tag{A4}$$

Combining equations (A2) and (A4), it is straightforward to show that

$$\frac{dB}{dr} = -DB\left(1 + \frac{d[cs(r)]}{dr}\right) \quad \text{(A5)}$$

Equation (A5) implies that there are three theoretical possible cases.

First, if credit spreads respond positively to an increase in interest rates, the derivative term inside the parentheses in (A5) will be positive and the term in parentheses will be higher than one. The bond yield will thus increase by more than the increase in the risk-free rate since both of its components go up, and the bond price will therefore fall by more than it would if credit spreads and interest rates were uncorrelated.

Second, if credit spreads on average do not respond in either direction to an increase in interest rates, the derivative term inside the parentheses in (A5) will be equal to zero and the term in parentheses will be equal to one. Equation (A5) then collapses to the traditional relation between bond price changes and duration. The bond yield will increase by exactly the same amount as the risk-free rate since the credit spread or risk premium is unaffected, and the bond price will therefore fall accordingly.

Finally, if credit spreads respond negatively to an increase in interest rates, the derivative term inside the parentheses in (A5) will be negative and of the following values or range:

- Strictly between 0 and -1 and the term in parentheses will still be positive. The bond yield will thus increase by less than the increase in the risk-free rate since one of its components (the risk-free rate) goes up while the other (the credit spread) goes down by a lesser amount. The bond price will therefore fall by less than it would if credit spreads and interest rates were uncorrelated.

- Equal to -1 and the term in parentheses will be equal to zero. The bond yield will thus stay the same since one of its components (the risk-free rate) goes up while the other (the credit spread) goes down by the exact same amount. The bond price will therefore remain the same.

- Strictly less than -1 and the term in parentheses will be negative. The bond yield will thus decrease since one of its components (the risk-free rate) goes up while the other (the credit spread) goes down by more than the former. The bond price will therefore go up.

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Figure 1. Three-month treasury-bill rates and investment-grade credit spreads from 1973.1 to 2014.12

This figure plots 3-month Treasury bill rates and investment-grade credit spreads from January 1973 to December 2014. The rates are expressed in percent and reported at a monthly frequency. The shaded areas are recession periods as defined by NBER.

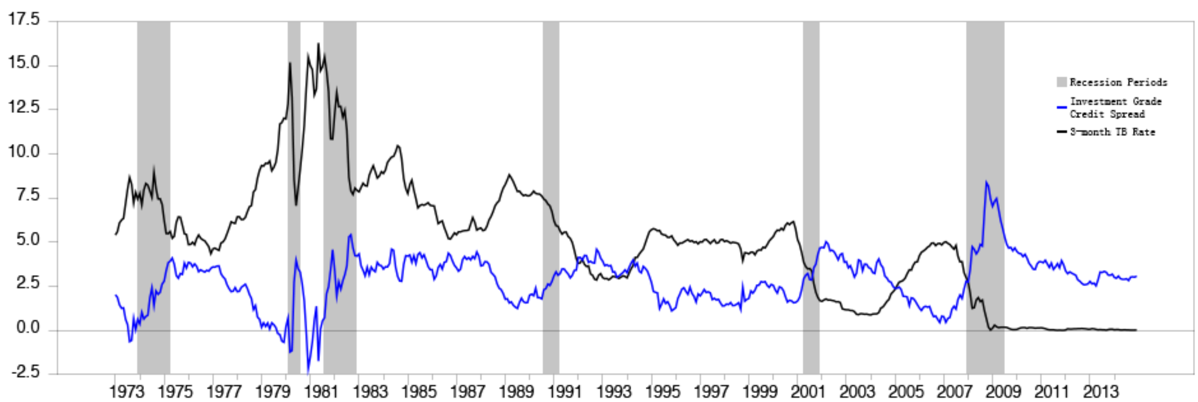

Table I

Descriptive Statistics

Table I summarizes monthly statistics for levels of, and changes in, 3-month Treasury Bill rates (TB), credit spreads for investment-grade bonds using 3-month Treasury bill rates (CS_IG_3M), credit spreads for investment-grade bonds using 5-year Treasury bond yields (CS_IG_5Y), credit spreads for investment-grade bonds using 10-year Treasury bond yields (CS_IG_10Y), credit spreads for high-yield bonds using 3-month Treasury bill rates (CS_HY_3M), credit spreads for high-yield bonds using 5-year Treasury bond yields (CS_HY_5Y), credit spreads for high-yield bonds using 10-year Treasury bond yields (CS_HY_10Y), inflation rate (INF), Fama-French excess market returns (RMRF), unemployment rate (UER), industrial productivity Index (IPI), personal disposable income (PDI) and personal consumer expenditures (PCE). The Δ symbol represents the first difference. The credit spreads are measured as yields of the corporate bond index minus the 3-month Treasury bill rate, the 5-year Treasury bond yield, and the 10-year treasury bond yield. Inflation (INF), extracted from the St. Louis FED, is the one-month percentage change in CPI. The excess return on the market (RMRF), retrieved from the Kenneth R. French – Data Library, is the value-weighted return on the CRSP index minus the one-month Treasury bill rate. Unemployment rate (UER), industrial productivity Index (IPI), personal disposable income (PDI) and personal consumer expenditure (PCE) are the one-month percentage changes for each variable, also obtained from the St. Louis FED. All variables are from January 1973 to December 2014, except CSHY available from January 1987 to December 2014 only.

Variable	Mean	Std. Deviation	Min	Max	AR(1)
TB (%)	5.052	3.440	0.010	16.300	0.992
ΔTB (%)	-0.010	0.484	-4.620	2.610	0.327
CS_IG_3M (%)	2.826	1.412	-2.160	8.380	0.944
ΔCS_IG_3M (%)	0.002	0.472	-3.110	3.860	0.088
CS_IG_5Y (%)	1.498	0.803	-0.070	6.320	0.930
ΔCS_IG_5Y (%)	0.001	0.300	-1.140	1.580	-0.154
CS_IG_10Y (%)	1.088	0.669	0.050	5.240	0.914
ΔCS_IG_10Y (%)	0.000	0.277	-0.960	1.520	-0.205
CS_HY_3M (%)	7.102	2.795	2.420	21.640	0.969
ΔCS_HY_3M (%)	-0.001	0.693	-2.940	5.220	0.346
CS_HY_5Y (%)	5.747	2.609	2.540	19.540	0.964
ΔCS_HY_5Y (%)	-0.002	0.697	-3.030	4.910	0.368
CS_HY_10Y (%)	5.199	2.530	2.310	18.300	0.964
ΔCS_HY_10Y (%)	-0.002	0.679	-3.100	4.640	0.367
INF (% change)	0.341	0.344	-1.771	1.810	0.642
RMRF (%)	0.541	4.596	-23.000	16.010	0.069
UER (%)	6.463	1.572	3.800	10.800	0.993
IPI (% change)	0.180	0.727	-4.208	2.089	0.346
PDI (% change)	0.525	0.792	-5.845	6.163	-0.156
PCE (% change)	0.540	0.546	-2.022	2.770	-0.062

**AR (1) is the estimated coefficient of an AR (1) process with a constant.*

Table II
Unit Root Tests for Levels of Interest Rates and Credit Spreads

Table II reports the results from the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests for both interest rates (TB) and credit spreads using different Treasury maturities (CS_IG and CS_HY for investment-grade and high-yield bonds respectively), along with test statistics and significance levels. The ADF and PP tests include a constant, a linear trend and three lags.

Variable	ADF	PP
TB	-3.165*	-3.285*
CS_IG_3M	-4.080***	-4.117***
CS_IG_5Y	-4.194***	-4.446***
CS_IG_10Y	-4.329***	-4.491***
CS_HY_3M	-3.378*	-2.857
CS_HY_5Y	3.880**	-3.164
CS_HY_10Y	-3.954**	-3.188

*** Significant at the 0.01 level.
** Significant at the 0.05 level.
* Significant at the 0.10 level.

Table III

Relationship between Changes in Interest Rates and Credit Spreads in Two Regimes without Common Macroeconomic Shocks

Table III reports regression estimates of the sensitivity of changes in monthly credit spreads (ΔCS_t) to changes in interest rates (ΔTB_t) for the January 1973 to December 2014 period for two regimes and four different cases, with t-statistics displayed in parentheses and with the "L" index representing up to three lags. The bootstrapped P-values are reported in brackets below the t-statistics. In regime I&III, shocks to interest rates and credit spreads are either average or significantly positive, while in regime II&III they are either average or significantly negative, as defined by their magnitude with respect to a one-sigma deviation from the mean. Case 1 is the base model where the residuals $\alpha\mu_t + \nu_t$ and $+\mu_t+\beta\nu_t$ in the VAR system ($\Delta CS_t=(\alpha\ \Delta TB_L+\theta\ \Delta CS_L + \alpha\mu_t + \nu_t)/(1-\alpha\beta)$ and $\Delta TB_t=(\beta\ \Delta CS_L+\lambda\ \Delta TB_L + \mu_t+\beta\nu_t)/(1-\alpha\beta)$) are estimated without any extra variable(s). Case 2 is the model where the residuals in the VAR system ($\Delta CS_t=(\alpha\ \Delta TB_L+\theta\ \Delta CS_L +\phi_1 D_t + \alpha\mu_t + \nu_t)/(1-\alpha\beta)$ and $\Delta TB_t=(\beta\ \Delta CS_L+\lambda\ \Delta TB_L +\psi_1 D_t +\mu_t+\beta\nu_t)/(1-\alpha\beta)$) are estimated with a dummy variable D_t set to 1 between January 1973 and August 1981 and set to zero between September 1981 and December 2014. Case 3 is the model where the residuals in the VAR system ($\Delta CS_t=(\alpha\ \Delta TB_L+\theta\ \Delta CS_L +\phi_2[TB_t-K_t]+ \alpha\mu_t +\nu_t)/(1-\alpha\beta)$and $\Delta TB_t=(\beta\ \Delta CS_L+\lambda\ \Delta TB_L +\psi_2[TB_t-K_t]+ \mu_t+\beta\nu_t))/(1-\alpha\beta)$) are estimated with a mean-reverting level K_t of interest rates calculated as a 5-year moving average. Case 4 is the model where the residuals in the VAR system ($\Delta CS_t=(\alpha\ \Delta TB_L+\theta\ \Delta CS_L +\phi_1 D_t +\phi_2[TB_t-K_t]+ \alpha\mu_t +\nu_t)/(1-\alpha\beta)$and $\Delta TB_t=(\beta\ \Delta CS_L+\lambda\ \Delta TB_L +\psi_1 D_t +\psi_2[TB_t-K_t]+ \mu_t+\beta\nu_t)/(1-\alpha\beta)$) are estimated with both a dummy D_t and a mean-reverting level K_t. Panel A reports the results for investment-grade bonds, while panel B reports the results for high-yield bonds.

	α (regime I&III)	α (regime II&III)
Panel A: Investment-grade bonds		
Base model	-0.950***	-0.891***
	(-9.716)	(-9.206)
	[0.000]	[0.004]
With dummy (D)	-0.944***	-0.900***
	(-9.461)	(-8.956)
	[0.001]	[0.002]
With mean-reverting variable	-0.935***	-0.891***
$[TB_t - K_t]$	(-9.168)	(-8.573)
	[0.001]	[0.009]
With dummy (D) &	-0.934***	-0.898***
mean-reverting variable	(-9.158)	(-8.590)
$[TB_t - K_t]$	[0.001]	[0.009]
Panel B: High-yield bonds		
Base model	-2.498***	-2.908***
	(-3.865)	(-4.765)
	[0.015]	[0.003]
With mean-reverting variable	-2.649***	-3.648***
$[TB_t - K_t]$	(-3.729)	(-4.217)
	[0.025]	[0.008]

*** Significant at the 0.01 level.
** Significant at the 0.05 level.
* Significant at the 0.10 level.

Table IV

Relationship between Changes in Interest Rates and Credit Spreads in Two Regimes with Common Macroeconomic Shocks

Table IV reports regression estimates of the sensitivity of monthly credit spreads (ΔCS_t) to interest rates (ΔTB_t) for the January 1973 to December 2014 period for two regimes and four different cases, when including M_t macroeconomic shocks obtained as residuals of AR(1) processes fitted to INF_t, $RMRF_t$, UER_t, IPI_t, PDI_t and PCE_t and business cycle dummy(BC), with t-statistics displayed in parentheses and with the "L" index representing up to three lags. The bootstrapped P-values are reported in brackets below the t-statistics. In regime I&III, shocks to interest rates and credit spreads are either average or significantly positive, while in regime II&III they are either average or significantly negative, as defined by their magnitude with respect to a one-sigma deviation from the mean. Case 1 is the model where the residuals $(\alpha\mu_t + \nu_t)/(1-\alpha\beta)$ and $(\mu_t+\beta\nu_t)/(1-\alpha\beta)$ in the VAR system ($\Delta CS_t=(\alpha\ \Delta TB_L+\theta\ \Delta CS_L+\gamma F_t+\alpha\mu_t+\nu_t)/(1-\alpha\beta)$ and $\Delta TB_t=(\beta\ \Delta CS_L+\lambda\ \Delta TB_L+\Gamma M_t+\mu_t+\beta\nu_t)/(1-\alpha\beta)$) are estimated with macroeconomic variable(s). Case 2 is the model where the residuals in the VAR system ($\Delta CS_t=\alpha\ \Delta TB_L+\theta\ \Delta CS_L+\phi_1 BC_t+\gamma M_t+\alpha\mu_t+\nu_t)/(1-\alpha\beta)$ and $\Delta TB_t=(\beta\ \Delta CS_L+\lambda\ \Delta TB_L+\psi_1 BC_t+\Gamma M_t+\mu_t+\beta\nu_t)/(1-\alpha\beta)$) are estimated with a dummy variable BC_t set to 1 for the NBER recession dates and set to zero for others. Case 3 is the model where the residuals in the VAR system ($\Delta CS_t=(\alpha\ \Delta TB_L+\theta\ \Delta CS_L+\phi_1 BC_t+\gamma M_t+\alpha\mu_t+\nu_t)/(1-\alpha\beta)$ and $\Delta TB_t=(\beta\ \Delta CS_L+\lambda\ \Delta TB_L+\psi_1 BC_t+\gamma M_t+\mu_t+\beta\nu_t)/(1-\alpha\beta)$) are estimated with both a business cycle dummy BC_t and macroeconomic shocks M_t . Panel A reports the results for investment-grade bonds, while panel B reports the results for high-yield bonds.

	α (regime I&III)	α (regime II&III)
Panel A: Investment-grade bonds		
Macroeconomic variables (M)	-0.979***	-0.940***
	(-12.075)	(-11.303)
	[0.000]	[0.001]
Business cycle dummy (BC)	-0.973***	-0.986***
	(-11.715)	(-10.485)
	[0.000]	[0.001]
Macroeconomic variables (M)	-0.992***	-0.952***
& business cycle Dummy (BC)	(-12.221)	(-11.443)
	[0.000]	[0.001]
Panel B: High-yield bonds		
Macroeconomic variables (M)	-2.990***	-3.297***
	(-4.046)	(-4.591)
	[0.012]	[0.004]
Business cycle dummy (BC)	-2.800***	-3.356***
	(-3.259)	(-3.364)
	[0.031]	[0.022]
Macroeconomic variables (M)	-3.163***	-3.377***
& business cycle dummy (BC)	(-4.141)	(-4.501)
	[0.009]	[0.002]

*** Significant at the 0.01 level.
** Significant at the 0.05 level.
* Significant at the 0.10 level.

Table V

Relationship between Changes in Interest Rates and Credit Spreads in Two Regimes for Aggregate Corporate Bond Indices with and without Options

Table V reports regression estimates of the sensitivity of changes in monthly credit spreads (ΔCS_t) to changes in interest rates (ΔTB_t) for the January 1995 to December 2014 period for two regimes and the base case for both the Aggregate Corporate Bond Index and the Corporate Bond Index that excludes Yankee and optionable bonds, with t-statistics displayed in parentheses and with the "L" index representing up to two lags. The bootstrapped P-values are reported in brackets below the t-statistics. In regime A, shocks to interest rates and credit spreads are either average or significantly positive, while in regime B they are either average or significantly negative, as defined by their magnitude with respect to a one-sigma deviation from the mean. The base case is the model where the residuals ν_t and μ_t in the VAR system ($\Delta CS_t=(\alpha\ \Delta TB_L+\theta\ \Delta CS_L + \alpha\mu_t + \nu_t)/(1-\alpha\beta)$and ($TB_t=\beta\ \Delta CS_L+\lambda\ \Delta TB_L + \mu_t+\beta\nu_t)/(1-\alpha\beta)$) are estimated without any extra variable(s).

	α (regime I&III)	α (regime II&III)
Corporate bond index with options	-1.941***	-1.567***
	(-5.007)	(-5.200)
	[0.139]	[0.103]
Corporate bond index without options	-1.921***	-1.545***
	(-5.121)	(-5.190)
	[0.105]	[0.096]

*** Significant at the 0.01 level.
** Significant at the 0.05 level.
* Significant at the 0.10 level.

Table VI

Interest Rate and Credit Spread Movements in Relation to Business Cycles

Table VI reports the average changes in interest rates and credit spreads for periods of expansions and contractions as defined by the NBER business cycle dates. The investment-grade bond index sample period extends from January 1973 to December 2014 while the high-yield bond index sample period stretches from January 1987 to December 2014. The t-statistics are reported below each average value.

	No. of observations	Mean
ΔTB (overall)	503	-0.011
		(-0.496)
ΔCS_IG (overall)	503	0.002
		(0.094)
ΔTB (contraction)	78	-0.260**
		(-2.519)
ΔTB (expansion)	425	0.035**
		(2.154)
ΔCS_IG (contraction)	78	0.239***
		(2.670)
ΔCS_IG (expansion)	425	-0.041**
		(-2.294)
ΔCS_HY (contraction)	37	0.280
		(1.030)
ΔCS_HY (expansion)	298	-0.035
		(-1.374)

*** Significant at the 0.01 level.
** Significant at the 0.05 level.
* Significant at the 0.10 level.

Table VII
Relationship between Changes in Interest Rates and Credit Spreads in Two Regimes Free of Macroeconomic or Business Cycles Effects

Table VII reports regression estimates of the sensitivity of monthly credit spreads (ε_{cs}) to interest rates (ε_{tb}) for the January 1973 to December 2014 period for two regimes and three different cases, when controlling for M_t macroeconomic shocks obtained as residuals of AR(1) processes fitted to INF_t, $RMRF_t$, UER_t, IPI_t, PDI_t and PCE_t and for a business cycle dummy (BC), with t-statistics displayed in parentheses and with the "L" index representing up to three lags. The bootstrapped P-values are reported in brackets below the t-statistics. In regime I&III, shocks to interest rates and credit spreads are either average or significantly positive, while in regime I&III they are either average or significantly negative, as defined by their magnitude with respect to a one-sigma deviation from the mean. Case 1 is the base model where the residuals ε_{cs} and ε_{tb} are estimated using the macroeconomic variables M_t. Case 2 is the model where the residuals ε_{cs} and ε_{tb} are estimated with a dummy variable D_t set to 1 for the NBER recession dates and set to zero for others. Case 3 is the model where the residuals ε_{cs} and ε_{tb} are estimated with both a business cycle dummy D_t and macroeconomic shocks M_t. Panel A reports the results for investment-grade bonds, while panel B reports the results for high-yield bonds.

	α (regime I&III)	α (regime II&III)
Panel A: Investment-grade bonds		
Macroeconomic variables (M)	-1.007***	-1.025***
	(-13.045)	(-12.445)
	[0.000]	[0.002]
Business cycle dummy (BC)	-0.942***	-1.012***
	(-12.923)	(-11.610)
	[0.000]	[0.003]
Macroeconomic variables (M) & business cycle dummy (BC)	-0.994***	-0.995***
	(-13.090)	(-12.275)
	[0.002]	[0.001]
Panel B: High-yield bonds		
Macroeconomic variables (M)	-2.928***	-3.051***
	(-4.022)	(-4.785)
	[0.012]	[0.004]
Business cycle dummy (BC)	-2.835***	-3.397***
	-3.130	(-3.244)
	[0.034]	[0.021]
Macroeconomic variables (M) & business cycle dummy (BC)	-3.153***	-3.385***
	(-4.159)	(-4.465)
	[0.006]	[0.004]

*** Significant at the 0.01 level.
** Significant at the 0.05 level.
* Significant at the 0.10 level.

Table VIII

Relationship between Changes in Interest Rates and Credit Spreads in Two Regimes without Common Macroeconomic Shocks: 5-Year Treasury Bond Yield

Table VIII reports regression estimates of the sensitivity of changes in monthly credit spreads (ΔCS_t), using 5-year Treasury bond yield, to changes in interest rates (ΔTB_t) for the January 1973 to December 2014 period for two regimes and four different cases, with t-statistics displayed in parentheses and with the "L" index representing up to three lags. The bootstrapped P-value was reported in brackets below the t-statistics. In regime I&III, shocks to interest rates and credit spreads are either average or significantly positive, while in regime II&III they are either average or significantly negative, as defined by their magnitude with respect to a one-sigma deviation from the mean. Case 1 is the base model where the residuals $\alpha\mu_t + \nu_t$ and $+\mu_t + \beta\nu_t$ in the VAR system ($\Delta CS_t = (\alpha\ \Delta TB_L + \theta\ \Delta CS_L + \alpha\mu_t + \nu_t)/(1-\alpha\beta)$ and $\Delta TB_t = (\beta\ \Delta CS_L + \lambda\ \Delta TB_L + \mu_t + \beta\nu_t)/(1-\alpha\beta)$) are estimated without any extra variable(s). Case 2 is the model where the residuals in the VAR system ($\Delta CS_t = (\alpha\ \Delta TB_L + \theta\ \Delta CS_L + \phi_1 D_t + \alpha\mu_t + \nu_t)/(1-\alpha\beta)$ and $\Delta TB_t = (\beta\ \Delta CS_L + \lambda\ \Delta TB_L + \psi_1 D_t + \mu_t + \beta\nu_t)/(1-\alpha\beta)$) are estimated with a dummy variable D_t set to 1 between January 1973 and August 1981 and set to zero between September 1981 and December 2014. Case 3 is the model where the residuals in the VAR system ($\Delta CS_t = (\alpha\ \Delta TB_L + \theta\ \Delta CS_L + \phi_2[TB_t - K_t] + \alpha\mu_t + \nu_t)/(1-\alpha\beta)$and $\Delta TB_t = (\beta\ \Delta CS_L + \lambda\ \Delta TB_L + \psi_2[TB_t - K_t] + \mu_t + \beta\nu_t))/(1-\alpha\beta)$) are estimated with a mean-reverting level K_t of interest rates calculated as a 5-year moving average. Case 4 is the model where the residuals in the VAR system ($\Delta CS_t = (\alpha\ \Delta TB_L + \theta\ \Delta CS_L + \phi_1 D_t + \phi_2[TB_t - K_t] + \alpha\mu_t + \nu_t)/(1-\alpha\beta)$and $\Delta TB_t = (\beta\ \Delta CS_L + \lambda\ \Delta TB_L + \psi_1 D_t + \psi_2[TB_t - K_t] + \mu_t + \beta\nu_t)/(1-\alpha\beta)$) are estimated with both a dummy D_t and a mean-reverting level K_t. Panel A reports results for investment-grade bonds, while panel B reports results for high-yield bonds.

	α (Regime I&III)	α (Regime II&III)
PANEL A: Investment-Grade Bonds		
Base Model	-0.462***	-0.504***
	(-3.644)	(-3.362)
	[0.003]	[0.009]
With Dummy (D)	-0.461***	-0.531**
	(-3.631)	(-3.320)
	[0.005]	[0.011]
With Mean-Reverting Variable	-0.475***	-0.577**
$[TB_t - K_t]$	(-3.581)	(-3.153)
	[0.007]	[0.011]
With Dummy (D) &	-0.475***	-0.584***
Mean-Reverting Variable	(-3.615)	(-3.172)
$[TB_t - K_t]$	[0.007]	[0.010]
PANEL B: High-Yield Bonds		
Base Model	-2.205	-3.707**
	(-2.479)	(-2.900)
	[0.107]	[0.037]
With Mean-Reverting Variable	-2.289*	-4.133*
$[TB_t - K_t]$	(-2.799)	(-2.721)
	[0.068]	[0.064]

*** Significant at the 0.01 level.
** Significant at the 0.05 level.
* Significant at the 0.10 level.

Table IX

Relationship between Changes in Interest Rates and Credit Spreads in Two Regimes without Common Macroeconomic Shocks: 10-Year Treasury Bond Yield

Table IX reports regression estimates of the sensitivity of changes in monthly credit spreads (ΔCS_t), using 10-year Treasury bond yield, to changes in interest rates (ΔTB_t) for the January 1973 to December 2014 period for two regimes and four different cases, with t-statistics displayed in parentheses and with the "L" index representing up to three lags. The bootstrapped P-value was reported in brackets below the t-statistics. In regime I&III, shocks to interest rates and credit spreads are either average or significantly positive, while in regime II&III they are either average or significantly negative, as defined by their magnitude with respect to a one-sigma deviation from the mean. Case 1 is the base model where the residuals $\alpha\mu_t + \nu_t$ and $+\mu_t + \beta\nu_t$ in the VAR system ($\Delta CS_t = (\alpha\, \Delta TB_L + \theta\, \Delta CS_L + \alpha\mu_t + \nu_t)/(1-\alpha\beta)$ and $\Delta TB_t = (\beta\, \Delta CS_L + \lambda\, \Delta TB_L + \mu_t + \beta\nu_t)/(1-\alpha\beta)$) are estimated without any extra variable(s). Case 2 is the model where the residuals in the VAR system ($\Delta CS_t = (\alpha\, \Delta TB_L + \theta\, \Delta CS_L + \phi_1 D_t + \alpha\mu_t + \nu_t)/(1-\alpha\beta)$ and $\Delta TB_t = (\beta\, \Delta CS_L + \lambda\, \Delta TB_L + \psi_1 D_t + \mu_t + \beta\nu_t)/(1-\alpha\beta)$) are estimated with a dummy variable D_t set to 1 between January 1973 and August 1981 and set to zero between September 1981 and December 2014. Case 3 is the model where the residuals in the VAR system ($\Delta CS_t = (\alpha\, \Delta TB_L + \theta\, \Delta CS_L + \phi_2[TB_t - K_t] + \alpha\mu_t + \nu_t)/(1-\alpha\beta)$and $\Delta TB_t = (\beta\, \Delta CS_L + \lambda\, \Delta TB_L + \psi_2[TB_t - K_t] + \mu_t + \beta\nu_t))/(1-\alpha\beta)$) are estimated with a mean-reverting level K_t of interest rates calculated as a 5-year moving average. Case 4 is the model where the residuals in the VAR system ($\Delta CS_t = (\alpha\, \Delta TB_L + \theta\, \Delta CS_L + \phi_1 D_t + \phi_2[TB_t - K_t] + \alpha\mu_t + \nu_t)/(1-\alpha\beta)$and $\Delta TB_t = (\beta\, \Delta CS_L + \lambda\, \Delta TB_L + \psi_1 D_t + \psi_2[TB_t - K_t] + \mu_t + \beta\nu_t)/(1-\alpha\beta)$) are estimated with both a dummy D_t and a mean-reverting level K_t. Panel A reports results for investment-grade bonds, while panel B reports results for high-yield bonds.

	α (Regime I&III)	α (Regime II&III)
PANEL A: Investment-Grade Bonds		
Base Model	-0.509**	-0.630**
	(-2.001)	(-2.086)
	[0.037]	[0.031]
With Dummy (D)	-0.471*	-0.704**
	(-1.901)	(-2.090)
	[0.051]	[0.030]
With Mean-Reverting Variable	-0.402*	-0.775**
$[TB_t - K_t]$	(-1.560)	(-1.968)
	[0.098]	[0.044]
With Dummy (D) &	-0.394*	-0.791**
Mean-Reverting Variable	(-1.558)	(-1.958)
$[TB_t - K_t]$	[0.094]	[0.044]
PANEL B: High-Yield Bonds		
Base Model	-1.939*	-3.367**
	(-2.390)	(-2.916)
	[0.082]	[0.024]
With Mean-Reverting Variable	-2.001*	-3.689**
$[TB_t - K_t]$	(-2.601)	(-2.753)
	[0.067]	[0.039]

*** Significant at the 0.01 level.

** Significant at the 0.05 level.

* Significant at the 0.10 level.

Table X

Relationship between Changes in Interest Rates and Credit Spreads in Two Regimes with Common Macroeconomic Shocks: 5-Year Treasury Bond Yield

Table X reports regression estimates of the sensitivity of monthly credit spreads (ΔCS_t)), using 5-year Treasury bond yield, to interest rates (ΔTB_t) for the January 1973 to December 2014 period for two regimes and four different cases, when including M_t macroeconomic shocks obtained as residuals of AR(1) processes fitted to INF_t, $RMRF_t$, UER_t, IPI_t, PDI_t and PCE_t and business cycle dummy(BC), with t-statistics displayed in parentheses and with the "L" index representing up to three lags. The bootstrapped P-value was reported in brackets below the t-statistics. In regime I&III, shocks to interest rates and credit spreads are either average or significantly positive, while in regime II&III they are either average or significantly negative, as defined by their magnitude with respect to a one-sigma deviation from the mean. Case 1 is the model where the residuals $(\alpha\mu_t + \nu_t)/(1-\alpha\beta)$ and $(\mu_t+\beta\nu_t)/(1-\alpha\beta)$ in the VAR system ($\Delta CS_t=(\alpha\ \Delta TB_L+\theta\ \Delta CS_L +\gamma F_t + \alpha\mu_t +\nu_t)/(1-\alpha\beta)$ and $\Delta TB_t =(\beta\ \Delta CS_L+\lambda\ \Delta TB_L +\Gamma M_t +\mu_t+\beta\nu_t)/(1-\alpha\beta)$) are estimated with macroeconomic variable(s). Case 2 is the model where the residuals in the VAR system ($\Delta CS_t=\alpha\ \Delta TB_L+\theta\ \Delta CS_L +\phi_1 BC_t +\gamma M_t + \alpha\mu_t +\nu_t)/(1-\alpha\beta)$ and $\Delta TB_t=(\beta\ \Delta CS_L+\lambda\ \Delta TB_L +\psi_1 BC_t +\Gamma M_t +\mu_t+\beta\nu_t)/(1-\alpha\beta)$) are estimated with a dummy variable BC_t set to 1 for the NBER recession dates and set to zero for others. Case 3 is the model where the residuals in the VAR system ($\Delta CS_t=(\alpha\ \Delta TB_L+\theta\ \Delta CS_L +\phi_1 BC_t +\gamma M_t +\alpha\mu_t +\nu_t)/(1-\alpha\beta)$ and $\Delta TB_t=(\beta\ \Delta CS_L+\lambda\ \Delta TB_L +\psi_1 BC_t + \gamma M_t +\mu_t+\beta\nu_t)/(1-\alpha\beta)$) are estimated with both a business cycle dummy BC_t and a macroeconomic shocks M_t . Panel A reports results for investment-grade bonds, while panel B reports results for high-yield bonds.

	α (Regime I&III)	α (Regime II&III)
PANEL A: Investment-Grade Bonds		
Macroeconomic variables (M)	-0.575***	-0.564***
	(-3.967)	(-3.843)
	[0.007]	[0.006]
Business Cycle Dummy (BC)	-0.542***	-0.561***
	(-3.211)	(-3.147)
	[0.010]	[0.010]
Macroeconomic variables(M)	-0.567***	-0.530***
& Business Cycle Dummy (BC)	(-3.972)	(-3.897)
	[0.007]	[0.007]
PANEL B: High-Yield Bonds		
Macroeconomic variables (M)	-2.597**	-2.861***
	(-3.142)	(-4.321)
	[0.032]	[0.001]
Business Cycle Dummy (BC)	-2.547*	-3.869*
	(-2.375)	(-2.269)
	[0.079]	[0.092]
Macroeconomic variables(M)	-2.886**	-2.903***
& Business Cycle Dummy (BC)	(-3.446)	(-4.224)
	[0.014]	[0.003]

*** Significant at the 0.01 level.
** Significant at the 0.05 level.
* Significant at the 0.10 level.

TABLE XI

Relationship between Changes in Interest Rates and Credit Spreads in Two Regimes with Common Macroeconomic Shocks: 10-Year Treasury Bond Yield

Table XI reports regression estimates of the sensitivity of monthly credit spreads (ΔCS_t), using 10-year Treasury bond yield, to interest rates (ΔTB_t) for the January 1973 to December 2014 period for two regimes and four different cases, when including M_t macroeconomic shocks obtained as residuals of AR(1) processes fitted to INF_t, $RMRF_t$, UER_t, IPI_t, PDI_t and PCE_t and business cycle dummy(BC), with t-statistics displayed in parentheses and with the "L" index representing up to three lags. The bootstrapped P-value was reported in brackets below the t-statistics. In regime I&III, shocks to interest rates and credit spreads are either average or significantly positive, while in regime II&III they are either average or significantly negative, as defined by their magnitude with respect to a one-sigma deviation from the mean. Case 1 is the model where the residuals $(\alpha\mu_t + \nu_t)/(1-\alpha\beta)$ and $(\mu_t+\beta\nu_t)/(1-\alpha\beta)$ in the VAR system ($\Delta CS_t=(\alpha\ \Delta TB_L+\theta\ \Delta CS_L+\gamma F_t + \alpha\mu_t+\nu_t)/(1-\alpha\beta)$ and $\Delta TB_t=(\beta\ \Delta CS_L+\lambda\ \Delta TB_L+\Gamma M_t+\mu_t+\beta\nu_t)/(1-\alpha\beta)$) are estimated with macroeconomic variable(s). Case 2 is the model where the residuals in the VAR system ($\Delta CS_t=\alpha\ \Delta TB_L+\theta\ \Delta CS_L+\phi_1 BC_t+\gamma M_t+\alpha\mu_t+\nu_t)/(1-\alpha\beta)$ and $\Delta TB_t=(\beta\ \Delta CS_L+\lambda\ \Delta TB_L+\psi_1 BC_t+\Gamma M_t+\mu_t+\beta\nu_t)/(1-\alpha\beta)$) are estimated with a dummy variable BC_t set to 1 for the NBER recession dates and set to zero for others. Case 3 is the model where the residuals in the VAR system ($\Delta CS_t=(\alpha\ \Delta TB_L+\theta\ \Delta CS_L+\phi_1 BC_t+\gamma M_t+\alpha\mu_t+\nu_t)/(1-\alpha\beta)$ and $\Delta TB_t=(\beta\ \Delta CS_L+\lambda\ \Delta TB_L+\psi_1 BC_t+\gamma M_t+\mu_t+\beta\nu_t)/(1-\alpha\beta)$) are estimated with both a business cycle dummy BC_t and a macroeconomic shocks M_t . Panel A reports results for investment-grade bonds, while panel B reports results for high-yield bonds.

	α (Regime I&III)	α (Regime II&III)
PANEL A: Investment-Grade Bonds		
Macroeconomic variables (M)	-0.495*	-0.499**
	(-1.788)	(-2.342)
	[0.060]	[0.016]
Business Cycle Dummy (BC)	-0.533*	-0.726**
	(-1.608)	(-2.118)
	[0.087]	[0.024]
Macroeconomic variables(M)	-0.486**	-0.525**
& Business Cycle Dummy (BC)	(-1.882)	(-2.377)
	[0.046]	[0.018]
PANEL B: High-Yield Bonds		
Macroeconomic variables (M)	-2.548*	-2.807***
	(-2.609)	(-4.052)
	[0.068]	[0.000]
Business Cycle Dummy (BC)	-2.287*	-3.494*
	(-2.256)	(-2.291)
	[0.065]	[0.065]
Macroeconomic variables(M)	-2.977**	-2.889***
& Business Cycle Dummy (BC)	(-2.970)	(-4.069)
	[0.039]	[0.000]

*** Significant at the 0.01 level.
** Significant at the 0.05 level.
* Significant at the 0.10 level.

Table XII

Relationship between Changes in Interest Rates and Credit Spreads in Two Regimes for Aggregate Corporate Bond Indices with and without Options: 5-Year Treasury Bond Yield

Table XII reports regression estimates of the sensitivity of changes in monthly credit spreads (ΔCS_t), using 5-year Treasury bond yield, to changes in interest rates (ΔTB_t) for the January 1995 to December 2014 period for two regimes and the base case for both the Aggregate Corporate Bond Index and the Corporate Bond Index that excludes Yankee and optionable bonds, with t-statistics displayed in parentheses and with the "L" index representing up to two lags. The bootstrapped P-value was reported in brackets below the t-statistics. In regime A, shocks to interest rates and credit spreads are either average or significantly positive, while in regime B they are either average or significantly negative, as defined by their magnitude with respect to a one-sigma deviation from the mean. The base case is the model where the residuals ν_t and μ_t in the VAR system ($\Delta CS_t=(\alpha\ \Delta TB_L+\theta\ \Delta CS_L + \alpha\mu_t + \nu_t)/(1-\alpha\beta)$and ($TB_t=\beta\ \Delta CS_L+\lambda\ \Delta TB_L + \mu_t+\beta\nu_t)/(1-\alpha\beta)$) are estimated without any extra variable(s).

	α (Regime I&III)	α (Regime II&III)
Corporate Bond Index	-1.252	-1.089
	(-3.793)	(-4.658)
	[0.196]	[0.101]
Corporate Bond Index without Options	-1.275	-0.977*
	(-3.517)	(-4.564)
	[0.218]	[0.090]

*** Significant at the 0.01 level.
** Significant at the 0.05 level.
* Significant at the 0.10 level.

Table XIII

Relationship between Changes in Interest Rates and Credit Spreads in Two Regimes for Aggregate Corporate Bond Indices with and without Options: 10-Year Treasury Bond Yield

Table XIII reports regression estimates of the sensitivity of changes in monthly credit spreads (ΔCS_t), using 10-year Treasury bond yield, to changes in interest rates (ΔTB_t) for the January 1995 to December 2014 period for two regimes and the base case for both the Aggregate Corporate Bond Index and the Corporate Bond Index that excludes Yankee and optionable bonds, with t-statistics displayed in parentheses and with the "L" index representing up to two lags. The bootstrapped P-value was reported in brackets below the t-statistics. In regime A, shocks to interest rates and credit spreads are either average or significantly positive, while in regime B they are either average or significantly negative, as defined by their magnitude with respect to a one-sigma deviation from the mean. The base case is the model where the residuals ν_t and μ_t in the VAR system ($\Delta CS_t=(\alpha\ \Delta TB_L+\theta\ \Delta CS_L + \alpha\mu_t + \nu_t)/(1-\alpha\beta)$ and $(TB_t=\beta\ \Delta CS_L+\lambda\ \Delta TB_L + \mu_t+\beta\nu_t)/(1-\alpha\beta))$ are estimated without any extra variable(s).

	α (Regime I&III)	α (Regime II&III)
Corporate Bond Index	-1.220	-0.820*
	(-2.936)	(-3.816)
	[0.195]	[0.082]
Corporate Bond Index without Options	-1.208	-0.821*
	(-2.961)	(-3.587)
	[0.192]	[0.093]

*** Significant at the 0.01 level.
** Significant at the 0.05 level.
* Significant at the 0.10 level.

Table XIV

Relationship between Changes in Interest Rates and Credit Spreads in Two Regimes excluding Business Cycles Effects: 5-Year Treasury Bond Yield

Table XIV reports regression estimates of the sensitivity of monthly credit spreads (ε_{cs}), using 5-year Treasury bond yield, to interest rates (ε_{tb}) for the January 1973 to December 2014 period for two regimes and three different cases, when controlling M_t macroeconomic shocks obtained as residuals of AR(1) processes fitted to INF_t, $RMRF_t$, UER_t, IPI_t, PDI_t and PCE_t and business cycle dummy(BC), with t-statistics displayed in parentheses and with the "L" index representing up to three lags. The bootstrapped P-value was reported in brackets below the t-statistics. In regime I&III, shocks to interest rates and credit spreads are either average or significantly positive, while in regime I&III they are either average or significantly negative, as defined by their magnitude with respect to a one-sigma deviation from the mean. Case 1 is the base model where the residuals ε_{cs} and ε_{tb} are estimated using macroeconomic variables M_t. Case 2 is the model where the residuals ε_{cs} and ε_{tb} are estimated with a dummy variable D_t set to 1 for the NBER recession dates and set to zero for others. Case 3 is the model where the residuals ε_{cs} and ε_{tb} are estimated with both a business cycle dummy D_t and a macroeconomic shocks M_t. Panel A reports results for investment-grade bonds, while panel B reports results for high-yield bonds.

	α (Regime I&III)	α (Regime II&III)
PANEL A: Investment-Grade Bonds		
Macroeconomic variables (M)	-0.599**	-0.593***
	(-3.599)	(-3.645)
	[0.018]	[0.007]
Business Cycle Dummy (BC)	-0.545**	-0.556**
	(-3.152)	(-3.156)
	[0.024]	[0.015]
Macroeconomic variables(M)	-0.629**	-0.612**
& Business Cycle Dummy (BC)	(-3.370)	(-3.449)
	[0.018]	[0.012]
PANEL B: High-Yield Bonds		
Macroeconomic variables (M)	-2.791**	-2.985***
	(-3.422)	(-4.563)
	[0.015]	[0.002]
Business Cycle Dummy (BC)	-2.630*	-3.803*
	(-2.321)	(-2.273)
	[0.077]	[0.077]
Macroeconomic variables(M)	-2.815***	-2.815***
& Business Cycle Dummy (BC)	(-3.643)	(-4.282)
	[0.006]	[0.005]

*** Significant at the 0.01 level.
** Significant at the 0.05 level.
* Significant at the 0.10 level.

Table XV

Relationship between Changes in Interest Rates and Credit Spreads in Two Regimes excluding Business Cycles Effects: 10-Year Treasury Bond Yield

Table XV reports regression estimates of the sensitivity of monthly credit spreads (ε_{cs}), using 10-year Treasury bond yield, to interest rates (ε_{tb}) for the January 1973 to December 2014 period for two regimes and three different cases, when controlling M_t macroeconomic shocks obtained as residuals of AR(1) processes fitted to INF_t, $RMRF_t$, UER_t, IPI_t, PDI_t and PCE_t and business cycle dummy(BC), with t-statistics displayed in parentheses and with the "L" index representing up to three lags. The bootstrapped P-value was reported in brackets below the t-statistics. In regime I&III, shocks to interest rates and credit spreads are either average or significantly positive, while in regime I&III they are either average or significantly negative, as defined by their magnitude with respect to a one-sigma deviation from the mean. Case 1 is the base model where the residuals ε_{cs} and ε_{tb} are estimated using macroeconomic variables M_t. Case 2 is the model where the residuals ε_{cs} and ε_{tb} are estimated with a dummy variable D_t set to 1 for the NBER recession dates and set to zero for others. Case 3 is the model where the residuals ε_{cs} and ε_{tb} are estimated with both a business cycle dummy D_t and a macroeconomic shocks M_t. Panel A reports results for investment-grade bonds, while panel B reports results for high-yield bonds.

	α (Regime I&III)	α (Regime II&III)
PANEL A: Investment-Grade Bonds		
Macroeconomic variables (M)	-0.541*	-0.556**
	(-1.936)	(-2.387)
	[0.099]	[0.015]
Business Cycle Dummy (BC)	-0.733*	-0.720*
	(-2.038)	(-2.098)
	[0.076]	[0.062]
Macroeconomic variables(M)	-0.627	-0.583**
& Business Cycle Dummy (BC)	(-1.800)	(-2.368)
	[0.116]	[0.015]
PANEL B: High-Yield Bonds		
Macroeconomic variables (M)	-2.494**	-2.893***
	(-3.057)	(-3.961)
	[0.023]	[0.004]
Business Cycle Dummy (BC)	-2.325*	-3.428*
	(-2.226)	(-2.269)
	[0.064]	[0.060]
Macroeconomic variables(M)	-2.523**	-2.769***
& Business Cycle Dummy (BC)	(-3.271)	(-3.753)
	[0.013]	[0.005]

*** Significant at the 0.01 level.
** Significant at the 0.05 level.
* Significant at the 0.10 level.