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The Relation Between Treasury Yields and Corporate Bond Yield Spreads

GREGORY R. DUFFEE*

ABSTRACT

Because the option to call a corporate bond should rise in value when bond yields fall, the relation between noncallable Treasury yields and spreads of corporate bond yields over Treasury yields should depend on the callability of the corporate bond. I confirm this hypothesis for investment-grade corporate bonds. Although yield spreads on both callable and noncallable corporate bonds fall when Treasury yields rise, this relation is much stronger for callable bonds. This result has important implications for interpreting the behavior of yields on commonly used corporate bond indexes, which are composed primarily of callable bonds.

COMMONLY USED INDEXES OF CORPORATE bond yields, such as those produced by Moody's or Lehman Brothers, are constructed using both callable and noncallable bonds. Because the objective of those producing the indexes is to track the universe of corporate bonds, this methodology is sensible. Until the mid-1980s, few corporations issued noncallable bonds, hence an index designed to measure the yield on a typical corporate bond would have to be constructed primarily with callable bonds.

However, any empirical analysis of these yields needs to recognize that the presence of the bonds' call options affects their behavior in potentially important ways. Variations over time in yields on callable bonds will reflect, in part, variations in their option values. If, say, noncallable bond prices rise (i.e., their yields fall), prices of callable bonds should not rise as much because the values of their embedded short call options also rise.

I investigate one aspect of this behavior: The relation between yields on noncallable Treasury bonds and spreads of corporate bond yields over Treasury yields. This relation conveys information about the covariation between default-free discount rates and the market's perception of default risk. But with callable corporate bonds, this relation should also reflect the fact that higher prices of noncallable Treasury bonds are associated with higher val-

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ues of the call options. Therefore the relation between Treasury yields and yield spreads of callable corporate bonds should be more negative than the relation between Treasury yields and noncallable corporate bonds.

I use monthly data on investment-grade trader-priced corporate bonds from January 1985 through March 1995 to examine how yield spreads vary with changes in the level and slope of the Treasury term structure. I find a modest negative relation between Treasury yields and yield spreads on noncallable corporate bonds. If, say, the short end of the Treasury yield curve shifts down by 10 basis points between months t and $t + 1$, average yield spreads on Aa-rated noncallable corporate bonds rise by around 1.5 basis points. The negative relation is stronger for lower-rated noncallable bonds.

However, the relation between Treasury yields and yield spreads on callable bonds is much more strongly negative than it is for noncallable bonds. Additionally, the relation is more negative for high-priced callable bonds than for low-priced callable bonds, a pattern that is consistent with the principle that a call option's value is less volatile when it is further out-of-the-money. Therefore, not surprisingly, I also find a strong negative relation between Treasury yields and yield spreads constructed with commonly-used indexes of corporate bond yields. Longstaff and Schwartz (1995) report similar evidence, which they attribute to a presumed negative correlation between firms' asset values and default-free interest rates. The analysis here indicates that any such conclusions should be based exclusively on the behavior of noncallable bond yields.

The remainder of this paper is organized as follows. The first section describes the data used. Empirical evidence based on noncallable bonds is reported in the second section. Section III considers both callable bond yields and yields on commonly used bond indexes. Section IV concludes.

I. The Data

A. Database Description

The Fixed Income Database (FID) from the University of Houston consists of month-end data on the bonds that make up the Lehman Brothers Bond Indexes. Almost all of the bonds have semiannual coupon payments. The version of FID used here covers January 1973 through March 1995. In addition to reporting month-end prices and yields, the database reports maturity, coupon, various call, put, and sinking fund information, and a business sector for each bond (e.g., industrial, utilities, or financial). It also reports monthly Moody's and Standard & Poor's (S&P) ratings for each bond. Until 1992 the Lehman Brothers Indexes covered only investment-grade firms, hence the analysis in this paper is restricted to bonds rated Baa or higher by Moody's (or BBB by S&P). See Warga (1991) for more information on this database.

The secondary market for corporate bonds is very illiquid compared to the stock market. Nunn, Hill, and Schneeweis (1986) and Warga (1991) discuss various implications of this illiquidity for researchers. The dataset distinguishes between trader-quoted prices and matrix prices. Quote prices are bid prices established by Lehman traders. If a trader is unwilling to supply a bid price because the bond has not traded recently, a matrix price is computed using a proprietary algorithm. Because trader-quoted prices are more likely to reflect all available information than are matrix prices, the analysis in this paper uses only quote prices.

This paper focuses on differences between callable and noncallable bonds. Unfortunately for this area of research, corporations issued few noncallable bonds prior to the mid-1980s. For example, the dataset has January 1984 prices for 5,497 straight bonds issued by industrial, financial, or utility firms. Only 271 of these bonds were noncallable for life. By January 1985, the number of noncallable bonds with price information had risen to 382 (of 5,755). Beginning in 1985, the number of noncallable bonds rose dramatically, so that the dataset contains March 1995 price information on 2,814 noncallable bonds (of 5,291). Because of the paucity of noncallable bonds in earlier years, I restrict my attention to the period January 1985 through March 1995.

B. Data Construction

B.1. Noncallable Corporate Bond Yields and Yield Spreads

Consider those corporate bonds that are noncallable, nonputable, and have no sinking fund option. I construct indexes of monthly corporate yields, yield spreads (over Treasuries), and changes in spreads for four business-sector categories (all sectors' bonds, industrial-sector bonds, utility-sector bonds, and financial-sector bonds), four rating categories (Aaa, Aa, A, and Baa), and three bands of remaining maturities (2–7 years, 7–15 years, and 15–30 years). Hence 48 ($4 \times 4 \times 3$) different time series of spreads and changes in spreads are constructed. Their construction is summarized here and is detailed in an Appendix available on request from the author.

My measure of the month t yield spread for sector s, rating i, and remaining maturity m is denoted $SPREAD_{s,i,m,t}$. It is the mean yield spread at the end of month t for all bonds with quote prices in the sector/rating/maturity group. I define the monthly change in the spread $\Delta SPREAD_{s,i,m,t+1}$ as the mean change from t to $t + 1$ in the spreads on that exact group of bonds. Note that bonds that are downgraded between t and $t + 1$ or that fall out of the maturity range between t and $t + 1$ are not included in the set of bonds used to construct the month $t + 1$ spread $S_{s,i,m,t+1}$, but they are included in my measure of the change in the spread from month t to month $t + 1$.[1] Most

[1] In other words, my index of changes in yield spreads is not based on a "refreshed" yield index—an index that holds credit ratings fixed over time. In principle, the use of refreshed yield indexes to measure changes in credit quality over time is problematic because such indexes hold constant a particular measure of credit quality. In practice, because rating changes are very unlikely over a one-month horizon (e.g., in my sample only 2.4 percent of bonds rated Baa in a given month had a different rating the next month), the index produced with this method differs minimally from one using refreshed yield indexes.

of the results discussed below use indexes constructed using all sectors' bonds instead of just those bonds in a particular business sector, thus the business sector subscript is usually dropped. The aggregate yield spreads are weighted averages of the sectors' yield spreads, where the weights are the number of bonds in each section.

Summary statistics for these time series of spreads and changes in spreads are displayed in Table I. There are many months for which spreads for a given sector's Aaa-rated bonds are missing because of a lack of noncallable Aaa bonds. Those observations that are not missing are based on very few bonds; for example, an average of two bonds is used to construct each nonmissing observation for long-term industrial Aaa bonds. In Panel D (all business sectors' bonds), changes in mean yield spreads are typically positively autocorrelated at one lag. This positive autocorrelation is likely the result of stale yield spreads for individual bonds.

B.2. Treasury Bond Yields

In order to investigate relations between changes in yield spreads and changes in the Treasury term structure, I need variables that summarize the information in the Treasury term structure. Litterman and Scheinkman (1991) and Chen and Scott (1993) document that the vast majority of variation in the Treasury term structure can be expressed in terms of changes in the level and the slope. I measure the level of the Treasury term structure with the three-month Treasury bill yield, denoted $Y_{T,1/4,t}$, and measure the slope with the spread between the 30-year constant-maturity Treasury yield and the three-month Treasury bill yield. This spread is denoted $TERM_t$. The three-month bill yield is from the Center for Research in Security Prices and is converted to a semiannually compounded return for proper comparison with the bond yield data used here.

This decomposition of the Treasury term structure is arbitrary because the level of the term structure can be measured at any point on the term structure. For example, we could decompose the term structure into the level of the thirty-year yield and $TERM_t$. Of course, the information in this alternative decomposition is identical to the decomposition described above. Because I measure the level of the term structure with the three-month yield, an increase in $TERM_t$ holding the level fixed corresponds to an increase in yields on Treasury securities with more than three months to maturity.

II. Empirical Results for Noncallable Corporate Bonds

A. Contemporaneous Relations

I estimate the following regression using ordinary least squares (OLS) over the period February 1985 through March 1995:

$$\Delta SPREAD_{s,i,m,t+1} = b_{s,i,m,0} + b_{s,i,m,1}\,\Delta\, Y_{T,1/4,t+1} + b_{s,i,m,2}\,\Delta TERM_{t+1} + e_{s,i,m,t+1}. \tag{1}$$

In equation (1), the change from month t to month $t+1$ in the mean yield spread on noncallable bonds issued by firms in industry s with rating i and maturity m is regressed on contemporaneous changes in the three-month Treasury bill yield $Y_{T,1/4,t+1}$ and the slope of the Treasury term structure $TERM_{t+1}$.

Table II reports estimation results for various maturities and credit ratings. To save space, the only results displayed are those for indexes constructed with all business sectors' bonds. Regressions are run separately for each maturity/credit rating group. I adjust the variance-covariance matrix of the estimated coefficients for generalized heteroskedasticity and two lags of moving average residuals.

The results indicate that an increase in the three-month bill yield corresponds to a decline in yield spreads. This relation holds for every combination of maturity and credit rating. The point estimates imply that for a 10-basis point decrease in the three-month Treasury yield, yield spreads rise by between 0.2 basis points (medium-term Aaa-rated bonds) and 4.2 basis points (long-term Baa-rated bonds). This relationship is weak for Aaa-rated bonds (it is statistically insignificant for long-maturity and medium-maturity Aaa-rated bonds) and strengthens as credit quality falls. The relation between yield spreads and the slope of the Treasury term structure is also generally negative. For long-maturity bonds, the coefficients on the Treasury slope are very similar to those on the three-month bill yield. Because the sum of three-month bill yield and $TERM_t$ is the thirty-year yield, this similarity implies that the thirty-year yield captures the information in the Treasury term structure relevant to long-maturity corporate bond yield spreads.

For medium-maturity and short-maturity bonds, the relation between yield spreads and the slope of the Treasury term structure is weaker, and the thirty-year yield no longer summarizes the relevant information in the term structure. The hypothesis that the coefficient on the Treasury slope equals the coefficient on the three-month bill yield is rejected at the 10 percent level for all but yield spreads on Aaa-rated medium-maturity bonds, and is rejected at the 1 percent level for yield spreads on short-maturity bonds of all ratings. (These rejections are not reported in any table.)

Note that the sign of this empirical relation between Treasury yields and corporate bond yield spreads is the opposite of what we would expect given the different tax rates that apply to corporate and Treasury bonds. Corporate bonds are taxable at the federal, state, and local levels; Treasury bonds are taxable only at the federal level. An increase in bond yields increases the tax wedge between corporate and Treasury bonds. To offset this increased tax wedge, corporate bond yields should rise by more than Treasury bond yields; that is, yield spreads should rise when Treasury yields rise.[2]

There is no theory that indicates various business sectors' bond yields should react identically to changing Treasury yields. In fact, given that different sectors are affected by macroeconomic fluctuations in different ways,

[2] See Friedman and Kuttner (1993) for a similar discussion of the variability of the spread between yields on commercial paper and Treasury bills.

Table I

Summary Statistics for Corporate Bonds in Fixed Income Dataset That Have No Option-like Features, January 1985 to March 1995

For a given group of bonds (defined by sector, month t maturity, and month t rating), $SPREAD_t$ is defined as the mean yield spread in month t (over the appropriate Treasury instrument) on all noncallable, nonputable bonds with no sinking fund option which have yields based on quote prices in both months t and $t + 1$. $\Delta SPREAD_{t+1}$ is the mean change in the spreads on these bonds from month t to $t + 1$. If there are no such bonds in month t, $SPREAD_t$ and $\Delta SPREAD_{t+1}$ are set to missing values. Maturities of fifteen to thirty years are "long," maturities of seven to fifteen years are "medium," and maturities of two to seven years are "short." The first-order autocorrelation coefficient for $\Delta SPREAD_{t+1}$ is denoted AR(1).

Maturity	Rating	Number of Monthly Obs.	Mean Number of Bonds per Monthly Obs.	Mean Years to Matur.	Mean *SPREAD*	$\Delta SPREAD$ Std. Dev.	$\Delta SPREAD$ AR(1)
			Panel A. Industrial Sector				
Long	Aaa	62	2.3	28.4	0.59	0.042	0.112
	Aa	101	7.5	20.8	0.87	0.095	−0.002
	A	122	33.7	22.1	1.17	0.141	0.195
	Baa	105	21.5	21.0	1.98	0.192	0.007
Medium	Aaa	40	3.9	10.4	0.47	0.048	0.128
	Aa	116	11.8	9.5	0.69	0.097	−0.016
	A	122	50.6	9.6	0.96	0.108	−0.117
	Baa	122	29.6	8.9	1.48	0.161	0.110
Short	Aaa	107	6.0	3.4	0.46	0.095	−0.265
	Aa	122	15.1	4.0	0.56	0.083	−0.068
	A	122	58.4	4.5	0.87	0.108	0.085
	Baa	122	33.7	4.7	1.49	0.222	0.064
			Panel B. Utility Sector				
Long	Aaa	38	2.7	26.1	0.59	0.047	0.124
	Aa	91	1.0	27.4	0.80	0.085	−0.008
	A	98	4.1	20.9	1.01	0.110	0.134
	Baa	66	4.8	23.9	1.73	0.142	0.205
Medium	Aaa	38	5.6	9.8	0.39	0.033	−0.194
	Aa	98	11.5	9.2	0.58	0.086	−0.329
	A	120	17.9	9.1	0.79	0.096	0.006
	Baa	119	20.1	9.7	1.32	0.170	−0.017
Short	Aaa	25	2.0	6.1	0.34	0.026	−0.221
	Aa	90	10.4	4.5	0.54	0.076	−0.246
	A	122	15.8	4.4	0.78	0.091	−0.007
	Baa	122	21.6	4.3	1.15	0.145	0.011

			Panel C. Finance Sector				
Long	Aaa	77	10.4	19.1	0.89	0.107	0.077
	Aa	96	2.0	19.1	1.06	0.089	−0.028
	A	118	7.7	20.0	1.30	0.131	−0.033
	Baa	75	2.7	19.8	1.49	0.184	−0.157
Medium	Aaa	115	7.2	11.0	0.81	0.106	0.052
	Aa	122	8.0	9.0	0.79	0.094	0.104
	A	122	39.5	9.2	1.14	0.152	0.164
	Baa	120	17.0	8.8	1.56	0.223	0.167
Short	Aaa	122	11.1	3.6	0.83	0.092	−0.079
	Aa	122	36.4	3.9	0.75	0.088	0.241
	A	122	96.5	4.0	0.99	0.120	0.226
	Baa	122	29.7	4.3	1.50	0.243	0.348
			Panel D. All Sectors' Bonds				
Long	Aaa	105	10.0	23.9	0.79	0.088	0.115
	Aa	103	10.1	21.3	0.91	0.087	−0.005
	A	122	44.4	21.7	1.18	0.125	0.150
	Baa	109	25.5	21.2	1.84	0.177	0.033
Medium	Aaa	115	10.4	10.1	0.77	0.102	0.046
	Aa	122	28.4	9.2	0.71	0.084	0.088
	A	122	107.6	9.4	1.01	0.106	0.149
	Baa	122	65.9	9.1	1.47	0.153	0.170
Short	Aaa	122	16.7	3.8	0.67	0.083	−0.127
	Aa	122	59.1	4.0	0.69	0.083	0.191
	A	122	170.7	4.2	0.93	0.107	0.183
	Baa	122	84.9	4.4	1.42	0.184	0.236

Table II

Regressions of Changes in Corporate Bond Yield Spreads on Changes in Treasury Yields

Noncallable bonds issued by industrial, utility, and financial firms are grouped by their month-t Moody's rating i and remaining maturity m. Maturities of fifteen to thirty years are "long," maturities of seven to fifteen years are "medium," and maturities of two to seven years are "short." For each group, mean month-t yield spreads over equivalent-maturity Treasury bonds are calculated using those bonds for which trader-quoted prices are available in the given month.

Monthly changes in yield spreads are regressed on contemporaneous changes in the three-month Treasury yield (3 mo. T-bill yield) and the slope of the Treasury term structure (Treasury slope), measured by the difference between the thirty-year constant-maturity Treasury yield and the three-month bill yield. Estimation uses OLS regression. The data range is February 1985 through March 1995. In parentheses are the absolute values of t-statistics, adjusted for generalized heteroskedasticity and two lags of moving average residuals. The hypothesis that the coefficients are equal across industrial, utility, and financial bonds is tested using GMM estimation. In brackets are p-values of the resulting $\chi^2(4)$ tests.

			Coefficient on			
Maturity	Rating	Obs.	3-mo. T-bill Yield	Treasury Slope	Adj. R^2	$\chi^2(4)$ Test of Equality of Coefs. across Sectors
Long	Aaa	105	−0.048	−0.053	0.014	7.51
			(1.63)	(1.42)		[0.111]
Long	Aa	103	−0.171	−0.122	0.243	4.66
			(4.68)	(1.92)		[0.324]
Long	A	122	−0.239	−0.232	0.330	4.08
			(4.73)	(2.83)		[0.396]
Long	Baa	109	−0.424	−0.334	0.378	3.74
			(6.11)	(5.00)		[0.442]
Medium	Aaa	115	−0.021	0.001	−0.014	3.82
			(0.58)	(0.03)		[0.431]
Medium	Aa	122	−0.153	−0.103	0.235	5.67
			(4.73)	(2.81)		[0.226]
Medium	A	122	−0.173	−0.116	0.188	2.31
			(5.07)	(3.28)		[0.679]
Medium	Baa	122	−0.249	−0.147	0.182	3.823
			(4.99)	(2.88)		[0.430]
Short	Aaa	122	−0.103	−0.034	0.102	6.33
			(2.35)	(1.09)		[0.176]
Short	Aa	122	−0.130	−0.038	0.173	4.64
			(4.72)	(1.57)		[0.326]
Short	A	122	−0.171	−0.060	0.175	5.04
			(4.93)	(2.10)		[0.283]
Short	Baa	122	−0.259	−0.089	0.134	2.00
			(5.87)	(2.08)		[0.735]

it would be surprising to find that bond spread behavior is identical across sectors. To test whether bonds spreads from the three business sectors studied (industrial, utilities, and financial) behave similarly, I jointly estimate equation (1) for each sector with generalized method of moments (GMM). I estimate twelve different three-equation GMM regressions, one for each combination of credit rating and maturity band. The $\chi^2(4)$ test of equality of $b_{s,i,m,1}$ and $b_{s,i,m,2}$ across the three sectors is reported in the final column of Table II.

The χ^2 test does not reject the hypothesis of constant coefficients across the business sectors for any category of bonds. Thus, from the perspective of statistical significance, there is no compelling evidence that yield spreads for different business sectors react differently to Treasury yields. However, this lack of rejection may simply reflect lack of power resulting from an insufficient number of observations. This is most likely for the regressions involving Aaa-rated bonds. For example, there are only twenty-five monthly observations available to jointly estimate the regressions for these yield spreads. Perhaps more relevant is the economic significance of the differences among the estimates. In results that are available on request, I find that the estimated coefficients for the three sectors are very similar. In the remainder of this paper, I use only yield spreads constructed with all business sectors' bonds.

B. The Persistence of Changes in Yield Spreads

How persistent are the changes in corporate bond yield spreads that are associated with changes in Treasury yields? I investigate this question using vector autoregressions (VARs) of the three-month Treasury bill yield, the slope of the Treasury term structure, and corporate bond yield spreads.[3]

For the sake of brevity, I present detailed results only for Baa-rated bond yields, which, as Table II indicates, are the most responsive to changes in Treasury yields. (Results for A-rated bonds are similar and available on request.) I estimate a fourth-order VAR for each maturity band. After accounting for lags, the sample period is May 1985 through March 1995. The ordering of the variables is: three-month T-bill yield, Treasury slope, Baa spread. Because innovations in the three-month Treasury yield and the Treasury slope are highly negatively correlated (in the neighborhood of -0.5), the order affects the implied impulse response functions. With this ordering, innovations in the three-month bill yield are much more important than innovations in the Treasury slope in explaining the variance of future Baa yield spreads. When the ordering of the bill yield and the slope are reversed, the explanatory power of the bill yield still exceeds that of the slope (for all three maturity bands), thus I do not present the results for the alternative ordering.

Figure 1 displays impulse responses of yield spreads on Baa-rated bonds to orthogonalized one-standard-deviation innovations in the three-month T-bill yield, the Treasury slope, and Baa yield spreads. Each column represents a

[3] The variables are measured in levels, although yield spread levels are artificially constructed by summing monthly changes in yield spreads. This method produces a "level" that differs slightly from levels of spreads on refreshed yield indexes. See footnote 1.

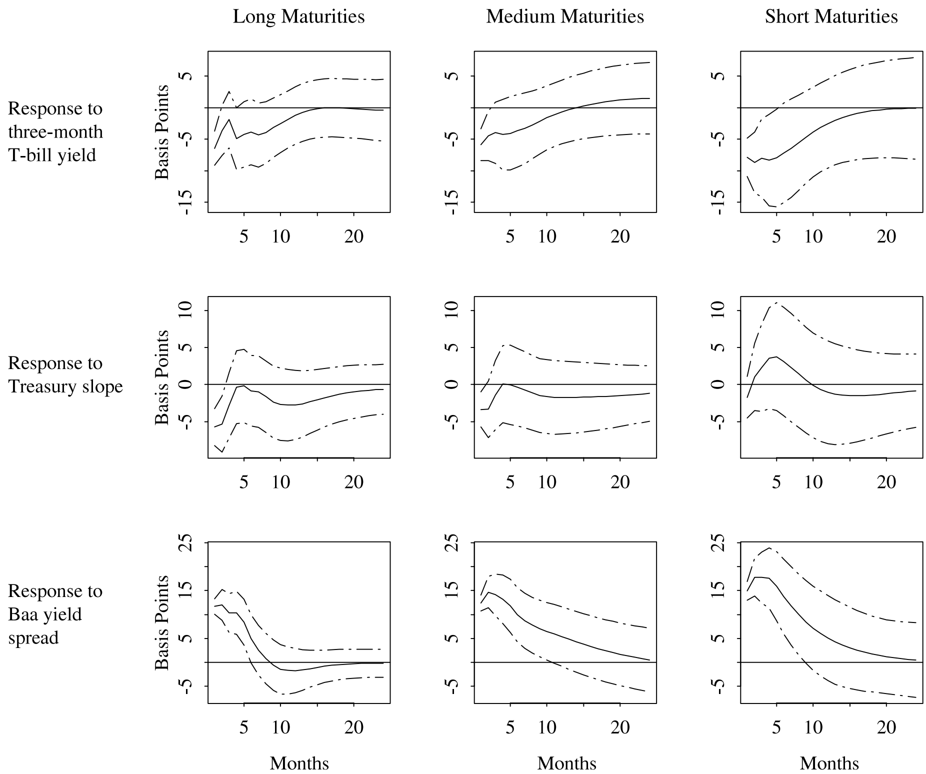

Figure 1. Impulse Responses of Yield Spreads on Baa-Rated Bonds, May 1985 through March 1995. Each column represents the impulse response of yield spreads on Baa-rated non-callable bonds of a given maturity band implied by a vector autoregression with four lags of three-month Treasury bill yields, the slope of the Treasury structure, and the given yield spread, in that order. Two-standard-deviation bounds on the impulse responses are also displayed.

different VAR, corresponding to different corporate bond maturity bands. The twenty-four months of impulse responses are bounded above and below by bands that represent two standard errors of the impulse responses.

There are two features of Figure 1 worth emphasizing. First, the standard errors of the impulse responses are so large that reliable inferences cannot be made about the responses at horizons greater than two to three months. In other words, the VARs' coefficients are too uncertain for any firm conclusions to be drawn about the persistence of changes in yield spreads in response to innovations in Treasury yields. Second, responses of yield spreads to innovations in the three-month bill yield are not largely reversed within one or two months. The point estimates of the impulses indicate that the half-life of the initial response ranges from eight to ten months, depending on the corporate bond maturity. One implication of these results is that if staleness in corporate bond prices is the explanation for the observed relation between yield spreads and Treasury yields, traders' bond-price quotes must take many months to adjust to new information.

C. The Effects of Coupons

Table II documents that yield spreads on lower grade, long-maturity bonds are strongly inversely related to the slope of the Treasury yield curve, holding the short end of the curve constant, but that spreads on lower grade, short-maturity bonds are less strongly related to this slope. A plausible interpretation of these results is that corporate bond yield spreads for a given maturity are most closely related to yields on equivalent-maturity Treasury bonds. However, I argue here that much of this inverse relation observed with long-maturity bonds results from the presence of coupons.

Corporate bonds have higher coupons than do Treasury bonds, thus a corporate bond with the same maturity as a Treasury bond will have a shorter duration. Short-duration instruments are more (less) sensitive to short-maturity (long-maturity) discount rates than are long-duration instruments. Therefore an increase in the slope of the Treasury yield curve, holding the zero-coupon bond yield spread constant, raises the yields on Treasury bonds relative to yields on corporate bonds of equal maturity, and hence decreases the yield spread of corporate coupon bonds over Treasury coupon bonds. This "coupon effect" is stronger for long-maturity bonds than for short-maturity bonds because coupon-induced differences in duration are larger for bonds with more coupon payments.

I explore the empirical importance of the coupon effect with a simple arithmetic exercise. I assume that spreads of zero-coupon corporate bond yields over zero-coupon Treasury bond yields are linear in maturity, and this linear relation is fixed over time. I also assume that the yield curve for Treasury zero-coupon bonds is linear but that the slope and level can vary over time. I then examine what happens to coupon bond yield spreads when the Treasury term structure rotates upward.

Denote the time-t yield on an n-period zero-coupon Treasury bond as $Y_{T,n,t}$ and the yield on an n-period zero-coupon corporate bond as $Y_{F,n,t}$. The time-t zero-coupon Treasury yield curve is assumed to satisfy:

$$Y_{T,n,t} = 0.066 + 0.0014n. \tag{2}$$

This upward-sloping zero-coupon yield curve results in yields on 8.4 percent coupon bonds that roughly match the mean level and slope of the Treasury coupon bond term structure for maturities of two and ten years over the sample period. (The choice of two and ten years is arbitrary, but the results are not sensitive to this choice.) The zero-coupon yield spread $Y_{F,n,t} - Y_{T,n,t}$ is denoted $S_{n,t}$. The term structure of spreads is assumed to satisfy:

$$S_{n,t} \equiv S_n = 0.012 + 0.0005n. \tag{3}$$

The parameters in equation (3) produce yield spreads on 9.56 percent coupon corporate bonds (over 8.4 percent Treasury bonds) that roughly match the mean yield spreads for Baa bonds in Panel D of Table I.[4] The coupon rate for corporate bonds is chosen to match the mean coupon on the long-maturity Baa bonds in the sample.

Given equations (2) and (3) we can calculate time-t prices, yields, and yield spreads of corporate coupon bonds. The question here is what happens to these coupon bond yield spreads when the parameters of equation (2), but not equation (3), change over time. I assume that at time $t + 1$, the new Treasury zero-coupon bond term structure satisfies:

$$Y_{T,n,t+1} = 0.0659085 + 0.0017664n. \tag{2'}$$

It can be verified easily that this new zero-coupon bond yield curve produces a three-month bill yield identical to that produced by equation (2), but the yield on a thirty-year Treasury bond paying 8.4 percent coupons is 50 basis points higher with equation (2′) than with equation (2). Given equations (2), (2′), and (3), we can calculate changes in yield spreads on coupon corporate bonds of varying maturities and coupons. I compute them for bonds with maturities of 22.0, 9.5, and 4.0 years. These maturities match the average maturities of the "long," "medium," and "short" bond categories summarized in Panel D of Table I. Each bond is assumed to have 9.56 percent coupons.

For the parameters specified here, this 50-basis-point increase in the long end of the Treasury term structure relative to the short end results in a decrease in the yield spread on twenty-two-year coupon bonds of 5.5 basis points. In terms of the regression equation (1), this coupon effect produces a negative coefficient on $\Delta TERM_{t+1}$ of -0.11. For shorter maturity bonds, which have fewer coupon payments, this coupon effect disappears; for example, the yield spread on 9.5-year coupon bonds falls by less than a basis point. The results of this arithmetic exercise suggest that the coupon effect explains perhaps half of the difference between the typical slope coefficient reported in Table II for long-maturity, non-Aaa bonds and the corresponding typical coefficient for short-maturity, non-Aaa bonds.

III. A Comparison with Callable Bonds

Most of the commonly used yield indexes are constructed with both callable and noncallable bonds. Consider, for example, the composition of Moody's Industrial Indexes as of May 1989, when there were nine bonds included in the Aaa Index. All were callable, although two of the nine had not yet reached

[4] Iwanowski and Chandra (1995) estimate such linear spread relations for various business sectors over roughly the same time period. The mean, across business sectors, of their full-sample relations for BBB-rated firms is $S_n = 0.0128 + 0.0003n$.

their date of first call. Eleven of the twelve bonds in May 1989's Aa Index were callable; ten of the eleven were currently callable. Essentially, the composition of Moody's Indexes reflects the composition of the universe of corporate bonds. As mentioned earlier, firms have historically issued many more callable bonds than noncallable bonds.

The joint behavior of Treasury yields and yield spreads based on these combined indexes is quite different from that documented for noncallable bonds. For example, when equation (1) is estimated for Moody's Aaa Industrials Index over the sample period of February 1985 through March 1995, the estimated coefficients on the differenced three-month T-bill yield and differenced Treasury slope are -0.400 and -0.378 respectively—roughly eight times the corresponding estimates for Aaa-rated bonds in Table II.[5]

Qualitatively similar evidence is in Table III, which reports estimates of equation (1) for yield spreads constructed with Lehman Brothers Corporate Bond Indexes. Yields on such indexes are value-weighted yields on almost all publicly issued, fixed-rate, nonconvertible corporate debt registered with the Securities and Exchange Commission. Yield spreads are constructed by subtracting interpolated constant-maturity Treasury yields. The estimation period is February 1985 through March 1995.

Regardless of credit quality, yield spreads on these indexes are all strongly negatively related to Treasury yields. This negative relationship is somewhat stronger for lower quality bonds, but the differences across credit ratings are substantially smaller than those reported in Table II for noncallable bonds. Moreover, for each index, the coefficient on the three-month T-bill yield is statistically indistinguishable from the coefficient on the Treasury slope. This implies that the long end of the Treasury curve drives changes in yield spreads even for shorter-maturity bonds, in contrast to the results in Table II.[6]

The callability of the bonds is an obvious possible explanation for the large sensitivities of yield spreads on such indexes. Callability can also explain why the coefficients on the three-month Treasury bill yield and the Treasury slope are roughly equal; or, equivalently, why yield spreads are driven by the long end of the Treasury curve instead of the short end. The call option value of a corporate bond depends on the Treasury yield of an equivalent-maturity Treasury bond. Thus, even for five-year corporate bonds, variations in the value of the call should be more closely tied to the thirty-year Treasury yield than the three-month Treasury yield, because the five-year Treasury bond yield is more closely related to the thirty-year Treasury yield. (During the sample period, the correlation of monthly changes in the constant-maturity

[5] For this regression, I create a yield spread by subtracting the thirty-year constant-maturity Treasury yield from the Moody's Aaa Industrials yield. The results are not sensitive to the precise calculation of the spread.

[6] Equality of the coefficients cannot be rejected at the 5 percent level for any index, and can be rejected at the 10 percent level only for the Long Baa Index.

Table III

The Relation between Yield Spreads on Lehman Brothers Bond Indexes and Treasury Yields

Corporate bond yields are from Lehman Brothers Corporate Bond Indexes. Bonds with maturities between one and ten years are included in Intermediate Indexes; bonds with maturities of ten years or longer are included in Long Term Indexes. Yield spreads are constructed by subtracting interpolated constant-maturity Treasury yields. This table reports results of regressing changes in yield spreads on contemporaneous changes in the three-month Treasury yield (3-mo. T-bill yield) and the slope of the Treasury term structure (Treasury slope), measured by the difference between the 30-year constant-maturity Treasury yield and the three-month bill yield. Estimation uses OLS regression. The data range is February 1985 through March 1995. In parentheses are the absolute values of t-statistics, adjusted for generalized heteroskedasticity and two lags of moving average residuals.

Index Used to Construct Yield Spread	Mean Maturity (years)	Coefficient on 3 mo. T-bill Yield	Coefficient on Treasury Slope	Adj. R^2
Long Aaa	22.3	−0.242	−0.238	0.418
		(5.27)	(6.05)	
Long Aa	22.6	−0.237	−0.231	0.439
		(5.39)	(6.27)	
Long A	21.3	−0.295	−0.272	0.492
		(6.26)	(6.75)	
Long Baa	21.0	−0.350	−0.283	0.370
		(6.19)	(5.99)	
Intermediate Aaa	4.8	−0.326	−0.256	0.408
		(5.23)	(6.52)	
Intermediate Aa	5.5	−0.310	−0.251	0.480
		(7.99)	(7.26)	
Intermediate A	5.7	−0.341	−0.292	0.476
		(7.74)	(8.04)	
Intermediate Baa	5.9	−0.399	−0.318	0.291
		(6.23)	(6.16)	

five-year Treasury yield with changes in the thirty-year constant-maturity Treasury yield is 0.91 and 0.67 with changes in the three-month Treasury bill yield.)

To test whether inclusion of callable bonds in these indexes accounts for the sensitivity of their yield spreads to Treasury yields, I investigate the following two questions. First, are callable corporate bond spreads more sensitive to movements in Treasury yields than are noncallable corporate bond spreads? Second, does the sensitivity of callable bond spreads depend on how close the bond price is to the call price? For this investigation, I restrict my attention to long-term Aa bonds.

I construct callable long-term Aa bond spreads in the same way that I earlier created spreads on noncallable bonds. For each month t, I form six groups of callable long-term Aa bonds, distinguished by their month t prices

Table IV

Regressions of Changes in Long-term Aa-Rated Callable Corporate Bond Yield Spreads on Changes in Treasury Yields

Long-term, Aa-rated callable bonds are sorted by their month-t call status (currently callable or call protected for at least another year) and month-t price. Mean monthly changes in their yield spreads over Treasuries from t to $t + 1$ are regressed on contemporaneous changes in the three-month Treasury yield (3-mo. T-bill yield) and the slope of the Treasury term structure (Treasury slope), measured by the difference between the 30-year constant-maturity Treasury yield and the three-month bill yield. Estimation uses OLS regression. The data range is February 1985 through March 1995. In parentheses are the absolute values of t-statistics, adjusted for generalized heteroskedasticity and two lags of moving average residuals.

			Coefficient on		
Bond Type	Bond Price (100 = par)	Obs.	3-mo. T-bill Yield	Treasury Slope	Adj. R^2
Currently callable	$100 < p_t$	109	−0.614	−0.540	0.797
			(15.30)	(12.89)	
	$90 < p_t < 100$	119	−0.310	−0.239	0.330
			(5.94)	(4.87)	
	$p_t < 90$	114	−0.189	−0.069	0.243
			(5.55)	(2.36)	
Not callable for at least 1 year	$100 < p_t$	122	−0.540	−0.467	0.781
			(12.45)	(11.70)	
	$90 < p_t < 100$	118	−0.241	−0.204	0.396
			(4.74)	(5.32)	
	$p_t < 90$	69	−0.128	−0.098	0.167
			(3.90)	(2.88)	

and their current call status. To investigate the importance of a bond's current call status, I distinguish between bonds that are currently callable and bonds that will remain call protected for at least another year. I drop bonds that are currently call protected but will be callable within a year. I further divide both groups using three price categories: less than 90, between 90 and 100, and greater than 100 (par equals 100).[7]

I estimate equation (1) for each time series of spread changes. The results are displayed in Table IV. Two important conclusions can be drawn from a comparison of the results in this table with those in Table II. First, the sensitivity of a callable bond's spread to changes in Treasury yields is positively related to the bond's price, as option pricing theory implies. Yield spreads on Aa-rated callable bonds with low prices (less than 90) behave similarly to spreads on Aa-rated noncallable bonds. In both cases, the esti-

[7] It would be more appropriate to sort bonds by the differences between their current bond prices and their call prices. However, the data set does not report a call price for callable bonds that are in their call-protection period. Therefore I have no call prices for callable bonds that reach their first call date after March 1995.

mated coefficients from equation (1) range from −0.06 to −0.19. By contrast, yield spreads on high-priced callable bonds exhibit very strong inverse relationships with Treasury yields. For high-priced (prices above par) currently callable bonds, the estimated coefficient on the three-month T-bill yield is −0.61. The estimated coefficient on the Treasury slope is almost identical, implying that the relation between yield spreads on these long-term callable bonds and Treasury term structure can be collapsed into a relation between the yield spreads and the long-term Treasury yield. The adjusted R^2 of this regression is 0.80. Yield spreads on medium-priced bonds fall between high-priced bonds and low-priced bonds in their responsiveness to Treasury yields.

The second important conclusion is that yield spreads constructed with callable, but currently call-protected, bonds behave similarly to yield spreads constructed with currently callable bonds. For each price band, the estimated coefficients for currently callable bonds are typically slightly more negative than the corresponding estimates for currently call-protected bonds, but the differences are small. Thus yield spreads on call-protected bonds behave more like yield spreads on currently callable bonds than like yield spreads on bonds that are noncallable for life. This suggests that it is inappropriate to use yields on temporarily call-protected bonds as proxies for yields on noncallable bonds.

V. Concluding Remarks

Yield spreads on investment-grade noncallable bonds fall when the three-month Treasury bill yield rises. The extent of this decline depends on the initial credit quality of the bond; for example, the decline is small for Aaa-rated bonds and large for Baa-rated bonds. These changes in yield spreads appear to persist for more than a year, although there is much uncertainty in the estimates of persistence.

The inverse relation between Treasury yields and corporate bond yield spreads is much stronger for callable bonds. This is a natural consequence of variations in the value of the option to call. Thus, yield spreads based on indexes constructed using both callable and noncallable bonds, such Moody's and Lehman Brothers' yield indexes, are also much more strongly inversely related to Treasury yields. Hence, variations in yield spreads based on such indexes should not be viewed simply as proxies for variations in investors' perceptions of credit quality.

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