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EMPIRICAL DURATION OF CREDIT SECURITIES: DEPENDENCE ON SPREAD

Introduction

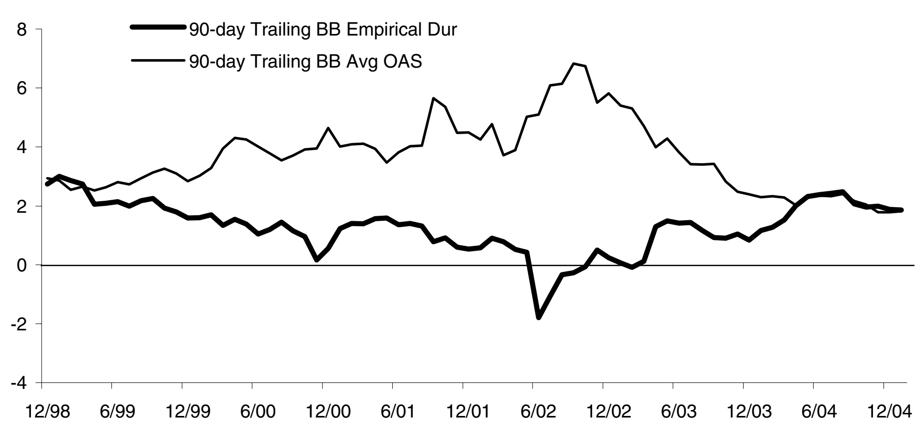
Several months ago, we examined how the empirical duration of high yield credit is related to its analytical value.[1] The issue is particularly relevant to core-plus portfolio managers with high yield securities in their portfolios but not in their benchmarks, who need to know what effect their high-yield exposures have on their yield curve positioning. The results reported in the paper, based both on an empirical study of asset class data and on our risk model, corroborate the market perception that the observed yield curve sensitivity of high yield securities is much lower than indicated by their reported analytical duration. For BB-rated debt, the ratio between the two was found to be roughly a quarter. Lower-quality investments, such as those rated B and C, exhibit close to zero, or even negative, interest rate sensitivity.

We argued that the very low interest rate sensitivity of high yield debt is largely due to the negative correlation between interest rates and credit spreads. If a change in interest rates is likely to be accompanied by an opposing change in spread, then the rate change will have a smaller net effect on prices and returns. As we move to lower-rated asset classes with higher spreads and higher spread volatilities, the magnitude of this opposing spread change effect continues to grow, until it is comparable with that of the rate change itself. This interaction gives rise to an empirical duration that, depending on the time period and other factors, hovers around zero.

A logical extension of this argument would be that even within a given credit rating, the empirical duration could change over time, in response to changes in spread levels and spread volatility. In the current study, we extend our analysis of empirical duration to investigate this possibility. We find strong evidence that empirical durations do, indeed, depend on spreads. In today's low spread, low volatility environment, this means that

[1] "Empirical Duration of High-Yield Credit," *Global Relative Value*, Lehman Brothers, November 8, 2004.

Figure 1. **Time Series of Empirical Duration and OAS for BB Credit Index**
Based on 90-Day Trailing Observations, December 1998-January 2005



empirical durations can be expected to be significantly higher than the long-term average results that we reported in November, for all credit qualities.

Empirical Examinations

To gain a better understanding of the relationship between empirical duration and spread level, we first look at the contemporaneous changes in empirical duration and spread level. Figure 1 plots the time series of 90-day trailing empirical duration between December 1998 and January 2005 alongside the average spread during that period for the BB credit index. The figure illustrates two issues: First, there is considerable variation in empirical duration, which ranges in the sample between -1.8 and 3.0. Second, empirical duration is negatively correlated to spread. Duration rises when spreads fall and vice versa.

Are the findings in Figure 1 applicable to the lower end of the high-yield credit universe as well? In order to answer this question, we divide the sample period into three spread regimes: Wide, Neutral and Tight. Wide and Tight OAS regimes are defined as periods in which the average OAS of the three credit quality groups (BB, B, and CCC-C) is above and below the 75th and 25th percentiles respectively.[2] Figure 2 plots the three daily spread time series classified by regime between August 1998 and February 2005. Not surprisingly, the persistent decrease in spreads since the end of 2002 resulted in the period since August 2003 being classified as a Tight spread regime. The period between November 2000 and February 2003 encompasses three separate sub-periods classified as a Wide regime. The rest of the observations in that time period and those before November 2000 fall into the Neutral category.

The table in Figure 2 reports empirical duration figures by quality and regime (i.e., three separate calculations are performed for each credit quality, with duration calculated as the sensitivity of daily price returns to daily changes in the 10-year yield). The results demonstrate a striking difference between the empirical duration in the three different regimes. Whereas empirical duration figures during the Neutral spread period are similar to those reported previously[3] for the entire period, the figures for the Tight and Wide regimes are significantly different. Empirical duration is higher than average in tight spread periods and lower than average in wide spread periods.

Figures 1 and 2 illustrate that empirical duration is correlated with the spread level. To quantify the effect of a change in spread level on empirical duration explicitly, we regress the index price change of both investment-grade and high-yield credit between August 1998 and February 2005 against two explanatory variables. The first variable is simply the daily yield change of the 10-year Treasury, whereas the second variable is the product of the 10-year yield change and spread level (OAS).[4] The results of this regression form a simple linear approximation for the empirical duration of each quality group as a function of spread:

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[2] We take the average spread of the three credit qualities in order to get a more stable classification of the observation into regimes. The results do not change substantially if we repeat the analysis with separate bounds for each credit quality.

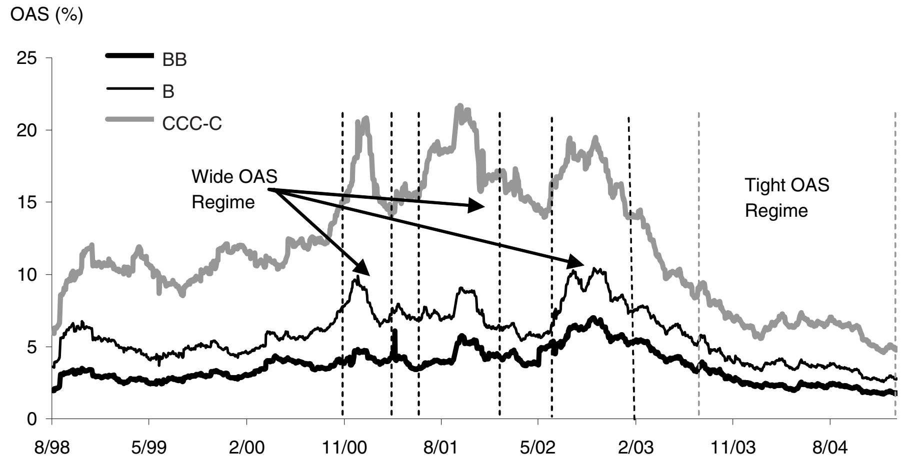
[3] "Empirical Duration of High-Yield Credit," *Global Relative Value*, Lehman Brothers, November 8, 2004.

[4] Specifically we estimated the following regression:

$$\left(\frac{\Delta P}{P}\right)_{j,t} = -\left(\Delta Y_t \times \sum_j I_{j,t}\beta_j + \Delta Y_t S_{j,t} \sum_j I_{j,t}\gamma_j\right) + \varepsilon_{j,t} \qquad j \in \{AAA/AA, A, BBB, BB, B, CCC-C\}$$

where Y is the 10-year Treasury yield, S is the option-adjusted spread, and I_j is a dummy variable that equals 1 if the return is on the j quality group and zero otherwise. Pooling all observations instead of estimating six separate regressions is more efficient but still allows for separate estimates of the coefficients by quality.

Figure 2. **Empirical Duration in Various Spread Regimes**
Daily Observations, August 1998-February 2005



Empirical Duration by OAS Regime

	BB	B	CCC-C
Entire Period	1.30	0.03	-0.28
Tight Spread	1.83	0.46	0.06
Neutral Spread	1.69	0.17	-0.06
Wide Spread	0.34	-0.52	-0.83

$$(1) \qquad D_j^{emp}(S) = \beta_j + \gamma_j S$$

The first coefficient, β_j, gives an upper limit to the empirical duration that might be expected for a given quality as spreads approach zero; the second coefficient, γ_j, which tends to be negative, describes the reduction in empirical duration as spreads widen. Since the unrealistic zero-spread case is not represented in the data, it is more meaningful to restate this relationship by centering around the mean OAS, $\bar{S}_j$:

$$(2) \qquad D_j^{emp}(S) = \left(\beta_j + \gamma_j \bar{S}_j\right) + \gamma_j\left(S - \bar{S}_j\right) = D_{j,avg}^{emp} + \gamma_j\left(S - \bar{S}_j\right)$$

The first term in this expression is the empirical duration at the average spread; the second term gives an upward or downward adjustment for spreads that are tighter or wider than average.

The regression estimates for the coefficients of empirical duration (β_j) and spread slope (γ_j) are reported in Figure 3. The spread slope coefficient is negative and significant for all qualities except AAA/AA, which confirms the assertion that duration has a significant spread-dependent component even for IG bonds. For all qualities, duration increases as spreads tighten. To see the effect of changes in OAS on duration, the table reports the average, minimum, and maximum OAS levels over the period and the associated empirical durations. For example, the empirical duration of BB ranges between -0.31 and 2.35, with a value of 1.39 at the average OAS level of 362 bp. For comparison, Figure 3 also shows the long-term empirical durations for the entire time period that are obtained if we ignore the spread dependence, as in our previous publication. We find that using the spread-adjusted method, our duration estimates are somewhat longer than the long-term numbers even for mean OAS levels and significantly longer when spreads are tighter than average, as is currently the case.

A potential criticism of the regression results reported in Figure 3 is that they fail to control for fundamental changes in index duration that affect both analytical and empirical durations. Such changes can arise from a decline in yields (i.e., simply moving on the price-yield curve) or as a natural result of index turnover (e.g., an increase in supply at the long end of the curve). To control for all such effects, we re-estimate the regression after making a simple modification. The two explanatory variables are multiplied by the OAD, so that our regression yields an estimate of the hedge ratio directly (empirical duration divided by OAD), as opposed to an estimate of the empirical duration. The results in Figure 4 illustrate once again that the hedge ratios are spread dependent, except for AAA/AA, and that the spread effect is stronger for HY than for IG,

Figure 3. **Regression Estimates of Empirical Duration with Spread Dependence**
Daily Data, August 7, 1998-February 10, 2005; Adjusted $R^2 = 0.38$

	AAA/AA	A	BBB	BB	B	CCC-C
Empirical Duration (Limit)	4.40	5.85	6.34	3.20	1.15	0.82
t-Stat	12.38	16.46	17.24	9.19	3.14	2.55
Spread Coefficient	0.02	-0.72	-0.78	-0.50	-0.19	-0.09
t-Stat	0.03	-2.68	-4.42	-5.75	-3.23	-3.66
OAS Range						
Min	0.32	0.59	1.08	1.71	2.53	4.60
Mean	0.73	1.23	1.93	3.62	5.82	11.91
Max	1.22	2.30	3.74	7.01	10.44	21.71
Empirical Duration at						
Min OAS	4.41	5.43	5.50	2.35	0.67	0.41
Mean OAS	4.41	4.96	4.83	1.39	0.04	-0.25
Max OAS	4.42	4.20	3.42	-0.31	-0.83	-1.13
Long-Term Empirical Duration (No Spread Dependence)	4.41	4.95	4.78	1.30	0.03	-0.28

Figure 4. **Direct Estimation of Hedge Ratios**
Daily Data, August 7, 1998-February 10, 2005; Adjusted $R^2 = 0.38$

	AAA/AA	A	BBB	BB	B	CCC-C
Empirical Hedge Ratio (Limit)	0.92	0.97	1.00	0.64	0.26	0.21
t-Stat	12.21	15.27	16.52	8.94	3.22	2.77
Spread Slope	-0.04	-0.09	-0.11	-0.10	-0.04	-0.02
t-Stat	-0.44	-1.83	-3.87	-5.52	-3.29	-3.79
			Hedge Ratio Calculated at:			
Min OAS	0.91	0.91	0.88	0.47	0.15	0.11
Mean OAS	0.89	0.86	0.78	0.28	0.02	-0.06
Max OAS	0.87	0.76	0.58	-0.06	-0.18	-0.28

as reflected in the higher t-statistics and in the wider variation of hedge ratios across the observed range of spreads. For BB-rated debt, in particular, the empirical hedge ratio can be anywhere from 0 to 0.5, depending on spreads.

Based on the results in Figure 4, we can form an expression for the empirical hedge ratio as a linear function of spread, much as we did in equation (2) for empirical duration:

$$H_j^{emp}(S) = H_{j,avg}^{emp} + Slope_j\left(S - \bar{S}_j\right) \qquad (3)$$

$H_{j,avg}^{emp}$ denotes the hedge ratio that would be expected at average spread levels, and the slope is the rate at which this hedge ratio would change with widening spreads. Figure 5 plots this linear function, separately for each quality, across the range of OAS levels observed during our sample period (August 1998-February 2005). There is a striking amount of overlap among the hedge ratios for different quality groups, especially considering that each line segment shown was estimated independently. The empirical duration of a C-rated bond at a period when spreads are tight can be the same as that of a B-rated bond when spreads are wider. It seems that the three investment-grade qualities could fit quite well to a single model for empirical duration as a function of spread; the three high-yield quality groups could be combined as well. However, there does seem to be a significant gap between the behavior of high-yield and investment-grade assets. BBB-rated assets with a spread of 200-300 bp have exhibited hedge ratios between 0.6 and 0.8, while BBs in the same range have hedge ratios closer to 0.3 or 0.4.

This fundamental difference between investment-grade and high-yield bonds is primarily the role of default risk. When the likelihood of default is perceived as high, the primary determinant of a bond's value is the assumed rate of recovery upon default. In extreme cases, this may cause all bonds of a given issuer (at the same seniority level) to be marked at the same dollar price, regardless of maturity. Clearly, such a valuation would be little influenced by changes in Treasury yields. In situations such as this, the perceived negative correlation between Treasury yields and spreads is just an artifact of a misspecified

Figure 5. **Hedge Ratios as a Function of Spread, by Credit Quality**

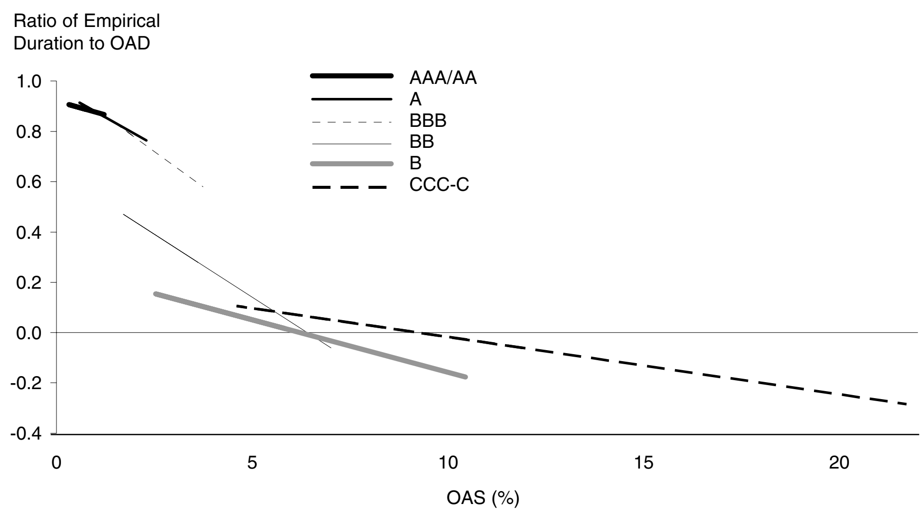


Figure 6. **Empirical Durations and Hedge Ratios Estimated Using Different Approaches**, as of February 10, 2005

		AAA/AA	A	BBB	BB	B	CCC-C
OAS (%)		0.33	0.59	1.10	1.74	2.73	4.86
OAD		4.80	5.83	6.52	5.32	4.34	4.19
Empirical Durations	90-Day Trailing Estimate	4.16	5.22	5.47	1.94	0.22	-0.02
	Estimated as a Function of Spread - from Eq. (2)	4.40	5.43	5.48	2.32	0.64	0.38
	Long-Term Average	4.41	4.95	4.78	1.30	0.03	-0.28
Empirical Hedge Ratios	90-Day Trailing Estimate	0.87	0.90	0.84	0.36	0.05	0.00
	Estimated as a Function of Spread - from Eq. (3)	0.91	0.91	0.88	0.47	0.14	0.10
	Long-Term Average	0.89	0.86	0.78	0.26	0.01	-0.06

model, in which the bond's price is related to the discounted value of cash flows that the market assumes will never arrive.

Even in less extreme situations, the pricing of credit-risky securities is influenced by the probabilities that the issuer will default at different points in time and the assumptions investors make about what the recovery rate would be should this occur. Including the possibility of a recovery event in which we receive a principal payment smaller than the full amount, but earlier in time, lessens the sensitivity of the pricing model to changes in Treasury rates. A recent paper from our Quantitative Credit Research team[5] presents a survival-based valuation framework that offers an analytical approach to the calculation of interest rate sensitivity, as opposed to the empirical approach explored here.

Would the gap between investment grade and high yield in Figure 5 disappear if we could screen out bonds trading to a default assumption? To investigate this possibility, we repeated the regressions shown in Figures 4 and 5 after screening our database to remove all bonds with a dollar price of 80 or less. To our surprise, we found that the results hardly change. The large difference between investment grade and high yield persists, with substantially lower hedge ratios for high yield bonds than for investment-grade bonds at similar spreads. This suggests that the difference between the interest rate sensitivities in the two markets may not be entirely due to considerations of default and recovery, but rather might be due to market segmentation effects. It is typical for investors in investment-grade credit to measure their performance in terms of excess returns over Treasuries (or swaps), while high yield performance is usually measured in terms of total return. This difference in approach (and the hedging practices that result from it) could well be an additional factor that mitigates the effect of interest rate movements on high yield valuations.

Summary

So where do we stand today? In the current low spread environment, how should one hedge the duration of a high-yield investment? Figure 6 offers several answers to this question. First, we present simple estimates of empirical duration calculated over the most recently observed 90 business days and divide by the OAD to obtain the corresponding estimate of the hedge ratio. Second, using the linear estimates we have developed for empirical

[5] "Consistent Risk Measures for Credit Bonds," *Quantitative Credit Research Quarterly*, vol. 2004-Q3/4, Lehman Brothers.

durations and hedge ratios as functions of spread, we plug in the current spread levels. We then compare these results with the long-term averages, with no adjustment for spread level. We find agreement between these two approaches that the current hedge ratio should be higher than the historical long-term average; however, our spread-dependent estimate gives values that are even higher than indicated by the most recent empirical tests. For example, our estimate suggests that the BB hedge ratio should be 0.47 based on the current spread level; the observed 90-day trailing result of 0.36 is about halfway between this value and the long-run ratio of 0.26.

In conclusion, we have shown that the empirical duration of credit securities varies over time in response to changes in the spread environment; in particular, it increases as spreads tighten. The interest rate sensitivity of BB credit, for example, can be anywhere between 0% and 50% of its OAD, a wide range around the long-term mean of 25%. This relationship is not confined just to high-yield credit but is evident in investment-grade as well. In light of the current tight spread environment, our results stress that the interest rate sensitivity of high yield bonds should not be overlooked.

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Publications-L. Pindyck, B. Davenport, W. Lee, D. Kramer, R. Madison, A. Acevedo, T. Wan, M. Graham, V. Monchi, K. Banham, G. Garnham, Z. Talbot