Arik Ben Dor 212-526-7713
abendor@lehman.com
Lev Dynkin 212-526-6302
ldynkin@lehman.com
Jay Hyman 9-723-623-8745
jhyman@lehman.com

DTS (DURATION TIMES SPREAD) – SCOPE AND APPLICABILITY. EMPIRICAL DURATION AND DEBT SENIORITY

Arik Ben Dor, Lev Dynkin, and Jay Hyman

Introduction

In two recent studies, we presented a detailed analysis of the behavior of credit spread changes.[1] Using our extensive U.S. corporate bonds database, we demonstrate that systematic changes in spread across a sector tend to follow a pattern of relative spread change, in which bonds trading at wider spreads experience larger spread changes. The non-systematic spread component of a particular bond or issuer is proportional to its spread as well. These findings also carry over entirely to the Euro corporate market despite its shorter history and different composition relative to the U.S. market. We, therefore, advocate using DTS (Duration Times Spread) rather than spread duration as a superior measure of spread exposure.[2]

In this article, we formalize the connection between DTS and the empirical duration of credit securities. In previous research, we found that the empirical duration of credit securities, and high yield in particular, exhibits a strong dependence on the level of spread.[3] Using a highly simplified factor model framework, we illustrate that proportional spread changes, coupled with the negative correlation between changes in treasury yields and credit spreads, imply a negative linear relation between empirical duration and spread as we observe in practice (e.g., securities that trade at higher spreads have shorter empirical durations). Estimates of empirical duration based on our simplified two-factor model match closely the regression-based figures we presented previously.

Another issue we investigate in this article is the extent to which DTS accurately captures the risk associated with different seniority classes. We compare the excess return volatility of several portfolios comprised of bonds from a single seniority class (e.g. “senior notes,” “debentures,” etc.) but with a very similar DTS. If spreads already incorporate the likelihood of default and the recovery value in such a case, then all portfolios should exhibit the same excess return volatility.

An initial analysis suggests that subordinated debt exhibits higher excess return volatility than senior debt with the same level of DTS. If as many investors believe spreads do not fully reflect the informational content of debt seniority, then this result should come as no surprise. However, a careful analysis of the data that controls for issuer-specific characteristics reveals that debt seniority does not affect excess return volatility beyond what is implied by the level of DTS, in contrast to the initial results.

[1] “A New Measure of Spread Exposure in Credit Portfolios,” Lehman Brothers, June 2005, and “DTS—Further Insights and Applicability,” *Global Relative Value*, Lehman Brothers, August 8, 2005.

[2] We performed several tests that support the use of DTS. First, we verified that portfolios with very different spreads and spread durations but with similar product of the two exhibit the same excess return volatility. Second, we demonstrate that modeling spread changes in relative terms, rather than absolute terms, generates improved estimates of excess return volatility. Finally, a controlled index replication experiment showed that matching index sector/quality allocations in terms of contributions to DTS tracks the Credit Index more closely than matching to duration.

[3] “Empirical Duration of Credit Securities: Dependence on Spread,” *Global Relative Value*, Lehman Brothers, March 14, 2005, and “Empirical Duration of High Yield Credit,” *Global Relative Value*, Lehman Brothers, November 8, 2004.

The Link between Empirical Duration and DTS

Our study of the empirical duration of credit securities in general, and high yield in particular, documented a strong linear relation between the treasury yield sensitivity and the level of spread as follows:

$$(1) \qquad D_j^{emp}(s) = \beta_j + \gamma_j \times s \qquad j \in \{\text{Aaa/Aa, A, Baa, Ba, B, Caa - C}\}$$

where 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 is negative in general, reflects the reduction in empirical duration as spreads widen.

The more recent study of DTS similarly found a linear relation between spreads and spread changes. In this section, we formalize the connection between these two empirical regularities using a highly simplified two-factor model.

Let us assume that in a macro sense, the returns of credit securities can be broadly described by a simple two-factor model, where the two factors are a parallel shift in yield Δy and a relative change in spreads $\Delta s_{rel} = \Delta s / s$ (as indicated by our DTS research). If we assume further that the treasury duration and the spread duration of a particular security *i* are the same and given by D_i, then the return to this security can be approximated as follows:

$$(2) \qquad R_i \cong -D_i \times \Delta y - \underbrace{(D_i \times s_i)}_{DTS_i} \times \Delta s_{rel}$$

We wish to measure the sensitivity of the overall return to a change in treasury yields. While we do not have an explicit formula for the dependence of spreads on yields, we wish to reflect the well-known correlation between the two. We can form a simple approximation for this relationship based on the sample variances and covariance of the two factors:[4]

$$(3) \qquad \frac{\partial s_{rel}}{\partial y} \cong \frac{\mathrm{cov}(\Delta y, \Delta s_{rel})}{\mathrm{var}(\Delta y)} = \frac{\rho_{y,s}\sigma_y\sigma_s}{\sigma_y^2} = \rho_{y,s}\frac{\sigma_s}{\sigma_y}$$

Using the above relationship to obtain the partial derivative with respect to the first risk factor, we have:

$$(4) \qquad \frac{\partial R_i}{\partial y} \cong -D_i - D_i \times s_i \times \frac{\mathrm{cov}(\Delta y, \Delta s_{rel})}{\mathrm{var}(\Delta y)} = -D_i\left(1 + s_i\rho_{y,s}\frac{\sigma_s}{\sigma_y}\right)$$

The expression in Equation (4) is the theoretical value for what we term "empirical duration"—the amount by which the absolute return will change given a particular yield change.

[4] The Lehman Brothers Global Risk Model uses a similar approximation to report the portfolio outperformance that would result from a 1-stdev shift in any single risk factor, assuming correlated movements of all other factors.

In Figure 1, we evaluate this expression based on direct observation of daily corporate index spread changes. For each of six quality groups, we measure the standard deviation of relative spread changes, as well as the correlation with changes in treasury yield. We then use these to calculate the linkage factor shown in Equation (3), which gives approximately the amount of relative spread widening one would expect if yields were to drop by 100 bp. This number, along with the average spread level for each quality group over the period, is used to calculate the average hedge ratio—the quantity in parentheses at the end of Equation (4). This number is compared with the average hedge ratio found for each quality group in our study of empirical duration (i.e., the ratio of empirically observed treasury duration to analytical duration).

The results are consistent with our previous research on DTS and on empirical duration. As we have seen, relative spread volatility is fairly level across quality groups. However, our study of empirical duration has shown that there is a steep drop in the hedge ratio to treasury yields as we cross over into high yield territory. This analysis shows that one way to interpret this result is that the correlation between yields and spreads is much stronger for high yield bonds than it is for investment grade bonds.

DTS across Seniority Classes

Perhaps the most convincing evidence in support of the DTS concept was the fact that portfolios (comprised of either U.S or European bonds) that are remarkably different in terms of their spread and spread-duration but where the product of the two (DTS) is similar, exhibit the same excess return volatility.

If, on average, spreads incorporate all publicly available information and exhibit a pattern of relative rather than parallel changes, then assigning bonds to portfolios based on a certain characteristic (for example credit rating) should result in the same excess return volatility across portfolios for the same level of DTS. Some investors, however, doubt that spreads fully reflect the informational content of debt seniority and, consequently, that DTS is able to accurately capture the risk differential among bonds of different seniority classes.

Figure 1. **Comparison of HY Empirical Duration Based on an Analytical Model and Regression Analysis**
Using Daily Observations from August 7, 1998 to February 10, 2005

	Aa	A	Baa	Ba	B	Caa
s_s - Daily Vol. of Relative Spread Changes	2.1%	1.7%	1.3%	2.4%	1.9%	1.7%
$r_{y,s}$ - Correlation with 10-Year Treasury Yield	-0.15	-0.17	-0.31	-0.50	-0.59	-0.36
s_y - Daily Vol. of Treasury Yield Changes	0.06	0.06	0.06	0.06	0.06	0.06
$r_{y,s} \times (s_s / s_y)$ - Linkage Factor	5.1%	4.8%	6.4%	19.6%	18.6%	9.9%
Average Spread Level (bp)	73	23	193	362	582	1,191
Hedge Ratio (Equation 4)	0.96	0.94	0.88	0.29	-0.08	-0.18
Hedge Ratio from Empirical Duration Study*	0.92	0.86	0.78	0.28	0.02	-0.06

* Based on Figure 5 from "Empirical Duration of Credit Securities: Dependence on Spread," *Global Relative Value*, Lehman Brothers, March 14, 2005.

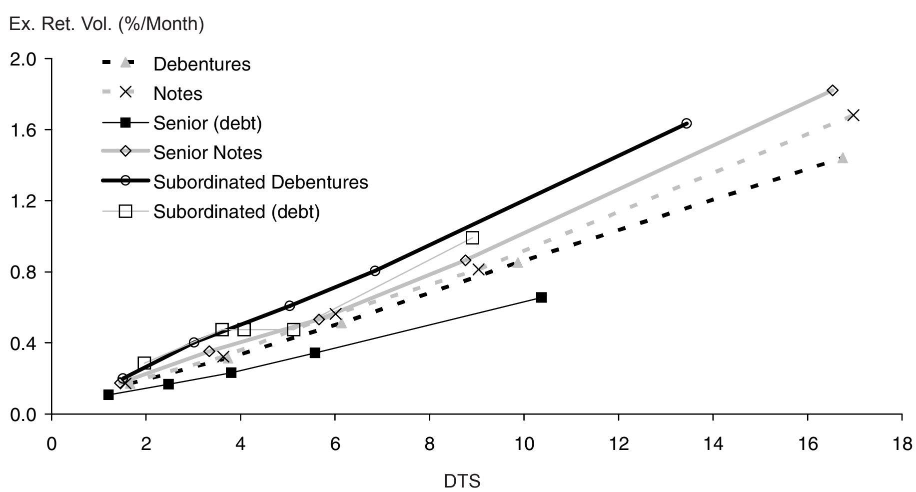
Unlike credit rating which naturally lends itself to cross-sectional comparisons, constructing portfolios based on debt seniority presents a challenge. The classification of a bond as senior or subordinated is based on its payment priority in case of a default. The recovery value of any bond will be affected by the existence of other claims *issued by the same issuer* that are more or less senior to that bond. Across issuers, however, the same seniority class does not necessarily imply a similar recovery value in case of a default. Furthermore, even for a given issuer, it not always clear if a certain claim is senior to another claim (e.g., a debenture versus a senior note).[5] As a result, simply grouping bonds into portfolios based on the seniority class is inappropriate. However, in order to have results comparable to our previous findings, we start by examining the relation between excess return volatility and DTS for portfolios composed of different seniority classes.

Figure 2 shows the results of such an analysis when bonds are first divided monthly by DTS into quintiles and then assigned into six separate portfolios based on seniority class (Debentures, Notes, Subordinated Debentures, Senior Notes, Subordinated Debt, and Senior Debt). The excess return volatility and average DTS of each portfolio is calculated separately based on the time-series of monthly excess returns and median DTS of the portfolio.

Looking at Figure 2, it is clear that excess return volatility increases linearly with DTS, consistent with our previous results. However, the sensitivity of excess return volatility to changes in DTS (i.e., the slope) varies across seniority classes. The slope of the line

[5] When a bank is owned by a holding company, owners of subordinated claim issued by the bank have priority in case of a default over owners of a senior claim issued by the holding company and skew the results. We would like to thank Lea Carty for pointing this out.

Figure 2. **Excess Return Volatility versus DTS by Seniority Class**
Using All Bonds Comprising the Lehman Brothers Corporate Index;
Bonds Are Assigned Monthly (9/1989-1/2005) to One of Five DTS Buckets,
Then Further Subdivided by Seniority Class



connecting the portfolios composed of subordinated debt and subordinated debentures is higher than that of the line connecting senior debt and debentures.

If debt seniority has informational content that is not fully reflected by spread, then this constitutes a serious challenge to the DTS concept. However, the results in Figure 2 may be misleading.[6]

To examine whether the initial results are driven by the method used to partition the data, we perform a more detailed analysis at the issuer level (identified by a ticker symbol). Each month, we construct two portfolios for each issuer—"SENIOR" and "SUBORD"—which include all the securities (often just a single security) that are defined as senior and subordinated, respectively. Months in which only one of the portfolios is populated are discarded.

We compute the market-weighted DTS and excess return for each portfolio and the DTS ratio of the "SENIOR" portfolio to the "SUBORD" portfolio. We then scale the DTS of the "SENIOR" portfolio so that it matches that of the "SUBORD" portfolio and adjust the excess return accordingly.[7] This procedure yields for every issuer, a time-series of excess returns for two portfolios with equal DTS in each month.

Using this approach for portfolio construction has clear advantages over the cross-sectional technique. First, it controls for any issuer-specific effect. Second, it accurately captures the relative seniority of different claims. Third, the fact that by construction the two portfolios have the same DTS has empirical implications: the ratio of excess-return volatility of the two portfolios should be one, on average. In addition, any difference in excess return should be relatively small and reflect only idiosyncratic risk (for example, one portfolio may include bonds that are smaller on average and "older" than bonds in the second portfolio and are, therefore, less liquid).

Figure 3 presents the 25th percentile, 50th percentile and 75th percentile of the ratio of excess return volatility of the "SUBORD" portfolio to that of the "SENIOR" portfolios. These statistics are reported for different compositions of the "SUBORD" and "SENIOR" portfolios. The table also shows the difference in average excess returns between the two portfolios (e.g. the excess return of the "SUBORD" portfolio less the excess return of the "SENIOR" portfolio).

For example, the second row reports the case in which the "SUBORD" and "SENIOR" portfolios include notes and senior notes respectively. There were a total of 353 different issuers with the two portfolios being populated over some time-period. The median ratio of excess returns volatilities is 0.94 and does not indicate a significant difference between the two portfolios. One quarter of the issuers exhibited ratios below 0.79, and one quarter of the issuers has ratios above 1.08, with the remaining half falling

[6] In "DTS—Further Insights and Applicability," we demonstrate that when the parameter of interest has a time-varying distribution, using a pre-determined partition may introduce time dependence and affect the results.

[7] Recall that excess returns less the carry part (spread/12) are a linear function of DTS. For simplicity, however, we ignore the fact that the carry should not be adjusted and multiply the total excess returns by the DTS scaling factor (ratio of DTS of the two portfolios). Notice also that if this were to be implemented in practice, we would need to take into account financing costs. However, since we do not form a trading strategy but rather examine whether similar DTS portfolios exhibit similar excess return volatilities, borrowing costs can be ignored.

Figure 3. **Ratio of Excess Return Volatility and Difference in Average Excess Returns between "SENIOR" and "SUBORD" Portfolios**
Portfolios Are Constructed Separately for Each Issuer, with the Composition Updated Monthly; The DTS of the "SENIOR" Portfolio Is Matched Monthly to That of the "SUBORD" Portfolio, and Its Excess Return Is Adjusted Accordingly

Portfolio Composition		**# of issuers**	**Ratio of Excess Return Volatility**			**Difference in Excess Returns** (%/month)		
SENIOR	**SUBORD**		P_{25}	P_{50}	P_{75}	P_{25}	P_{50}	P_{75}
Senior Debt	Subordinated Debt	47	0.83	1.10	1.41	-0.15	-0.06	-0.01
Senior Notes	Notes	353	0.79	0.94	1.08	-0.08	-0.01	0.04
Sr. Debentures + Debentures	Sub. Debentures	46	0.80	0.94	1.04	-0.05	0.02	0.05
Sr. Debentures + Sr. Notes + Senior Debt	Debentures + Sub. Debentures + Notes + Subordinated Debt	535	0.80	0.93	1.08	-0.13	-0.04	0.01

between these values. The average performance of the two portfolios is also similar and the median difference is 1 bp/month (e.g. the "SUBORD" portfolio underperforms). The results reported for other portfolio compositions are similar (in particular, the bottom row, which represents the most inclusive case) and do not indicate the two portfolios exhibit different risk characteristics.

Although the results in Figure 3 suggest that the excess return volatility of the two portfolios is typically similar, there are also cases when the ratio is quite different than one (as reflected by the 25th percentile and 75th percentile). Are these deviations related to the average DTS or to the difference in excess returns between the two portfolios?

Figure 4 presents a scatter plot of the excess returns differential and average DTS (both shown on the y-axis) versus the ratio of excess return volatility of the two portfolios. Each observation represents a separate issuer; the "SENIOR" and "SUBORD" portfolios include senior notes and notes, respectively.

Is there a pattern for cases when the volatility ratio deviates from 1? Does this happen more often for high (low) DTS values? In portfolios with the ratio smaller than one senior debt is more risky that subordinate. Does it result in its excess return being superior?

Figure 4 shows no clear relation of the ratio of volatilities to either the average DTS of the portfolio or the Excess returns differential. Similarly, we do not detect any clear pattern when using different compositions of the "SENIOR" and "SUBORD" portfolios.

Figure 5 plots the time-series of differences in excess returns between the two portfolios, averaged across issuers. (That is, excess returns are averaged cross-sectionaly at each point in time, as opposed to Figure 3 in which the results for each issuer are averaged across time). Since our approach generates an equal number of "SENIOR" and "SUBORD" portfolios with the same DTS, we expect their performance to be similar. Figure 5 demonstrates this is indeed the case: the average excess return differential during the sample period was 3.1 bp/month with a volatility of 6.67 bp/month (to put these numbers in context, the overall excess return volatility of the "SENIOR" and "SUBORD" portfolios was 53.4 and 52 bp/month, respectively).

The issuer-level analysis found no evidence to indicate that senior and subordinated claims exhibit different excess return volatility after controlling for the level of DTS. As a final test, we re-examine the relation between DTS and excess returns volatility, as in Figure 2, using the new approach.

Figure 4. **Ratio of Excess Returns Volatilities versus DTS Level and Excess Return Differential for Individual Issuers**
The Ratio of Volatilities Is Based on the Time-Series of Excess Returns of the "SENIOR" and "SUBORD" Portfolios Composed of Senior Notes and Notes, Respectively

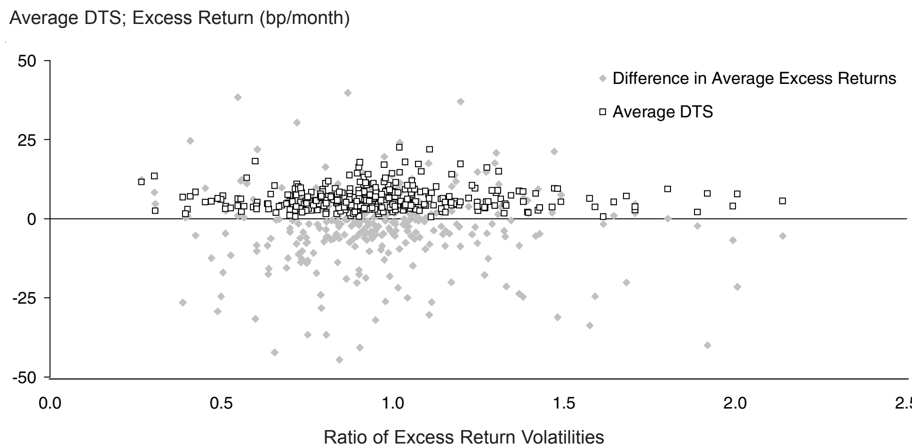
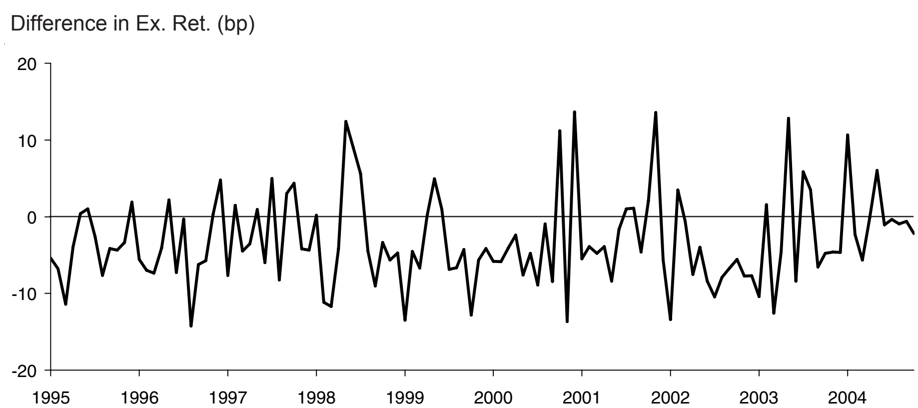


Figure 5. **Excess Return Differential between Portfolios of Subordinated and Senior Bonds**
Monthly Average across Issuers; The 'SENIOR' and 'SUBORD' Portfolios Are Composed of Senior Notes and Notes, Respectively; Each Observation Represents the Difference in Performance between the Two Portfolios



Each month, the "SENIOR" and "SUBORD" portfolios constructed for each issuer are divided to DTS quintiles. We then calculate the weighted excess return and DTS for each DTS quintile (separately by seniority class). The two aggregate portfolios in each quintile have the exact same DTS since at the issuer-level the DTS of the "SENIOR" and "SUBORD" portfolios is equal by construction. As before, we compute the time-series volatility of excess returns and the average DTS of the ten portfolios.

Figure 6 presents the results of the analysis comparing senior notes to notes and senior debentures to subordinated debentures. The scatter plot shows that the linear relation between excess return volatility and DTS is preserved and that the slope does not depend on the seniority level. In both cases, there is an almost exact match between the volatilities of the "SENIOR" and "SUBORD" portfolios. We obtain similar results for other compositions of the two portfolios reported in Figure 3.

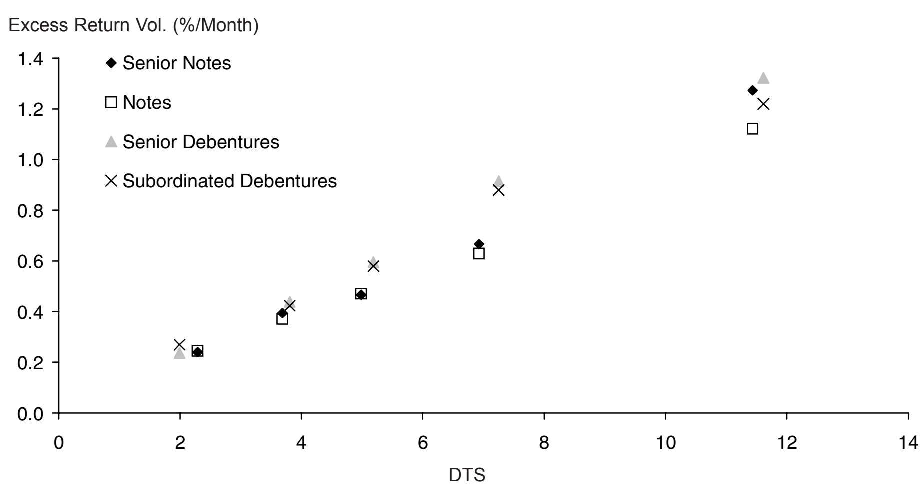
Conclusion

This article discusses two important issues related to our recent research on spread behavior and DTS as a superior measure of spread exposure.

We illustrate that empirical duration and DTS are closely related concepts. Using a simple factor model, we illustrate that proportional spread changes, coupled with the negative correlation between changes in treasury yields and credit spreads, imply that empirical duration should decrease with spread as we observe in practice. Estimates based on this analytical model match closely the regression-based figures we found previously.

Figure 6. **Excess Return Volatility versus DTS Controlling for Issuer Characteristics**

The "SENIOR" and "SUBORD" Portfolios Are Divided into DTS Quintiles, and the Weighted Excess Return and DTS Are Computed (Separately by Seniority Class); The Plot Presents the Time-Series Volatility of Excess Returns and the Average DTS of the Ten Aggregate Portfolios Composed of Senior Notes and Notes or Senior Debentures and Debentures



Some investors suggested that spreads may not fully reflect the informational content of debt seniority and as a result DTS may not accurately capture the risk associated with different seniority classes. An initial analysis indeed suggests that that subordinated debt exhibits higher excess return volatility than senior debt with the same level of DTS. However, a careful issuer-level analysis of the data shows no difference in excess return volatility of different seniority classes after controlling for DTS. The analysis provides further support to the notion that, on average, spreads correctly incorporate publicly available information and highlights the importance of controlling for issuer-specific characteristics when performing cross-sectional comparisons by debt seniority.

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