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DTS—FURTHER INSIGHTS AND APPLICABILITY

We follow our recent study of DTS (Duration Times Spread) as a superior measure of spread exposure and provide further insight into its scope and applicability.

1. INTRODUCTION

In a recent publication, we presented a detailed analysis of the behavior of spread changes.[1] Using our extensive corporate bonds database, which spans 15 years and contains well over 400,000 observations, we demonstrate that spread changes are proportional to the level of spread. 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 volatility of a particular bond or issuer is proportional to its spread as well. Following these findings, we advocate using DTS (Duration Times Spread) rather than spread duration as a measure of spread exposure. Sector exposures should be represented by contributions to DTS, computed as the product of market weight, spread duration, and spread.[2]

With respect to excess return volatility, we show that portfolios with very different spreads and spread durations but with similar product of the two (DTS) exhibit the same excess return volatility. We also demonstrate that modeling spread changes in relative terms rather than absolute terms generates improved forward-looking estimates of excess return volatility. Furthermore, in a controlled index replication experiment, we showed that matching index sector/ quality allocations in terms of contributions to DTS can track the Credit Index more closely than matching the contributions to duration.

This article provides further insight into the scope and applicability of DTS. We first examine spread volatility behavior as spreads approach zero. Using agency data, we find that the linear relation between spread volatility and spread level holds for spreads above 20 bp. For spreads below 20 bp, spread volatility is roughly constant; the levels of systematic and idiosyncratic “structural’ volatility are about 2.5-3.0 bp and 4.5 bp per month, respectively.

We also show that relative spread changes and the concept of DTS are not limited to the U.S. market. All our results carry over entirely to the Euro corporate market despite the differences between the two samples in terms of their quality composition and the time-periods they span. Interestingly, we observe a flattening of the relation between spread volatility and spread, as well as “structural” volatility levels that are very similar to those observed for agencies.

Another practical question this article addresses concerns the stability of the relation between spread volatility and spread level. We show that the effect of a change in spread level on spread volatility exhibits little variation both across time and across sector/duration.

[1] *A New Measure of Spread Exposure in Credit Portfolios*, Lehman Brothers, June 2005.

[2] An overweight of 5% to a market cell implemented by purchasing bonds with a spread of 80 bp and a spread duration of three years has the same exposure as an overweight of 3% using bonds with an average spread of 50 bp and a spread duration of eight years (0.05 x 0.80 x 3 = 0.03 x 0.50 x 8 = 0.12).

We conclude with a discussion of the difference between predetermined and relative data partitions. We show that employing different partitions to examine the relation between excess return volatility and DTS leads to conflicting conclusions. When the parameter of interest has a time-varying distribution, using a predetermined partition may introduce time dependence. We therefore advocate extra care when using a predetermined partition to analyze time-series data.

2. THE SCOPE OF DTS

2.1. Spread Volatility as Spreads Approach Zero

Perhaps the most fundamental empirical regularity we established is that absolute spread volatility is linearly proportional to spread level. We showed that an increase in spread of 100 bp over time leads to an average pickup in volatility of about 9 bp/month. The results were not confined to investment-grade credit. When the analysis was extended to include high yield securities, we found that the same relationship holds up to spreads of 450 bp.[3]

What do these findings imply for the level of spread volatility as spreads approach zero? Taking our results at face value suggests that there is no lower bound for volatility and that spread volatility should decline to almost zero for very low-spread securities. Spread volatility, however, is not driven solely by changes in risk but also by non-risk based factors. Non-risk based spread changes can result from "noise" (e.g., pricing errors), demand/supply imbalance (for example, when securities enter/exit the Lehman Brothers Corporate Index) and other factors.

Spread volatility (systematic or idiosyncratic) can therefore be expressed as the sum of two terms: a constant term that reflects non risk-based spread volatility and a second term that represents spread volatility due to changes in risk (which may be approximated by a linear function of spread) as follows:

$$\sigma(\Delta s) = \sqrt{\sigma^2_{non-risk} + \theta^2 \cdot s^2} \tag{1}$$

Equation (1) makes it clear that for sufficiently high spreads, the second term dominates the first term, and spread volatility can be well approximated by a linear function of spread, as we find for U.S. corporates. As spreads tighten and approach zero, the first term dominates, and spread volatility should converge to some minimum "structural" level.

A natural place to examine the formulation in Equation (1) is to look at the relation between spread volatility and spread level in agency debentures. Because of market perception that securities issued by the three main agencies are backed by the U.S. Government, these securities typically trade at very low spreads. Figure 1 presents the median spread for agency debentures between September 1989 and April 2005. The figure illustrates that except for a few distinct months, the median spread at which agencies traded ranged between 20 and 50 bp.

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[3] The slope of the line connecting spread volatility and spread level seemed to flatten beyond 450 bp. However, there were only three buckets representing securities with higher spread, which were scarcely populated during the sample period.

We study the relation between spread volatility and spread level as we did for U.S. corporates. Each month, bonds are partitioned based on beginning-of-month spread level. Average spread change and median spread level are computed separately for each bucket. We then examine the relation between the time-series volatility and average (median) spread level of each bucket.

The sample spans roughly the same time period as in the original study (September 1989-April 2005) and includes all Aaa rated, non-callable debentures from the Lehman Brothers Agency Index.[4] As before, extreme observations (which reside in either the top or bottom percentile of the spread distribution) are discarded. Since the total number of observations (73,000) is about 17% of the corporate sample size, we use only eight spread buckets.

The results are presented in Figure 2. To guarantee that our results are not driven by outliers, volatility is calculated in two ways: filtered (equal weighting excluding months with fewer than 20 bonds) and weighted (all months weighted by the number of issues). For comparison, Figure 2 also presents the spread volatility of long-duration financials we computed previously, which possess many of the same characteristics as agencies.

The plot in Figure 2 illustrates that spread volatility is roughly constant for spreads below 20 bp, and the level of "structural" systematic volatility is about 2.5-3.0 bp per month. Above 20 bp, the relation takes the usual linear shape and fits nicely with that of Long-Financials. A regression of spread volatility against spread level reveals a flatter slope than we estimated for corporates (5.7% versus 9%), consistent with Equation (1).[5]

[4] Including publicly issued debt of U.S. government agencies, quasi-federal corporations, and corporate or foreign debt guaranteed by the U.S. government (such as USAID securities).

[5] The results were unchanged when issues with a market value below $300 million were excluded or when non-U.S. agencies were excluded.

Figure 1. **Median Agency Spread**
Monthly Observations, September 1989 to April 2005;
Based on All Aaa-Rated, Non-Callable Debentures
Composing the Lehman Brothers Agency Index

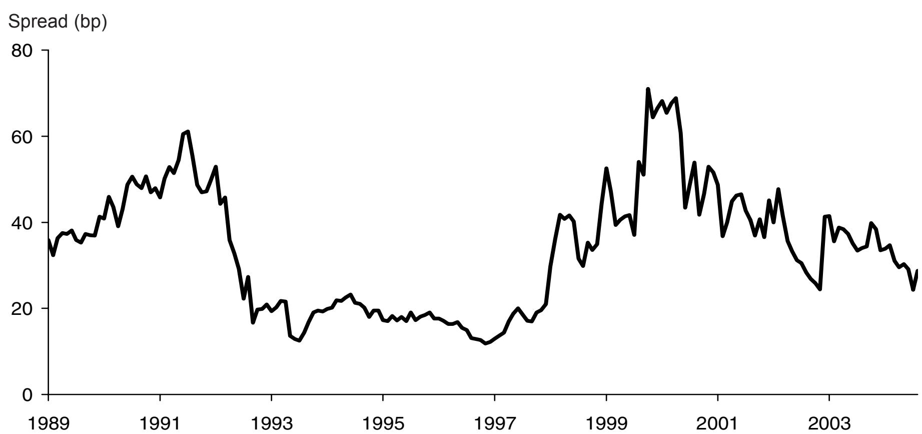


Figure 3 present the pooled cross-sectional spread volatility when individual idiosyncratic spread changes are aggregated across all periods. The results suggest that idiosyncratic volatility increases moderately as spreads increase from 20 bp to 80 bp and indicate a "structural" volatility level of 4.0-4.5 bp/month. The fact that idiosyncratic "structural" volatility is higher than the corresponding systematic level is to be expected, as pricing noise should be more pronounced for individual securities.

Figure 2. **Systematic Spread Volatility versus Spread Level**
Monthly Observations, September 1989 to April 2005;
Based on All Aaa-Rated, Non-Callable Debentures
Composing the Lehman Brothers Agency Index

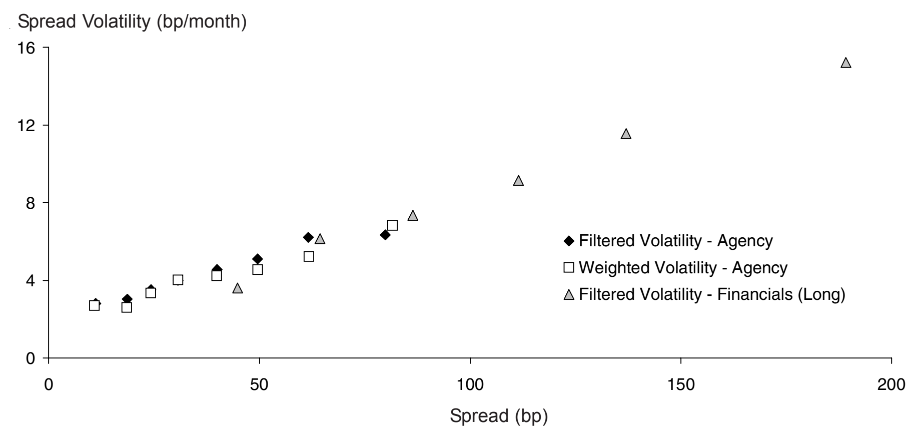
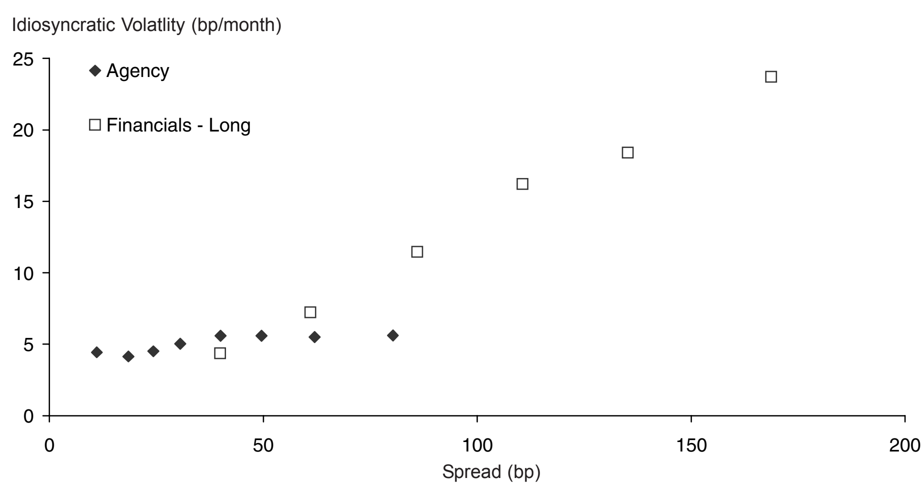


Figure 3. **Pooled Idiosyncratic Spread Volatility versus Spread Level**
Monthly Observations, September 1989 to April 2005;
Based on All Aaa-Rated, Non-Callable Debentures
Composing the Lehman Brothers Agency Index



To complete the analysis, the sample is partitioned into 12 DTS buckets and the excess return volatility of each bucket is plotted against its DTS (Figure 4). Similar to U.S. corporates, the results indicate that excess return volatility declines linearly with DTS (the estimated slope from the regression is 9.8%, versus 8.8% for corporates). As the DTS approaches zero, however, there is a clear flattening of the relation, and volatility does not decline further. Indeed, the regression yields a significant intercept of 3 bp, which is consistent with our previous estimate of "structural" systemic volatility.

2.2. DTS in the Euro Corporate Market

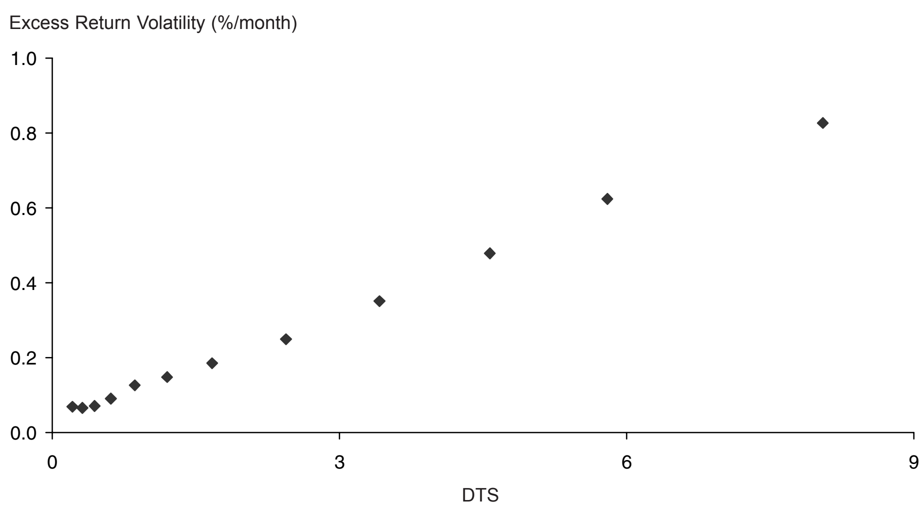
Is the proportionality of spread changes unique to the U.S. corporate market or is it a broader phenomenon? If we consider our results in the framework of a lognormal model in which a security spread reflects all the current information about its risk, then we can expect our findings to apply to corporate bonds in general and not just in the U.S.

This section presents results on the applicability of the DTS concept to the Euro corporate market. We conduct an analysis similar to the one we performed using U.S. data except for changes stemming from differences between the markets: First, the Euro sample spans a much shorter period, from January 2000 to May 2005, and is therefore more limited in size (roughly 48,000 observations).[6] Second, the overall credit quality of bonds in the Euro market is higher than in the U.S., which leads to a much narrower range of spreads.

In order to analyze spread volatility, the sample is divided into nine spread buckets (based on the results for U.S. corporates, we do not control for sector or duration). The results for

[6] We decided not to use any data prior to January 2000 in order to allow a one-year window following the introduction of the new currency.

Figure 4. **Excess Return Volatility versus DTS**
Monthly Observations, September 1989 to April 2005;
Using All Aaa-Rated, Non-Callable Debentures Composing the Lehman Brothers Agency Index; Bonds Are Assigned to One of Twelve Buckets based on DTS



both systematic and pooled idiosyncratic spread volatility are plotted in Figure 5 and illustrate two key points: First, spread volatility in the Euro market exhibits the same patterns as in the U.S. market. Both systematic and idiosyncratic spread volatility are proportional to the level of spread. Second, the generally higher quality of issuers in the Euro market results in a large number of observations with low spreads, which also allows us to examine the behavior of spread volatility in the limit. Consistent with the results we have found for agencies, spread volatility seems to stabilize around 20-30 bp. Furthermore, the level of "structural" volatility is similar as well: the systematic spread volatilities of Euro corporates and agencies are 2.5 and 2.0 bp/month, respectively; idiosyncratic spread volatilities are 6.0 and 5.2 bp.

The similarity between the U.S. and Euro markets is also evident in Figure 6, which plots excess return volatility for 24 buckets against their respective DTS level. Buckets are populated monthly by first splitting the sample into DTS sextiles and then dividing each sextile into spread quartiles. Figure 6 illustrates that excess return volatility increases linearly with DTS. (A regression of excess return volatility against DTS yields a significant intercept of 3.3 bp and a slope of 5.8% with a R^2 of 95%.) Buckets with similar DTS and different spreads tend to overlap quite nicely, although not as well as we have seen with U.S. data.

3. ADDITIONAL INSIGHTS INTO DTS

3.1 Stability of Spread Behavior

In our recent study of spread behavior, we found that a 100 bp rise in spreads leads to pickups in systematic and idiosyncratic volatility of roughly 9.0 bp and 11.5 bp/month respectively.[7] Can portfolio managers looking to utilize the DTS concept in managing

[7] *A New Measure of Spread Exposure in Credit Portfolios*, Lehman Brothers, June 2005.

Figure 5. **Spread Volatility versus Spread Level for Euro-Corporate Bonds**
Monthly Observations, September 1989 to April 2005;
Using All IG Euro Bonds Classified as Financials, Industrials, or Utilities

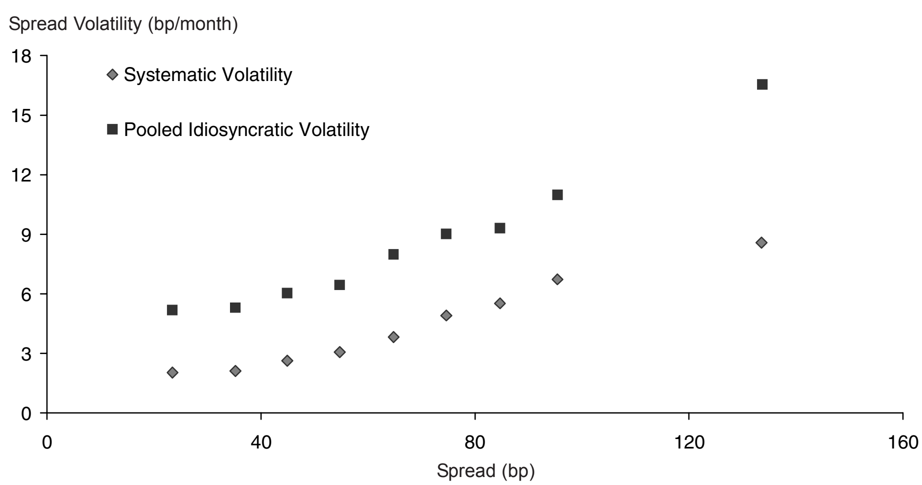
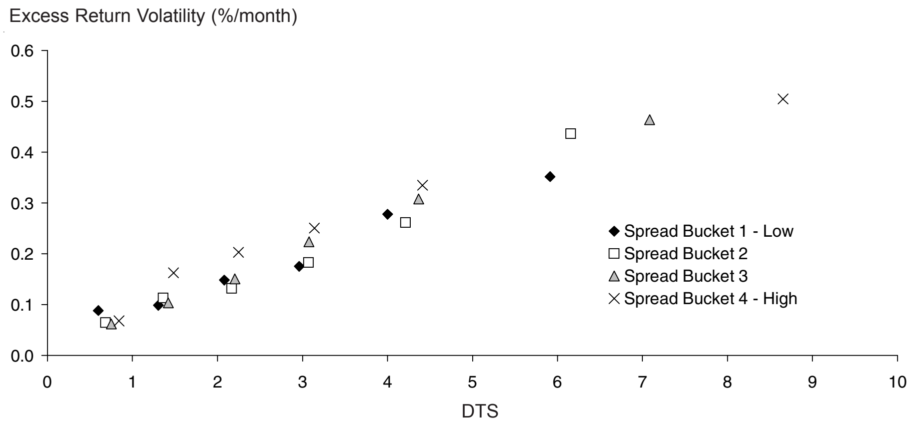


Figure 6. **Excess Return Volatility versus DTS**
Monthly Observations, January 2000 to April 2005;
Using All IG Euro Corporates: Each Month, Bonds Are Assigned to DTS Sextiles and Then Further Divided into Spread Quartiles



their portfolios use only these two figures, or do they need to make some adjustments? How much variation do these figures exhibit across sectors and time?

To examine the magnitude of variation over time, we use the same Sector X Duration X Spread partition we employed previously to analyze spread volatility in the U.S. market. We use monthly average spread changes to compute yearly systematic spread volatility figures (i.e., using 12 observations) with their corresponding spread level for each of the buckets separately. Depending on the sample composition and population, this procedure generates between 38 and 66 observations per year.[8] We then regress these estimates of systematic spread volatility against an intercept and a spread slope factor. We do the same for idiosyncratic spread volatility, except that we use the monthly cross-sectional volatility estimates, which results in 300-500 observations in each yearly regression.

Panels A and B of Figure 7 present the yearly spread slope estimates and corresponding adjusted R^2. The results are plotted two ways: using only IG credit and including HY securities as well. The estimated coefficients are all highly significant, with t-statistics ranging between 15 and 30 for both systematic and idiosyncratic spread volatility. Not surprisingly, Figure 7 reveals that including HY data generally increases the spread estimate for both systematic and idiosyncratic volatility. The spike in volatility caused by the 1998 Russian crisis is evident in the large estimate of spread slope in 1998 (except for the case of idiosyncratic volatility with HY). Except for 1998, the spread slope estimates are remarkably stable in light of the small number of observations used in the estimation.

[8] When high yield securities are included in the sample, the partition has a total of 66 buckets. Only observations that represent buckets that were populated with a minimum of 20 securities during the entire year are included in the analysis.

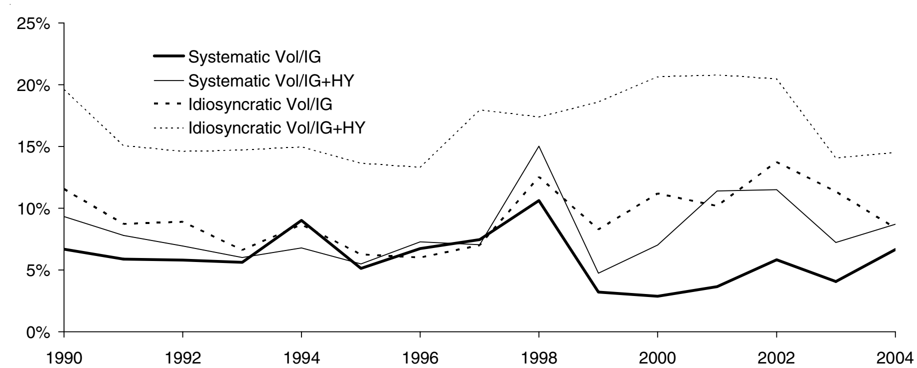
Panel B reveals that the explanatory power of the regressions is higher and more stable when HY securities are included. When we analyze IG data only, the R^2 of our regressions goes as low as 40% for systematic volatility and 30% for idiosyncratic volatility. When we include HY data as well, the regression results are much better, achieving R^2 values consistently over 70% for systematic volatility and 60% for idiosyncratic volatility. Overall, this pattern confirms that relative spread changes characterize both IG and HY credit.

To analyze the variation in the relation between spread volatility and level due to sector, duration, and credit quality, we conduct a similar analysis with one major difference: instead of estimating a common spread coefficient, we estimate an unconstrained model in which the spread slope coefficient may vary by sector and duration (a single spread volatility estimate per bucket is now calculated across all periods).

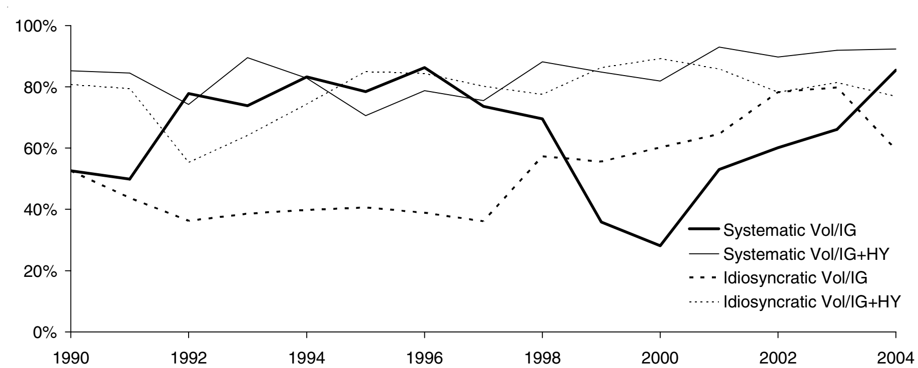
The estimation results for systematic and idiosyncratic spread volatility are presented in Figure 8, with separate columns for the case of IG credit alone and for the one that

Figure 7. **Yearly Regression of Spread Volatility against Spread Level**
Monthly Observations, January 1990 to December 2004;
Using All Coporate bonds Rated Aaa-Baa and
Separately Including High Yield Bonds Rated Ba-B

Panel A: **Spread Slope Estimates**



Panel B: **Adjusted R^2**



includes HY securities as well. The row titled "Spread Slope" represents the change in spread volatility due to a one bp change in spread for short-duration utilities and serves as a benchmark.[9] The coefficients reported at the bottom of the table represent marginal adjustment to the "spread slope" due to sector (Financials, Industrial) and duration (Medium, Long). The t-statistics indicate whether the marginal adjustments are statistically significant. For example, looking at systematic spread volatility with IG only, none of the adjustments are significant, implying that the same spread slope of 8.1% can be applied uniformly. When HY securities are included, the "spread slope" estimate changes to 10.7%, but the slope of Long-Industrials is hardly changed after it is adjusted downward by 2.7% (1.5% + 1.2%), to 8%.

Overall, the results confirm that relative spread volatility is not restricted to a single sector or maturity, but characterizes the entire market. They suggest that some adjustments by sector/maturity need to be made but all spread coefficients (except in the last column reflecting idiosyncratic volatility with HY) have the same magnitude of roughly 9 bp/month pickup in volatility for every 100 bp increase in spread over time.

[9] Specifically, we estimate the following regression:

$$\sigma(\Delta s)_{i,d,s} = s_{i,d,s} \times (\beta + \beta_{Fin} \cdot I_{Fin} + \beta_{Ind} \cdot I_{Ind} + \beta_{Med} \cdot I_{Med} + \beta_{Long} \cdot I_{Long}) + \varepsilon_{i,d,s}$$

where i,d and s denote the sector - duration - spread combination of each observation.

I_{Fin} *and* I_{Ind} are dummy variables equal to 1 if i = "Financials" or "Industrials," respectively, and zero otherwise.

Similarly, I_{Med} *and* I_{Long} equal 1 if d = "Medium" or "Long," respectively, and zero otherwise.

Figure 8. **Regression of Spread Volatility against Spread Level with an Adjustable Slope**

Using all Aaa-B rated U.S. Corporate Bonds, September 1989 to January 2005

		Systematic Volatility		Idiosyncratic Volatility	
		IG	**IG + HY**	**IG**	**IG + HY**
	Spread Slope	8.1%	10.7%	9.9%	14.7%
	t-Stat	18.98	52.98	35.88	24.42
	Adj. R^2	90.0%	96.6%	94.4%	97.7%
	N*	48	63	51	66
		Adjustments (t-Stat Reported Below Estimates)			
Sector	Financials	0.8%	0.3%	0.5%	0.2%
		1.73	1.15	1.50	0.28
	Industrials	-0.9%	**-1.5%**	0.1%	**-2.0%**
		-1.90	-7.22	0.31	-3.50
Duration	Medium	-0.2%	**-0.7%**	**-1.6%**	**-2.1%**
		-0.49	-3.35	-5.71	-3.97
	Long	-0.3%	**-1.2%**	**-2.1%**	**-2.3%**
		-0.63	-5.61	-7.62	-4.24

* The number of observations in the regression is equal to the number of buckets in the partition by sector-duration-spread. Three buckets were excluded from the regression of systematic volatility because they are scarcely populated.

3.2. DTS and Excess Returns under Various Partitions

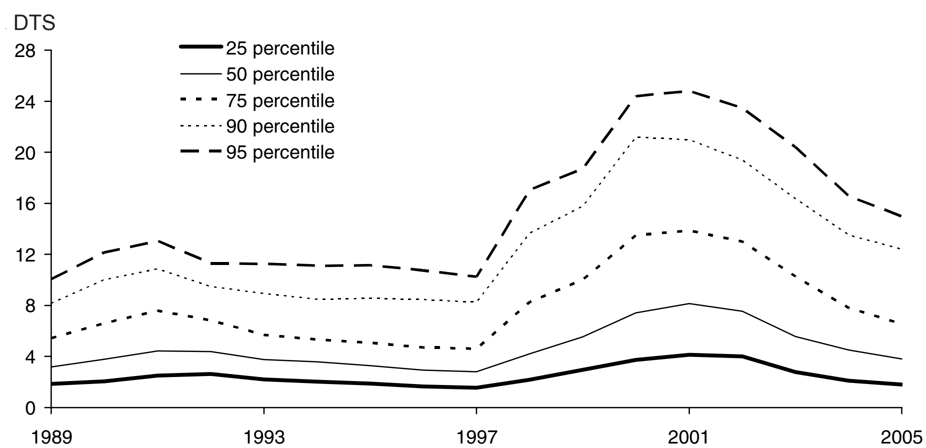
Analyzing time-series data often involves partitioning the data based on some variable of interest. Indeed, in the DTS study, we used this approach extensively to study the relation between spread volatility and spread and between excess return volatility and DTS. There are two basic types of partitions: a predetermined partition in which buckets are defined by constant breakpoints and a relative partition in which observations are first ranked based on the sorting variable and then assigned to the appropriate bucket.

Using a predetermined partition is advantageous in that the resulting buckets are well defined in terms of their composition. However, a relative partition ensures that irrespective of the sample size, all buckets are always equally populated. In contrast, if the sorting variable has a time-varying distribution, many buckets may end up being scarcely populated in some periods. For cases in which the time dependence of the ranked variable is correlated with common market factors, this may distort the results of the analysis. For example, a bucket that is populated by securities traded at some given low spread range will be highly populated in periods of low spreads and overall low volatility and only scarcely populated in other times.

In the context of analyzing the relation between excess return volatility and DTS, we demonstrate that employing different partitions can lead to conflicting conclusions. However, our results should not be seen as specific to the DTS study, but rather as demonstrating the need for extra care when using a predetermined partition to analyze data with a time-varying distribution.

We begin by illustrating the instability of the DTS distribution across time in the sample of U.S. corporates (Figure 9). The figure makes it clear that the distribution shifted up considerably in 1998 and more so for the higher percentiles (i.e., the 25 percentile is relatively stable, whereas the 95 percentile is very unstable). Looking at Figure 10 reveals that the variation in DTS is primarily driven by variation in spread levels, whereas duration is relatively stable.

Figure 9. **DTS Distribution by Year**
Monthly Observations, September 1989 to January 2005;
Using All Investment-Grade U.S. Corporates



In light of the time-varying DTS distribution, will the analysis of the relation between excess return volatility and DTS change if we use constant breakpoints rather than a relative partition?[10] We assign all bonds to one of five DTS buckets based on constant breakpoints and then further partition bonds to spread buckets (still formed using a relative partition as before). As before, we compute the time-series volatility of excess returns for each of the buckets.

Panel A of Figure 11 presents the results for this partition. For comparison purpose, Panel B shows the "original" results (i.e., using a relative partition twice). It seems that using predetermined DTS buckets does not affect our finding of a linear relation between excess return volatility and DTS. This is despite the fact that the unstable DTS

[10] In *A New Measure of Spread Exposure in Credit Portfolios,* bonds are partitioned by DTS and then by spread using a relative ordering.

Figure 10. **Spread and Duration Distribution by Year**
Monthly Observations, September 1989 to January 2005;
Using All Investment-Grade U.S. Corporates

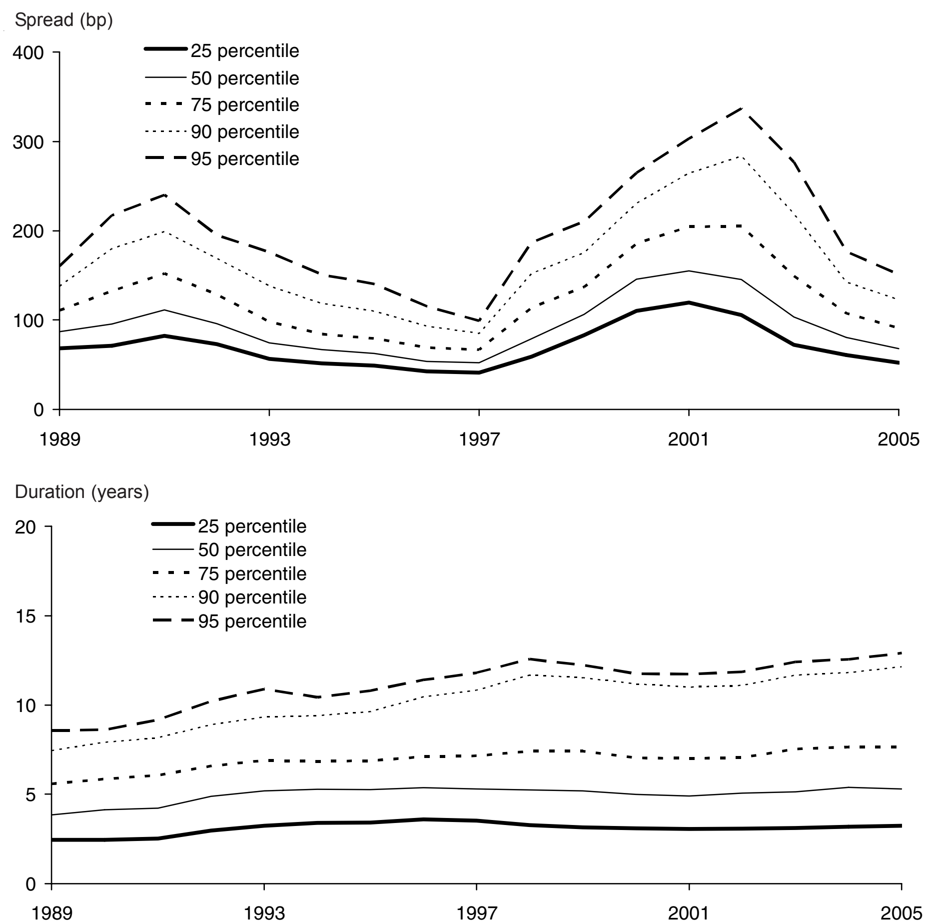
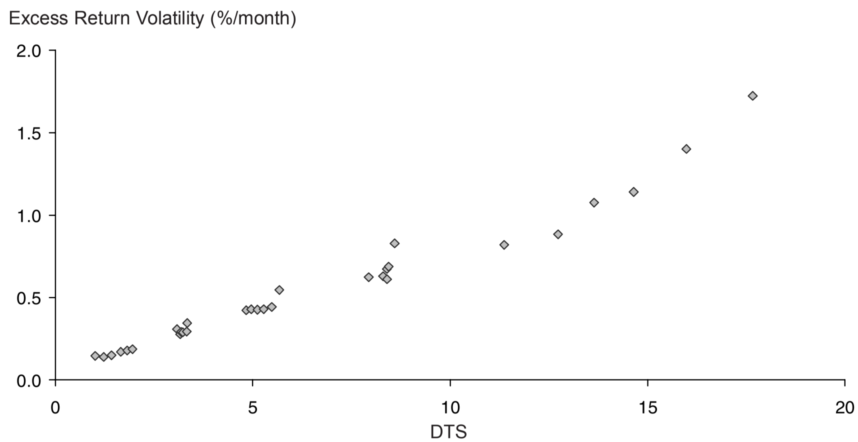
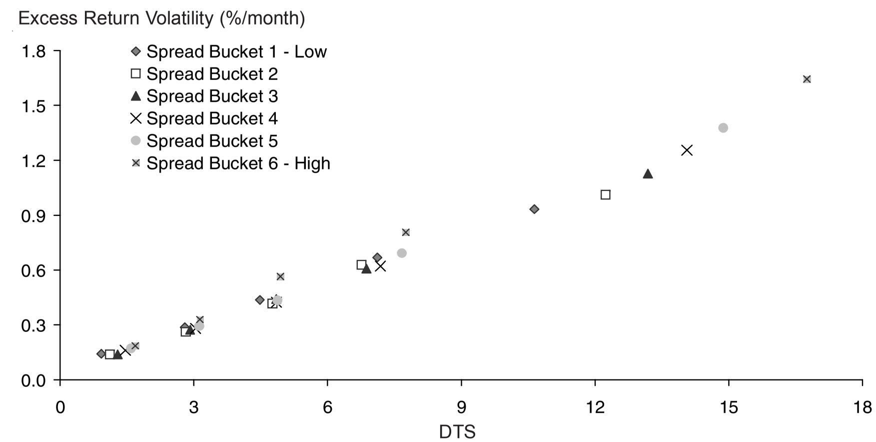


Figure 11. **Excess Return Volatility versus DTS Using Various Partitions**
Monthly Observations September 1989 to April 2005 using all U.S. IG corporates

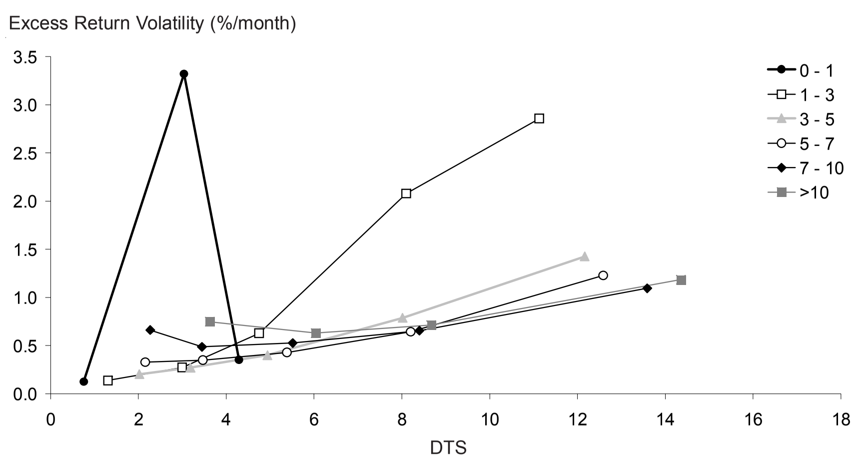
Panel A: **Constant DTS Partition and Then a Relative Spread Partition**



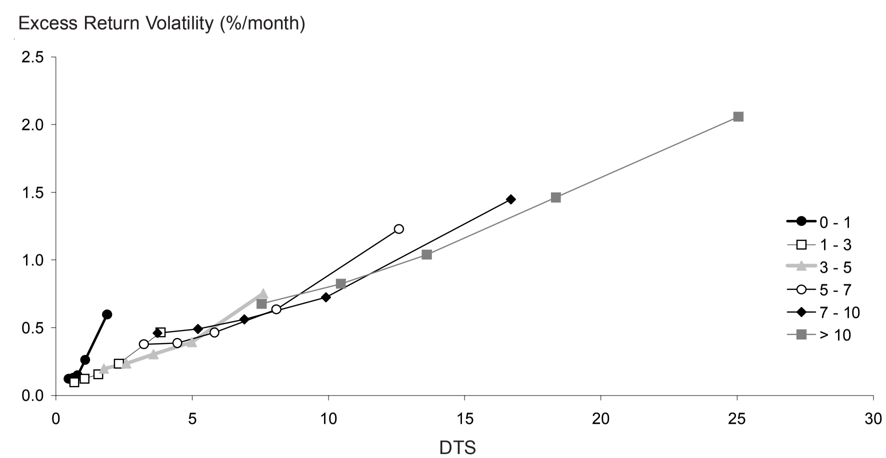
Panel B: **Relative DTS Partition and Then a Relative Spread Partition**



Panel C: **Constant DTS Partition and Then a Constant Duration Partition**



Panel D: **Constant Duration Partition and Then an Independent DTS Partition (by Duration Bucket)**



distribution leads to sharp variation in the yearly population of the buckets (Figure 12). For example, in 1996, the two extreme buckets (<250 and > 1000) hold 10,924 and 1,666 bonds, respectively, whereas in 2001, the numbers are 5,197 and 14,217.

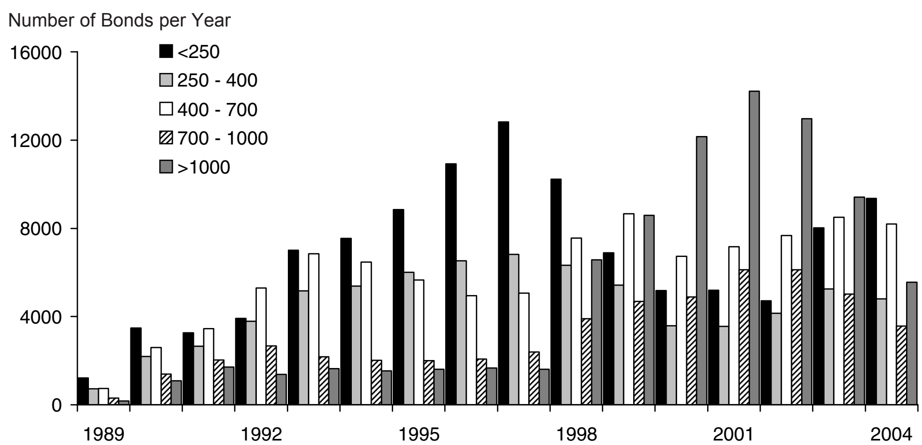
Consider instead the case in which bonds are divided into the same predetermined DTS buckets and are then further subdivided into predetermined duration buckets with the following breakpoints (in years): 0-1, 1-3, 3-5, 5-7, 7-10, and >10.[11] The results shown in Panel C of Figure 11 change dramatically and suggest that DTS buckets with shorter duration (or higher spread) have higher excess return volatility than buckets with similar DTS and longer durations.

What is driving this result? In Panel A, all the buckets are populated in each month, since the second-stage partition by spread is relative. In contrast, Panel C uses a predetermined partition to populate both DTS and duration buckets. This results in many months in which buckets are not populated, and in fact, three buckets are never populated.

To get a better understanding of why the results in Panels A and C are so different, we repeat the analysis but with a reverse order: we first allocate bonds to duration buckets and then to DTS buckets, but using different breakpoints for each duration bucket. This allows us to better accommodate shifts over time and achieve better, more equally populated buckets. Indeed, the results (shown in Panel D of Figure 11) look quite similar to those in Panel B and hardly reflect any dependency of the relation (between excess returns and DTS) on duration.

[11] Notice that the relative spread partition used in Panels A and B is (almost) equivalent to a relative duration partition (i.e., within a DTS quintile, bonds that are assigned to the highest spread bucket will also, in general, be assigned to the lowest duration bucket).

Figure 12. **Population of Predetermined DTS Buckets by Year**
Monthly Observations, September 1989 to January 2005
Using All Investment-Grade U.S. Corporates



4. CONCLUSION

This article is a follow-up to a recent Lehman Brothers publication, *A New Measure of Spread Exposure in Credit Portfolios*. It provides further insight into two key issues that are of interest to portfolio managers: the behavior of spread volatility as spreads approach zero and the stability of the relation between spread volatility and spread level.

Using agency data, we find that spread volatility is roughly constant for spreads below 20 bp. The level of systematic and idiosyncratic "structural" volatility is about 2.5-3.0 and 4.5 bp per month, respectively. We observe a similar phenomenon in the Euro corporate market, which is also characterized by a relatively large number of bonds traded at low spreads. We also find that our results on the relation between spread volatility and spread and excess returns and DTS in the U.S. corporate market carry over entirely to Euro market beyond the 20-30 bp range.

There are perhaps two key take-aways from these results. First, the scope of DTS is not limited to the U.S. market. Portfolio managers holding euro-denominated corporate bonds should find it superior to using spread-duration as well. Second, for portfolios primarily concentrated in low spread assets, such as Treasury/agency portfolios, DTS may not be the most appropriate measure of risk exposures. However, for portfolios containing a mix of credit and agency debt, DTS exposures are preferable. In most cases, the small understatement of risk for the securities with lowest spreads is insignificant compared with the increase in accuracy for the riskier portions of the portfolio.

Another practical issue we examined is the stability of the linear relationship between absolute spread volatility and spread level. We find only minor variation across time (in terms of the slope of the linear relation) and although some adjustments need to be made by sector/duration, they are small in magnitude. These results imply that estimates of relative spread volatility based on historical data are quite insensitive to the length of the time-series used in their construction. Furthermore, calculating portfolio risk as the product of its DTS and relative spread volatility can be done with a very limited number of spread volatility estimates.

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