U.S. Credit Strategies

Commentary

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Credit Strategy

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Credit Portfolio Management in the Turning Rates Cycle

The impressive gains of the U.S. economy since the second half of 2003 brought the prospect of rate hikes by the Fed and an overall turn to a rising interest rates cycle to the forefront of many investors' concerns. Barring unexpected geopolitical developments, it is now likely that we have entered a period of prolonged economic growth and a concurrent benign credit cycle associated with tight spreads and low volatility. The management of credit portfolios in such an environment requires a more precise positioning with respect to the movements of the underlying interest rates, as the credit-specific spread movements become less pronounced, and the effect of systemic factors becomes relatively more important.

We revisit the analysis of the co-movement between the interest rates and spreads originally published in June 2003[1]. We emphasize the results that are relevant to the benign credit cycle and extend the methodology to LIBOR OAS, which can be considered a close proxy for the behavior of CDS spreads. Our analysis is based on the Lehman Brothers multi-factor credit risk model covering the entire period from 1990 until the present. It is consistent with portfolio risk estimates delivered to our clients via POINT Portfolio and Index Tool system.

We find strong evidence that rates and spreads are negatively correlated in the long run: higher rates are associated with tighter spreads and steeper credit curves. The twists of the Treasury yield curve also have a significant effect on credit OAS: yield curve flattening is correlated with narrowing and steepening of credit spread curves. These results remain valid for the relationship between the swaps curve and LIBOR OAS as well.

The primary application of our results is the duration management and curve positioning of credit portfolios. To facilitate this task, we express our results in terms of effective durations and twist sensitivities by industry and rating sector. We also comment on the relative value opportunities induced by differential impact of interest rates across industry and rating sectors and combine tactical sector allocation views with long-term duration and curve positioning recommendations to obtain optimized sector allocation strategies.

We emphasize that the results reported here are based on the **long-term statistical analysis** of U.S. credit and interest rates. As such, they **may not reflect short-term aftershocks of Fed actions or the effect of a rapid change in investors' rates outlook**. We recommend that portfolio managers explicitly take into account the investment horizon and rebalancing

[1] A. Berd and E. Ranguelova, *The Co-Movement of Interest Rates and Spreads: Implications for Credit Investors,* Lehman Brothers U.S. Credit Strategies, June 19, 2003.

frequency in their response to the new rates cycle in order to avoid whipsaw effects, and note that our results apply to projections on the time scale of 6-12 months and longer.

THE FUNDAMENTAL RELATIONSHIP BETWEEN RATES AND SPREADS

Treasury yield and credit spread changes are correlated to the extent that they are caused by the same underlying economic expectations.

It is a widely held belief among credit bond portfolio managers and industry analysts that interest rates and credit spreads are negatively correlated. The main fundamental reason is that both Treasury yields and credit spreads reflect the state of the economy, and, therefore, one can expect their changes to be correlated to the extent that they are caused by the same underlying economic expectation. A worsening economy is generally associated with falling rates, while an improving economy is associated with rising overall level of interest rates (provided that inflation remains under control). For spreads, the direction of the dependence is precisely the opposite: they rise when the economy deteriorates and default rates rise and tighten as economic conditions improve. Accordingly, analysts find negative correlation between corporate bond spreads and U.S. Treasury yields.

The above statement on negative correlation applies only to overall changes in Treasury rates (i.e. to “parallel shifts” of the Treasury curve). However, the shape of the yield curve can change in a much more complex way, including twists and butterflies. The dependence of spreads on such changes in the underlying yield curve is much less documented. In terms of economic, as well as statistical significance, the parallel shifts and (flattening or steepening) twists are the primary modes of change of the Treasury curve, explaining more than 80% of its variability. Therefore, we focus on these factors and their effect on credit spreads.

In this paper, we derive the dependence of spreads on Treasury curve components across industry and rating sectors using the Lehman Brothers multi-factor credit risk model. We explain the characteristic differences in the effect of rates on various sectors and on spread curve shapes and OAS dispersion.

We also present a similar set of results relating LIBOR OAS to changes in the swaps curve (we do not consider the swap spreads themselves to be a proxy for credit in the current market environment because they are driven mostly by MBS and FX hedging, and because industry standard collateral requirements significantly mitigate the counterparty credit risk from over-the-counter swap trades). While qualitatively consistent with the results regarding the Treasury spreads, this additional set of estimates exhibits material quantitative differences that should be relevant to the growing number of LIBOR-funded credit investors, including the CDS protection buyers and sellers who can regard LIBOR OAS as a close proxy for otherwise unavailable historical statistics for credit derivatives during a benign credit cycle.

Our findings have significant implications for duration and curve management of credit portfolios.

Our findings have significant implications for credit portfolio managers. The negative correlation of spreads with rates affects the duration and curve management of credit portfolios, particularly when there is a significant under- or overweight position with respect to a benchmark containing Treasury bonds (or when the portfolio is managed on a total return basis without an explicit benchmark). Even if the portfolio is neutral to the benchmark in overall credit allocation, the cross-sector differences of the sensitivity to rates may still be important.

We derive simplified metrics, such as the effective duration multipliers and curve flattening sensitivities, to help portfolio managers in applying our results in practice. We also demonstrate how to combine tactical sector views with long-term curve positioning and present a set of specific recommendations to help investors navigate the choppy waters in the months ahead.

THE LONG-RUN BEHAVIOR VERSUS THE SHOCK EFFECT

The passage of economic cycles is characterized by large shifts and twists of the Treasury yield curve, and by wide range of changes in credit spreads. As we enter the expansion phase of the new cycle, the interest rates have started an upward shift, and the curve flattening is now restrained only by the Fed holding the overnight rates at the historically low 1%. As of April 2004, the Lehman Brothers Credit Index OAS has compressed to 86 bp, almost exactly the level achieved in the beginning of 1993, the lowest point of the previous Fed funds cycle.

Figure 1a shows the time series of the index OAS and the Fed Funds rate since 1990. The horizontal line corresponds to the Credit Index OAS level as of the end of April 2004. Figure 1b contrasts the credit spread dynamics with the overall Treasury curve movements. The definition of the Treasury curve shift and twist factors is presented in Appendix A. We show the incremental changes in shift and steepness (negative twist) from Jan 1990. Note that the changes in the shift and twist factor on which we focus in this analysis do not necessarily follow the changes in the Fed Funds rates tick by tick. In particular, they were mostly stable since the end of 2002, while the Fed Funds decreased by an additional 75 bp.

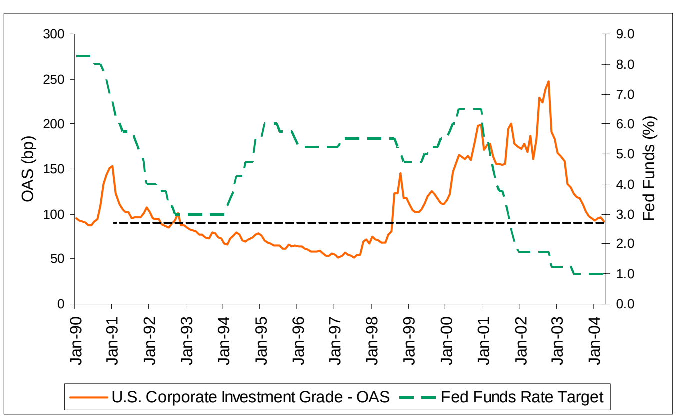
We can identify several periods in the past fourteen years when interest rate and curve changes have correlated with credit spreads.

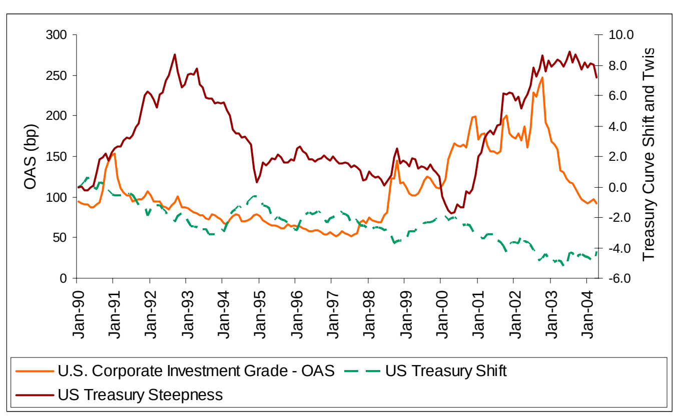
We can identify several periods in the past fourteen years when rate changes have correlated with credit spreads. First, the spreads rallied during 1992-1994, as the Treasury curve flattened following the end of the Fed easing cycle and the beginning of the rate hikes. The market reaction, in particular in the financial sector, was complicated by the Mexican peso crisis of 1994. The spreads experienced several short-lived widening waves, but maintained the overall rally trend through the rate hikes, and tightened even more once the Mexican peso crisis was over, and the rates settled on their new plateau in 1995-1997.

Then in August-October 1998, the Treasury curve shifted down and became steeper after the Russian default and LTCM crises prompted the Fed to cut rates. Spreads moved sharply wider, but then reversed just as the yield curve twist subsided; the rates themselves moved higher in the beginning of 1999. The credit markets were quick to anticipate the resolution of the crisis, and the October/November spread rally in 1998 may have slightly pre-dated the Treasury curve movement.

Figure 1a (left). Lehman Credit Index OAS vs. Fed Funds target rate, Jan 1990 – Apr 2004

Figure 1b (right). Lehman Credit Index OAS vs. Treasury Shift and Twist, Jan 1990 – Apr 2004





Next, the curve inverted in the latter part of 1999 and beginning of 2000, as the FOMC raised the Fed Funds rate up to 6.50%, pushing the 2-year yield to 6.90%, while the Treasury buybacks, budget surpluses, and dampened inflation expectations helped to keep the long yields subdued at 6.30%. Spreads widened precipitously, with credit investors concerned about the levels of leverage, even as the equity market rallied to all time highs during the same period.

Then the curve steadily shifted down and steepened during the rest of 2000 and 2001, as the Fed cut rates 11 times, from 6.50% to 1.75% (note that for these Figures, the definition of the twist corresponds to a steepening move of the yield curve, unlike in Appendix A and the rest of this paper). The same period saw the build-up of the pressures in the credit markets, with spreads hovering at then-highest levels, and the default rates beginning to rise sharply.

Finally, 2002 saw the last throes of the credit downturn. The spreads widened to all-time highs above 220 bp, and the Treasury curve steepened with the short rates pegged at 1.75% level. This was followed by the biggest spread rally in history since November 2002, which continues until the present time with little interruption, with the Fed cutting overnight rates by an additional 75 bp. Starting from the second half of 2003, the rally slowed, and the rates expectations began turning toward the rise in the levels and the flattening curve.

Given these experiences, it comes as no surprise that the correlation of spreads with the twists is positive, in contrast with the negative correlation with the level of rates. One can rationalize this by noting that spreads are more sensitive to expectations of the near-term economic outlook, related to the short end of the yield curve, rather than to the expectations of the long-run growth and inflation related to the long end of the yield curve.

Of course, spreads are influenced by many other factors beside the Treasury curve and the macroeconomic outlook encoded therein. The latest rally was driven much more strongly by a combination of credit-specific factors such as declining issuer-specific risk and overall spread volatility, declining effect of fallen angels, and improving balance in structured credit markets between buyers and sellers of credit protection. Having said this, the significant trends of the rate changes do get reflected in spread moves, and their effect is particularly important given the tight spread and low volatility environment we find ourselves in.

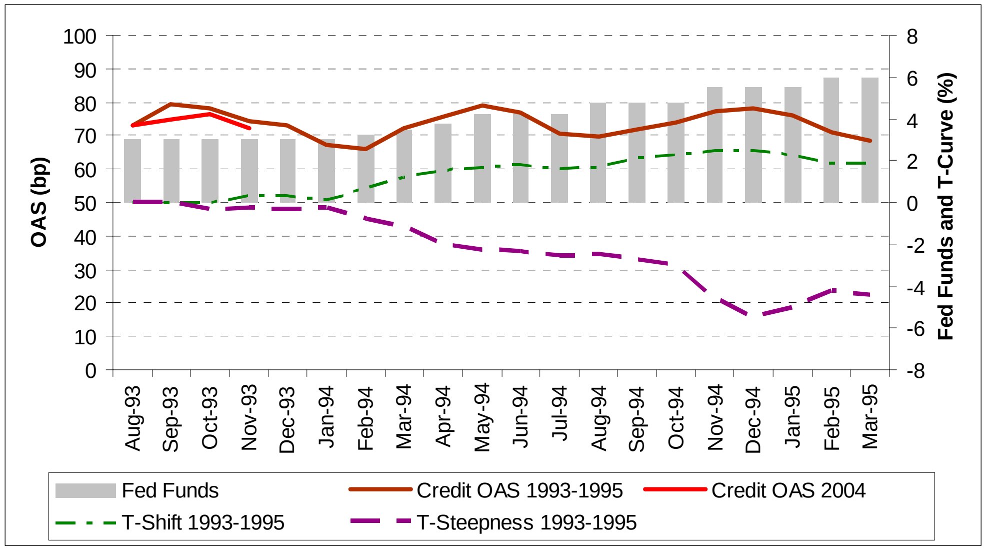
The long-run correlation between spreads and interest rates can run against the actual experience during the first Fed tightening moves.

The conclusion regarding the long-run correlation between the spreads and interest rates can run against the actual experience during the period immediately following the first Fed tightening moves. While the markets generally anticipate upcoming rate hikes, they often experience a shock once this anticipation gets realized. As a result, the risk premia associated with investing in credit and other risky asset classes also experience sudden changes leading to short- and intermediate-term spread widening waves.

The clearest example of this can be seen in the 1994-1995 experience (Figure 1c). We show the monthly dynamics of Lehman Credit Index OAS contrasted with the Fed Funds target levels, and Treasury curve shift and steepness.

The first spread wave lasted from August 1993 – February 1994 and preceded the actual rate hike – this was the “anticipatory” wave, tracking the rise in long rates. Spreads started at 73 bp in August, widened to 79 bp in September, and tightened back to 66 bp by February. The second wave (the “shock”) started with the rate hikes and also lasted roughly 6 months – from 66 bp in February 1994, to 79 bp in May, and back to 69 bp in August. The third wave (the “aftershock”) began at 69 bp in August, reached 78 bp in December 1994 (the time of the Mexican peso crisis) and tightened back to 68 bp by March 1995. The spreads then continued their tightening drive uninterrupted until 1997, reaching the level of 47 bp as measured by the Lehman Credit index.

Figure 1c. Lehman Credit Index OAS vs. Fed Funds, Treasury Shift and Twist, Aug 1994 – Mar 1995



We overlaid the OAS experience in the first four months of 2004 at the beginning of the first spread wave in 1994 (and scaled it to match the beginning point). The current "anticipatory" spread widening wave started after the Jan. 2004 FOMC meeting when the Fed dropped the explicit promise to hold the rates low for an "extended period" in favor of a less binding phrase to be "patient" in raising them. It appears that the first wave was over a bit faster than in 1994 – the spreads tightened back within three months instead of six. What we are witnessing after the FOMC meeting in May 2004 could very well be the beginning of the second wave, with markets discounting the summertime rate hike as a high likelihood event.

While we are not suggesting that the experience in 2004 will follow that of 1994 very closely, there are several reasons why the lessons from 1994 should not be dismissed out of hand.

First, many strategists agree that the beginning of the rate hikes will be accompanied by a modest spread widening wave. The question is how strong it will be and how long it will last. Right now, most evidence points to the possibility that it will be as limited as in 1994. Assuming a proportional widening of spreads, this would amount to perhaps 15-20 bp on top of the Lehman Credit Index spread levels just prior to the May 2004 FOMC meeting (i.e. 83 bp) – resulting in a wide target of 98-103 bp. In 1994, the second spread wave amplitude was 13 bp on top of 66 bp initial level, resulting in a widest level of 79 bp. Note that the index spread already made an interim peak at 94.5 bp on May 17 and currently stands at 93 bp, more than half way through the forecasted range.

We also think that this spread wave will probably last a shorter time, compared with those in 1994. Given the faster and more efficient nature of the markets today, in particular the effect of the liquid two-way credit derivatives market and a backstop provided by synthetic CDO issuance, as well as the active role of hedge funds and other relative value players, we guess that the spread wave will be over twice as fast (i.e. within three months instead of six).

Second, the possibility of an external aftershock cannot be dismissed either. Last time, it was Mexico; this time, all eyes are on China. The rising U.S. interest rates and the rising dollar may prompt Chinese authorities to address internal economic issues and foreign exchange regime more forcefully than they could afford otherwise (see the recent research report[2] for discussion of various issues facing China). If this scenario materializes, it may prove that the old seismologists' proverb about the "aftershocks" being more powerful than the first "shock" may be applicable in the financial markets, as well. We do not venture a guess as to how big such an aftershock spread wave could be, or how long it can last; such a question depends on much more than historical analysis to which we confine this particular study.

While the anecdotal evidence presented here helps in motivating our research and building intuition, it is not sufficiently precise to draw conclusions for credit portfolio management. To do that, we turn to a robust statistical estimation of the long-term correlation between the interest rates and credit spreads. We formulate the problem and present the answers in a form that should be useful to total return asset managers with investment horizons exceeding 6-12 months (i.e., longer than the possible duration of the spread widening waves).

THE LONG-TERM CORRELATION OF CREDIT SPREADS AND INTEREST RATES

To quantify the joint behavior of interest rates and credit spreads, we turn to the Lehman Brothers multi-factor credit risk model.[3] This is an econometric model that decomposes corporate bond returns into a linear combination of a number of factors including six Treasury (key-rate) factors, six swap spread factors, and a number of credit spread factors. The spread factors include 27 industry/rating sector factors measured in terms of LIBOR OAS, a spread twist factor which captures spread curve steepening or flattening, and an OAS dispersion factor which captures the dependence of bond's returns on its relative OAS to the sector average. The model estimates the covariance matrix of all common driving factors, as well as the issuer-specific risk of bonds belonging to each industry/rating sector. Our analysis is based on the most recent estimates as of the end of April 2003.

The Lehman multi-factor risk model also has a flexibility to consider either all past observations from January 1990 until present or to overweight recent relative to more distant historical experience.[4] Since we have just experienced a period of very fast change in the economic environment and are entering what appears to be a much calmer period, we believe that the equal-weighted version of the model is more appropriate for forward looking estimates, as it gives more weight to the long period of benign credit cycle from 1992 - 1998. The choice of a time-weighted model with its emphasis on the last 1-2 years would unduly skew the estimates toward a "high-vol" environment not likely to repeat itself in the next couple of years.

In order to take into account the issuer-specific risk and an incomplete diversification of typical investors' portfolios, we defined a sector portfolio to consist of 20 equally weighted bonds having on average the same maturity and same OAS as the corresponding sector. By construction of the risk model, such portfolio is not exposed to spread twist or OAS

[2] R. Gvozden*, Climbing the Great Wall of Worry,* Lehman Brothers Fixed Income Research, April 23, 2004

[3] M. Naldi, K. Chu, G. Wang, The New Lehman Brothers Credit Risk Model , *QCR Quarterly*, 2002-Q2

[4] A. Berd, M. Naldi, "New Estimation Options for the Lehman Brothers Risk Model", *QCR Quarterly*, 2002-Q3

dispersion factors. The sector correlations discussed in this paper are the correlations of OAS changes of these hypothetical sector portfolios with the Treasury shift and twist factors.

The results are shown in Figures 2, 3, and 4, and are discussed in the following sub-sections.

The Effect of a Treasury Curve Shift

Higher interest rates are associates with tighter credit spreads.

We define the shift factor of the Treasury curve as a parallel movement of all key rates (see Appendix A). It is associated with significant changes in the level of credit spreads as presented in Figure 2a. What can we infer from there?

1. Our results demonstrate **significant negative correlation** between parallel shifts of the Treasury yield curve and the level of credit spreads in each credit sector. A uniform increase in rates is associated with tighter spreads, while a uniform drop in interest rates leads to wider spreads. For example, a –27% correlation in case of the A-rated Consumer Cyclicals sector implies that if all rates rise by an amount equal to 1 standard deviation of the shift factor, the Consumer Cyclicals A sector spreads will likely tighten by 0.27 standard deviations of that sector's spread, all else equal.
2. The cyclical industries exhibit greater differential between the negative correlations across the ratings than do non-cyclical industries (e.g. Consumer Non-Cyclicals and Utilities which exhibit little dependence on rating).

The Effect of a Treasury Curve Twist

Flattening yield curve is associated with credit spread tightening

A twist of the Treasury curve has an additional effect on the credit spreads, separate from that of the shift. We define a **twist** as a flattening rotation of the yield curve around the 10-year maturity pivot point. For more details on the methodology, please refer to Appendix A. Here we discuss the main results which are presented in Figure 3a.

1. First of all, we find that the **correlations with a flattening yield curve are negative across all sectors and credit ratings**. A flattening yield curve is associated with tightening spreads and a steepening yield curve with widening spreads.
2. The rating dependence of the twist-spread correlation in the long-term model considered here is much more pronounced than the rating dependence of the shift-spread correlations.
3. Pro-cyclical industries, such as Energy and Transportation, Communications and Technology, and Consumer Cyclicals, exhibit growing levels of correlation with lower rating. This can be explained by higher sensitivity of these companies to the economic and credit cycles encoded in the Treasury curve twists.

The Treasury Curve Effect on Non-Sector Credit Factors

Next, we examine the correlations of Treasury shifts and twists with non-sector credit factors such as the **slope of the credit curve** and the **dispersion of credit spreads**.

Consider the results shown in Figure 4a.

1. The change in slope of the credit curve tends to be positively (11%) correlated with shifts of the Treasury curve (i.e. rising rates lead to steepening spreads). This is easy to understand because rising rates generally are associated with improving economy and credit quality, and the latter is in turn associated with greater surety regarding

the near-term outlook for the companies than for the long term, thus leading to steeper spread curves.

2. The spread twist is positively (9%) correlated with Treasury (flattening) twists (i.e. steepening yield curve is associated with flattening spreads). Again, this should be understood in the context of the economic downturn from which we are coming out – the steeper yield curve meant worse economy and, therefore, greater near-term risks for companies, hence the flatter, or even inverted, spread curves.

3. Spread dispersion is negatively (-27%) correlated with Treasury shifts. This reflects a familiar pattern where higher rates mean tighter spreads and less issuer-specific uncertainty.

4. Spread dispersion is negatively (-25%) correlated with Treasury (flattening) twists. As would be expected in a recovering economy (flattening curves), less issuer-specific risk results in a tighter distribution of spreads around the mean.

The Correlation of LIBOR Spreads with Swaps Curve Shifts and Twists

Figures 2b, 3b, and 4b present a similar set of results derived for the correlations of the LIBOR OAS with swaps rate curve. These results should be relevant for a growing number of LIBOR-funded investors. In addition, they may serve as a good proxy for the potential long-term behaviour of CDS in the absence of the actual observed historical levels for credit protection beyond most recent several years.

As we can see, most of the results are qualitatively consistent with the case of Treasury spreads versus Treasury curve. Note, however, that the level of correlations is significantly higher in Figures 2b and 3b, compared with Figures 2a and 3a. A part of the reason is that cash credit bonds tend to trade to the Treasury curve rather than to swaps. Given that since 1998 the swap spreads have been quite volatile and decoupled from credit spreads to Treasury, this amounts to an additional source of negative correlation between the swaps rates and spreads. In a somewhat oversimplified example, one may imagine an extreme case when the swap spreads move wider while the Treasury curve and the credit spreads to Treasury stay constant. This results in narrowing LIBOR spreads and increasing swap rate curve; thus, it contributes to a negative correlation between the swap rate curve and LIBOR spreads.

Figure 2a: Industry Portfolio Spread Correlations with Treasury Curve Shifts

	AAA/AA	A	BBB
FINANCIALS			
Banking and Brokerage	-18%	-24%	-20%
Financial Companies, Insurance and REITS	-23%	-28%	-26%
INDUSTRIALS			
Basic Industries and Capital Goods	-16%	-22%	-24%
Consumer Cyclicals	-14%	-27%	-23%
Consumer Non-Cyclicals	-17%	-19%	-21%
Communication and Technology	-17%	-21%	-24%
Energy and Transportation	-17%	-23%	-26%
UTILITIES	-17%	-20%	-20%
NON-CORPORATE	-4%	-17%	-21%

Figure 2b: Industry Portfolio L-OAS Correlations with Swap Curve Shifts

	AAA/AA	A	BBB
FINANCIALS			
Banking and Brokerage	-36%	-38%	-25%
Financial Companies, Insurance and REITS	-42%	-40%	-36%
INDUSTRIALS			
Basic Industries and Capital Goods	-37%	-41%	-37%
Consumer Cyclicals	-36%	-41%	-29%
Consumer Non-Cyclicals	-38%	-38%	-35%
Communication and Technology	-33%	-35%	-32%
Energy and Transportation	-37%	-41%	-39%
UTILITIES	-33%	-36%	-28%
NON-CORPORATE	-31%	-33%	-28%

Figure 3a: Industry Portfolio Spread Correlations with Treasury Curve Twists (Flattening)

	AAA/AA	A	BBB
FINANCIALS			
Banking and Brokerage	-16%	-19%	-16%
Financial Companies, Insurance and REITS	-19%	-24%	-22%
INDUSTRIALS			
Basic Industries and Capital Goods	-8%	-17%	-19%
Consumer Cyclicals	-9%	-23%	-20%
Consumer Non-Cyclicals	-11%	-12%	-16%
Communication and Technology	-12%	-16%	-20%
Energy and Transportation	-14%	-16%	-20%
UTILITIES	-9%	-15%	-16%
NON-CORPORATE	-3%	-11%	-17%

Figure 3b: Industry Portfolio L-OAS Correlations with Swap Curve Twists (Flattening)

	AAA/AA	A	BBB
FINANCIALS			
Banking and Brokerage	-29%	-32%	-21%
Financial Companies, Insurance and REITS	-35%	-34%	-30%
INDUSTRIALS			
Basic Industries and Capital Goods	-28%	-31%	-29%
Consumer Cyclicals	-29%	-32%	-24%
Consumer Non-Cyclicals	-28%	-29%	-27%
Communication and Technology	-25%	-27%	-25%
Energy and Transportation	-30%	-31%	-31%
UTILITIES	-24%	-28%	-23%
NON-CORPORATE	-22%	-27%	-22%

Figure 4a: Additional Spread Factor Correlations with Treasury Curve Changes

	Treasury Shift	Treasury Twist (Flattening)
Credit Spread Twist (Steepening)	11%	9%
Credit Spread Dispersion	-27%	-25%

Figure 4b: Additional L-OAS Factor Correlations with Swaps Rate Curve Changes

	Swaps Rate Shift	Swaps Rate Twist (Flattening)
Credit Spread Twist (Steepening)	7%	18%
Credit Spread Dispersion	-24%	-22%

CREDIT PORTFOLIO MANAGEMENT FOR THE LONG TERM

The results of our study have important implications for risk management as well as for identifying relative value opportunities across sectors with different interest-rate sensitivities.

Duration Management of Credit Portfolios

A government bond and a corporate bond with the same duration <u>do not</u> have the same interest-rate sensitivity due to credit spread dependence on interest rates

The directionality of credit spreads and interest rates poses a challenge to credit investors who want to manage the interest rate exposure of their portfolio. Because spreads tend to move in conjunction with underlying interest rates, a corporate bond is not fully insulated from rate movements if hedged with the same-duration Treasury bond. In other words, a credit bond portfolio benchmarked against a government bond index (such as the overweight credit portion of a typical fixed income portfolio) will not be neutral to interest rate movement if it has a matching duration with the Treasury benchmark.

For a given shift in interest rates, the corresponding change in the corporate yield is smaller because it gets partially offset by the tightening of the spread. To account for this fact, we introduce *effective duration*, which is defined as the fractional price sensitivity to parallel shift in the interest rate curve plus the correlated change in spreads (the sensitivity is defined with an overall negative sign, similar to modified duration).

We have derived this sensitivity in Appendix B. Recalling that the sum of the key rate durations is simply the modified duration of the bond, we can write down the result as:

$$D_{eff} = D_{mod} + \rho\left(S, F_{shift}\right) \cdot \frac{\sigma_{spread}}{\sigma_{shift}} \cdot OASD$$

Here, D_{eff} stands for the effective duration, D_{mod} is the modified duration, $OASD$ is the spread duration, $\rho\left(S, F_{shift}\right)$ is the correlation between credit spreads and parallel shift factor of interest rates, σ_{spread} is the volatility of spreads, and σ_{shift} is the volatility of the Treasury shift factor (both volatilities must be measured in absolute terms and expressed in equal units, e.g. bp/month).

Since the correlation of spreads and yields is negative and quite substantial, the effective duration will be typically a fraction of the modified duration. We denote this fraction as *Effective Duration Multiplier* (EDM) and show it in Figure 5a for the same representative sector portfolios for which we calculated the correlations in the previous section.

$$EDM = 1 + \rho\left(S, F_{shift}\right) \cdot \frac{\sigma_{spread}}{\sigma_{shift}} \cdot \frac{OASD}{D_{\mathrm{mod}}}$$

To illustrate with an example, consider two par bonds – a Treasury and a typical corporate bond in A-rated Consumer Cyclicals. Suppose both have modified duration of 6.30 years, and the spread duration of the corporate bond is 6.15 years (we take the average values for this sector from Figure C1), and the correlation between the 10-year yield and the spread on the corporate is -27%. Then, 1 standard deviation increase in Treasury rates will be typically accompanied by a 0.5 standard deviation decrease in the spread of this bond. The standard deviation of the rate shift factor, as defined in Appendix A, is 25 bp/month, and the standard deviation of the spreads in A Consumer Cyclicals is 10.3 bp/month.

The price effect of the 26 bp increase in rates is 6.30 * 0.25 = 1.575 decrease in price per 100 initial value in both bonds. However, in case of the corporate bond, this price decrease will be offset by a decrease in spreads by 0.27 * 10.3 = 2.8 bp, and an associated price impact of 6.15 * 0.028 = 0.171 per 100 initial value. Thus the price of the corporate bond will decrease only by 1.575 – 0.171 = 1.404. Since this price change was effected by a 25 bp rise in rates, the effective duration is 1.404 / 0.25 = 5.62 years. This effective duration value represents 90% of the original modified duration of 6.30 years.

Thus, a credit portfolio that is overweight in this corporate bond, while benchmarked to a Treasury portfolio with matching modified duration will in fact be mismatched in terms of effective duration, and consequently in terms of expected sensitivity to interest rate moves.

Figure 5b shows a similar set of results relevant for LIBOR-funded investors. In this case, we measure the effective duration with respect to a parallel shift of the swaps rate curve, and express it in terms of a fraction of the bond's OAS Duration. The reason for this is that most LIBOR-funded investors use LIBOR OAS duration as their main risk measure for purposes of portfolio construction.

As we can see, for most sectors the effective duration multipliers are very close whether we consider the Treasury-based or swaps-based measures. Notable exceptions are the utility sectors, which exhibit much higher effective duration in terms of swaps than they do in terms of Treasury curve sensitivity.

Figure 5a: Effective Duration Multipliers for Industry / Rating Sectors vs. Treasury Curve

	AAA/AA	A	BBB
FINANCIALS			
Banking and Brokerage	85%	87%	83%
Financial Companies, Insurance and REITS	89%	84%	82%
INDUSTRIALS			
Basic Industries and Capital Goods	93%	90%	86%
Consumer Cyclicals	93%	85%	74%
Consumer Non-Cyclicals	92%	91%	89%
Communication and Technology	93%	88%	80%
Energy and Transportation	87%	90%	86%
UTILITIES	94%	90%	83%
NON-CORPORATE	92%	92%	83%

Figure 5b: Effective Duration Multipliers for Industry / Rating Sectors vs. Swaps Curve

	AAA/AA	A	BBB
FINANCIALS			
Banking and Brokerage	81%	84%	83%
Financial Companies, Insurance and REITS	86%	81%	80%
INDUSTRIALS			
Basic Industries and Capital Goods	91%	87%	84%
Consumer Cyclicals	90%	82%	72%
Consumer Non-Cyclicals	90%	89%	86%
Communication and Technology	90%	86%	78%
Energy and Transportation	84%	88%	84%
UTILITIES	104%	88%	82%
NON-CORPORATE	87%	90%	81%

Curve Flattening/Steepening Sensitivity of Credit Portfolios

The duration of credit bonds represents a good risk measure if the anticipated Treasury (or swaps) yield curve movements are indeed close to a parallel shift. However, the market conditions are often such that the parallel shift is an oversimplification, and one should consider additional factors, most notable the flattening/steepening twists of the underlying yield curves. In fact, the current market conditions are precisely such, with most investors expecting a flattening yield curve as the Fed will gradually raise the overnight rates.

A careful study of the effect of curve twists on cash bonds requires in general the knowledge of its entire set of key rate durations. Recall, however, that our chosen shape of the twist factor is very close to the principal component analysis result, indicating that the second-most important mode of yield curve changes is a rotation around the 10-year point (see Appendix A). Therefore, we can use the sensitivity to this factor in a summary form similar to the effective duration with respect to parallel shift.

Appendix B defines the precise expression for the effective twist sensitivity D_{twist} of a credit bond. We simplify this definition by expressing it as an *Effective Twist Sensitivity Multiplier* (ETM) which is defined as the ratio of the effective twist sensitivity and bond's modified duration $ETM = D_{twist} / D_{\text{mod}}$:

$$ETM = \frac{2 \cdot KRD_2 + KRD_5 - KRD_{20} - 2 \cdot KRD_{30}}{KRD_2 + KRD_5 + KRD_{10} + KRD_{20} + KRD_{30}} + \rho(S, F_{twist}) \cdot \frac{\sigma_{spread}}{\sigma_{twist}} \cdot \frac{OASD}{D_{\text{mod}}}$$

Here, KRD_i are the key rate durations, D_{mod} is the modified duration, $OASD$ is the spread duration, $\rho(S, F_{twist})$ is the correlation between credit spreads and flattening twist factor of interest rates, σ_{spread} is the volatility of spreads, and σ_{twist} is the volatility of the twist factor (both volatilities must be measured in absolute terms and expressed in equal units, e.g. bp/month).

While this expression looks quite complicated, its usage is relatively straightforward. Once the ETM fraction is known numerically, an investor can get a good idea about the price return of a bond due to a rotation twist around the 10-year key rate by simply multiplying its modified duration by the ETM and the magnitude of the twist, with an overall negative sign. The sign of the ETM, and, therefore, the sign of the overall price return, depends on key rate durations of the bond. Generally speaking, for bonds with maturity less than 10 years, the ETM will be positive because their cash flows lie on the segment of the curve which moves up during the flattening rotation around the 10-year point. Similarly, for bonds with much longer maturity, the ETM will tend to be negative because most of their cash flows lie in the section of the curve that goes down.

Figure 6a shows the ETMs calculated for Lehman Brothers U.S. Credit Index sectors using the market value weighted average key rate durations for each sector (see the details of the key rate sensitivities in Appendix C). The interplay between the curve loadings of each sector shown in Figure C1, and their correlations with the yield curve twists shown in Figure 3a, is responsible for the pattern of positive and negative signs in this table. In particular, most A-rated industrial sectors exhibit low twist sensitivity because their curve loadings are fairly close to the 10-year point, and they also exhibit a relatively high negative spread-twist correlation. Higher-rated Financials, on the other hand, exhibit high twist sensitivity because they are loaded heavier on the front end of the curve.

Figure 6b shows a similar set of results relevant for LIBOR-funded investors. For this case, we define the ETM as a ratio of swaps curve twist sensitivity to OASD. The higher degree of correlations between the LIBOR OAS and swaps rate curve seen in Figure 3b leads in this case to significantly lower flattening sensitivities, with many sectors even changing signs, compared with the Treasury spread case.

Figure 6a: Effective Twist (Flattening) Sensitivity for Industry / Rating Sectors vs. Treasury Curve

	AAA/AA	A	BBB
FINANCIALS			
Banking and Brokerage	95%	44%	7%
Financial Companies, Insurance and REITS	51%	36%	1%
INDUSTRIALS			
Basic Industries and Capital Goods	31%	40%	-13%
Consumer Cyclicals	80%	5%	-35%
Consumer Non-Cyclicals	16%	9%	29%
Communication and Technology	59%	6%	-31%
Energy and Transportation	67%	-11%	-22%
UTILITIES	7%	22%	-8%
NON-CORPORATE	120%	20%	-18%

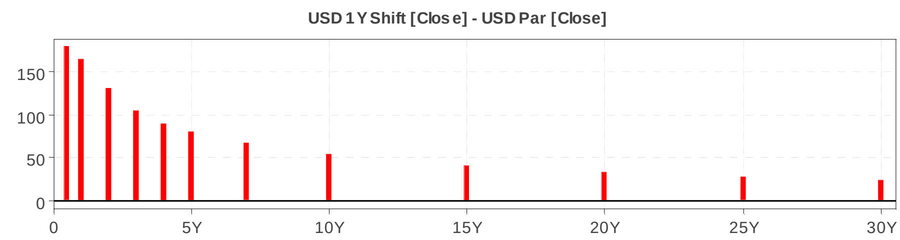
Figure 6b: Effective Twist (Flattening) Sensitivity for Industry / Rating Sectors vs. Swaps Curve

	AAA/AA	A	BBB
FINANCIALS			
Banking and Brokerage	76%	24%	-8%
Financial Companies, Insurance and REITS	30%	16%	-19%
INDUSTRIALS			
Basic Industries and Capital Goods	7%	20%	-32%
Consumer Cyclicals	58%	-12%	-48%
Consumer Non-Cyclicals	-6%	-13%	10%
Communication and Technology	40%	-14%	-46%
Energy and Transportation	46%	-33%	-43%
UTILITIES	-15%	2%	-28%
NON-CORPORATE	100%	-3%	-32%

Combining Tactical and Long-Term Views

The current state of the market is characterized by a significant amount of expected changes in the interest rate curve. Figure 7 shows the difference between the 1-year forward and the current Treasury curve.

Figure 7. Expected change in Treasury curve based on 1-year forwards



As we can see, the market prices both an upward shift and a significant flattening twist. The inter-sector differences in sensitivity to yield curve shifts and flattening highlighted in this paper can be used for defensive curve positioning with respect to these expected changes.

While all fixed-coupon bonds are likely to post negative price return in a rising interest rate environment, some credit sectors will be more insulated than others from the effects of curve changes. Picking the right overall duration target and sector-specific curve positioning will have an important role in outperforming passive benchmarks during the period dominated by macro factors.

Since the effective duration of most credit sectors is between 85%-95% of the nominal duration (Figure 5a), our first recommendation is to have on average 12% longer nominal duration in the credit portion of investor's portfolios compared to their nominal portfolio duration target. This will result in an effectively neutral stance with respect to the stated target. For example, if an investor has an explicit interest rate duration target is 6.2 years, we recommend the credit portion of the portfolio to have 6.9 years nominal duration, as this would result in an effective duration of 90% x 6.9 = 6.2 years, equal to the investor's target.

Second, we recommend using the differences in the flattening sensitivity between various credit sectors as a guide to selection of the sector-specific curve targets. Namely, we recommend reducing the target duration of the sectors which have high effective twist sensitivity, and extending the target duration of the sectors which have low or negative effective twist sensitivity. The net overall duration change of the portfolio should be extended in accordance with our first recommendation.

The curve positioning on a portfolio level can be achieved either by an underweight or overweight of the corresponding sector, or by weight-neutral selection of shorter/longer duration securities within the sector, depending on the investor's short-term spread and credit views. Combining the tactical sector allocation recommendations from Lehman Brothers credit strategy team[5] with the curve sensitivities in Figure 6a, we arrive at the net recommendations shown in Figure 8.

[5] J. Genirs, M. Koziol, N. Seyffert, *Market Advisor: U.S. Credit Strategy*, May 11, 2004, Lehman Brothers Fixed Income Research

Figure 8. Combining tactical sector allocation with long-term curve positioning

Sector	*Tactical Sector Allocation*	*Rating*	*Long-Term Duration Allocation*	*Net Recommendation*
Banking and Brokerage	Banking Underweight	**AAA/AA**	Decrease	
	Brokerage Neutral	**A**	Decrease	Underweight A-or better Banking
		BBB	Neutral	
Financial Companies, Insurance and REITS	Insurance Overweight	**AAA/AA**	Decrease	Underweight Financial Cos.
	REITs Neutral	**A**	Decrease	Overweight short duration A-rated Life Insurance
	Financial Cos. Underweight	**BBB**	Increase	Overweight long duration BBB P&C Insurance
Basic Industries and Capital Goods	Paper Overweight	**AAA/AA**	Decrease	
	Others Neutral	**A**	Decrease	Sector-weight neutral, reduce duration (except BBB Paper)
		BBB	Increase	Overweight BBB Paper
Consumer Cyclicals	Automotive and Entertainment Overweight	**AAA/AA**	Decrease	
		A	Neutral	Underweight A Retailers
	Retailers Underweight	**BBB**	Increase	Overweight long duration BBB Automotive and Entertainment
Consumer Non-Cyclicals	Consumer Products, Food & Bev., Healthcare Neutral	**AAA/AA**	Decrease	Underweight long duration Pharmaceuticals
		A	Neutral	
	Pharmaceuticals Underweight	**BBB**	Decrease	Sector-weight neutral, reduce duration in BBB Healthcare
Communication and Technology	Media-Cable Overweight	**AAA/AA**	Decrease	Sector-weight neutral, reduce duration in higher-rated Telecom
	Others Neutral	**A**	Neutral	
		BBB	Increase	Overweight long duration BBB Media Cable
Energy and Transportation	Integrated Energy Underweight	**AAA/AA**	Decrease	
	Others Neutral	**A**	Increase	Sector-weight neutral, increase duration in Independent Energy
		BBB	Increase	Underweight short duration BBB Integrated Energy
Utilities	Electric Overweight	**AAA/AA**	Neutral	
	Others Neutral	**A**	Decrease	
		BBB	Increase	Overweight long duration BBB Electrics
Non-Corporate	Sovereigns Neutral	**AAA/AA**	Decrease	Underweight A-or better Foreign Agencies, Foreign Local Govts., and Supranationals
	Others Underweight			
		A	Decrease	
		BBB	Increase	

Correspondence with the Portfolio Construction Process and POINT Risk Analysis

The Lehman Brothers POINT portfolio analytics system fully accounts for the correlation between rates and spreads when estimating the portfolio risk.

We would like emphasize that when measuring the risk of credit portfolios within the Lehman Brother POINT portfolio analytics system, the effect of the correlation between the credit spreads and Treasury rates is fully taken into account by virtue of using the complete multi-factor risk model with the full covariance matrix of dependencies. The exposition above illustrates the source of high contribution of interest rate risks to the tracking error of many credit portfolios even when they are apparently well balanced in terms of modified duration.

Many credit portfolio managers are not actively managing the duration or curve position of their portfolios, but are instead following the constraints imposed by broader multi-asset class and duration allocations within risk budgeting frameworks of aggregate fixed income portfolios. In such cases, either the portfolio managers responsible for asset allocation can take into account the rates-spreads directionality in setting the goals for the credit PMs, or the credit portfolio managers can explicitly adjust their duration targets, if the implicit assumption in the asset allocation process is that of independence of rates and spreads.

CONCLUSIONS

In this study, we used the statistically robust framework of the Lehman Brothers multi-factor risk model to analyze co-movements of interest rates and credit spreads. The main message is that both shifts and twists of the Treasury yield curve are accompanied by significant changes in both the level and slope of the credit spread curve.

We would like to reiterate that our study concerns contemporaneous correlations and is not, by itself, a statement of causal relationship. Rather, the existence and robustness of correlations across a long historical period from 1990 until the present can be taken as an evidence for the common economic driving factors between rates and spreads.

Portfolio managers need to consider the rates-spreads directionality effects when fine-tuning their interest-rate hedging strategies and relative value decisions across credit sectors in an environment in which credit-specific news is dominated by macroeconomic news, leading to significant Treasury (and/or swaps) curve moves.

APPENDIX A: IMPLEMENTING YIELD CURVE SHIFT AND TWIST

To analyze the effect of a Treasury yield curve shift and twist in the context of the multi-factor credit model, we employ the following technique. We define a **Treasury shift factor** as a 10 bp increase in the five key-rate factors included in the Risk Model[6]. This corresponds to a uniform widening of Treasury yields by 10 bp.

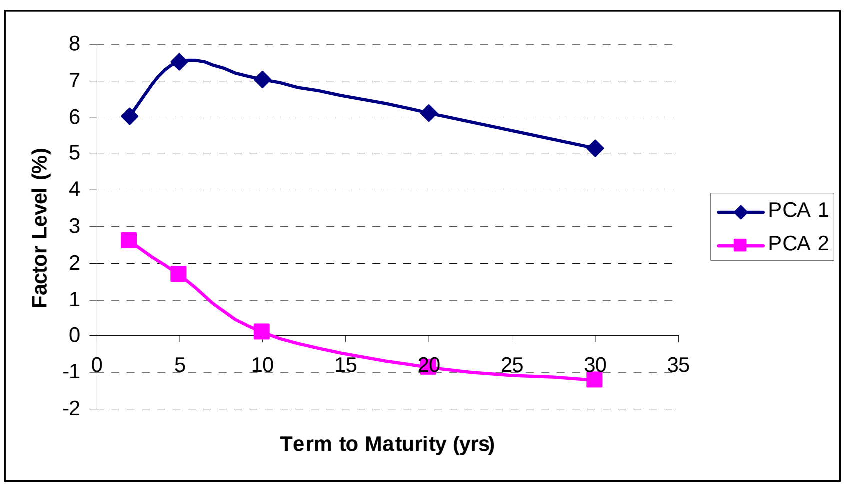
Analogously, we define a **Treasury twist factor** as a series of changes in the key-rate factors that correspond to a steepening rotation around the 10-year maturity. Consider Figure A1 for illustration.

Figure A1. Treasury Curve Shift and Twist Factors

Key Rate Maturity (years)	**2**	**5**	**10**	**20**	**30**
Treasury Curve Shift (bp)	10	10	10	10	10
Treasury Curve Twist (bp)	10	5	0	-5	-10

These definitions differ slightly from the statistically more precise approach known as *principal component analysis* (see the PCA factors in Figure A2). However, they get us pretty close to the true principal components of rates changes and are easier to visualize and discuss. Note that the PCA-1 factor is indeed close to a constant level (i.e., a parallel shift), and the PCA-2 factor indeed crosses zero at 10-year point (i.e., has a meaning of a flattening/steepening twist around the 10-year point).

Figure A2. Treasury Curve PCA Factors



Let us explain the factor definitions in practical terms. Assume that the yield curve has undergone an arbitrary change in each of its key rate points, denoted as Δy_i, where the index i corresponds to maturities 2, 5, 10, 20, and 30 years. Let us now define the approximation to

[6] We exclude the 0.5 year key rate factor in order to avoid picking up dependencies on peculiar movements of the short end of the Treasury curve.

the yield curve change in terms of the shift and twist factors as a linear combination of a unit parallel shift and a unit steepening twist with yet undetermined coefficients and the residual term containing the portion of the yield curve change that is not captured by shift and twist:

$$\begin{bmatrix} \Delta y_2 \\ \Delta y_5 \\ \Delta y_{10} \\ \Delta y_{20} \\ \Delta y_{30} \end{bmatrix} = \Delta F_{shift} \cdot \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} + \Delta F_{twist} \cdot \begin{bmatrix} 2 \\ 1 \\ 0 \\ -1 \\ -2 \end{bmatrix} + \begin{bmatrix} \varepsilon_2 \\ \varepsilon_5 \\ \varepsilon_{10} \\ \varepsilon_{20} \\ \varepsilon_{30} \end{bmatrix}$$

If we assume that, by construction, the residual term does not contain either a parallel shift of a steepening/flattening component, we can easily find the factor loadings ΔF_{shift} and ΔF_{twist} of the two primary yield curve components as follows:

$$\Delta F_{shift} = \frac{1}{5} \cdot \left(\Delta y_2 + \Delta y_5 + \Delta y_{10} + \Delta y_{20} + \Delta y_{30} \right)$$

$$\Delta F_{twist} = \frac{1}{10} \cdot \left(2 \cdot \Delta y_2 + \Delta y_5 - \Delta y_{20} - 2 \cdot \Delta y_{30} \right)$$

These formulas justify the representation of the shift and twist factors in Figure A1. One can use them to derive the time series of these factors which are shown in Figure 1.

APPENDIX B: EFFECTIVE SHIFT AND TWIST SENSITIVITY

In this Appendix we derive the formulas for effective sensitivity to shifts and twists, that generalize the concept of the effective duration introduced in the main part of the paper and allow investors to fine tune the curve positioning of credit portfolios.

The Lehman Brothers multi-factor risk model allows us to estimate the volatility σ_F of the shift and twist factor of the yield curve, as well as the volatility σ_S of the typical industry/rating sector portfolio spread and its correlation $\rho(S, F_{treas})$ with the rate factors. Given these values, the change in credit spread can be decomposed into portions driven by a change in the shift factor, a change in the twist factor, and an uncorrelated credit-specific change δ_S :

$$\frac{\Delta S}{\sigma_S} = \rho(S, F_{shift}) \cdot \frac{\Delta F_{shift}}{\sigma_{shift}} + \rho(S, F_{twist}) \cdot \frac{\Delta F_{twist}}{\sigma_{twist}} + \delta_S$$

On the other hand, the price effect of a generic change in the yield curve and spreads is given by:

$$\frac{\Delta P}{P} = -\sum_{i=1}^{\#KRDs} KRD_i \cdot \Delta y_i - OASD \cdot \Delta S$$

Substituting the definitions of the yield curve shift and twist factors from Appendix A, and of the spread change decomposition from above, we get the following result:

$$\frac{\Delta P}{P} = -\left(\sum_{i=1}^{\#KRDs} w_i^{shift} \cdot KRD_i + OASD \cdot \rho\left(S, F_{shift}\right) \cdot \frac{\sigma_S}{\sigma_{shift}}\right) \cdot \Delta F_{shift}$$
$$- \left(\sum_{i=1}^{\#KRDs} w_i^{twist} \cdot KRD_i + OASD \cdot \rho\left(S, F_{twist}\right) \cdot \frac{\sigma_S}{\sigma_{twist}}\right) \cdot \Delta F_{twist}$$
$$- \sum_{i=1}^{\#KRDs} KRD_i \cdot \varepsilon_i - OASD \cdot \delta_S$$

The loading vectors for the shift ($w_i^{shift} = [1,1,1,1,1]$) and twist ($w_i^{twist} = [2,1,0,-1,-2]$) factors with respect to 2, 5, 10, 20 and 30-year key rates are the same as those in Appendix A. The last two terms of the above expression represent, by construction, the effect of uncorrelated changes in the yield curve and spreads. Therefore, the first two terms determine the sensitivities to the shift and the twist factor, respectively.

The effective sensitivity to the shift factor is (it coincides with the effective duration):

$$D_{shift} = \left(KRD_2 + KRD_5 + KRD_{10} + KRD_{20} + KRD_{30}\right) + OASD \cdot \rho\left(S, F_{shift}\right) \cdot \frac{\sigma_S}{\sigma_{shift}}$$

The effective sensitivity to the twist factor is given by the following expression (it is closely related to, though not equivalent to, the effective convexity of the bond):

$$D_{twist} = \left(2 \cdot KRD_2 + KRD_5 - KRD_{20} - 2 \cdot KRD_{30}\right) + OASD \cdot \rho\left(S, F_{twist}\right) \cdot \frac{\sigma_S}{\sigma_{twist}}$$

These two sensitivity measures summarize more than 80% of the sensitivity of the credit bonds to interest rate moves. We can assume with good accuracy that the residual interest rate sensitivity of credit bonds has a low correlation with the shift and twist factors, as well as with the credit-specific changes in credit spreads δ_S that are above and beyond the correlated portion taken into account by D_{shift} and D_{twist} .

APPENDIX C: TREASURY SPREADS VERSUS LIBOR SPREADS

In the new version of the Lehman Brothers multi-factor risk model, the price returns of credit bonds are broken into three broad categories according to their underlying driving risk type: Treasury key rate duration factors, swap spread key rate factors, and credit factors.

$$R = -D_{\text{mod}} \cdot \sum_{i=1}^{\#KRDs} W_i \cdot \Delta y_i - OASD \cdot \sum_{i=1}^{\#KRDs} W_i \cdot \Delta S_i^{swap} - OASD \cdot \sum \Delta f_{credit}$$

$$W_i = KRD_i / D_{\text{mod}}, \qquad \text{where} \qquad D_{\text{mod}} = \sum_{j=1}^{\#KRDs} KRD_j$$

Note that the non-sector credit factors, namely the OAS twist and OAS dispersion factor, do not require an adjustment because they are defined in terms relative to the sector; therefore, the common swap spread does not enter in the consideration.

Figure C1 shows the market value weighted average modified duration, spread duration, and key rate weightings for industry/rating sectors of the Lehman Brothers U.S. Credit Index:

Figure C1. Treasury and Swap Key Rate Sensitivities (Market Value Weighted)

Sector	*Rating*	*Mod Duration*	*OASD*	*W(6mo)*	*W(2yr)*	*W(5yr)*	*W(10yr)*	*W(20yr)*	*W(30yr)*
Banking and Brokerage	**AAA/AA**	3.88	3.83	8.14%	42.76%	34.06%	9.84%	4.12%	1.08%
	A	5.17	5.06	4.07%	27.48%	36.68%	22.67%	5.01%	4.09%
	BBB	5.32	5.14	1.09%	19.86%	43.65%	27.18%	5.73%	2.49%
Financial Companies, Insurance and REITS	**AAA/AA**	5.32	5.22	3.96%	29.84%	35.45%	20.16%	3.41%	7.18%
	A	5.10	5.01	4.10%	30.88%	36.05%	19.77%	3.97%	5.22%
	BBB	5.77	5.60	3.84%	19.90%	33.84%	30.51%	7.47%	4.43%
Basic Industries and Capital Goods	**AAA/AA**	6.71	6.57	2.05%	10.30%	34.63%	43.58%	4.36%	5.08%
	A	5.84	5.73	3.28%	23.47%	35.13%	25.08%	7.46%	5.58%
	BBB	6.92	6.75	3.14%	15.41%	29.59%	27.93%	13.76%	10.17%
Consumer Cyclicals	**AAA/AA**	4.98	4.90	3.08%	28.14%	44.47%	16.64%	4.42%	3.24%
	A	6.30	6.15	4.64%	23.26%	33.07%	18.06%	9.66%	11.30%
	BBB	5.92	5.77	5.56%	24.67%	30.30%	20.71%	9.26%	9.50%
Consumer Non-Cyclicals	**AAA/AA**	7.19	6.97	3.40%	21.81%	24.75%	22.00%	17.31%	10.73%
	A	7.17	6.98	3.36%	19.66%	25.83%	25.67%	12.92%	12.57%
	BBB	5.87	5.76	3.13%	22.94%	33.04%	26.80%	7.83%	6.26%
Communication and Technology	**AAA/AA**	5.49	5.40	0.50%	21.73%	41.73%	31.95%	4.09%	0.00%
	A	6.56	6.37	3.68%	21.45%	28.88%	22.64%	11.74%	11.61%
	BBB	6.52	6.35	4.20%	19.58%	29.39%	23.63%	11.92%	11.28%
Energy and Transportation	**AAA/AA**	5.00	4.87	7.35%	31.48%	35.55%	12.60%	8.53%	4.50%
	A	7.51	7.28	2.95%	13.09%	33.18%	19.81%	16.37%	14.60%
	BBB	7.19	6.99	3.37%	17.06%	28.02%	23.69%	13.64%	14.23%
Utilities	**AAA/AA**	6.24	5.46	0.41%	7.39%	31.69%	35.22%	25.29%	0.00%
	A	6.44	6.29	2.70%	23.59%	29.43%	25.52%	7.49%	11.28%
	BBB	6.36	6.19	4.08%	18.31%	31.15%	29.55%	7.62%	9.29%
Non-Corporate	**AAA/AA**	3.96	3.91	7.38%	46.78%	29.82%	8.82%	5.21%	1.99%
	A	6.74	6.57	1.73%	21.61%	27.36%	24.25%	19.10%	5.94%
	BBB	6.41	6.26	2.03%	12.70%	37.18%	30.54%	12.91%	4.64%

Accordingly, the industry/rating sector credit spread factors now correspond to LIBOR OAS changes. For this paper, we combine these three groups of factors in two different ways:

- **Treasury yields versus Treasury spreads:** we add the swap spread factors to industry/rating sector LIBOR OAS factors to obtain the composite industry/rating sector Treasury spread factors. These composite factors are then used to derive the Treasury-spread correlations and related results, shown in Figures 2a, 3a, 4a, 5a, 6a.
- **Swap rates versus LIBOR OAS:** we add the swap spread factors to the corresponding Treasury key rate factors to obtain composite swap rate factors. We then measure the correlation of these composite factors with the risk model's LIBOR OAS factors of the industry/rating sectors, shown in Figures 2b, 3b, 4b, 5b, 6b.

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