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We propose a new approach to top-down sector and security selection. We first establish that the performance of credit markets can be predicted based on a variety of macro variables. Using a Credit Factor Model (CFM), we then show that we can explain the excess returns of different portfolios of bonds with three factors relating to credit quality, the credit curve and default risk. By forecasting the performance of these factors using economic and financial indicators, we can predict the performance of individual securities and sectors. Credit portfolio managers can use these forecasts to help construct overweight/underweight overlays on a benchmark index, or long-short portfolios of issuers. We document the back-testing of these strategies, finding good performance on both an absolute and risk-adjusted basis.

Correlation Station is a tool for the analysis of standard and bespoke synthetic CDO tranches. Available through LehmanLive (Keyword CS), it provides pricing and risk for the standard tranches within a base correlation framework. Users can define and save their own bespoke tranches, and price and risk manage these within a base correlation framework. Users can also generate portfolio statistics and scenario analyses.

We introduce a new LehmanLive calculator for options on credit default swaps. The calculator can be used for valuation/pricing and to calculate risk measures such as delta, gamma, vega, and theta. The user must specify a curve of credit default swap spreads, as well as a spread volatility. The underlying analytics are Black formulas and a standard credit default swap model, such as the LehmanLive Credit Default Swap Calculator. The calculator can be used for both single-name and portfolio (CDX and iTraxx) swaptions.

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Introducing MISTRAL: A Framework for Macro Trading in Credit Markets[1]

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We propose a new approach to top-down sector and security selection. We first establish that the performance of credit markets can be predicted based on a variety of macro variables. Using a Credit Factor Model (CFM), we then show that we can explain the excess returns of different portfolios of bonds with three factors relating to credit quality, the credit curve and default risk. By forecasting the performance of these factors using economic and financial indicators, we can predict the performance of individual securities and sectors. Credit portfolio managers can use these forecasts to help construct overweight/underweight overlays on a benchmark index, or long-short portfolios of issuers. We document the back-testing of these strategies, finding good performance on both an absolute and risk-adjusted basis.

1. INTRODUCTION

Macro-level investment strategies attempting to benefit from the evolution of aggregate economic and financial variables are commonplace in the interest rate, currency and equity markets. Indeed, it has been argued that macro-positioning decisions are the most important ones in portfolios. Of course, there is no reason to restrict fixed income macro-strategies to the rates and currency world – credit markets are equally affected by macro forces such as economic and business cycle developments and movements in the other financial markets. With the advent of liquidly traded index products such as the Dow Jones CDX, implementing macro credit strategies has also become simpler and cheaper.

In this article we propose a new model-driven approach to macro positioning of corporate credit portfolios, called *MISTRAL* (Macro Investment STRategic ALlocation). Using a combination of aggregate financial and economic signals, *MISTRAL* generates overweight and underweight signals for credit market industry sectors, ratings and other baskets of bonds. A further output is issuer-level "MISTRAL Scores" indicating which issuers are favoured given the current macro-economic environment. These can be used directly or combined with other scoring systems and qualitative or fundamental views.

In a previous article (Naik, Trinh and Rennison 2003), we introduced the Credit Factor Model (CFM), which explains the systematic component of excess returns in global credit markets. We have identified credit market factors that explain a significant proportion of credit returns. These factors capture the movements in the premium for credit quality measured by spreads, variations in the slope of the credit curve, and changes in the default risk premium commanded by bonds with high issuer equity volatility.

The MISTRAL system builds on CFM by looking for predictability in these three factors using financial and economic indicators. If the factors are predictable, it should be possible to forecast the performance of any portfolio of bonds (such as a rating group or industry sector) by contemporaneously relating the excess returns of the portfolio to the excess returns of factor mimicking portfolios. Predictability of the factors may come from variations in risk premium that compensate investors for bearing systematic risk or from market inefficiencies due, for instance, to investors' under-reaction to news. It is also plausible that we might find

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macro-level cross-market momentum effects. At a micro-level, such effects have already been documented in the Lehman Brothers ESPRI model.

In this way, MISTRAL can be used to generate a variety of outputs. We demonstrate the effectiveness of recommendations from MISTRAL by testing the model on 15 years of Lehman Brothers Corporate index data, finding good performance both in absolute terms and on a risk-adjusted basis.

This paper proceeds as follows. In section 2, we introduce a macro framework that uses a reduced CFM model with its factors. In section 3, we document the predictability of the CFM factors using macro information. In section 4, we examine the prediction of the sector excess returns according to two index partitions. In section 5, we describe the *MISTRAL* Score as a potential application of our model. We present our conclusions in the final section.

2. THE MACRO FRAMEWORK

MISTRAL is an integrated framework that converts macro signals into overweight/underweight recommendations on fine-buckets of the index, such as industry sectors, ratings and issuers. The framework involves three steps:

a) We first break down broad movements in the credit market into the three CFM factors which together capture a high percentage of the time variation of excess returns at the issuer or fine-bucket level.

b) Next, we relate the movements of the CFM factors to the changes in a series of financial and economic indicators, chosen for their economic and empirical relevance. This allows us to forecast the direction and magnitude of future changes in the factor realisations.

c) The final step is to forecast the excess return performance of the fine-buckets by using the contemporaneous relationships between the factors and the buckets from step (a) and the factor forecasts from step (b).

2.1. Constructing the credit factors

Our objective is to identify market wide factors which explain a large portion of credit returns. Our approach is to construct proxy portfolios of bonds which will mimic our credit factors. As in Naik *et al*. (2003), we form factor-mimicking portfolios to represent the following economic factors: (i) variations in the premium for credit quality; (ii) variations in the slope of the credit spread curve; (iii) variations in the default risk premium. Due to the high co-linearity between the credit market return and the credit quality factor, we have refrained from using the return on the credit market portfolio as a factor. We describe the methodology for constructing these factors below.

1. **Quality Factor:** The quality factor is the excess returns on a zero investment portfolio that is long wide spread bonds and short tight spread bonds. A positive realisation will occur when high spread bonds outperform low spread bonds.

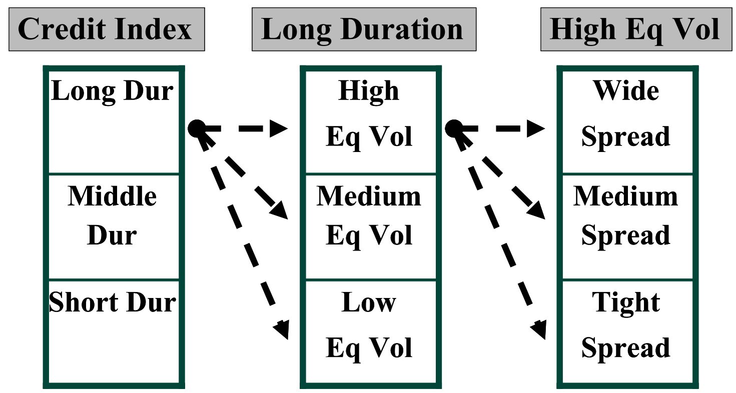
2. **Slope Factor:** The slope factor is the excess returns on a zero investment portfolio that is long high duration bonds and short low duration bonds, in a duration-neutral ratio. A positive realisation corresponds to a flattening of the average credit spread curve.

3. **Default Factor:** We take the equity volatility of the issuer as a reasonable indicator of its default probability. Consequently we construct the default factor as the excess returns on a zero investment portfolio that is long bonds for which the past long-run equity volatility of the issuer is high and short bonds for which the past long-run equity volatility of the issuer is low. The default factor is derived from the Merton model

relating equity volatility to default risk. Higher equity volatility increases default risk, everything else being held constant.

For each of the above factor mimicking portfolios, the long and short parts are formed after controlling for the two remaining factor variables. For example, for the quality factor, wide and tight spreads are defined amongst bonds of similar duration and similar past long-run equity volatility. This is demonstrated in Figure 1, where we control for duration and equity volatility by picking bonds in homogenous duration and equity volatility categories.

Figure 1. Construction of factors – example for quality factor



Source: Lehman Brothers.

2.2. Characteristics of the credit factors

In this section, we describe the credit factors. Figure 2 presents some summary statistics. Over the period 1990-2005, the quality factor delivers a positive average monthly excess return indicating a positive risk premium for spread and credit quality risk. The two other factors have negative excess returns. A negative return on the slope factor implies that an investor would have been better off investing in steepening positions (long short maturity bonds and short long maturity bonds in a duration-neutral fashion). A negative return on the default factor means that low default risk names outperformed high default risk names, controlling for spreads. The same statistics for the Lehman Brothers US Corporate index are also reported. Note that each of the factors has a higher auto-correlation than the index, which may marginally add to any predictability.

Figure 3 shows the correlation matrix between the US factors. As expected, the correlation between the quality factor and the credit index is high. That is, periods of outperformance of the credit index also tend to be periods when higher spread names outperform low spread names. The correlation is also high (above 50%) between the credit index and the default factor. Interestingly, the correlation between the slope factor and the index return is negative. That is, the credit curve steepens (flattens) when the market outperforms (underperforms).

Figure 2. Summary statistics for the US credit factors – Feb 1990-April 2005

	Quality Factor	Slope Factor	Default Factor	Index
Avg Exc Rtn (bp/month)	12.1	-17.9	-5.7	3.6
Std Dev (bp/month)	91	68	43	61
Autocorrelation	14%	29%	15%	11%

Source: Lehman Brothers.

Figure 3. Correlation matrix of US credit factors – Feb 1990-April 2005

	Quality	Slope	Default	Index
Quality	100%			
Slope	-57%	100%		
Default	66%	-27%	100%	
Index	85%	-44%	56%	100%

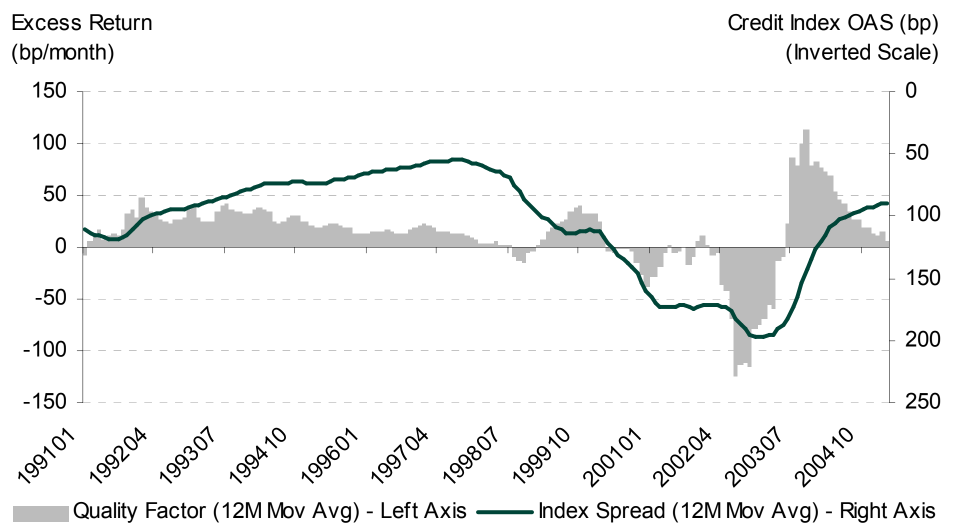
Source: Lehman Brothers.

In Figure 4, we plot the US quality factor realisations, along with the option-adjusted spread of the Lehman Brothers US Corporate index (inverted axis). There is a consistent pattern, with positive realisations during periods of index spread tightening and conversely in periods of index spreads widening.

In Figure 5, we present the realisations of the slope factor, along with the credit curve slope of the Lehman Brothers US Corporate index. The factor realisations are clearly positive when the curve flattens and negative in periods of curve steepening.

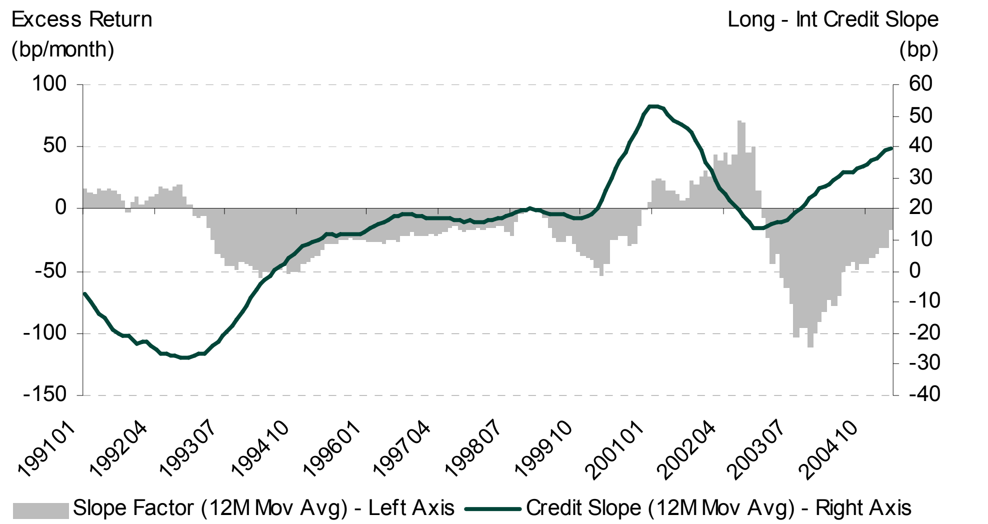
Finally, in Figure 6, we see that the default factor rarely has positive realisations except during the 2003 market rally. Furthermore, we see a clear correlation between the default factor realisations and the high yield default rate: when the default rate is high, the factor realisations are negative.

Figure 4. Quality factor and credit index OAS (1Y Mov. Avg.) – Jan 1991 to Mar 2005



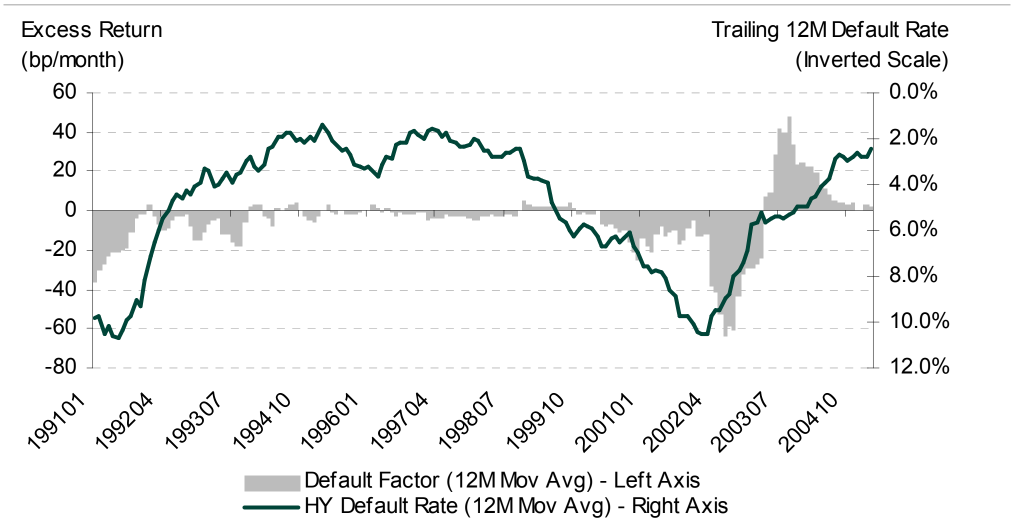
Source: Lehman Brothers.

Figure 5. Slope factor and credit index slope (1Y Mov. Avg.) – Jan 1991 to Mar 2005



Source: Lehman Brothers.

Figure 6. Default factor and high yield default rate (1-year moving average) – Jan 1991 to Mar 2005 (Lehman Brothers calculation using Moody's data)



Source: Lehman Brothers.

2.3. Contemporaneous regression results

We have identified the credit factors as potential explanatory variables in a multi-factor model of excess returns on corporate bonds. In this section, we examine contemporaneous relationships between these credit factors and excess returns on fine buckets of the credit index.

The results for the regressions on rating buckets are given in Figure 7. As expected, the lower the rating, the higher is the loading on the quality factor because of the spread difference. The loadings on the slope and default factors are not significant because the rating buckets do not differ too much in terms of duration and equity volatility (Figure 8). Interestingly, the R-squared falls as credit quality increases: this may be because correlation weakens between the market and high quality names during volatile periods.

Figure 7. Rating category level time series regressions (US) Feb 1990-Dec 2002

		Quality	Slope	Default	R-Squared
AA	*Beta*	0.29	0.06	-0.07	33%
	Tstat	7.0	1.4	-0.9	
A	*Beta*	0.49	0.07	0.05	59%
	Tstat	10.4	1.4	0.6	
BBB	*Beta*	0.92	0.06	-0.01	81%
	Tstat	17.7	1.0	-0.1	

The above results are from the model $S_t^j = F_t\beta^j + \varepsilon_t^j$.

S_t^j *is the monthly excess return of quality bucket j in period t*

F_t *is vector of realisations of the three factor mimicking portfolios in period t.*
Source: Lehman Brothers.

Figure 8. Rating category properties

	Avg Dur	Avg OAS	Avg Eq Vol
AA	5.4	70.9	27.2
A	5.5	95.1	28.5
BBB	5.6	151.1	31.8

Source: Lehman Brothers.

We run the same regressions at the sector level. The results of these regressions are reported in Figure 9.

The quality factor is significant across all the sectors. The higher spread sectors tend to have the higher loading on the quality factor. The slope factor is significant only for the telecoms sector. The default factor is significant for the telecoms sector and also for the utilities, financials and non-cyclical sectors with a negative loading, indicating these sectors have been less exposed to default risk.

Figure 9. Sector level time series regressions (US) – Feb 1990-Apr 2005

		Quality	Slope	Default	R-Squared
BASIC	*Beta*	0.40	0.01	-0.04	38%
	Tstat	6.9	0.2	-0.4	
ENERGY	*Beta*	0.54	0.06	-0.31	40%
	Tstat	8.5	0.9	-2.8	
BANKING	*Beta*	0.30	-0.03	0.10	27%
	Tstat	4.6	-0.4	0.9	
UTILITY	*Beta*	1.35	0.16	-0.97	69%
	Tstat	15.9	1.8	-6.5	
CYCLICAL	*Beta*	0.78	0.09	-0.02	61%
	Tstat	11.2	1.3	-0.2	
FINANCIAL	*Beta*	0.48	-0.06	-0.17	53%
	Tstat	9.3	-1.1	-1.9	
NON-CYCLICAL	*Beta*	0.36	0.09	-0.22	29%
	Tstat	7.3	1.8	-2.5	
COMMUNICATION	*Beta*	0.70	0.19	1.15	73%
	Tstat	8.9	2.3	8.4	

The above results are from the model $S_t^j = F_t\beta^j + \varepsilon_t^j$.

S_t^j is the monthly excess return of industry bucket j in period t
Ft is vector of realisations of the three factor mimicking portfolios in period t.
Source: Lehman Brothers.

Figure 10. Properties of sectors

	Avg Dur	Avg OAS	Avg Eq Vol
Banking	4.7	107	32.1
Basic	6.1	121	30.5
Communication	6.1	107	31.3
Cyclical	5.6	125	32.8
Energy	6.1	122	30.5
Financial	4.5	109	29.3
Non	6.0	100	28.5
Utility	5.6	112	25.7

Source: Lehman Brothers.

It is informative to replace sectors or ratings on the left-hand side of the regression with a further partition of the index[2]. We define this new partition directly on our factor construction variables – spread, duration and equity volatility – and designate it the SDV partition. The SDV partition is then closely related to the factors and forms a key part of the MISTRAL system in the following sections. The SDV partition is constructed by dividing bonds into high, medium and low categories based on spread, duration and volatility, forming 27 buckets in total. A typical bucket might therefore be defined as: wide spread, low duration, medium equity volatility.

Figure 11 shows summary statistics of the four "corner" buckets from the SDV partition (where a "corner" bucket is high/low in each variable – ie, we remove all the medium categories). Running through the cells of the table quickly confirms that the buckets have the properties matching the bucket name.

Figure 11. Properties of spread-duration-volatility (SDV) buckets

	High Equity Volatility					
	Long Duration			Short Duration		
	Avg OAS	*Avg Dur*	*Avg Eq Vol*	*Avg OAS*	*Avg Dur*	*Avg Eq Vol*
Wide Spread	177	9.4	46%	205	2.5	42%
Tight Spread	64	8.4	36%	58	2.2	37%

	Low Equity Volatility					
	Long Duration			Short Duration		
	Avg OAS	*Avg Dur*	*Avg Eq Vol*	*Avg OAS*	*Avg Dur*	*Avg Eq Vol*
Wide Spread	152	9.2	21%	173	2.5	20%
Tight Spread	61	8.3	21%	53	2.3	21%

Source: Lehman Brothers.

Figure 12 summarises the regression results for the eight corner buckets. Since the SDV partition relates so closely to the factors themselves, we expect to see some clear patterns in the regression betas. For example, in each wide spread bucket, the beta for the quality factor is significantly higher than the beta in the corresponding tight spread bucket. Similarly in

[2] *A partition of the index is simply a division of the bonds into a set of buckets in such a way that every bond in the index is assigned to exactly one bucket.*

each long duration bucket, the slope factor beta is significantly higher than the beta in the corresponding short duration bucket, and again for high/low equity volatility buckets.

Figure 12. Spread-duration-volatility (SDV) time series regressions

		High Equity Volatility							
		Long Duration				Short Duration			
		Quality	*Slope*	*Default*	*R-Sq*	*Quality*	*Slope*	*Default*	*R-Sq*
Wide Spread	*Beta*	1.2	0.5	1.0	91%	-0.1	-0.6	0.8	34%
	Tstat	23.3	9.3	11.1		-1.3	-6.2	4.8	
Tight Spread	*Beta*	-0.2	0.3	0.2	41%	-0.6	-0.2	0.1	81%
	Tstat	-5.3	5.6	2.0		-20.6	-5.6	1.9	

		Low Equity Volatility							
		Long Duration				Short Duration			
		Quality	*Slope*	*Default*	*R-Sq*	*Quality*	*Slope*	*Default*	*R-Sq*
Wide Spread	*Beta*	1.3	0.3	-1.6	71%	-0.1	-0.3	-0.8	44%
	Tstat	20.0	4.7	-14.2		-1.2	-5.4	-8.2	
Tight Spread	*Beta*	-0.2	0.2	-0.2	66%	-0.6	-0.2	-0.1	80%
	Tstat	-6.1	6.2	-4.1		-18.2	-4.9	-1.2	

Source: Lehman Brothers.

3. PREDICTING THE FACTORS

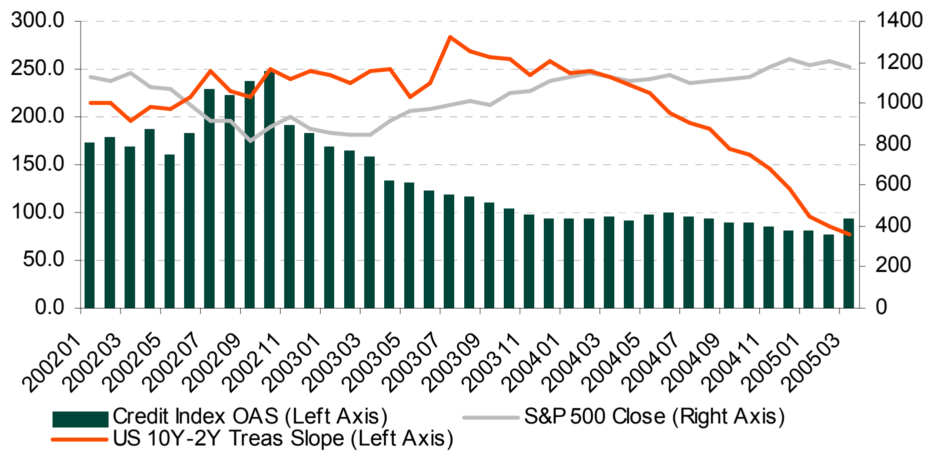
3.1. Predictability

The predictability of the credit market and the credit factors originates from the variation in risk premium that compensates investors for bearing systematic risk or from market inefficiencies due for instance to investors' under reaction to news.

Business cycle fluctuations cause variations in the risk premium. In an economic downturn, the risk premium tends to be high because a lower wealth among financial intermediaries, firms and consumers causes a higher level of risk aversion. During an economic boom, the risk premium is lower because of an increased wealth effect. Banks typically tighten their lending policies during recessions and loosen them during expansions, causing credit spreads to be procyclical.

It is therefore natural to expect interest rates, the equity market and business cycle indicators to have explanatory power to forecast changes in the risk premium and therefore future excess returns. As we show below, there is empirical support for this predictability based on a variety of macro-economic and financial variables. Figure 13 illustrates some of these ideas by showing the contemporaneous movements in the equity, credit and Treasury markets between 2002 and 2005.

Figure 13. Relationship of stock market performance, yield curve slope and credit spreads



Source: Lehman Brothers.

3.2. Predictability in the credit market

We present evidence for predictability using simple trading strategies. The first example (Figure 14) shows excess returns (over duration matched treasuries) from investing in the Lehman Brothers US Corporate index based on the signals from three variables: the S&P 500 excess return; changes in the VIX; and changes in the Treasury yield curve slope (2-10y). The table shows the average return in the months following a positive signal and in the months following a negative signal. The benchmark is the strategy which unconditionally invests in the index each month.

We report back-testing results from February 1990 to March 2005. In these tests, as well as in other tests of strategies in this article, we assume zero transaction costs. Since our aim is to show that a model-based macro-credit framework can form a useful part of the investment process, and is not simply a mechanical trading strategy, the effect of transaction costs is irrelevant. The annualised information ratio (IR) is the annualised average excess return of the strategy divided by the annualised volatility, and is a measure of the risk-adjusted return of the strategy. An IR of 0.5 or above (or of -0.5 or below) is statistically significant. We see that even conditioning on simple indicators yields interesting and often significant performance as measured by the IRs. For instance, investing in the index only in months following an outperforming month for the S&P 500 gives an IR of 0.9 and return of 13bp/month compared with 0.2 and 4bp/month when simply investing in the index every month.

Figure 14. Trading strategies on credit index – Feb 1990 to Mar 2005

Strategy		Last Month Excess Return Of S&P500 Index	Change in VIX Over Previous Month	Change in 2Y-10Y Yield Curve Slope Over Previous Month
Invest In Credit Index If Signal Positive	*# of Months*	112	88	88
	Avg Exc Rtn (bp/month)	13	-8	11
	Annual Info Ratio	0.9	-0.4	0.5
Invest In Credit Index If Signal Negative	*# of Months*	70	94	94
	Avg Exc Rtn (bp/month)	-11	14	-3
	Annual Info Ratio	-0.5	0.9	-0.3
Unconditional Long Credit Index	*# of Months*	182	182	182
	Avg Exc Rtn (bp/month)	4	4	4
	Annual Info Ratio	0.2	0.2	0.2

Source: Lehman Brothers.

Similar empirical relationships can be demonstrated at the rating level. In the following tests, the strategy goes long AA-rated credit and short BBB-rated credit, conditional on the same macro signals (Figure 15). The benchmark strategy here unconditionally goes long AA and short BBB each month.

Figure 15. Trading strategies on BBB minus AA – Feb 1990 to Mar 2005

Strategy		Last Month Excess Return Of S&P500 Index	Change in VIX Over Previous Month	Change in 2Y-10Y Yield Curve Slope Over Previous Month
Invest In BBB-AA If Signal Positive	*# of Months*	112	88	88
	Avg Exc Rtn (bp/month)	10	-15	1
	Annual Info Ratio	0.7	-0.8	0.1
Invest In BBB-AA If Signal Negative	*# of Months*	70	94	94
	Avg Exc Rtn (bp/month)	-19	12	-3
	Annual Info Ratio	-0.8	0.8	-0.2
Unconditional Long BBB-AA	*# of Months*	182	182	182
	Avg Exc Rtn (bp/month)	-1	-1	-1
	Annual Info Ratio	-0.1	-0.1	-0.1

Source: Lehman Brothers.

3.3. Predicting the factors

Motivated by this empirical evidence of simple credit market predictability, it is reasonable to look for predictability in our three CFM factors. Here we use a more elaborate forecasting system, which combines information in several indicator variables to form a forecast for the future realisation of each CFM factor. In each case we include an indicator variable only if it is both significant empirically and justifiable economically.

The effectiveness of this forecasting can be directly back-tested in a fully out-of-sample framework. Figure 16 summarises the performance of a long-short trading strategy which takes a position between -1 and 1 in each factor each month, based on the forecast from the model. We assume zero transaction costs and take an initial 48-month learning period so that out-of-sample forecasts begin only in February 1994.

Figure 16. Performance of factor forecasting – Feb 1994 to Mar 2005

	Quality Factor	Slope Factor	Default Factor
Number of Trades	134	134	134
Avg Exc Return (bp/month)	9.6	6.2	3.9
Std Dev (bp/month)	51.2	34.7	21.6
Annual Inf Ratio	**0.65**	**0.62**	**0.62**
Hit Ratio	**63%**	**54%**	**60%**

Source: Lehman Brothers.

We report several metrics for measuring performance. The average excess returns over Treasuries is positive for each factor, with the quality factor forecasting strategy delivering the strongest absolute return. According to the information ratios (IRs), the forecasting of the three factors is roughly equal in strength, with all three IRs significant at about 0.6. Finally, the hit ratio is a basic metric defined simply as the percentage of months for which the sign of the forecast was correct, ignoring the magnitude of returns. We would expect to see hit ratios above 50%. In these tests the slope factor has the weakest hit ratio at 54%, while the other factors are both reasonably strong with hit ratios of 60% or more.

4. FORECASTING CREDIT PERFORMANCE

4.1. The MISTRAL system

We now give a more detailed description of the MISTRAL system, a summary diagram of which is shown in Figure 17.

In section 3.3 we saw that the macro indicators can be used to generate a forecast of the future realisations of each of the three CFM factors. In particular, we use a robust non-linear regression framework to generate, for each factor, a probability that the next realisation is positive. Separately, we calculate the conditional expected excess return, given the realisation is positive and negative, on each of the factor-mimicking portfolios. Together with the probability, we can then compute a robust estimate of the next period excess return of the factor-mimicking portfolio.

Next, we return to the contemporaneous regressions, introduced in section 2.3, of excess returns of the buckets of a partition of the credit index on the excess returns of the factor mimicking portfolios. By substituting the returns forecasts generated by the macro signals, we generate a forecast for the excess return of the bucket.

Figure 17. Diagram of the MISTRAL system

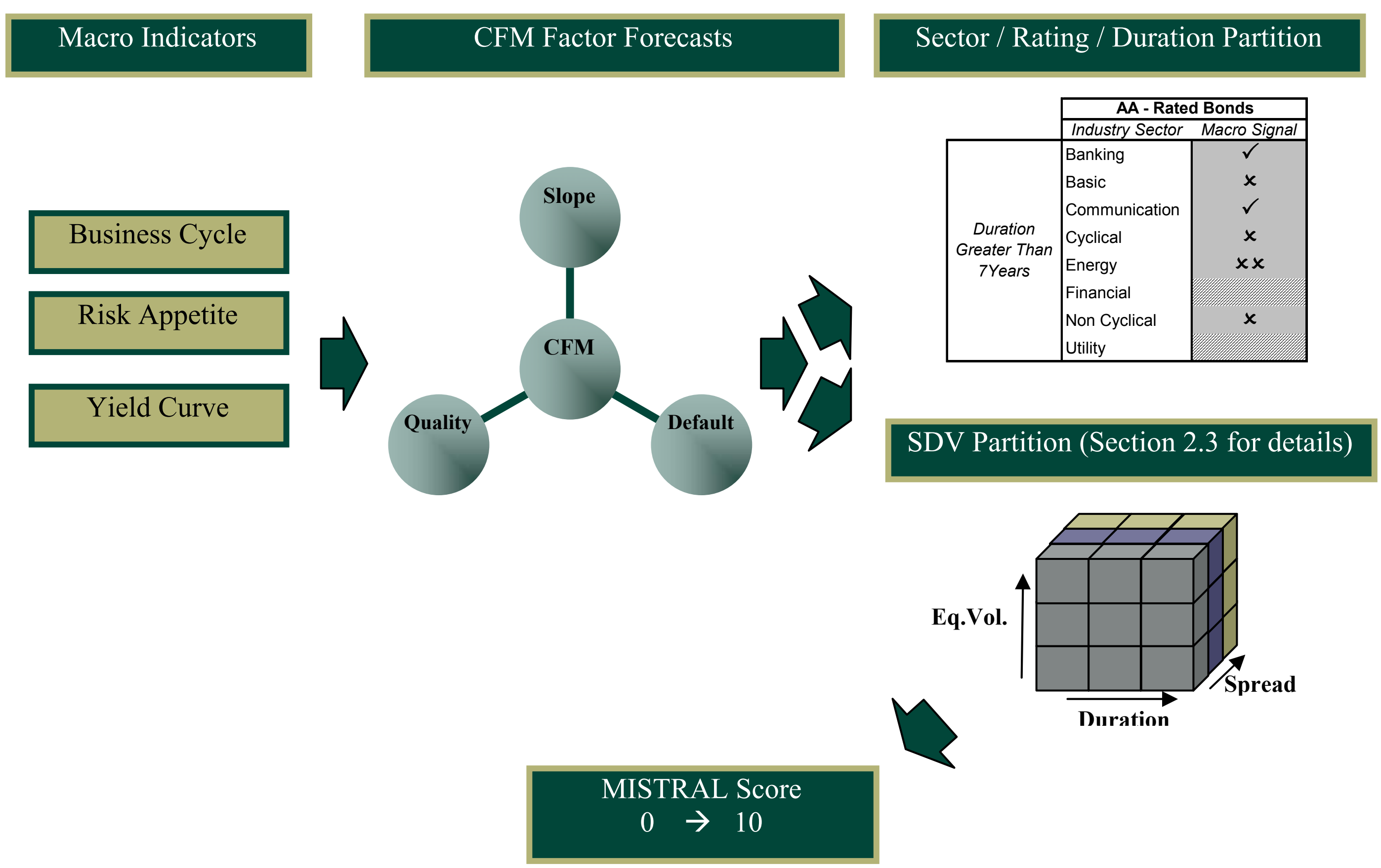


Figure 17 summarises the forecasting steps as well as the different partitions for which forecasts are generated. The MISTRAL score is introduced in detail in section 5.

In section 2.3 we looked at the properties and regression results of various buckets partitioned into broad rating categories and industry sectors. Although forecasting the performance of sectors and rating categories is intuitively appealing, applying *MISTRAL* to these partitions is less effective because of the insufficient variability of the buckets along the dimensions of spread, duration and volatility (see also section 4.4). For this reason, we can replace the sector and rating partition with one based on a combination of industry sector, broad rating category and duration category. So a typical bucket of this partition might be Banking-AA-Long Duration.

Also in section 2.3 we defined the SDV (spread, duration, volatility) partition by dividing bonds into 27 buckets based directly on their spread, duration and equity volatility. We can now test the performance of the *MISTRAL* system on both the SDV partition and the sector/rating/duration partition.

4.2. SDV partition results

The *MISTRAL* system can be tested directly by measuring the performance of an index overlay strategy which overweights and underweights the various buckets of the index partition. Such an overlay could then be combined with a standard index-tracking portfolio to form a long-only strategy to outperform the index. An overlay can also be viewed as a long-short portfolio in the absence of a benchmark index.

Figure 18 shows the summary performance of the *MISTRAL* overlay[3] on the SDV partition, assuming zero transaction costs. The information ratio is slightly above 1 and the hit ratio well above 50%. Returns are slightly positively skewed and have fat tails.

Figure 18. Performance of SDV overlay – Feb 1994 to Mar 2005

Number of Trades	134
Avg Exc. Return (bp/month)	6.7
TEV (bp/month)	22.8
Annual Inf Ratio	**1.02**
Hit Ratio	**73%**
Min Return (bp)	-47.7
Max Return (bp)	134.9
Median Return (bp/month)	5.9
Skewness	1.8
Kurtosis	11.9

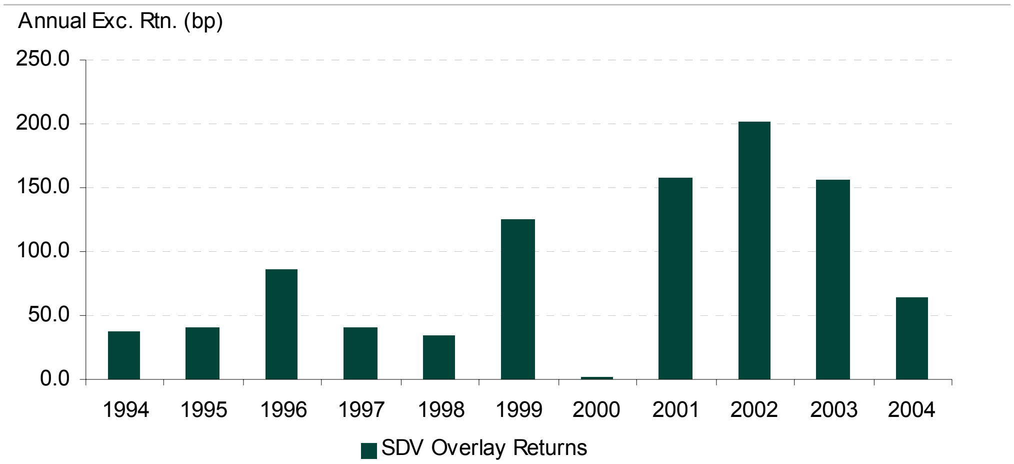
Source: Lehman Brothers.

We can get an idea of the annual performance profile of the strategy from Figure 19. The strategy delivers a positive annual excess return every year up to the end of 2004. We should note that the sample is only ten years long and is not necessarily representative of future returns. The strategy had the highest excess returns in 2001 and 2002, when the credit market

[3] *The MISTRAL overlay is constructed as follows. MISTRAL ranks each bucket of the partition and assigns it a value between -1 and 1. We refer to the vector of these values as the overlay. Buckets ranked higher by MISTRAL receive an overlay value closer to 1 while buckets ranked lower by MISTRAL receive an overlay value closer to -1. This value can be viewed as a percentage overweight or underweight position to be taken for that bucket relative to the index. The index has a 100% weight for each bucket of the partition. Therefore, a bucket with an overlay value of 1 corresponds to a 100% overweight – i.e. double the index weighting for that bucket. Conversely, a bucket with an overlay value of -1 corresponds to a 100% underweight – i.e. zero weight for that bucket. The excess return of the overlay is then simply the scalar product of the overlay vector with the vector of excess returns of the partition buckets in the following month.*
Now, the overlay vector can be scaled without changing the relative weights on partition buckets. For example, a 5% scaling would give a maximum overweight of 5% - corresponding to 105% of the index weighting – and maximum underweight of -5% - corresponding to 95% of the index weighting. Changing the scaling factor controls how closely the portfolio tracks the index – the greater the scaling factor the higher the tracking error volatility. The excess return of the overlay is also directly proportional to the scaling factor. However, the information ratio is unaffected (the scaling factor cancels) and is therefore the most meaningful performance metric.
In all the reported test results we use a scaling factor of 5% to calculate average excess returns and tracking error volatility (TEV).

performed poorly. The lowest return was in 2000 after the burst of the equity bubble. In that year, the break in the trend of the macro variables must have impacted the strategy negatively.

Figure 19. Annual performance profile of SDV overlay – 1990 to 2004



Source: Lehman Brothers.

4.3. Sector/rating/duration partition results

An alternative partition is the sector/rating/duration which is closer to the traditional approach used by credit portfolio managers. We expect performance to be slightly weaker than for the SDV partitions because sectors do not necessarily differ markedly in terms of spread, duration and equity volatility.

Figure 20 shows the summary performance of the MISTRAL overlay on the sector/rating/duration partition. The information ratio is 0.62 and the hit ratio above 50% at 58%. Skewness and kurtosis (measure of fat tails) are the same as for the SDV partition. Still, the decrease in the performance indicators highlights the superiority of the SDV partition over the more traditional sector partition.

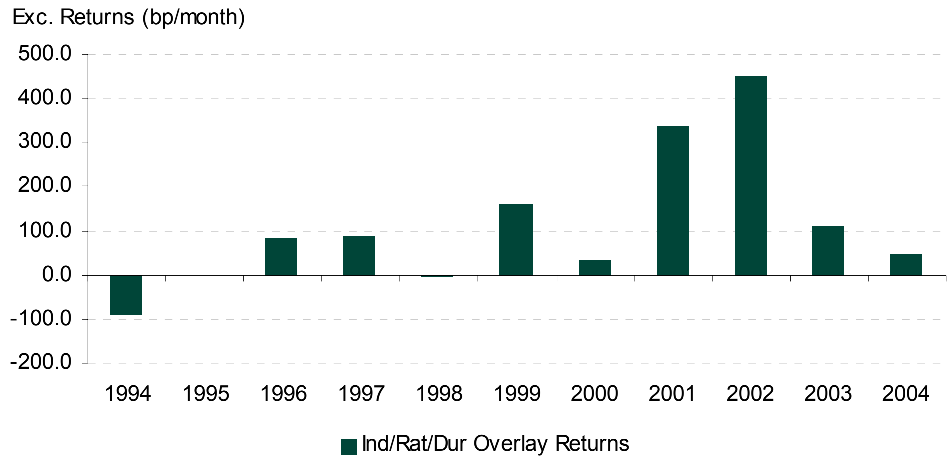
Figure 20. Performance of sector/rating/duration overlay

Number of Trades	134.0
Avg Exc. Return (bp/month)	8.8
TEV (bp/month)	49.4
Annual Inf Ratio	**0.62**
Hit Ratio	**58%**
Min Return (bp)	-162.3
Max Return (bp)	259.4
Median Return (bp/month)	5.0
Skewness	1.8
Kurtosis	11.8

Source: Lehman Brothers.

The annual performance profile of the strategy is presented in Figure 21. The strategy performs reasonably well, delivering a positive annual excess return during most years in the sample period. The weakest years are 1994 and 1998. The highest returns are obtained in periods of spread widening such as in 2001 and 2002.

Figure 21. Annual performance profile of sector/rating/duration overlay

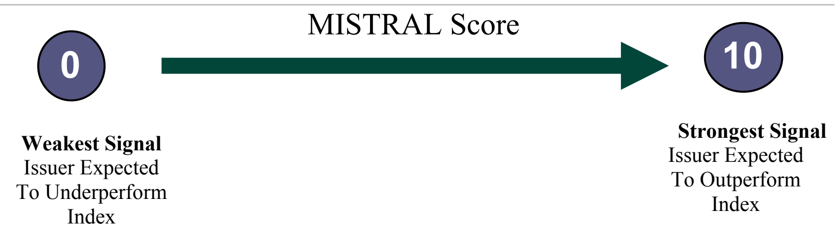


Source: Lehman Brothers.

5. MISTRAL SCORES

5.1. Constructing issuer-level Scores

The most directly applicable output of the MISTRAL system is the issuer-level MISTRAL score. The MISTRAL score for an issuer is derived from the forecast relative performance of the issuer's SDV bucket. It is a value between zero and ten: the higher the score, the stronger the model signals that the issuer will outperform the credit index. A score of five indicates a neutral view.



Source: Lehman Brothers.

The validity of the MISTRAL score as a performance indicator can be directly back-tested. Each month we form portfolios (equally-weighted) of the top 50 and bottom 50 issuers ranked by their score. We then measure the performance of going long the top 50 and going short the bottom 50. We also look at the long-short portfolio combined. Figure 22 reports the results, showing strong performance in each portfolio based on information ratios and return numbers. These results are based on a one-month holding period and assume zero transaction costs.

Figure 22. Testing the MISTRAL scores as a performance indicator – Feb 1990 to Mar 2005

	Long Top 50 Portfolio	Short Bottom 50 Portfolio	Long Minus Short
Number of Months	133	133	133
Avg Exc Rtn (bp/month)	12.3	14.8	27.1
Std Deviation (bp/month)	41.7	35.9	64.8
Annualised Info Ratio	1.0	1.4	1.5
Hit Ratio	71%	70%	73%

Source: Lehman Brothers.

5.2. Combining MISTRAL scores with bottom up scoring

Using the MISTRAL score offers a simple and effective way of translating macro signals into issuer-level performance indicators. It is a natural extension to combine the MISTRAL "top-down" signals with other "bottom-up" issuer signals such as the Lehman Brothers ESPRI, OneScore and CDSscore systems.

Figure 23 shows a sample output that is possible using both MISTRAL and ESPRI scores.

Figure 23. Combining MISTRAL Scores, ESPRI Scores and OneScores.

Ticker	Broad Rating	Issuer Mkt Value ($'000)	Issuer OAS (bp)	Issuer Mod. Adj. Dur	ESPRI Score	MISTRAL Score	OneScore
AA	A	6540154	56	5.3	**1.0**	**1.7**	**3.0****
AAB	A	4448624	57	3.8	**4.1**	**4.1**	**4.0*****
ABBEY	A	4419135	96	7.8	**3.6**	**2.8**	**1.6****
ABS	BBB	4256442	136	8.3	**5.9**	**4.3**	**7.9****
ABT	A	3879483	41	3.8	**3.2**	**2.7**	**4.4****
ADM	A	3575996	82	10.6	**7.5**	**4.4**	**6.2****
AEE	BBB	1773710	112	7.8	**3.3**	**9.8**	**4.1****
AEP	BBB	6769712	104	6.4	**3.7**	**5.5**	**4.8****
AIG	AA	17554958	63	4.1	**10.0**	**3.2**	**8.0****
AL	BBB	3357155	80	9.0	**3.6**	**1.7**	**3.8*****
ALL	A	4512516	67	6.0	**4.5**	**5.2**	**3.7*****
AMR	BBB	1641142	303	4.8	**3.9**	**7.4**	**6.2****
APC	BBB	4111329	81	7.3	**4.0**	**2.7**	**5.1*****
AT	A	3550478	95	7.5	**8.5**	**7.6**	**6.0***
AWE	BBB	11539309	120	6.5	**7.9**	**5.0**	**6.4****
AXASA	BBB	2817329	113	9.7	**6.5**	**1.9**	**5.7*****
AXP	A	4354410	40	3.9	**2.4**	**2.6**	**3.2****
BA	A	9813327	87	5.8	**6.2**	**3.6**	**6.6*****
BAC	A	39665444	58	4.7	**6.5**	**4.4**	**5.2****
BBT	A	3121619	58	6.2	**1.2**	**3.6**	**2.7****
BHP	A	2708736	54	6.9	**4.0**	**0.6**	**4.5*****

Source: Lehman Brothers.

6. CONCLUSION

MISTRAL offers a systematic approach for extracting information in macro-level indicators to help top-down sector and securities selection. By breaking down the excess returns of credit portfolios into the three factors of our CFM framework, and by relating the performance of these factors to a set of economic and financial indicators, we can forecast the performance of these portfolios. We have documented the predictability of the CFM factors directly, as well as the historical performance of overlays based on the model's signals. We have also shown that constructing long-short portfolios based on the MISTRAL issuer-level scores delivers good excess return performance over a number of years.

Forecasts generated by MISTRAL can be used by portfolio managers as part of a broader investment process to come up with model-driven macro-level views on sectors and ratings. The MISTRAL score system allows further flexibility for including macro-information in issuer selection.

REFERENCES

Naik, V., M. Trinh and G. Rennison, "Systematic Variations in Corporate Bond Excess Returns", Lehman Brothers *Quantitative Credit Research Quarterly*, April 2003.

APPENDIX A

A.1. Euro CFM factors

We run the same analysis for euro credit factors. Because of the smaller universe, euro factors are divided into 2x2x2 sets to define high/low spreads, etc. Consequently, the SDV partition in euros consists of only eight buckets rather than 27. Figure 24 shows the summary statistics of these factors and Figure 25 gives the correlation matrix.

Figure 24. Summary statistics for the euro credit factors – Feb 1999 to Mar 2005

	Quality Factor	Slope Factor	Default Factor	Euro Index
Avg Exc Rtn (bp/month)	7	-2	-3	5
Std Dev (bp/month)	44	36	25	31
Autocorrelation	9%	9%	11%	11%

Source: Lehman Brothers.

Figure 25. Correlation matrix of euro credit factors – Feb 1999 to Mar 2005

	Quality	Slope	Default	Index
Quality	100%			
Slope	-77%	100%		
Default	87%	-70%	100%	
Index	95%	-70%	85%	100%

Source: Lehman Brothers.

A.2 Performance of Euro MISTRAL

Euro MISTRAL uses a slightly simplified methodology compared with the US system. Owing to the shorter time series available, fewer parameters can be estimated reliably. The outputs from the model are the same, however, and Figure 26 shows the euro overlay performance. The results are similar to the US overlay, with a strong information ratio of 1.05 indicating good risk-adjusted performance.

Figure 26. Performance of euro SDV overlay – Feb 1999 to March 2005

Number of Trades	72.0
Avg Exc. Return (bp/month)	1.5
TEV (bp/month)	5.0
Annual Inf Ratio	**1.05**
Hit Ratio	**64%**
Min Return (bp)	-10.9
Max Return (bp)	20.5
Median Return (bp/month)	0.8
Skewness	1.1
Kurtosis	4.0

Source: Lehman Brothers.

A Guide to Correlation Station

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Correlation Station is a tool for the analysis of standard and bespoke synthetic CDO tranches. Available through LehmanLive (Keyword **CS***), it provides pricing and risk for the standard tranches within a base correlation framework. Users can define and save their own bespoke tranches, and price and risk manage these within a base correlation framework. Users can also generate portfolio statistics and scenario analyses.*

INTRODUCTION

Correlation Station is a tool for the pricing, risk management, trade analysis and scenario analysis of synthetic CDO tranches. This version of correlation station includes the ability to not only do all of this for the standard tranches on the liquid CDS portfolio indices, it also incorporates the ability to create, price and analyse bespoke synthetic CDOs.

Features of the current version of Correlation Station include:

- Daily updated pricing on the standard tranches on the liquid CDS indices
- Real-time calculation of implied compound and base correlation
- Real-time calculation of tranche risk measures[1], including systemic delta, gamma, theta, delta per name, and the name-specific value on default
- Analysis of multiple tranche trades, e.g. convexity versus carry trades
- Creation, storage and analysis of bespoke CDO tranches
- Tranche scenario analysis using the IRR vs Annual Default Rate (ADR) approach
- Pricing of non-standard tranches within the base correlation framework
- Daily updated CDS spread term structures for all of the names in the standard indices
- Use of live interest rate curves for discounting future expected cash flows
- User overrides for extensive scenario analyses
- Portfolio statistics (ratings, spreads, regional diversity) for all of the standard indices

The rest of this document describes in detail how to access this functionality

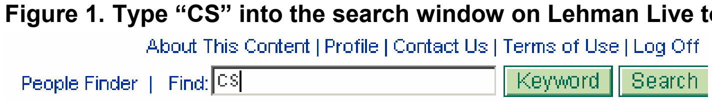
HOW TO ACCESS CORRELATION STATION

The fastest way to access Correlation Station is to use the keyword **CS** in the search window located at the upper right hand side of the LehmanLive web page. Simply, type in "CS" and hit the Keyword button as shown below. If a message appears saying that

"The keyword CS was found but you are not authorized to view the page",

you should contact your Lehman Brothers sales person to have your access enabled.

Figure 1. Type "CS" into the search window on Lehman Live to begin



Source: LehmanLive.

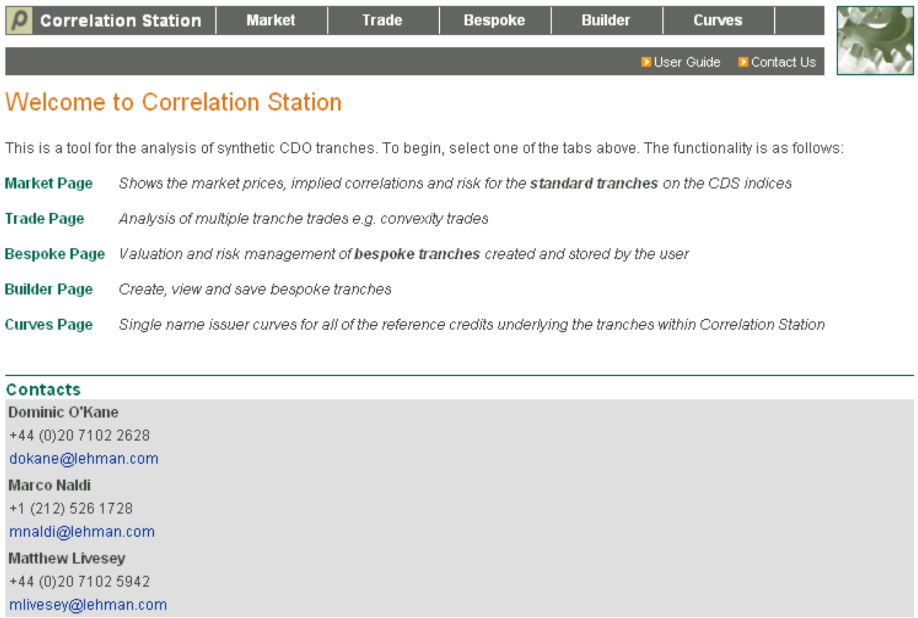
[1] *The model underlying this version of Correlation Station is an enhanced version of the Large Homogeneous Portfolio model as described in Greenberg, O'Kane and Schloegl (2004).*

Once selected, a welcome page will appear.

THE WELCOME PAGE

As soon as you enter Correlation Station you will see the Welcome page. This has a summary of the pages in Correlation Station, each of which can be accessed via a tab. It also has a list of contacts.

Figure 2. The Correlation Station Welcome page



Source: LehmanLive.

You can also see a link to a User Guide, which when selected opens a new window. This is essentially a version of this document which you can consult while using Correlation Station. Embedded within this guide are links to some of the technical documents describing the model underlying Correlation Station.

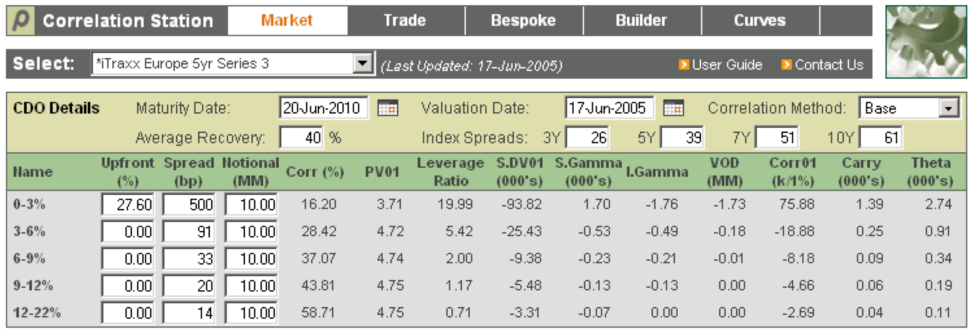
The “Contact Us” link opens an email box window from which you can send us a comment, question, or suggestion about Correlation Station.

The five main tabs of Correlation Station are: Market, Trade, Bespoke, Builder and Curves. We describe each of these in turn.

THE MARKET PAGE

The Market page shows the market prices for the standard tranches, plus implied correlations, risk analyses, portfolio statistics, and pricing of non-standard tranches.

Figure 3. The Market page



Name	Upfront (%)	Spread (bp)	Notional (MM)	Corr (%)	PV01	Leverage Ratio	S.DV01 (000's)	S.Gamma (000's)	I.Gamma	VOD (MM)	Corr01 (k/1%)	Carry (000's)	Theta (000's)
0-3%	27.60	500	10.00	16.20	3.71	19.99	-93.82	1.70	-1.76	-1.73	75.88	1.39	2.74
3-6%	0.00	91	10.00	28.42	4.72	5.42	-25.43	-0.53	-0.49	-0.18	-18.88	0.25	0.91
6-9%	0.00	33	10.00	37.07	4.74	2.00	-9.38	-0.23	-0.21	-0.01	-8.18	0.09	0.34
9-12%	0.00	20	10.00	43.81	4.75	1.17	-5.48	-0.13	-0.13	0.00	-4.66	0.06	0.19
12-22%	0.00	14	10.00	58.71	4.75	0.71	-3.31	-0.07	0.00	0.00	-2.69	0.04	0.11

Source: LehmanLive.

When you enter the Market page, shown in Figure 3, you will find a dropdown menu asking you to select an index. This menu lists all the indices for which Correlation Station has tranche prices. This currently includes:

- CDX North America Series 2, 3 and 4 to both 5-year and 10-year maturity
- iTraxx Europe Series 2 and 3 to both 5-year and 10-year maturity
- CDX Emerging Markets Series 1 to 5-year maturity
- iTraxx Japan Series 2 and 3 to 5-year maturity

As new indices are issued, these will be added to this list.

Once you have chosen an index, the associated tranche information including the most recent pricing updates will automatically load. This information consists of the following:

- Attachment and detachment points of the standard tranches on the selected index
- Maturity date of the tranche (the same as the underlying index)
- Price of the tranches in terms of upfront payment and running spreads
- Notional of each tranche (set to 10m units of the currency of the index)
- Term structure of the underlying CDS index at the 3,5,7 and 10-year points
- Average recovery rate of the collateral in CDS index (initially set at 40%)

Changing the Correlation Method used

Correlation Station will also calculate the price-implied correlation and associated risk measures for all of the tranches on that index according to the Correlation Method that has been selected on the right hand side dropdown menu. This can be either *Compound Correlation* or *Base Correlation*. This menu defaults to *Base Correlation*. See O'Kane and Livesey [04] for a full description of these different implied correlation measures.

Risk measures on the Market page

For each standard tranche the Market Page calculates the PV01, Leverage, Systemic DV01, Systemic Gamma, Idiosyncratic Gamma, VOD, Correlation 01, Carry and Theta. These are all defined in Figure 4.

Figure 4. The implied correlation and risk measures on the markets page

Measure	Description
Implied Correlation	Either the Compound Correlation for the tranche or the Base Correlation corresponding to the upper strike of the tranche.
PV01	Present value of a $1 risky annuity paid on the risky premium leg of the tranche, i.e. each coupon is paid on the outstanding notional of the tranche.
	For a 5-year maturity senior tranche, this is a number close to the risk-free PV of a 5-year annuity, i.e. it is a number close to 5. For example, in Figure 3 we see that the PV01 of the low risk 12-22% tranche is 4.75.
	For a riskier equity tranche, the PV01 is smaller to reflect the risk that the notional of the tranche is likely to fall through time. In the example above, we see that the 5-year 0-3% equity tranche has a PV01 equal to 3.71.
Leverage	The Leverage is the ratio of the sensitivity of the tranche to index spread movements, compared with the whole portfolio.
	The tranche notional multiplied by the leverage gives the notional of the index on which protection would have to be purchased in order to hedge the tranche against movements in the index spread.
S.DV01	This stands for the systemic dollar value 01. It is the change in PV of the tranche when the index spread increases by 1bp. This is expressed in units of 000's.
S.Gamma	This stands for the systemic gamma. This is the change in the S.DV01 when the index spread increases by 1bp. This is a measure of the convexity of the tranche and can be positive or negative depending on the tranche.
I.Gamma	This stands for the idiosyncratic gamma. This is the change in the Idiosyncratic DV01 when a single credit in the portfolio has a CDS spread increases of 1bp. This is a measure of the single-name convexity of the tranche and can be positive or negative depending on the tranche.
VOD	This stands for the Value on Default. It is the PV change of a tranche when a single credit in the portfolio defaults. The index spreads and the Base Correlation Curve are assumed to remain the same after the default occurs. This is expressed in units of millions.
Corr01	This stands for the Correlation 01. This is the PV change of a tranche when correlation increases by 1% i.e. a 20% correlation moves to 21%. For base correlation this means that the base correlation for the attachment and detachment points increase by 1%.
Carry	Accrued payment from the tranche over one day, measured in thousands. It does not include the upfront payment of the tranche, simply the running spread.
Theta	Change in PV of the tranche when the valuation date is moved one day on. Theta is expressed in 000's and assumes that the interest rate curve and correlation inputs remain the same. The theta calculation does not include the payment that is accrued over the one day period because this is taken into account as the carry.

Changing the tranche information

It is possible to change most of the inputs that are used to calculate the implied correlation and risk measures for the tranche. In particular, it is possible to change the following:

- Tranche prices defined in terms of an upfront payment expressed as a percentage of notional and the running spread in basis points
- Tranche notionals defined in units depending on the currency of the index
- The average recovery rate of the names in the index expressed as a percentage

- The term structure of index spreads (3yr, 5yr, 7yr and 10yr) in basis points
- The valuation date
- The maturity date of the tranches

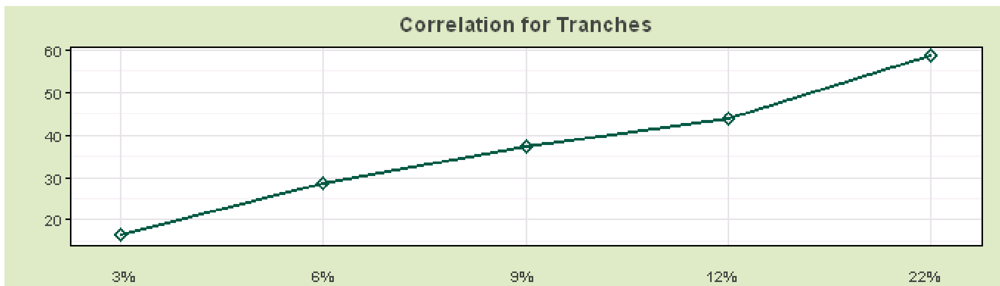
If any of these values are changed, the implied correlation and risk measures will **automatically** recalculate.

Towards the bottom of the Market page you can see the tabs of the sub-pages that are available within the Market page. These are the Skew, iRisk, ADR, Non-Std and Breakdown tabs. Each enables further analysis of the chosen tranche and is described below.

THE SKEW SUB-PAGE

The Skew sub-page graphically displays the implied correlation curve.

Figure 5. Skew sub-page implied correlation graph.



Source: LehmanLive.

For base correlation, the x-axis is labelled with the width of the base tranche and the y-axis has the corresponding base correlation. For compound correlation, the x-axis is the tranche label.

THE IRISK SUB-PAGE

The iRisk sub-page shows the idiosyncratic (name-specific) risk measures including the name-specific delta.

In the lower half of the Market page, there is an iRisk tab which, once selected, shows each of the underlying issuers in the chosen index, their spread, recovery rate, notional and associated risk measures.

Figure 6. iRisk sub-page

Skew | iRisk | ADR | Non-Std | Breakdown

Idiosyncratic Risk for Tranche: 0-3% Launch LOTUS (loss distribution analysis)

Issuers	Spread (bp)	Recovery Rate	Correlation (%)	Notional (MM)	PV01	I.Delta (MM)	I.DV01 (000's)
ABN AMRO BANK N.V.	14	40%	16.20	2.67	4.74	1.19	-0.56
ACCOR	74	40%	16.20	2.67	4.65	1.48	-0.69
ADECCO S.A.	88	40%	16.20	2.67	4.62	1.51	-0.70
AEGON N.V.	36	40%	16.20	2.67	4.70	1.35	-0.64
AKTIEBOLAGET ELECTROLUX	63	40%	16.20	2.67	4.66	1.45	-0.68
AKZO NOBEL N.V.	37	40%	16.20	2.67	4.70	1.36	-0.64
ALLIANZ AG	26	40%	16.20	2.67	4.71	1.30	-0.61
ALLIED DOMECQ PLC	166	40%	16.20	2.67	4.51	1.61	-0.73
ALTADIS, SA	31	40%	16.20	2.67	4.71	1.33	-0.62
ANGLO AMERICAN PLC	29	40%	16.20	2.67	4.71	1.31	-0.62
ARCELOR FINANCE	72	40%	16.20	2.67	4.64	1.48	-0.69
AVENTIS	27	40%	16.20	2.67	4.71	1.30	-0.61

Source: LehmanLive.

These risk measures can only be shown for one of the tranches at a time, and different tranches can be selected from the dropdown menu. For the chosen tranche, the following risk measures are calculated for each issuer: the PV01, Idiosyncratic Delta and Idiosyncratic DV01. These are defined in the table below.

Figure 7. The name specific risk measures shown on the iRisk sub-tab

Measure	Description
Spread	The CDS spread in basis points of the issuer to the maturity of the trade
Recovery Rate	The assumed recovery rate for the issuer
Correlation	The value of implied correlation that is used to calculate I.Delta and I.DV01. When the Correlation Method is set to Compound, this will be a single number corresponding to the tranche. When the Correlation Method is Base Correlation there will be two correlations, corresponding to the lower and upper strikes of the tranche (except for the equity tranche)
Notional	The notional of the issuer in the portfolio
PV01	The PV of the risky annuity on the single name
Delta	The amount of single name CDS notional protection that would have to be bought in order to delta hedge against movements in that issuer's CDS spread quoted in millions.
DV01	The change in PV of the tranche when the issuer's CDS spread increases by 1bp and quoted in 000's.

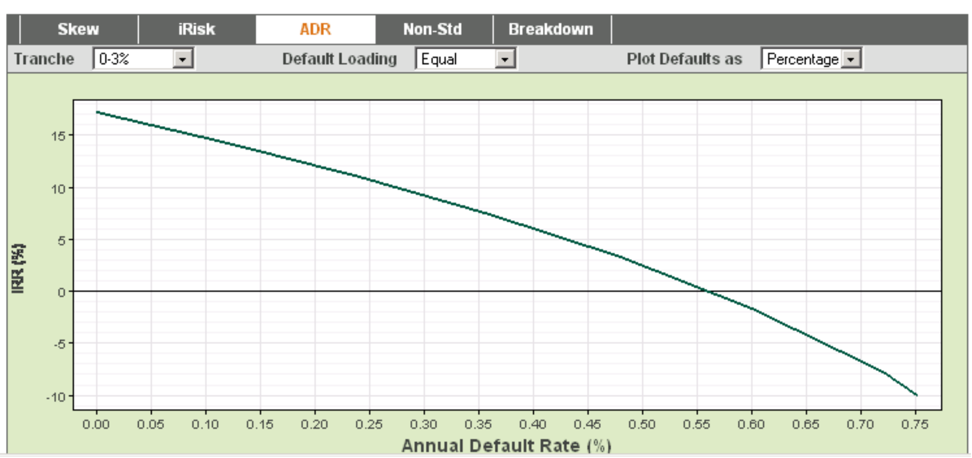
The single-name risk calculations can be exported to Excel by clicking on the Excel symbol and then pasting the results into Excel (Ctrl-v).

THE ADR SUB-PAGE

The ADR (Annual Default Rate) sub-page calculates the Internal Rate of Return (IRR) for the different standard tranches assuming different levels of annual default rate.

The ADR sub-page provides basic scenario analysis of CDO tranches, based upon the assumption of different rates of default on the underlying collateral.

Figure 8. The ADR sub-page



Source: LehmanLive.

Selecting a tranche

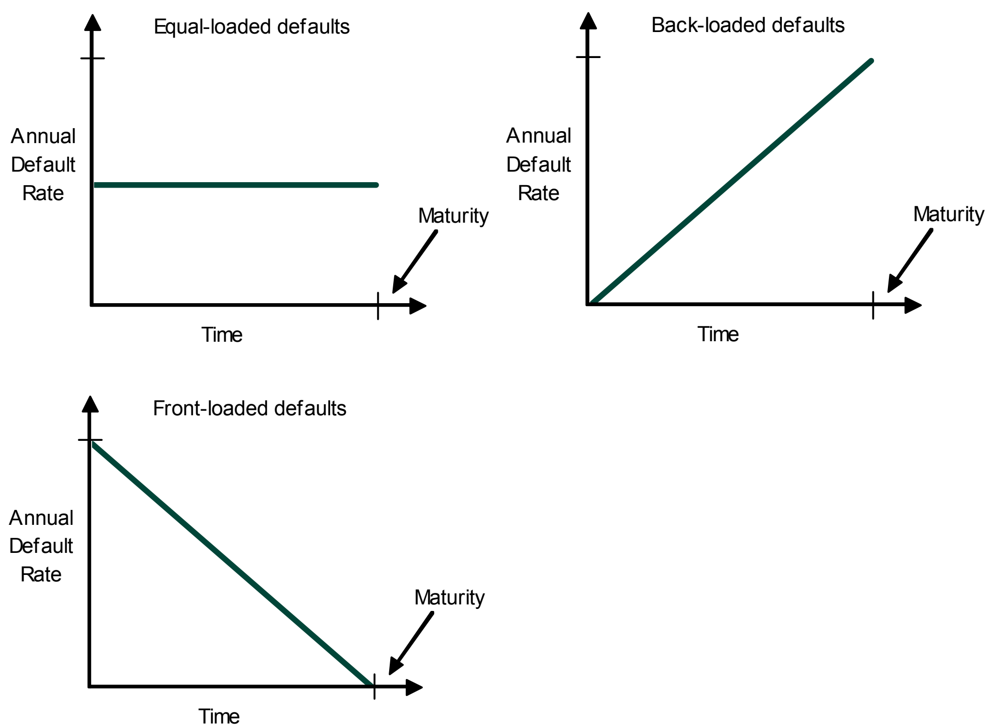
The Tranche dropdown menu is used to select the required tranche for the ADR analysis. This can be a single tranche or all tranches simultaneously.

Changing the default loading

Using a default loading, we can vary the timing of the defaults. This is done by using the Default Loading dropdown menu. The Default Loading can be set to Equal-loaded, Back-loaded, Front-loaded or all three. All keep the rate of default over the whole life of the trade equal to the ADR:

- **Equal**: The default rate is held constant until the maturity of the trade.
- **Front**: The immediate default rate is twice the ADR, falling linearly to 0% at maturity.
- **Back**: The immediate default rate is 0%, rising linearly to twice the ADR at maturity.

Figure 9. Distribution of defaults under different default loading assumptions: (i) Equal-loaded; (ii) Back-loaded; and (iii) Front-loaded



Source: Lehman Brothers.

Annual Default Rate or Number of Defaults per year

For this ADR analysis the tranche is converted into a funded format by assuming that it is purchased in conjunction with a bond paying the relevant swap rate. This allows an IRR to be calculated as shown in Figure 10.

The IRR can be plotted against either of the following:

- Annual Default Rate (i.e. the percentage of the portfolio that defaults each year)
- Number of Defaults per year

To change this, choose from the "Plot Defaults As" dropdown menu and the graph will switch to the selected choice.

Figure 10. Comparison of the cash flows of a 0-3% equity tranche assuming 0% ADR and 0.50% ADR. See the note below for details

Time (in years)	0-3% Tranche Cash flows at 0% ADR	0-3% Tranche Cash flows at 0.5% ADR
0.00	-100 + 28.75 = -71.25	-100 + 28.75 = -71.25
0.25	1.75	1.71
0.50	1.75	1.66
0.75	1.75	1.62
1.00	1.75	1.58
1.25	1.75	1.53
1.50	1.75	1.49
1.75	1.75	1.44
2.00	1.75	1.40
2.25	1.75	1.36
2.50	1.75	1.31
2.75	1.75	1.27
3.00	1.75	1.23
3.25	1.75	1.18
3.50	1.75	1.14
3.75	1.75	1.09
4.00	1.75	1.05
4.25	1.75	1.01
4.50	1.75	0.96
4.75	1.75	0.92
5.00	101.75	50.88
Annualised IRR	16.2%	1.53%

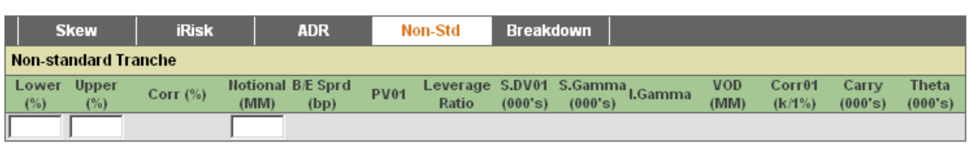
Note: Here the upfront of the 0-3% tranche is 28.75% so the initial cost of the funded tranche is 71.25%. The annual spread of the tranche is 500bp which equates to 125bp per quarter. The funding coupon is assumed to be a flat 2% which gives a further coupon of 50bps per quarter. So assuming there are no defaults, the coupon per quarter is 175bp.

NON-STD SUB-PAGE

The Non-Std sub-page calculates risk for a non-standard tranche on the standard index.

One of the advantages of base correlation is that it extends easily to the pricing of non-standard tranches on the standard indices. These tranches are non-standard in the sense of having non-standard attachment and detachment points. When selected, the Non-Std sub page looks as shown in Figure 11.

Figure 11. The Non-Std sub-page



Source: LehmanLive.

If a lower attachment point, upper attachment point and a tranche notional are entered, then the breakeven spread and tranche risk measures are instantly calculated using a linear interpolation of the base correlation curve of the standard tranches on this same index.

Figure 12 shows an example of a non-standard tranche. The interpolated base correlations are shown for the 4% attachment and 8% detachment points. In this example, they are 20.28% and 34.19% respectively. The associated risk measures for this tranche are also automatically calculated and displayed.

Figure 12. An example of a non-standard tranche on a standard index

Skew | iRisk | ADR | Non-Std | Breakdown

Non-standard Tranche

Lower (%)	Upper (%)	Corr (%)	Notional (MM)	B/E Sprd (bp)	PV01	Leverage Ratio	S.DV01 (000's)	S.Gamma (000's)	I.Gamma	VOD (MM)	Corr01 (k/1%)	Carry (000's)	Theta (000's)
4	8	20.28 - 34.19	10	48.24	4.74	3.06	-14.37	-0.36	-0.33	-0.05	-12.75	0.13	0.52

Source: LehmanLive.

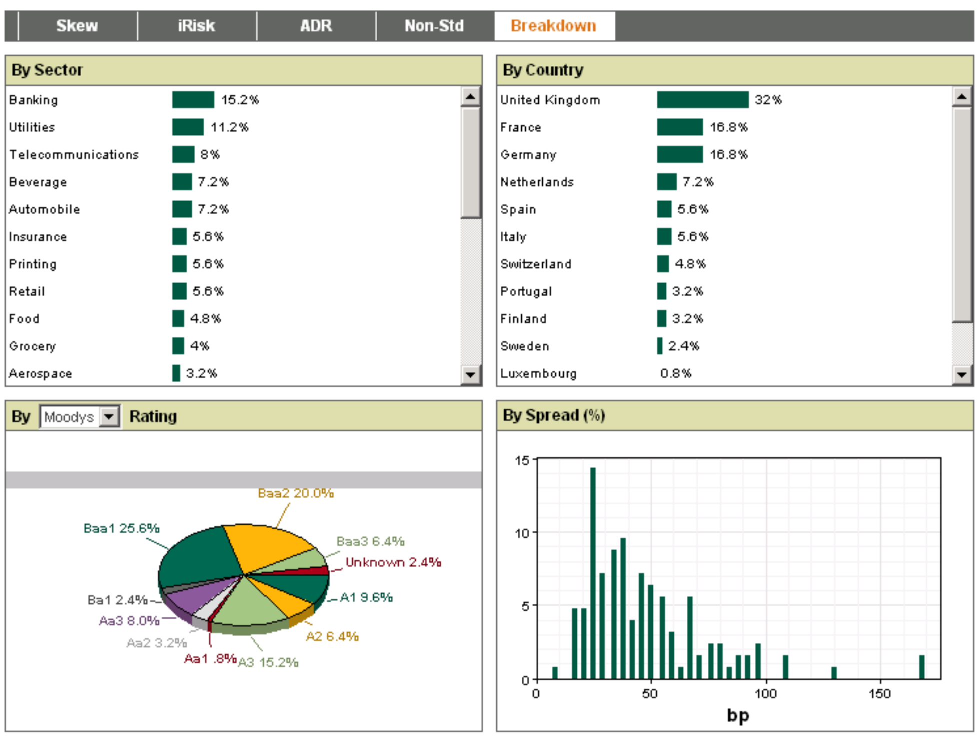
If the correlation method has been set to *compound*, this functionality is not available.

BREAKDOWN SUB-PAGE

The Breakdown sub-page shows the characteristics of the reference portfolios of the CDO.

For analysis and reporting purposes, it is useful to be able to represent the breakdown of the portfolio constituents of a CDO in terms of its sector, country, credit rating and spread distribution.

Figure 13. Breakdown page



Source: LehmanLive.

The Breakdown sub-page does exactly that. It is divided into four sections:

- **Sector**: This is a breakdown of the portfolio constituents by their sector. The percentage notional of the portfolio assigned to each sector is shown. A vertical scrollbar can be used to see the full list of sectors.
- **Country**: This is a breakdown of the portfolio constituents by country of domicile of the reference credit. The percentage notional of the portfolio assigned to each sector is shown. A vertical scrollbar can be used to see the full list of countries.
- **Rating**: This is a breakdown of the portfolio constituents by rating of the reference credit. This is displayed as a pie chart in which the percentage notional of the portfolio assigned to each sector is shown. The user can switch between the S&P rating and the Moody's rating using the dropdown menu.
- **Spread**: This is a breakdown of the portfolio constituents by their CDS spread to the portfolio maturity. This is shown as a histogram where the spreads have been split into 40 buckets. The number on the y-axis is the number of credits in that bucket. These numbers are automatically updated as market spreads change.

TRADE PAGE

The Trade page allows the user to analyse a trade consisting of a number of tranches.

Filtering the view to shorten the list of indices

Filtering the page to reduce the number of visible indices can be done using the dropdown menus in the Filter selection. Using these dropdowns allows filtering by index, term and series.

Figure 14. The top of the Trade page showing the filters

Source: LehmanLive.

Alternatively, the user may simply select the tranche index from the list by clicking on the "+" symbol on the left hand side of the page to expand the index into its standard tranches.

Entering a set of trades

The idea of the Trade page is to analyse a trade consisting of a combination of tranches.

Assuming that the "Spread implies correlation" option has been selected, users are able to enter the following information about each tranche in their trading strategy:

- **Contractual**: The contractual price at which the tranche was entered in terms of its upfront payment and spread.
- **Market**: The current tranche price, which may differ from the price at which the tranche was traded. This is also entered in terms of the upfront payment and spread.
- **Tranche notional**: A positive notional corresponds to selling protection. A negative notional corresponds to buying protection.

- **Index term structure**: This link shows the current market spreads for the underlying CDS portfolio indices. Changing these spreads will affect the PV and risks of the trades under consideration.
- **Valuation date**: It is also possible to move the valuation date both forward and backward to examine how the trade looks at different horizons.

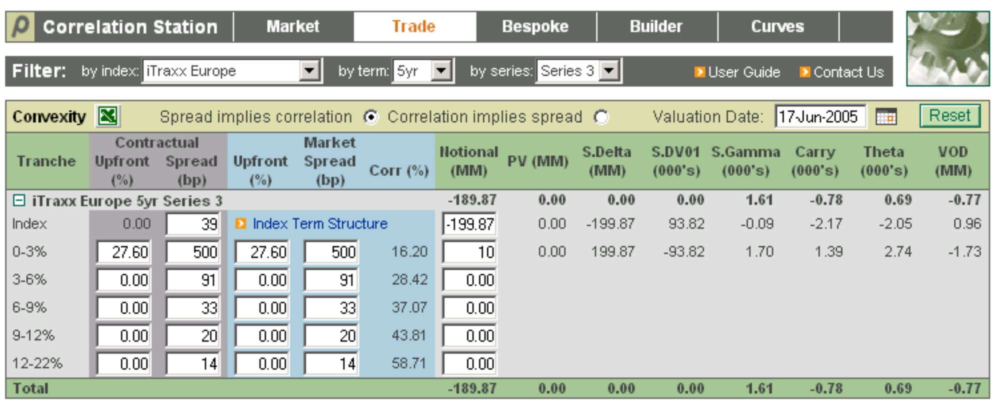
Once the price has been entered, the base correlations are calculated as follows: the base correlation for a tranche is that for the upper strike of the tranche as implied by the current market price.

We consider a convexity style trade as an example.

Figure 15 shows a convexity trade in which the investor is long €10m of the iTraxx 5-year 0-3% tranche, and bought €199.87m of the iTraxx 5-year CDS index. From the "Total row" at the bottom, we see that the notional of the CDS index has been chosen so that the net delta is zero, i.e. we have a trade which is instantaneously hedged to systemic movements in 5-year iTraxx.

However, the investor has a positive gamma of 1.61 and so, assuming nothing else changes, should benefit from volatility in the 5-year iTraxx index. A 1bp widening in the index spread results in an increase in PV equal to €1,610. This is offset by a negative carry of €780 per day. However, the overall theta for the trade is a positive value of €690 per day. This assumes that nothing else changes and that there are no defaults. A sudden default of one credit with a 40% recovery rate would result in a loss of €0.77m.

Figure 15. Analysis of a delta neutral equity trade on 5-year iTraxx



Tranche	Contractual Upfront (%)	Contractual Spread (bp)	Market Upfront (%)	Market Spread (bp)	Corr (%)	Notional (MM)	PV (MM)	S.Delta (MM)	S.DV01 (000's)	S.Gamma (000's)	Carry (000's)	Theta (000's)	VOD (MM)
iTraxx Europe 5yr Series 3						-189.87	0.00	0.00	0.00	1.61	-0.78	0.69	-0.77
Index	0.00	39	Index Term Structure			-199.87	0.00	-199.87	93.82	-0.09	-2.17	-2.05	0.96
0-3%	27.60	500	27.60	500	16.20	10	0.00	199.87	-93.82	1.70	1.39	2.74	-1.73
3-6%	0.00	91	0.00	91	28.42	0.00							
6-9%	0.00	33	0.00	33	37.07	0.00							
9-12%	0.00	20	0.00	20	43.81	0.00							
12-22%	0.00	14	0.00	14	58.71	0.00							
Total						-189.87	0.00	0.00	0.00	1.61	-0.78	0.69	-0.77

Source: LehmanLive.

If the "Correlation implies spread" option has been selected, then the page has the slightly different form shown below in Figure 16. The market price input is now a correlation which implies a spread for the tranche which is calculated automatically. This feature is a useful way to examine the effect of correlation changes on the PV of a trade.

Figure 16. The Trade page with correlation implies spread selected

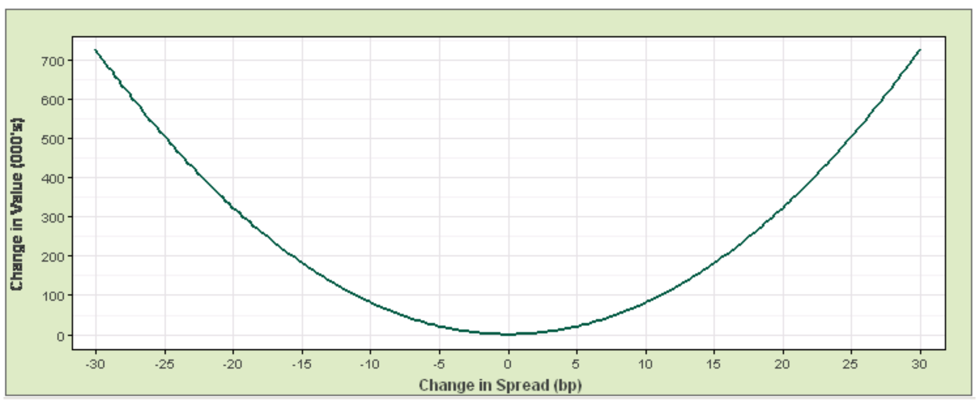
Tranche	Contractual Upfront (%)	Contractual Spread (bp)	Corr (%)	Market Upfront (%)	Market Spread (bp)	Notional (MM)	PV (MM)	S.Delta (MM)	S.DV01 (000's)	S.Gamma (000's)	Carry (000's)	Theta (000's)	VOD (MM)
iTraxx Europe 5yr Series 3						-189.87	0.00	0.00	0.00	1.61	-0.78	0.69	-0.77
Index	0.00	39	Index Term Structure			-199.87	0.00	-199.87	93.82	-0.09	-2.17	-2.05	0.96
0-3%	27.60	500	16.203	27.60	500.00	10	0.00	199.87	-93.82	1.70	1.39	2.74	-1.73
3-6%	0.00	91	28.422	0.00	91.00	0.00							
6-9%	0.00	33	37.073	0.00	33.00	0.00							
9-12%	0.00	20	43.812	0.00	20.00	0.00							
12-22%	0.00	14	58.706	0.00	14.00	0.00							
Total						-189.87	0.00	0.00	0.00	1.61	-0.78	0.69	-0.77

Source: LehmanLive.

Once a position has been entered, the Trade page will automatically re-calculate the PV and risk measures using the implied Base Correlation.

The graph at the bottom of the Trade page shows the Change in PV as the index spread changes. This uses the total S.DV01 and S.Gamma from the trades and illustrates the convexity effect on the overall PV.

Figure 17. The convexity graph shows how the value of a trade changes for absolute changes in the spread of the underlying index



Source: LehmanLive.

Resetting the inputs

The inputs can be reset to the defaults by clicking on the Reset button.

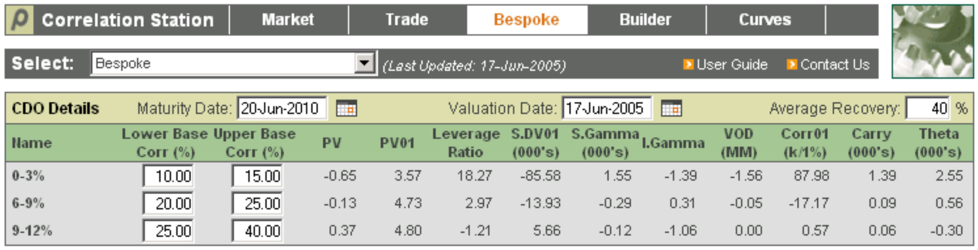
The trades can be exported to Excel using the Excel button. This copies any trades with a non-zero notional, along with their PV and risk measures to the clipboard, from where they can be copied to Excel (using Paste or Ctrl-V).

BESPOKE PAGE

The Bespoke page calculates the PV and risk measures for bespoke tranches.

To begin using the bespoke page, it is necessary to create a bespoke CDO. If you have not already done so, please access the **Builder** page to do this first, and then return to this page.

Figure 18. The Bespoke page showing an example CDO with three tranches



Name	Lower Base Corr (%)	Upper Base Corr (%)	PV	PV01	Leverage Ratio	S.DV01 (000's)	S.Gamma (000's)	I.Gamma	VOD (MM)	Corr01 (k/1%)	Carry (000's)	Theta (000's)
0-3%	10.00	15.00	-0.65	3.57	18.27	-85.58	1.55	-1.39	-1.56	87.98	1.39	2.55
6-9%	20.00	25.00	-0.13	4.73	2.97	-13.93	-0.29	0.31	-0.05	-17.17	0.09	0.56
9-12%	25.00	40.00	0.37	4.80	-1.21	5.66	-0.12	-1.06	0.00	0.57	0.06	-0.30

Source: LehmanLive.

The Bespoke page differs from the Market page in the following respects:

- It only allows you to select bespoke tranches stored under your user name
- The contractual spread details have been set up on the Builder page
- The PV of the tranche and risk measures are calculated using user-specified base correlations

The remaining functionality of the Bespoke page is similar to the Market page with iRisk, ADR and Breakdown sub-pages.

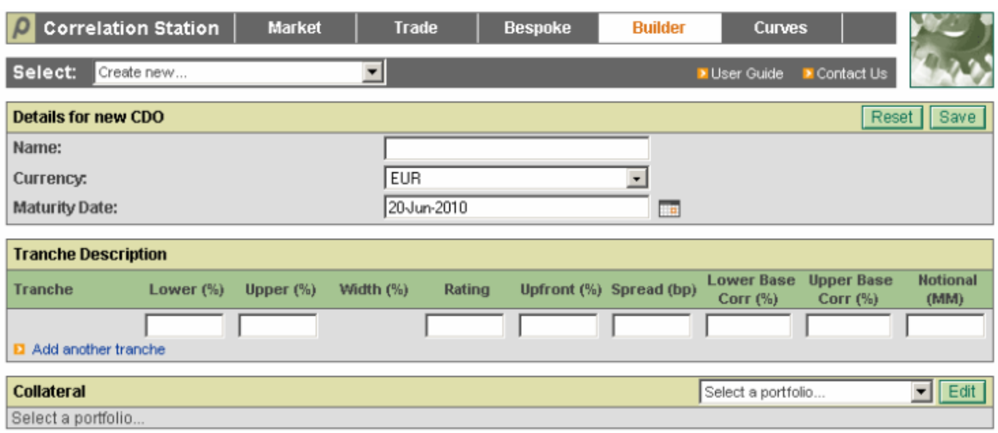
There is no Skew sub-page and Non-Std sub-page because these are not relevant for bespoke CDOs.

BUILDER PAGE

The Builder page is where you create, save and edit bespoke CDO tranches.

Before we can begin to analyse a bespoke CDO, we must create it in terms of its attachment and detachment points, maturity, coupon and reference portfolio. This is done via the Builder page. This is shown in Figure 19.

Figure 19. The initial Builder page



Source: LehmanLive.

We start with how to create a new CDO. For this, you select "Create new …" from the drop down menu at the top of the Builder page. You then need to enter:

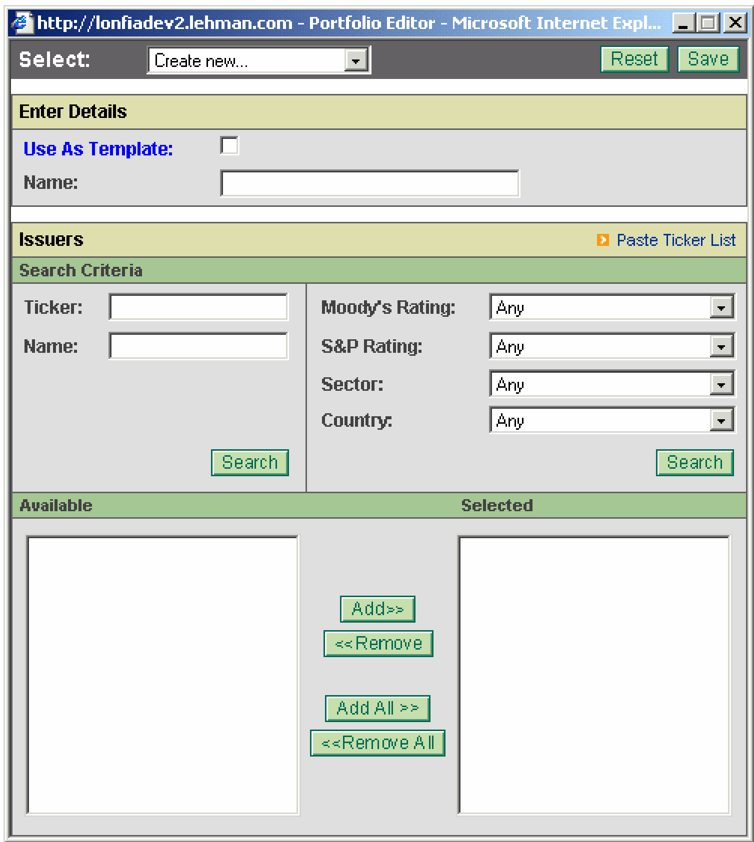
- A name for the CDO, which must be unique
- The currency of the CDO which can be USD, JPY or Euro
- The maturity date of the CDO

- The lower and upper strikes (attachment and detachment points)
- The rating – this is displayed as part of the tranche name
- The price in terms of upfront payment and annual spread
- Base correlations for the lower and upper strikes (attachment and detachment points)

There is no need to enter a full capital structure, simply the tranche which interests you. To add another tranche, simply click on the "Add another tranche" link and another tranche will appear. There is currently a limit of five tranches per CDO.

The Collateral must then be selected. This can be an existing portfolio if a bespoke portfolio has already been created. If not, to create or edit an existing portfolio, click "Edit" and a window similar to the one shown in Figure 20 will appear.

Figure 20. The portfolio editor window



Source: LehmanLive.

If you want to create a new portfolio which is not similar to any existing portfolio, simply type in a name and then begin to select credits using the filters and search buttons available. The aim is to move into the right-hand-side "Selected" window, the names of all of the reference credits in the reference portfolio of the CDO.

It is not possible to create a bespoke CDO where the reference portfolio is one of the standard indices. To get around this problem, you should load the standard index in the portfolio builder window and then select "Save as" to save it under a different name. This new reference portfolio can then be used.

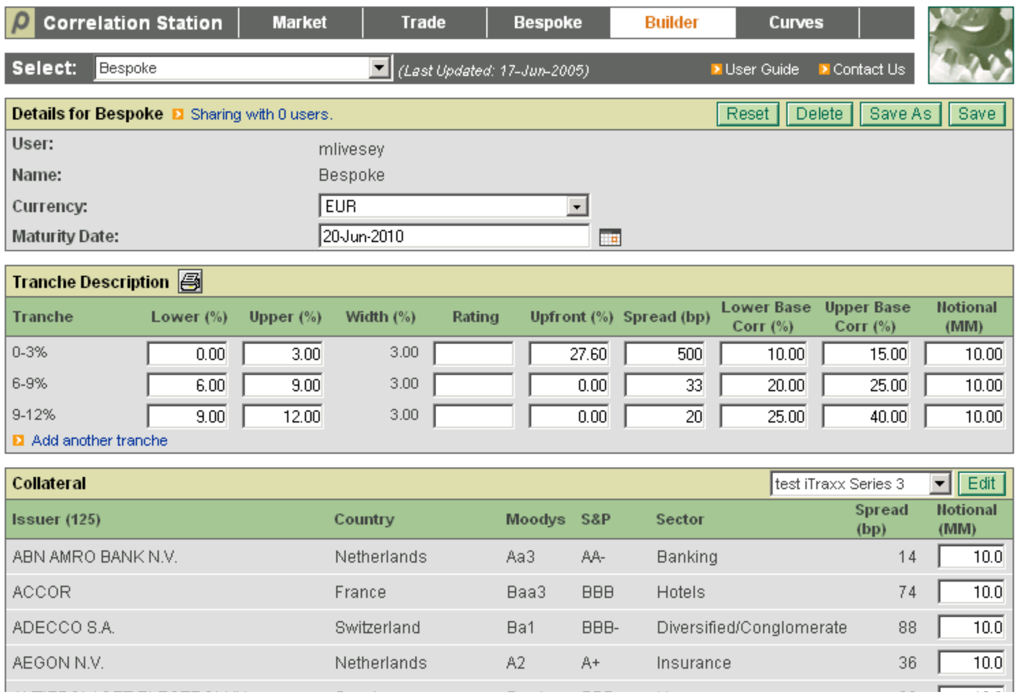
However, if you want to create a portfolio which is similar to an existing portfolio, simply select the existing portfolio and press "Save As" to save it under a different name. This portfolio can then be edited until it matches your required reference portfolio.

Note that it is also possible to paste a list of tickers into a window by first clicking on the "Paste Ticker List" text and then copying a list of tickers into the window.

Once you have built the reference portfolio, simply press "Save" and close the window by clicking on the top right corner.

Returning to the Builder page will show the CDO capital structure with the list of reference credits in the portfolio. An example is shown in Figure 21.

Figure 21. The portfolio editor window

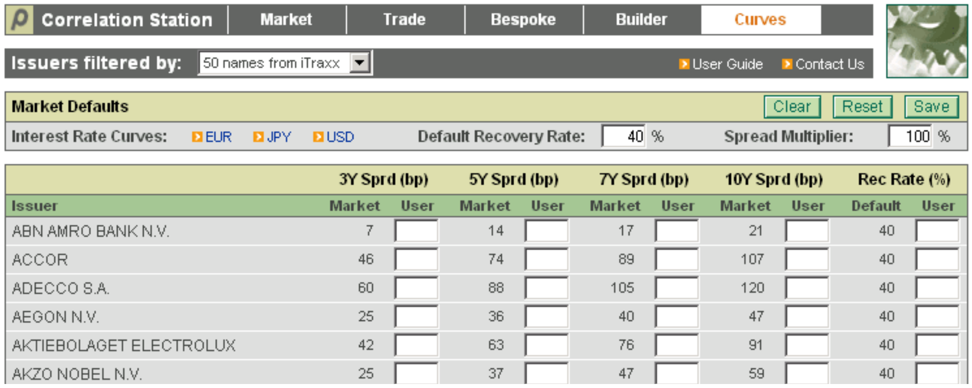


Source: LehmanLive.

CURVES PAGE

The Curves page displays the term structure of CDS spreads for each reference credit across all of the CDOs in Correlation Station. These can be overridden.

Figure 22. The CDS curves page



Correlation Station | Market | Trade | Bespoke | Builder | Curves

Issuers filtered by: 50 names from iTraxx — User Guide — Contact Us

Market Defaults — Clear — Reset — Save

Interest Rate Curves: EUR JPY USD — Default Recovery Rate: 40 % — Spread Multiplier: 100 %

	3Y Sprd (bp)		5Y Sprd (bp)		7Y Sprd (bp)		10Y Sprd (bp)		Rec Rate (%)	
Issuer	Market	User	Market	User	Market	User	Market	User	Default	User
ABN AMRO BANK N.V.	7		14		17		21		40	
ACCOR	46		74		89		107		40	
ADECCO S.A.	60		88		105		120		40	
AEGON N.V.	25		36		40		47		40	
AKTIEBOLAGET ELECTROLUX	42		63		76		91		40	
AKZO NOBEL N.V.	25		37		47		59		40	

Source: LehmanLive.

It is possible to manually override these spreads at either a global level or a name specific level. The "Spread Multiplier" box allows you to multiply all spreads by a common factor. This can be used to adjust spreads for bid-offer and other effects. Beside each spread is an input box into which you can type a spread override. Note that this effect will apply to all CDOs which contain this reference credit. To remind you of this fact, any overridden spread will be coloured blue in the Market or Bespoke page on the iRisk sub-page.

Also accessible are the LIBOR curves associated with the currency of the index. Clicking on the LIBOR curve link will open a pop-up window which shows the current term structure of par swap rates. Currently, these are available for USD, JPY and Euro.

REFERENCES

O'Kane and Livesey (2004), "Base Correlation Explained", Lehman Brothers Fixed Income Research, *Quantitative Credit Research Quarterly*, November 2004, pp. 3-20.

Greenberg, O'Kane and Schloegl (2004), "LH+: A Fast Analytical Model for CDO Hedging and Risk Management", *Quantitative Credit Research Quarterly*, June 2004, pp. 19-31.

Introducing the LehmanLive Credit Default Swaption Calculator

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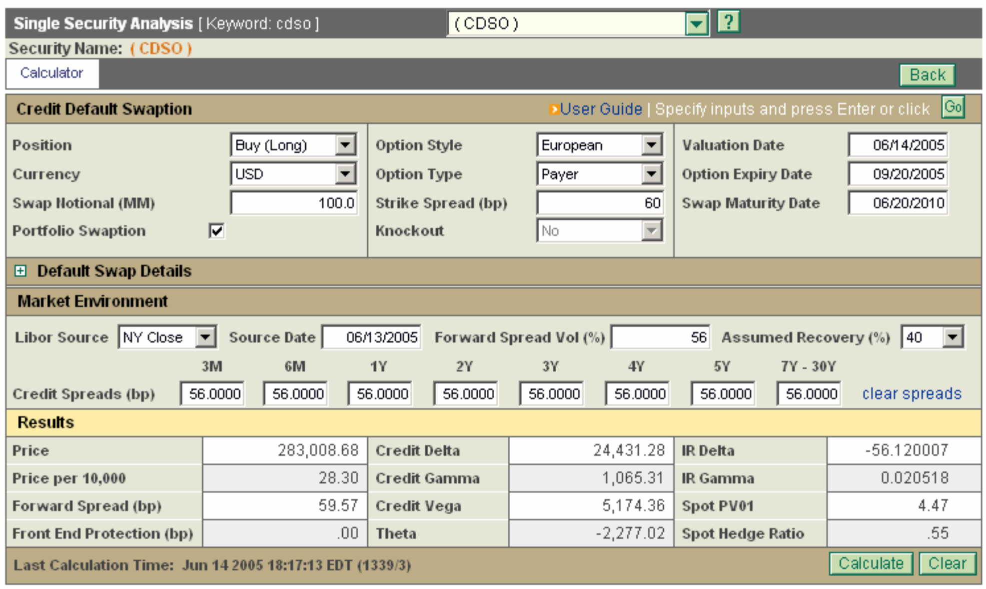
We introduce a new LehmanLive calculator for options on credit default swaps. The calculator can be used for valuation/pricing and to calculate risk measures such as delta, gamma, vega, and theta. The user must specify a curve of credit default swap spreads, as well as a spread volatility. The underlying analytics are Black formulas and a standard credit default swap model, such as the LehmanLive Credit Default Swap Calculator. The calculator can be used for both single-name and portfolio (CDX and iTraxx) swaptions.

USING THE MODEL

The model can be accessed on LehmanLive with the keyword CDSO or through the Credit Quant Toolkit page.



The input fields are fairly self-explanatory and are described in detail in the *Glossary*. The Glossary can be accessed through the link at the top of the calculator and is reprinted below.

For details about credit default swaptions, see our earlier reports:

- "Introduction to Credit Default Swaptions", *Quantitative Credit Research Quarterly*, Vol 2004-Q3/Q4.
- "Valuation of Portfolio Credit Default Swaptions", *Quantitative Credit Research Quarterly*, Vol 2003-Q4.

Inputs and outputs

The Calculator is divided into an Inputs section and a Results section. The Inputs section is subdivided into three types of input:

- Credit Default Swaption
- Default Swap Details
- Market Environment

In the Credit Default Swaption section, inputs such as notional, option type, strike, option expiry date, and swap maturity date are specified. The valuation date is also specified in this section.

The user selects various daycount and payment conventions for the underlying credit default swap (CDS) in the Default Swap Details section. The default settings are the standard market conventions.

In the Market Environment section, the user selects the LIBOR/swap interest rate curve and specifies the CDS spread curve, recovery rate, and spread volatility for the reference entity.

The calculator's results section shows the value (*price*) of the swaption; various risk measures such as delta, gamma, vega and theta; and other key numbers such as forward spread and hedge ratio.

See the Glossary below for a detailed description of the inputs and outputs.

EXPLAINING THE MODEL

The calculator is based on standard Black formulas that we explain below. Adjustments are made to the formulas for:

- Non-knockout swaptions
- Portfolio swaptions[1]

The user must first choose whether a single-name or a portfolio swaption is being priced. If a single-name swaption is chosen, the user must decide whether the swaption knocks out, or cancels, following the default of the reference issuer.

Below, we show how the valuation is done for knockout single-name swaptions and then how we make an adjustment for single-name non-knockout payer swaptions. Finally, we show how we make adjustments to both payer and receiver swaptions when referencing a portfolio rather than a single entity.

Standard Black model

The market standard for pricing default swaptions is a modification of the Black formula for interest rate swaptions. The inputs for the valuation are:

- Time to maturity (in years) of the default swaption
- Strike spread
- Implied volatility for the given strike, option expiry, and swap maturity
- Forward CDS spread from the option expiry to the swap maturity. This is the breakeven spread in a CDS that offers default protection from the option expiry to the swap maturity, with premium paid periodically between those dates.
- Forward credit risky PV01 from the option expiry to the swap maturity. This is the value of 1bp premium flow in the forward CDS defined above.

The formulas are[2]

$$\text{Payer} = \text{PV01} \cdot \left(\text{FwdSpread} \cdot \text{N}(d_1) - \text{Strike} \cdot \text{N}(d_2)\right)$$

$$\text{Receiver} = \text{PV01} \cdot \left(\text{Strike} \cdot \text{N}(-d_2) - \text{FwdSpread} \cdot \text{N}(-d_1)\right)$$

[1] *A portfolio swaption (or portfolio credit default swaption) is also called an index option by some market participants.*

[2] *A payer swaption is an option to become protection buyer (or premium payer). A receiver swaption is an option to become protection seller.*

$$d_1 = \frac{\log(\text{FwdSpread} / \text{Strike}) + \sigma^2 T / 2}{\sigma\sqrt{T}} \text{ and } d_2 = d_1 - \sigma\sqrt{T}$$

where T is the time to maturity, σ is the volatility, N(·) is the standard normal distribution function, and log(·) is the natural logarithm.

Derivation of the formulas requires mathematical finance methods, yet readers familiar with the Black formulas for futures options will notice the similarities.

If FwdSpread were replaced with the futures price and PV01 were replaced with the risk-free discount factor, we would have the standard Black formulas for futures options. We are multiplying with the forward PV01 rather than the risk-free discount factor because the PV01 gives the dollar value of 1bp. The forward PV01 includes discounting from the option expiry date to the valuation date.

Calculating the forward spread and the forward PV01 requires a CDS curve model such as the one underlying the LehmanLive Credit Default Swap Calculator (or equivalently the Bloomberg CDSW calculator)[3].

It is important to recognize that the formulas give the values of swaptions that knock out if default occurs before option expiry. We explain this next.

Adjustment for non-knockout

First, we must recognize that the knockout feature matters only for a payer swaption. An investor should always exercise a non-knockout payer swaption after a default because after the payer swaption has been exercised the investor can settle the underlying CDS and receive compensation for the default. The knockout feature is not relevant for a receiver swaption because no investor would ever exercise a receiver swaption after a default, as the investor would then become liable to pay default protection.

The next step is to recognize that a combination of a long knockout payer swaption and a short receiver swaption is equivalent to a standard (knockout) forward CDS from the option expiry to the swap maturity. If we combine this with the fact that when we set the strike equal to the forward spread in the formulas above the value of the payer minus the value of the receiver is zero, then we see that the formulas are for knockout swaptions.

For a non-knockout payer swaption, we must make an adjustment. The value added to a knockout payer swaption by making it non-knockout is the value of default protection from trade date to option expiry. We call this the value of front-end protection. So:

$$\text{NonKOPayer} = \text{KOPayer} + \text{FrontEndProtection}$$

The value of front end protection is primarily determined by the spread on a CDS that matures at option expiry.

The market standard in the U.S. for single-name swaptions is non-knockout.

Single-name swaptions are options to buy or sell default protection between option expiry and swap maturity. This is the case for both knockout and non-knockout payer swaptions, as well as for receiver swaptions. It means that single-name swaptions are exposed to changes in two CDS spreads: to both option expiry and swap maturity. These two spreads determine (through the forward spread) the value of default protection between the two dates.

[3] *The Credit Default Swap Calculator can be accessed on LehmanLive with the keyword CDS.*

Adjustment for portfolio swaptions

The standardized liquid portfolio (CDX and iTraxx) swaptions are non-knockout. This means that an investor who exercises a portfolio payer swaption buys protection on all reference entities, including those that have defaulted before option expiry. Similarly, an investor who exercises a portfolio receiver swaption sells protection on all reference entities including the defaulted ones.

Portfolio swaptions are options to buy or sell default protection between the trade date and the swap maturity date. This is the fundamental difference with single-name swaptions. It means that a portfolio swaption primarily is exposed to only one CDS spread: the spread to swap maturity.

Even though portfolio swaptions are non-knockout, we cannot use the formulas for single-name non-knockout swaptions. We must make adjustments to both the payer and receiver formulas. The receiver formula is wrong because it gives the receiver swaption significant exposure to the spread to option expiry, which it should not have. The payer formula is also wrong because the value of a portfolio payer swaption should approach zero as the strike becomes high.

Instead of adding the value of front-end protection to the Black knockout payer swaption value, we adjust the forward spread and value portfolio swaptions using the knockout Black formulas. By using the knockout Black formulas, we ensure that the value of deep out-of-money options is close to zero. By adjusting the forward spread, we remove the dependence of both payer and receiver swaptions on the CDS spread to the option expiry. Our approach is to incorporate the value of the front-end protection directly into the forward spread.

The adjusted forward spread must have the property that the value of a long payer short receiver position is zero when both swaptions have a strike equal to the adjusted forward spread. A long payer short receiver position is a non-knockout forward CDS, and the adjusted forward spread should be the non-knockout forward spread (i.e., the spread [or rate] to write in a non-knockout forward contract such that the forward contract has an initial value of zero).

The only difference between a knockout and a non-knockout forward CDS is that the non-knockout forward CDS provides front-end protection (i.e., protection between the trade date and the option/forward maturity date). This is paid by a higher spread in the non-knockout forward. How much higher the spread needs to be to compensate for the extra protection depends on the value of receiving 1bp from option/forward maturity to swap maturity (i.e., the knockout forward PV01). This is because there are no premium payments in the non-knockout forward between the trade date and the option/forward maturity date.

The analysis leads us conclude that:

$$\text{Adjusted Forward Spread} = \text{Knockout Forward Spread} + \frac{\text{Value of Front End Protection}}{\text{Knockout Forward PV01}}$$

To summarize: Given a curve of portfolio swap spreads, we calculate the regular knockout forward spread and knockout forward PV01, as well as the value of front-end protection. We then calculate the adjusted forward spread according to the formula above and plug into the standard knockout Black formulas using the knockout forward PV01.

GLOSSARY

Below is a description of the calculator's input and output fields. They are listed in the order they appear in the calculator.

Section: Credit Default Swaption

Position

Buy (Long) or Sell (Short). Specifies whether the user is buying or selling the swaption.

Currency

Currency in which all payments are to be made.

Swap Notional (MM)

Notional (in millions) of the credit default swap the investor enters into upon option exercise. If the swap notional is 10 million and the issuer defaults, a buyer of protection will receive a cash payment of 10 million in return for delivering 10 million notional of defaulted bonds.

Portfolio Swaption

This box should be checked if a portfolio (CDX or iTraxx) swaption is being valued. The model then adjusts the forward spread and does the valuation for a knockout single-name swaption. The adjustment is: Adjusted Forward Spread = Forward Spread + (Front End Protection / PV01 of Forward Swap).

Option Style

Determines when the option can be exercised. A European option can only be exercised on the option expiry date.

Option Type

Payer or Receiver. A payer swaption gives the right to enter into a CDS as protection buyer, paying the Strike Spread (see below) as premium rate. Conversely, a receiver swaption is an option to sell protection.

Strike Spread (bp)

Premium rate of the underlying credit default swap, in basis points. Following option exercise, the buyer of protection will pay this premium rate. For example, if the swap notional is $10 million and the Strike Spread is 100bp, the premium will be about $25,000 every quarter.

Knockout

A knockout swaption is cancelled if default occurs before option expiry. A non-knockout swaption, if exercised, entitles the protection buyer to protection payment on the defaulted entity. The knockout feature is relevant only for payer swaptions, as receiver swaptions should never be exercised following a default.

Valuation Date

Date for which the output in the Results section is valid. The valuation is done assuming the trade settles on this date. The valuation date will differ from the LIBOR Source Date if the LIBOR data for the Valuation Date is not available.

Option Expiry Date

Last date the option can be exercised.

Swap Maturity Date

The date that default protection terminates in the underlying credit default swap.

Section: Default Swap Details

Payout Type

Specifies the type of cash flows on the premium leg of the underlying default swap. The standard is *fixed rate*.

Premium Rate

The premium rate on the underlying default swap. The field is the same as the Strike Spread (see above).

Payment Timing

Determines whether the premium payment is to be made at the beginning of an accrual period (*in advance*) or at the end of it (*in arrears*). The standard is *in arrears*.

Payment Frequency

The length of accrual periods. The standard is three months (3M). A payment frequency of *3M* means that the underlying default swap pays premium four times a year.

Day Count Basis

Convention used to calculate the accrual factor between two payment dates. The standard is Act/360. For example, there are 91 days between December 20, 2007 and March 20, 2008. The accrual factor between those two dates is therefore 91/360 = 0.25278, so a $10 million notional, 100 bp premium CDS with those payment dates would pay $25,278 on March 20, 2008 (if Payment Timing is *in arrears*).

Stub Rule

Is used to determine the scheduled dates for the underlying CDS. Under all rules, the Option Expiry Date is the first scheduled date (for European options), and the Swap Maturity Date is the last scheduled date.

Under the *short start* and *long start* rules, the length of any interval between two adjacent scheduled dates, except the first interval, is equal to Payment Frequency. Under the *short start* rule, the length of the first interval will be shorter than or equal to the Payment Frequency, whereas under the *long start* rule, it will be longer than or equal to Payment Frequency.

Under the *short end* and *long end* rules, the length of any interval between two adjacent scheduled dates, except for the last interval, is equal to Payment Frequency. Under the *short end* rule, the length of the last interval will be shorter than or equal to Payment Frequency, whereas under the *long end* rule, it will be longer than or equal to Payment Frequency.

The standard is *short start*.

Business Calendar

Determines the calendar used for deciding which dates are business days.

Accrual Date Adjustment

Determines which dates should be used to calculate the accrual factor between two dates if the start date or the end date for the accrual period is not a business day. As explained above for the Day Count Basis, the accrual factor is used to calculate the actual premium payment made.

The standard is *maturity adjusted*. Under this rule, a date that is not a business day is moved to the closest following business day. The adjustment is made for all scheduled payment dates except the maturity date.

Payment Date Adjustment

Determines on which dates premium payments should be made if a scheduled payment date is not a business day. Note that this adjustment is relevant only for when the payment is made, not for the size of the payment (see Accrual Date Adjustment above).

The standard is *modified following*. Under this rule, a date that is not a business day is moved to the closest following business day unless it falls in a different month, in which case the date is moved to the previous business day.

Section: Market Environment

LIBOR Source

Determines together with Source Date the LIBOR/swap rates used. Currently only *NY Close* is available. The rates will be as of close of business in New York on the date specified in Source Date.

Source Date

See under LIBOR Source above. If the date is left unspecified, the most recent business day is used.

Forward Spread Volatility (%)

The volatility of the forward spread of the underlying default swap.

Assumed Recovery (%)

The recovery rate given default of the issuer. The recovery rate, together with the Credit Spreads (see below), determines the default probabilities for the issuer.

Credit Spreads (bp)

A term structure of credit default swap (CDS) spreads for the reference issuer.

The maturity dates for the CDS spreads are the standard CDS maturity dates (sometimes referred to as the IMM dates). For example, if the valuation date is May 18, 2005, the date for the 5-year point will be June 20, 2010. Other settings, such as Payment Frequency, Day Count Basis, etc., are set to the standard values (these are the default settings in the Default Swap Details section).

If a flat curve is desired, only a single spread needs to be entered. If some spreads are not specified, the calculator will populate the empty fields with the values that have been used to generate the results.

Section: Results

Price

The model generated value of the option.

Price per 10,000

The Price scaled to a 10,000 notional

Forward Spread (bp)

For single issuer swaptions, this is the standard knockout forward spread from the Option Expiry Date to the Swap Maturity Date. For portfolio swaptions, this is an adjusted forward spread given by Adjusted Forward Spread = Forward Spread + (Front End Protection / PV01 of Forward Swap), where Forward Spread is the standard knockout forward spread displayed for single-name swaptions, the Front End Protection is explained below, and the PV01 of Forward Swap is the value of a 1bp premium flow for the knockout forward swap.

Front End Protection (bp)

For single-name swaptions, this is the value of default protection from the valuation date to the option expiry date per 10,000 notional. It is the value as of the Valuation Date of a contract that allows the protection buyer to deliver 10,000 notional of defaulted bonds at the Option Expiry Date and receive 10,000 cash in return if the entity defaults before the Option Expiry Date. The contract is worthless if the issuer does not default before Option Expiry Date.

For portfolio swaptions, a value of zero is always displayed.

Credit Delta

Change in Price caused by a 1bp (marginal) increase in the Credit Spreads for all maturities.

Credit Gamma

Change in Credit Delta caused by a 1bp (marginal) increase in the Credit Spreads for all maturities.

Credit Vega

Change in Price caused by a 1 percentage point (marginal) increase in the Forward Spread Volatility (e.g., from 50% volatility to 51% volatility).

Theta

The change in the Price due to moving the valuation date forward by one business day. The calculation assumes no change in the LIBOR/swap rates and the Credit Spread (as opposed to assuming the rates and spreads obtain their forward values).

Interest Rate Delta

Change in Price caused by a 1bp (marginal) increase in all interest rates defining the LIBOR/swap curve.

Interest Rate Gamma

Change in Interest Rate Delta caused by a 1bp (marginal) increase in all interest rates defining the LIBOR/swap curve.

Spot PV01

The value (as of the Valuation Date) of a 1bp premium flow for a 10,000 notional credit default swap that starts on the Valuation Date and ends on the Swap Maturity Date. The PV01 is approximately equal to the Credit Delta for this credit default swap (this approximation breaks down when credit spreads are very high).

Spot Hedge Ratio

This number is calculated as (Credit Delta / Swap Notional) / (Spot PV01 / 10,000).

Consider an example of how to use this number. Suppose the Spot Hedge Ratio is 0.55, and the swaption notional (this is field Swap Notional in the calculator) is 10 million. Suppose an investor has bought the swaption and wants to delta hedge it using a standard (spot) credit default swap with maturity date equal to the Swap Maturity Date for the swaption. In this case, the investor should sell 0.55·10 million = 5.5 million notional of protection.

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