Systematic CDS Index Trading

Quantitative Credit Strategy

Foreword

The current period marks the first credit downturn where investors have been able to trade aggregate credit risk in a deep, liquid, low transaction cost fashion. CDS indices have become the new benchmarks of the credit crisis, for investors and market observers, with estimated daily global trading volumes regularly exceeding $100bn. This period is also the first in which the indices are being tested in a real credit risk environment with high spread volatility and actual defaults. A broad cross-section of market participants are now actively trading in the various indices, for both hedging and speculative purposes.

This handbook serves as a comprehensive guide to systematic trading and analysis of CDS indices. We introduce systematic frameworks for analysing a wide range of topics from long-short risk positioning and market timing, to curves and relative value, and high-frequency dynamics. Alongside these, we propose a number of rules-driven systematic strategies. Further, to build a deep understanding around trading credit indices, we provide a number of more technical sections including topics on index pricing, calculation conventions, off-the-runs, forwards, skew and Bloomberg functionality.

This handbook is application focused rather than theoretical, and we build on our experience over the past two years of actively recommending and tracking index trades. The format should be familiar to readers of the *CDS Curve Trading Handbook 2008*.

Quantitative Credit Strategy

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Map of handbook – systematic strategies

Strategy	Applies to which indices					Indicative Sharpe Ratio range (with – without estimated transaction costs)	Transaction cost sensitivity	Typical annual trading frequency	Intended Beta	Relative Tail risk	Implementation complexity
	CDX IG	iTraxx Main	iTraxx HiVol	iTraxx Xover	iTraxx Financials						
Barclays Long-Short Steepener (BLSC) – rules based curve switching (page 164)	✗	✗	✗	✓	✗	0.8-1.0	Medium	2x-5x	NA	Medium	Low
Index Dynamic Indicator of Equity Momentum (iDIEM) – index relative value using equity momentum (page 135)	✓	✓	✓	✓	✗	0.5-0.8	Low	4x	NA	Medium	Medium
Financials Index Ratio Reversion (FIRRE) – Dynamic mean-reverting strategy (page 125)	✗	✗	✗	✗	✓	0.3-1.0	High	10x	NA	Medium	Medium
Momentum in Index Relative Performance (MIRP) – long-short trend following (page 114)	✓	✓	✓	✓	✗	0.3-0.7	Medium	5x-20x	NA	Low	Medium
iNtraday Exponential Momentum (NEMO) – high frequency momentum following strategy (page 80)	✓	✓	✗	✓	✗	1.0-2.0	Medium	100x	NA	Low	High
Risk Premium Adjusted Regime Switching (RPARS) – applied to curves (page 159)	✓	✓	✗	✓	✗	0.5-0.8	Medium	1x-3x	NA	Medium	Low
Risk Premium Adjusted Regime Switching (RPARS) – applied to market (page 51)	✓	✓	✗	✓	✗	0.5-0.6	Low	1x-3x	NA	Medium	Low
Variable Default EXposure (VDEX) – enhanced beta strategy using forwards (page 50)	✓	✓	✗	✓	✓	NA	Medium	10x	~90%	Medium	Medium
Mean-variance optimised medium-return combination strategy (page 15)	✓	✓	✓	✓	✓	1.0 – 2.2	High	100x	NA	Low	High

Note: Indicative Sharpe ratios based on testing are detailed in relevant sections of this guide. For some strategies Sharpe ratios are calculated in-sample – see relevant section. Sharpe ratio set to NA for enhanced beta strategies since performance is dependent on a sample period. Transaction cost sensitivity assesses the qualitative impact on the Sharpe ratio of (full standard bid-offer) transaction costs. Sensitivity is a function of trading frequency and instruments used. Intended beta set to NA for alpha strategies. Relative tail risk assessed on both an historical realised basis and forward looking potential. Details available in individual sections. Implementation complexity based on frequency of trading, complexity of generating signals and number/types of legs involved in positions. Post-transaction cost performance of combined strategy has not yet been evaluated.
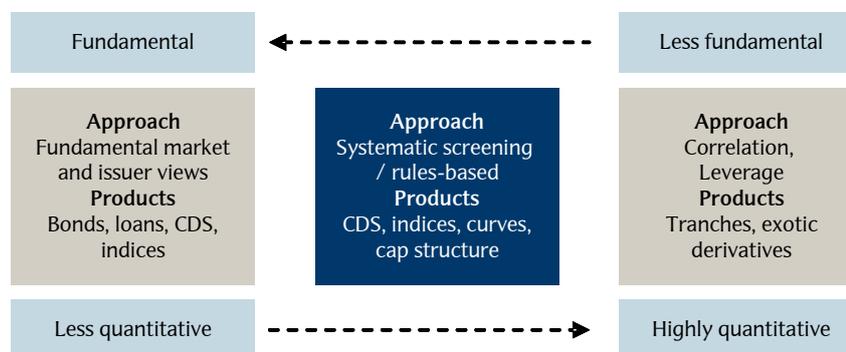*Source: Barclays Capital*

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Completing the spectrum of credit strategies

Credit has, curiously, evolved differently from other asset classes in terms of the sophistication of approaches and products. Credit is traditionally a fundamentally oriented asset class, especially at the high-yield and distressed levels, where in-depth expert analysis is required to gauge the ability of firms to repay creditors. With the advent of the CDS market in the late 1990s, a rapid derivatisation of the market began, with products, especially in the synthetic CDO space, increasing exponentially in complexity. This development over the past ten years has produced a dichotomy in which the credit asset class has split into two separately evolving spaces between fundamentally-driven traditional investment and structured credit. This is true both in terms of the products themselves and in terms of the types of analysis, categories of investor bases and style of strategies employed.

These parallel worlds of credit have, until now, had relatively little linkage in the real world. Although that is now in the process of change as default rates rise, there remains a substantial void in terms of strategies that employ more quantitative or systematic approaches but using standard instruments such as single-name CDS and indices. This is where there is a notable contrast with other asset classes, which have typically evolved more linearly in this respect. For instance, in the liquid fixed income markets, as well as in the equity markets, more advanced strategies are commonplace, using quantitative methods to select stocks, analyse curves, and implement algorithmic trading models.

Figure 1 is a schematic representing a simplified spectrum of credit strategies and products, spanning from the least quantitative to the most. We highlight the middle ground as the under-represented niche in systematic credit strategies that the Barclays Capital Quantitative Credit strategy team targets.

Figure 1: Completing the spectrum of credit strategies

Fundamental	← - - - - - - - - - - - - -	Less fundamental
Approach Fundamental market and issuer views **Products** Bonds, loans, CDS, indices	**Approach** Systematic screening / rules-based **Products** CDS, indices, curves, cap structure	**Approach** Correlation, Leverage **Products** Tranches, exotic derivatives
Less quantitative	- - - - - - - - - - - - - →	Highly quantitative

Source: Barclays Capital

This guide focuses specifically on systematic strategies involving the credit indices. Please see our other *publications* which discuss other quantitative credit strategies.

Changes in the landscape of CDS indices

The iTraxx and CDX indices have proven through the credit crunch to be the most reliable credit instruments available for active strategies. Indices are also relatively simple to trade and accessible to the majority of investors. We review both the basics CDS indices in *Indices: The basics* and more advanced topics in *Advanced topics*.

Spread histories of the indices

Figure 2 shows the two investment grade indices, the North American CDX IG and European iTraxx Main, from 2001 to date. The indices were actually launched only in

2003 and 2004, for CDX and iTraxx, respectively, but we have reconstructed proxy indices prior to these dates using our QCX technology (see *Appendices*), allowing us to conduct a more robust analysis of the behaviour of CDS indices over the full credit cycle. Although iTraxx indices trade in other regions, including Japan, Asia ex-Japan and Australia, liquidity is inferior to that in the US and European indices and consequently, trading can be extremely technical from time to time. As such, we exclude them from the strategies in this handbook.

Figure 2: iTraxx Main and CDX IG on-the-run 5y spreads, from 2001 to October 2008
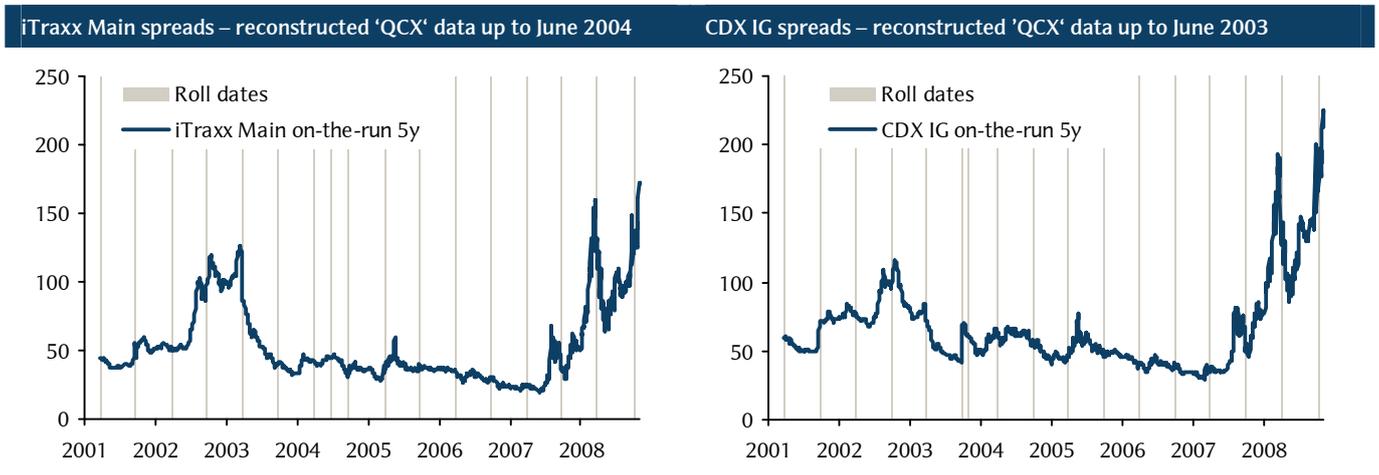
Source: Markit, Barclays Capital

Spread volatility is highly persistent

As mentioned above, volatility, a hindrance to many trading activities, is necessary for more systematic-style strategies. Spread volatility of on-the-run indices has varied enormously over the seven years we have data. Figure 3 details the daily spread changes in the on-the-run iTraxx Main index. A strong persistency in volatility is evident. It is striking how the volatility in 2007-08 has been substantially greater than in the previous credit downturn in 2001-02.

Figure 3: Daily spread change in iTraxx Main and CDX IG from 2001 to October 2008
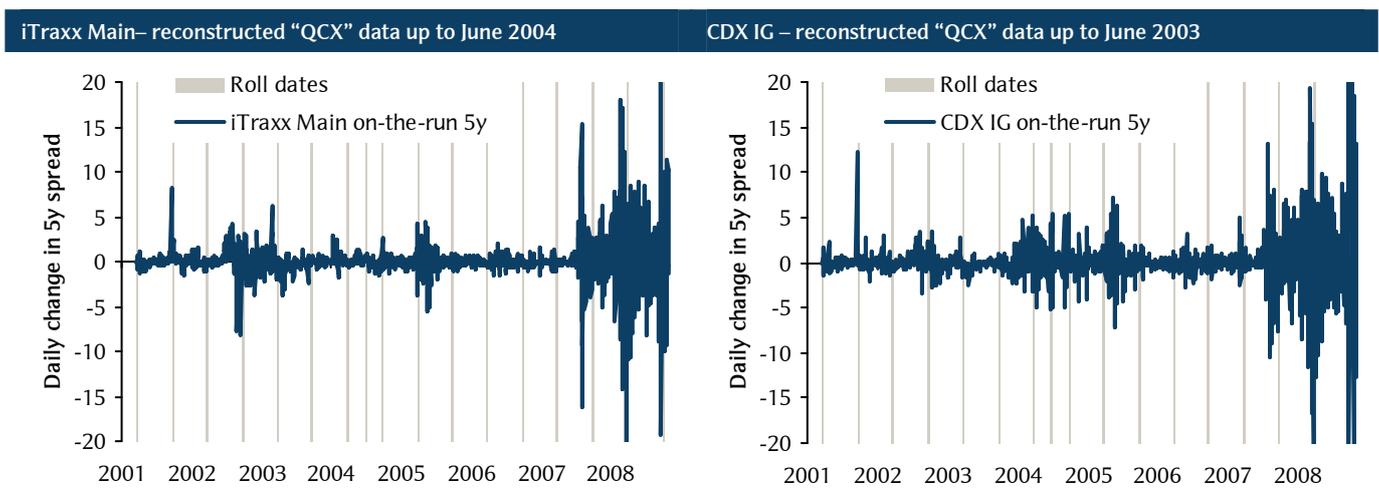
Source: Markit, Barclays Capital

Changing volatility patterns

The extreme volatility witnessed in investment grade indices through the credit crunch has contrasted with comparatively muted volatility so far in the high-yield indices. This has been driven by the systemic and financial sector-related concerns, as well as unprecedented technical forces from the unwinding of structured credit products.

Figure 4 shows time-series of iTraxx Main volatility contrasted with iTraxx Crossover volatility. Volatility of Main on a percentage basis has massively surpassed Crossover vol during the credit crunch. Typically they have traded more in line. While we expect investment grade volatility to remain high for some time in this current crisis, we do expect high-yield volatility, proxied through future iTraxx Crossover series, to increase substantially as default rates inevitably rise.

Figure 4: Contrasting investment grade and high yield annualised 60-day percentage spread volatility
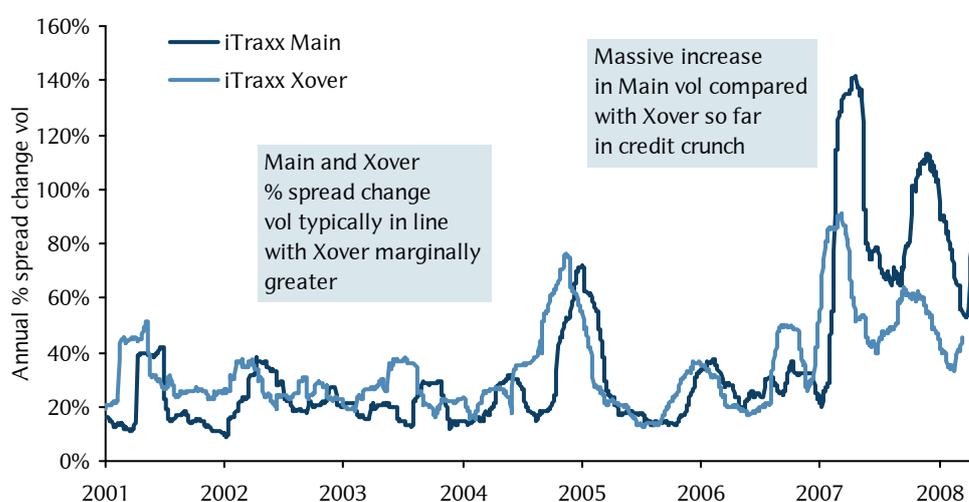
Source: Markit, Barclays Capital

A shift from end-of-day to intra-day analysis

A further change of note that has occurred during the credit crunch has been the marked increase in intra-day volatility of indices. Rapidly we have moved from an environment where end-of-day spread dynamics summarised effectively the true behaviour of indices to an environment where intra-day analysis is essential for many trading and risk-management purposes.

Over the past year we have extensively published on this transition and the reasons why we believe investors should now consider high-frequency data (see *Publications list*). Substantial parts of this handbook are dedicated to high-frequency analysis (see *High-frequency trading of CDS indices*). Figure 5 plots an example of such effects, demonstrating the insufficiency of end-of-day pricing to correctly summarise true dynamics. We simply find that the imprecision of assuming that an index traded at 150bp on one day when the actual trading range was between 140-160bp is too large. This discrepancy may have given rise to scepticism about systematic strategies developed on the basis of traditional end-of-day analysis. We argue that, with this new technology at hand, intraday moves should be seen as an opportunity to improve execution rather than as an obstacle for trading strategies.

Figure 5: End-of-day pricing is insufficient to capture true dynamics in this new regime of volatility – iTraxx Main S9, September 2008
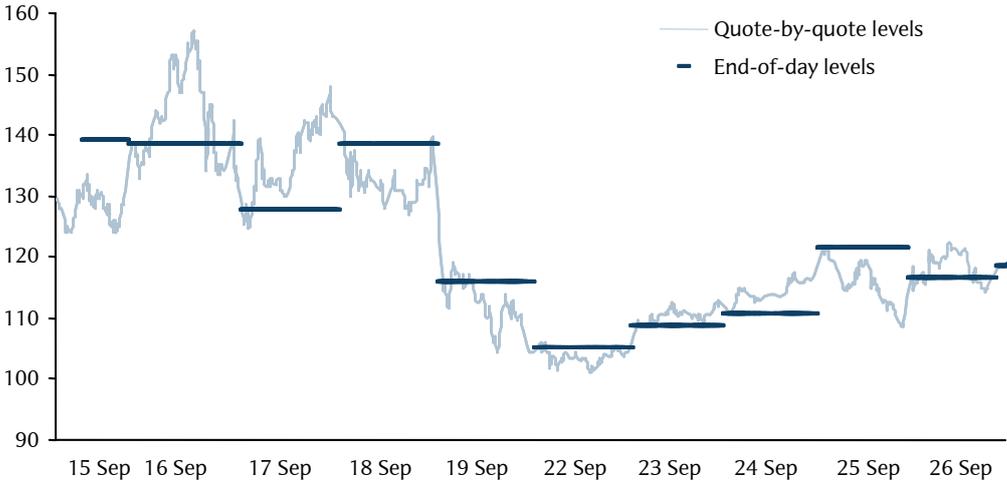
Source: Barclays Capital

Implementation of CDS index strategies

All CDS indices trade as standard over-the-counter (OTC) transactions between the protection buyer and seller. The contracts are highly standardised and have remained fully functional throughout the volatility. Nonetheless, the credit crisis has sparked much debate over whether the indices, and credit derivatives more generally, should be converted to exchange-traded products, or at least function through a clearing house to centralise counter-party risk. While any potential changes along these lines will no doubt have wide-ranging implications for credit trading, we actually believe that any efforts to improve transparency and liquidity can only benefit more systematic type trading activity.

Barclays Capital has, in parallel with these changes, taken leading steps toward increasing transparency and ease of access for credit indices and strategies through the launch earlier this year of the Barclays Capital Credit Index Family.

Barclays Capital Credit Index Family

In an attempt to broaden the appeal, transparency and functionality of credit indices, Barclays Capital launched a family of credit strategy index products (see *A new direction in credit indices*, 21 January 2008). These indices are based around the iTraxx and CDX families. Figure 6 shows a tree of the family of indices as it currently stands. A dedicated website (http://ecommerce.barcap.com/indices) provides up to date information on all indices.

Figure 6: Barclays Capital Credit Index Family
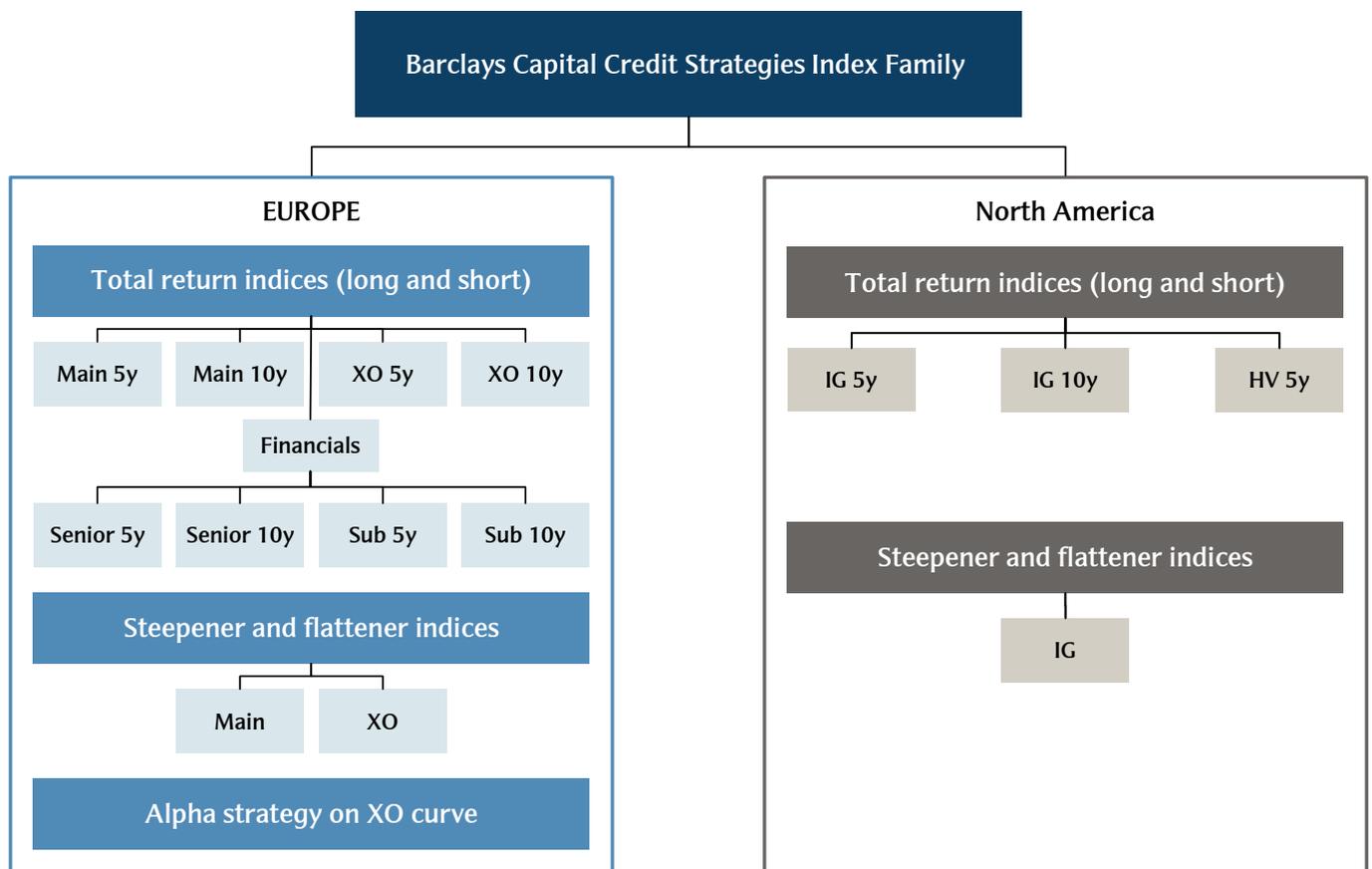
Source: Markit, Barclays Capital

The indices fall into two groups, which can be roughly defined as:

Access products

The Barclays Capital credit indices reflect the equivalent total returns on funded versions of the iTraxx and CDX indices. Since the standard index contracts trade only in swap form, these products allow investors who have investment restrictions (eg, unable to go short, unable to use unfunded derivatives) to proxy credit index returns for hedging or view-taking purposes.

Alpha products

Systematic strategies can be implemented in index form, benefiting from transparency, easy access and liquidity. The BLSC strategy index is the first example of such an alpha index which is a funded index that tracks the performance of the BLSC strategy (*Barclays Capital Long-Short Credit Steepener Strategy (BLSC)*). Over time we plan to add more algorithmic credit strategies to the Barclays Capital credit index family.

Barclays Capital index products – contacts

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Systematic strategies in credit – Why the wait?

There are several reasons, we believe, why there has been a surge in popularity for quantitative techniques in the CDS index strategy space over 2007-08:

- **Transaction costs:** Transaction costs for CDS and indices, while falling gradually over time, have always been high, especially relative to the volatility. Most active strategies involving high turnover have a significant drag factor associated with transaction costs. This is especially true for single names and curve strategies. Indices consistently have the lowest transaction costs as a percentage of spread.

- **Volatility:** During the credit bull market years of 2003 to 2007, volatility in most instruments was low (with the exception of during the 2005 correlation storm). Returns available from active strategies were, therefore, not compelling without substantial amounts of leverage. This essentially led to the bypassing of active strategies to the development of structured credit with higher yields based on higher leverage.

- **Liquidity:** Finally, liquidity is variable across credit derivative instruments and has always been somewhat of an unknown in the case of distressed markets. The experience of the turn of the cycle in 2007-08 has indicated to us that CDS indices have remained liquid, especially compared to other assets in the credit markets. In times so distressed that other fixed income instruments outside credit have had a hard time to function, we are yet to see similar seize-ups in CDS indices.

Naturally, all three of these are closely linked. We argue that the first two in particular should be considered together – specifically, what is the transaction cost per unit of volatility on each instrument. In Figure 7 we show a time series of the ratio of the average intraday bid-offer to the intraday range for the iTraxx Main and Crossover on-the-run indices. Although absolute bid-offer spreads have increased during the credit crunch, their proportion to volatility has fallen markedly, meaning that active strategies lose a smaller proportion of profit to transaction costs.

Figure 7: The surge in volatility has outpaced the increase in index trading costs – average bid-offer divided by intra-day trading range on iTraxx Crossover and Main, 2007-08
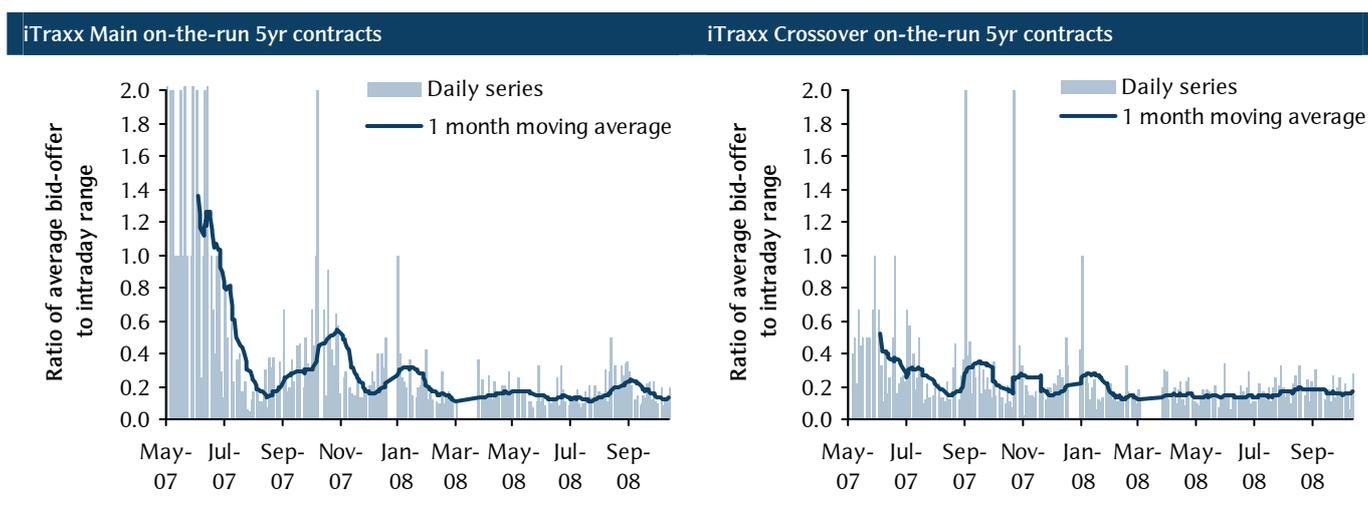
Source: Barclays Capital

It is worth noting that bid-offers on a percentage basis of quoted spot spreads have actually decreased through these testing times. With 5yr positions in the indices costing around 1-2% of quoted spread level to trade (see Figure 8), the CDS index markets is actually not far off the trading costs in equity volatility indices, for example. Hence, one of the remaining unknowns – whether the market could actually be subjected to rules-driven strategies in volatile and stressed market conditions without trading costs exploding – has been cleared, in our mind.

Figure 8: Qualitative assessment of liquidity in distressed market conditions by instrument, extrapolating from credit crunch experience

Instrument	Liquidity availability	Approximate range of bid-offer
Single-name CDS 5yr	Moderate	8% to 12% of 5yr spread
Single-name CDS curves	Poor	20-50% of slope
Indices, on-the-run 5yr	Good	1-2% of 5yr spread
Indices on-the-run curves	Moderate	15-30% of slope
Indices off-the-run	Moderate	3-5% of 5yr spread

Note: Percentage measures of slope become meaningless for curves trading near flat. Source: Barclays Capital

Systematic strategies: Frameworks versus rules-driven

We allow a fairly broad definition of systematic strategies in this handbook. It is useful to distinguish between strategies in two categories:

▪ **Frameworks:** These include quantitative models that systematically screen for anomalies or potential trading opportunities, but do not specify automatic trade recommendations. We also include in this category frameworks for analysing trades, for instance sophisticated scenario modelling. In both cases, manual intervention is required to assess individual trades and timing of entry.

▪ **Rules-driven:** The second category of strategies we look at are fully rules-driven, in which manual intervention should be reduced to the tasks of data inputting and trade execution. A summary of systematic rules-driven strategies introduced in this handbook is given in the *Map of handbook – systematic strategies*.

The points made above, as well as a degree of conservatism in core credit investor groups have previously made rules-driven strategies fairly uncommon, especially relative to other asset classes. Quantitative frameworks become more and more valuable as the number of reference entities and instruments in credit increase and require systematisation of information.

Combining rules-based strategies

An exciting avenue of further research is that of forming portfolios of rules-based strategies which have improved risk and return properties over the individual strategies. To illustrate the potential of this we analyse some simple portfolio optimisation techniques here, using a selection of the rules-based strategies that appear in this handbook. It is important to note that this exercise is intended as illustrative since some of the strategies involved are not yet at a perfected implementation stage. Several of the strategies would benefit greatly from joint execution, as well as a common platform for signal generation. For example, the volatility and momentum measures derived from the high-frequency NEMO strategy should be used for timing trades in the iDIEM and RPARS strategies.

Figure 9 lists the five example strategies we propose as components of a combined strategy portfolio for the purposes of this example. Each strategy is introduced formally in the respective section of the handbook, but a short description is given here along with summary statistics on full sample performance from 2001 to 2008 and risk measures. All the risk measures used here are defined in the final section of this introduction. Naturally, all risk measures are in-sample and vary through time, depending on the macro environment.

Figure 9: Component rules-based strategies and indicative pre-transaction cost performance

Strategy	Description	Annual return	Annual volatility	Sharpe ratio	99% VaR	Worst 3mth drawdown
iDIEM	Equity momentum based relative value between iTraxx Main and Xover indices	3.4%	4.5%	0.74	-2%	-4%
FIRRE	Mean-reversion strategy on financials sub & senior indices	0.6%	0.9%	0.67	0%	0%
MIRP	Trading iTraxx Main versus CDX IG on a trend-following basis	0.5%	0.9%	0.60	0%	-1%
NEMO-DT	High-frequency momentum trading on iTraxx Main	3.0%	1.8%	1.73	-1%	-2%
RPARS	Curve regime-switching strategy on iTraxx Xover	2.3%	2.3%	0.99	-1%	-2%

Note: We run the following analysis on a pre-transaction cost basis for several reasons. Since some of these strategies are still at an outline stage, we want to test for potential signal-strength before optimising for transaction costs. Secondly, transaction cost assumptions are tricky when numerous strategies are involved trading at different frequencies – taking full bid-offer into account may overly penalise the strategy and obscure potential for development. Source: Barclays Capital

A first stage of analysing these strategies is to compute returns correlations. Naturally, highly correlated strategies will offer limited diversification value in a portfolio context. Figure 10 shows a sample correlation matrix of the five strategies. We find low correlations across the board, on the basis of weekly returns, with most values being not significantly different from zero.

Figure 10: Weekly returns correlation matrix, 2001 to 2008

	iDIEM	FIRRE	MIRP	NEMO-DT	RPARS
iDIEM	100%				
FIRRE	5%	100%			
MIRP	0%	-2%	100%		
NEMO-DT	13%	-9%	8%	100%	
RPARS	2%	-7%	2%	3%	100%

Source: Markit, Barclays Capital

Finding the efficient frontier

For the purposes of this example it is sufficient to use straightforward mean-variance optimisation to select optimal allocations between strategies and generate efficient frontiers. We run a standard constrained optimisation based on full sample mean and covariance estimates. The other assumptions used are as follows:

- No shorting of strategies – minimum weight is equal to zero.

- Correspondingly, maximum leverage is also equal to 1x.

- Optimisation carried out on weekly returns data, which is annualised for presentation purposes.

- Transaction costs are excluded.

Figure 11 shows the corresponding efficient frontier. Each individual strategy is indicated on the chart. A number of interesting observations can be made at this stage. On the basis of unlevered returns, iDIEM has the highest expected return and also the highest volatility. NEMO-DT and RPARS are in the middle of the chart, and NEMO-DT's higher position reflects the superior Sharpe ratio of this strategy. The FIRRE and MIRP strategies are very similar in terms of mean return and risk sitting on the lower end of the volatility scale. NEMO-DT and iDIEM are the two strategies which are closest to the frontier, indicating near-optimality as individual strategies for those levels of risk.

We identify two optimal portfolios on the frontier, chosen for their return characteristics. The first, which we denote the medium-return portfolio, has an annual return around 2.0%. The second, the high-return portfolio, has an annual return around 3.0%, and is close to the NEMO-DT strategy in terms of risk-return.

Figure 11: Mean-variance efficient frontier for chosen strategies
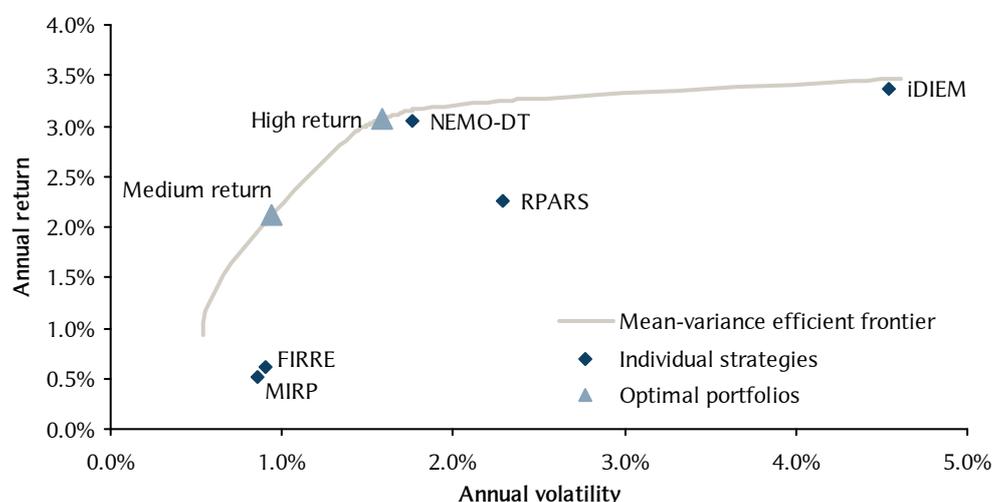
Source: Markit, Barclays Capital

Figure 12 shows actual optimal allocations for different return levels. It is interesting to see a good mix of strategies being optimal at the lower end of the return spectrum. Gradually the MIRP and FIRRE strategies are dropped in favour of NEMO for most intermediate return portfolios. Eventually, weight shifts more and more to iDIEM in order to generate very high returns without leveraging NEMO.

Figure 12: Efficient portfolio allocations for different levels of return
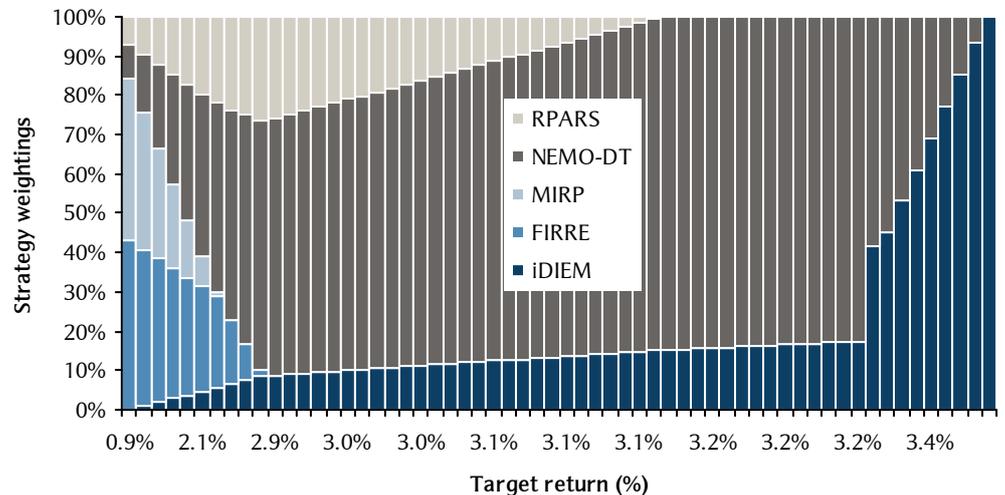
Source: Markit, Barclays Capital

Figure 13 extracts the allocations for our two chosen portfolios. The medium-return portfolio has a mix of all five strategies. The higher-return portfolio does not use MIRP or FIRRE. In both cases, NEMO-DT is the dominant strategy.

Figure 13: Optimal portfolio allocations

Strategy	iDIEM	FIRRE	MIRP	NEMO-DT	RPARS
Medium return	5%	27%	8%	41%	20%
High return	13%	0%	0%	77%	10%

Source: Markit, Barclays Capital

Figure 14 reports the performance and risk statistics for the two optimal portfolios, and Figure 15 the cumulative returns. It is important to note that performance here is 100% in-sample and can be viewed only as indicative of possible out-of-sample performance. Glancing between Figure 14 and Figure 9 it is easy to establish the superiority of both these strategies over any individual strategies, in terms of performance and risks together. Sharpe ratios look strong in both optimal combinations, and tail measures (VaR and drawdown) are within reasonable bounds.

Cumulative performance charts look promising, albeit on the basis of in-sample testing. As with most of our strategies, clear bias of performance is evident in the more volatile trading conditions, but even in benign markets the strategies appear steady.

Figure 14: Performance of optimal portfolios (in-sample)

Strategy	Annual return	Annual Volatility	Sharpe ratio	99% VaR	Worst 3mth drawdown
Medium return	2.1%	0.9%	2.25	0%	-1%
High return	3.1%	1.6%	1.94	-1%	-2%

Source: Markit, Barclays Capital

Figure 15: Cumulative returns of optimal portfolios (in-sample)
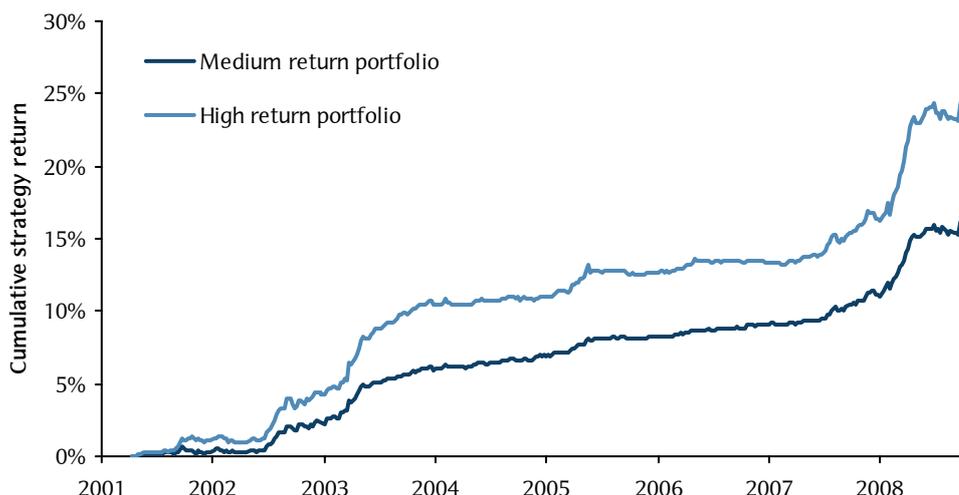
Source: Markit, Barclays Capital

Finally, we can look at another representation of the efficient frontier, this time on the axes of worst three-month drawdown versus annual return in Figure 16. This serves as a check that by minimising variance we do not inadvertently select combinations that suffer extended draw-downs. The chart is very close to being a mirror image of the mean-variance efficient frontier, with relative positions of the strategies consistent. It turns out that the same chart again with 99% VaR as the risk measure also looks similar. In this case, this would suggest that the volatility is a good measure of the risk of these strategies, in that optimising on the basis of other tail-measures would reveal similar results. In theory, this should be the case when returns of underlying strategies are approximately normally distributed.

Figure 16: Efficient frontier and strategies on axes of worst three-month drawdown and annual return
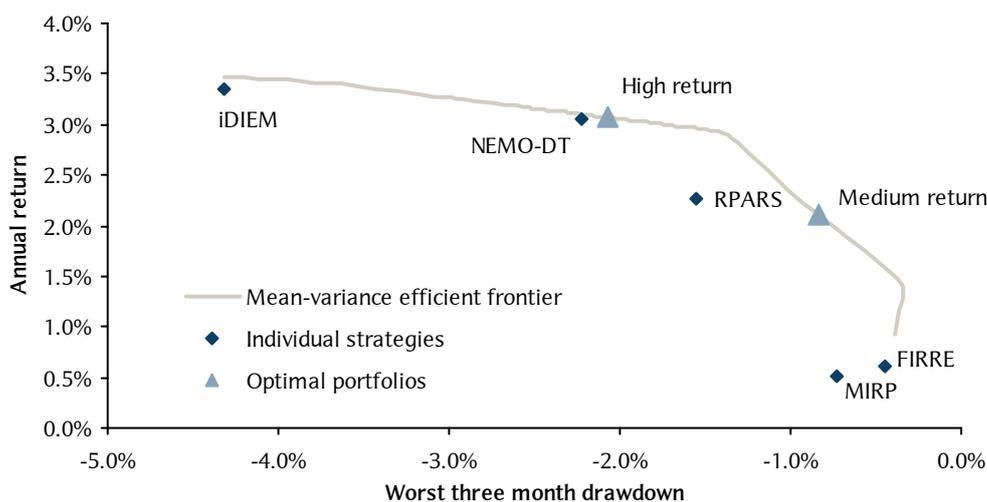
Source: Markit, Barclays Capital

Optimal strategies – Conclusion

As discussed, we include this section as an illustration of the potential from combining systematic strategies, even using straightforward techniques. Further investigation is required, both on some individual strategies, and on combination techniques, to perfect an executable strategy with reasonable trading costs. Look out for this in future Barclays Capital Quantitative Credit Strategy research.

Metrics of credit strategy performance

With the task at hand of developing either alpha or beta strategies, benchmarking performance becomes crucial. Measuring the performance of strategies involving unfunded derivatives is surprisingly complex, and there many different conventions. In this section, we review some of the technicalities around this topic and run through some sample calculations illustrating how performance is measured throughout this handbook.

Measuring return

Calculating a measure of return on an unfunded derivative such as a credit default swap is not a clearly defined concept, in the way that it is for an instrument such as a stock. As there is typically no initial investment in a swap (and even in cases where there is) there is no meaning in dividing final value by initial value. There are instead a number of standard alternatives which we define here. Conventions vary between asset classes and instruments so these definitions are specific to credit default swaps (single-names and indices).

Unlevered total return

The unlevered return is calculated as the mark-to-market on a trade, including accrued premiums, divided by the total notional exposure. We refer to this as unlevered as it is a similar measure of return to that used when entering into a fully funded note on the same notional with the same mark-to-market gain or loss.

As an example, consider an a trade in which an investor sells €100mn 5yr iTraxx Main protection at 100bp and after six months the trade is closed out at 60bp, and there have been no defaults. Assume for simplicity that the index coupon was set to 100bp also. The total mark-to-market gain is calculated as:

Mark-to-market gain = €1.6mn (capital gain) + €0.5mn (accrued premiums) = €2.1mn

These calculations are approximate – for details of mark-to-market calculations on indices refer to *Indices: The basics*. The total notional exposure was €100mn, so the unlevered return on the trade is 2.1%.

Similarly, we can measure the unlevered return on a strategy consisting of a sequence of trades as the average unlevered return on each trade.

This definition runs into difficulties when multi-leg positions are involved. For example, on a standard DV01-neutral curve steepener an investor might sell €170mn 5yr iTraxx Main protection and buy €100mn 10yr iTraxx Main protection. Suppose the total P&L of the trade is €1mn upon closing out of the position. There is now some ambiguity over which number to divide by:

- The sum of all notionals involved: Unlevered return = 0.37%

- Net notionals involved: Unlevered return = 1.43%

- Just the 10yr notional: Unlevered return = 1.00%

Unfortunately, there no clear right or wrong here – the first two options arguably deflate and inflate (respectively) the return rather artificially. Most market participants tend to use the last rule as a compromise. Whatever method is used, these calculations highlight the importance of stating the return calculation method.

Funded total return

Credit default swaps can be traded on a funded basis, for example as credit-linked notes. This makes the return much simpler to calculate as there is usually an initial investment of the market value of the note. Funded instruments add the complication of risk-free

interest earned on the principal. For example, if an investor carries out the above trade selling €100mn 5y iTraxx main protection in funded form, the return may be calculated as 2.1% plus the risk-free return earned, for example calculated using EONIA.

Excess returns

For many real-money / benchmarked credit investors, the concept of excess return is used. Typically, this is used on cash instruments – for example, the excess return over swaps of buying a cash bond. For such an investor using derivative strategies, the unlevered return shown above can be viewed as an excess return as it has no risk-free return component. For a benchmarked investor, fund constraints will typically only allow derivatives to be used in place of similar-size cash positions. For example, rather than buying €10mn of a bond and funding this / removing interest rate risk by selling €10mn government bond futures, the investor might sell €10mn protection on the name instead.

For such investors considering systematic strategies, it is therefore also most meaningful to consider the unlevered return.

Return on capital (ROC)/Leveraged return

Some investors, in particular hedge funds and bank proprietary trading desks, consider returns on leveraged basis, and calculate instead a return on capital employed number. Unfortunately, capital employed is another somewhat loosely defined concept and varies between users.

For typical hedge funds, CDS products are traded on a standardised basis where margin is posted against potential losses. An initial margin is set at trade inception, and a variation margin charged (or received) as trades go in or out of the money over time. The initial margin requirements, which are designed to guard against jumps in the value of the contract, depend on a number of factors:

- Whether the trade is buying or selling protection. Selling protection would typically involve higher margin.

- The spread of the index or name. A higher spread would involve a higher margin

- The assessed credit-worthiness of the counterparty. A weaker counterparty would expect a higher margin requirement.

Variation margin typically covers 100% of the current mark-to-market of the trade.

A simplistic measure of capital employed is taken simply to be the initial margin. An effective leverage can then be calculated at trade inception. For example, if the initial margin is 4% of the trade notional then the effective leverage is 25x. Return on capital is simply calculated as the ratio of final trade P&L to the initial margin amount.

An additional amount of capital is needed when an index trades off-par – that is, when the index coupon is significantly different from the market spread. In such a situation an index investor is required to pay of receive an upfront payment to enter into the trade. A more sophisticated capital measure would include initial margin, capital associated with upfront costs, and perhaps an average variation margin cost over the life of the trade. In this case, leverage is much harder to assess. The return on capital calculated will naturally depend significantly on the method used.

To illustrate this, Figure 17 shows the analysis of a hypothetical trade selling €10mn iTraxx Xover series 9 initiated on 1 April 2008 and closed on 31 July 2008. The chart shows the 5y spread over the period on the right-hand axis, and the two different measures of capital employed on the left-hand axis. In this example, the Xover index was trading well away from par. The coupon was at 650bp and market spread at 544bp, meaning an upfront payment of €400,000 needed to be made. The trade P&L was

€283,000. Based on initial margin only, the ROC was 28%. Including variation margin and upfront costs, the ROC falls to 17%.

Figure 17: Example trade selling €10mn protection on iTraxx Crossover S9 on 1 April 2008 and closing on 31 July 2008, Comparison of return on capital (ROC)

Trade details
Notional short protection = €10mn
Initial margin = 10%
Upfront payment = €400,000
Trade P&L = €283,000
ROC (Initial margin) = 28%
ROC (Average total capital) = 17%

Legend:
- Initial margin only
- Total capital including variation margin
- Xover S9 5y spread (RH axis)
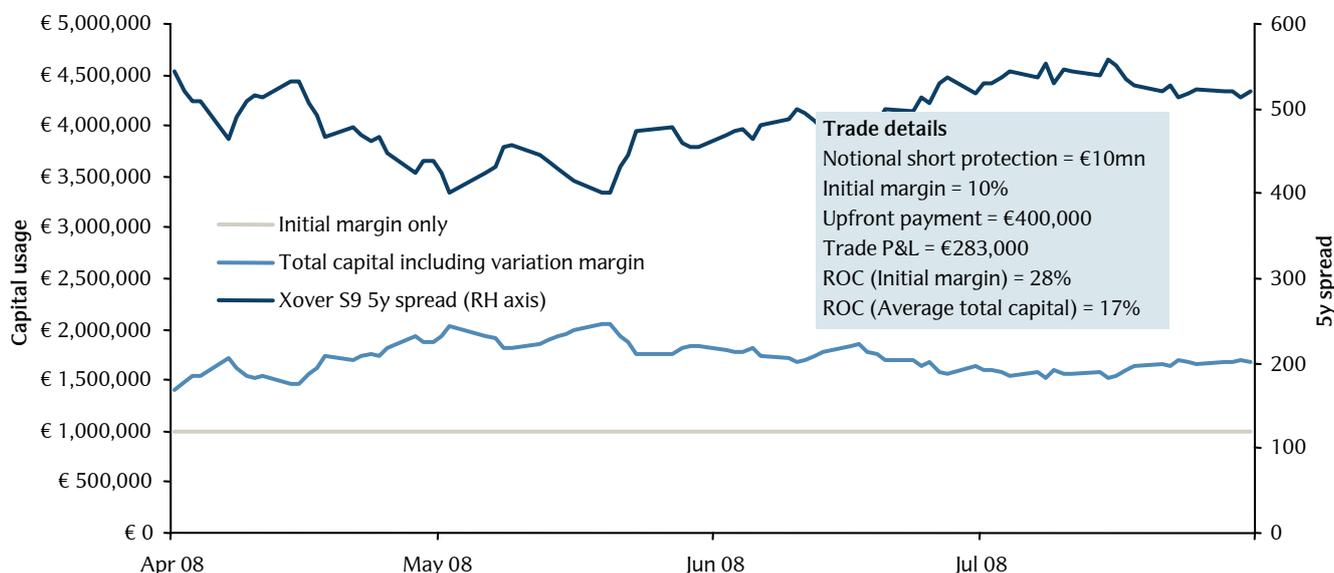
Note: The initial margin requirements are entirely illustrative and do not relate to any Barclays Capital official levels. Source: Markit, Barclays Capital

For multi-leg trades, margining rules and netting become more complex making effective leverage and return on capital trickier to estimate.

Other leveraged investors, such as bank prop desks, tend to assign capital based on other risk measures described in the next section, such as Value-at-Risk (VaR). Trading positions are typically limited by a total VaR of the portfolio. Leverage is then tricky to estimate.

Risk measures

A return measure on its own does not give any information about the level of risk that was employed to attain it. All investors are bound by some form of risk limits, and therefore it makes sense to assess trading strategies on the grounds of risk-adjusted returns. We distinguish between two sets risk measures that might be used to assess a strategy:

- 'Forward-looking' risk measures: Measures that can be calculated before a strategy is launched that specify risk in certain predefined scenarios.

- 'Back-testing' risk measures: Measures that can only be computed on historical testing of a strategy with realised performance. Forward-looking estimates of these measures can be made on the basis of realised measures.

Figure 18 summarises some common risk measures for strategies. Note that this is certainly not intended to be a comprehensive set of risk measures for general risk-management purposes.

Figure 18: Some common credit strategy risk measures

Risk measure	Forward / backward looking	Advantages	Disadvantages
DV01 (credit duration)	Forward	A simple measure of market direction risk of a strategy	Very simplistic, not useful for variable directionality strategies
Value on default	Forward	A simple measure of extreme losses	Only one (usually unlikely) scenario for the strategy, recovery rate assumption required
VaR (based on the component positions)	Forward/Backward	An intuitive tail loss measure derived from the instruments involved	Dependent on historical returns distribution. Ignores the strategy itself
VaR (based historical strategy returns)	Forward/Backward	A useful tail measure of potential losses from following the intended strategy	Dependent on historical returns distribution of the strategy.
Realised volatility	Backward	A good measure of returns variability	Dependent on historical returns distribution of the strategy. Positive returns contribute equally with negative returns to volatility.

Source: Barclays Capital

Strategy performance metrics

Completing the discussions of the last sections we look at different metrics that can be used to assess strategies. It is hard to justify the sufficiency of any one measure on its own. In most circumstances, it makes to calculate as many measures as feasible for a given strategy.

- Average annualised return: The most obvious measure. Although we argue that risk-adjusted return is more informative, a minimum level of absolute return is of course essential to make a strategy economically worthwhile. Different investor types require different target returns. A real-money or benchmarked investor may look for stable outperformance of perhaps 100bp, while a hedge fund would require target return on capital of 20% to 50%

- Risk-adjusted return: Perhaps the most important single measure. Usually the Sharpe ratio is used, annualised return divided by volatility. Typically Sharpe ratios after transaction costs of below 0.5 are regarded as significant. Sharpe ratios above 1.0 are considered very attractive if sustainable.

- Hit ratio: A simplistic measure of performance is the proportion of trades that make money out of the total number of trades made. This is the hit ratio. It is useful more from a trade psychology point of view – a high hit ratio strategy is easier to sustain than a low hit ratio strategy – but may not be a good measure of actual strategy performance since the magnitude of gains (and losses) is ignored.

- Tail measures: Strategies with the possibility of sustaining very large losses, even with small probability, are clearly less attractive than those that do not have such features. Tail measures tend to be calculated on a more forward-looking / scenario basis.

- Returns skew: Similarly, strategies with 'right-hand' skews of returns are more attractive. This means that returns that are large in magnitude tend to be positive returns rather than negative ones.

- Drawdown analysis: A wholly backward-looking metric, it is important to test what the total drawdown is in periods of sustained losses of a strategy, to ensure that solvency can be maintained in such scenarios.

As examples of some of these results, Figure 19 shows returns and drawdown analysis of the Financial Index Ratio Reversion (FIRRE) strategy which is introduced in *Financials Index Ratio Reversion (FIRRE) strategy.*

Figure 19: Example returns and drawdown analysis, pre-transaction costs, for the Financials Index Ratio Reversion strategy, 2001 to 2008

| Cumulative returns profile | Drawdown analysis – Cumulative losses |

Strategy performance metrics
Avg annual return: 0.78%
Annual Sharpe ratio: 1.01
Avg # trades per year: 11

Maximum drawdown
-79bp
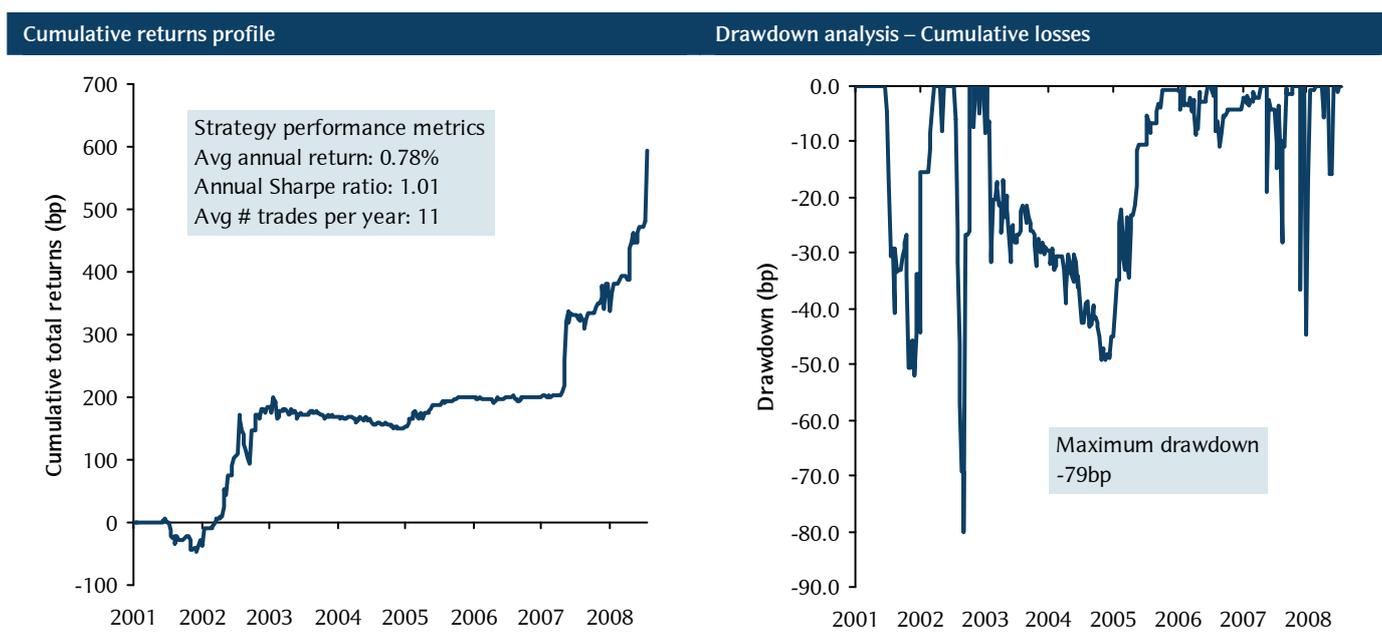
Source: Markit, Barclays Capital

Drawdown analysis

The right-hand chart in Figure 19 is an example of a drawdown chart which we use at various points. It is calculated as follows. First the back-testing returns, R_t, are calculated over each period (e.g. each day) over the whole testing period. Then the drawdown, D_t, is calculated as:

$$D_0 = 100\% \quad \text{and} \quad D_t = D_{t-1} + \min\left(R_t, 100\% - D_{t-1}\right)$$

In other words, the chart shows only cumulative losses and allows calculation, for instance, of average time to recoup cumulative losses, and maximum time to recoup cumulative losses.

Other conventions used in this handbook

Measures used

Given the complexity and variability of margin and capital requirements used by different investors, we express all returns as unlevered total returns on unfunded derivatives. We usually report Sharpe ratios and other measures discussed above.

Reinvestment and annualising

We tend to report strategy performance on an annualised basis to make strategies comparable. We assume no reinvestment or compounding. For individual trades, we report performance on a non-annualised basis.

Transaction costs

Transaction costs, as described above, can have a substantial impact on performance. They are also hard to estimate accurately, especially in volatile periods. We report performance sometimes pre- and post- transaction costs, where the transaction cost assumptions will always be stated. It is useful to compare pre- and post- transaction costs to i) indicate the proportion of returns lost to trading costs and ii) to allow an assessment of whether our assumptions are realistic. Some investors may be able to trade more efficiently and realise performance in between these two estimates.

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Systematic directional strategies

For a large proportion of credit investors, the baseline investment decision will be whether to be long or short (equivalently, overweight or underweight) the market. The question then becomes how best to implement market-directional views and, if possible, how to time positioning. This section explores some systematic approaches to taking credit market directional exposure. We subdivide these into beta strategies and alpha strategies. In reality, this distinction is imprecise, as many strategies intended to capture alpha are in fact beta strategies in disguise. Although it is true that all investment strategies have some component of market risk embedded, here we look at those strategies which specifically aim to take directional exposure.

We examine four broad types of beta strategy, focusing on methods of enhancing the risk-return profile of "long credit" strategies:

- *Standard strategies that take full default exposure to the underlying names.*

- *Curve strategies that take limited default exposure the underlying names*

- *Forward strategies that take no default exposure until the forward start dates.*

- *Variable default exposure beta strategies (VDEX).*

We consider two systematic alpha strategies:

- *Macro/fundamental motivated strategies including RPARS/ML.*

- *Micro/high-frequency strategies (NEMO).*

A summary of systematic beta strategies

Figure 20 shows a summary of beta strategies. Each approach in turn is described in the following sections along with justification of the particular characteristics claimed.

Figure 20: Comparison of index trades that are long credit risk/positive beta to the market

Strategy	Mark-to-market sensitivity/beta to spread tightening	Default risk/impact on performance	Expected volatility	Complexity	Liquidity	Historical risk-adjusted performance
Selling on-the-run 5y protection	High, constant	Medium	High	Low	High	Poor
Hold-to-maturity 5y protection	High, decreasing with time to zero	High	High, decreasing to medium	Low	High, decreasing to medium	Medium
On-the-run steepeners	Medium, constant	Low	Low	Medium	Medium	Poor
Hold-to-maturity steepeners using fixed JTD weighting	Medium, decreasing with time to zero	High	Medium, decreasing to low	Medium	Medium decreasing to low	Medium to good
Hold-to-maturity steepeners using static weighting	Medium, decreases and reverses with time	Medium, decreasing to zero with time	Low, increasing to high	Low	Medium decreasing to low	Poor
Selling forward on-the-run protection	Medium	Zero	Medium	Medium	Medium	Medium
Variable Default EXposure (VDEX)	High, constant	Low to medium	High	High	Medium	Medium

Source: Barclays Capital

For example, selling 5y protection on the on-the-run index as a "credit market long" is a low cost, straightforward trade with very strong liquidity support. However, it is subject to rather extreme mark-to-market sensitivity making it hard to stay on the strategy in periods of elevated spread volatility. In comparison, buying the curve/holding on-the-

run steepeners mitigates some part of this mark-to-market sensitivity and decreases the impact of defaults, at the cost of higher complexity and lower liquidity. The trade-off between liquidity and volatility profile must be subjected to the individual investor's own preferences, which is why we would not necessarily claim the superiority of one over another.

Market directional exposure via the 5yr spot: stay on-the-run or hold-to maturity?

To start off, we look at one of the more common decisions an investor in CDS must make: should an investor roll my long/short risk positions into new on-the-run contracts? CDS indices have in some ways an easier task versus single name CDS, in that rolls only occur every six months. However, the underlying reference portfolio changes slightly on each roll date, making the decision of whether or not to roll less than trivial. Barclays Capital Global Credit Strategy teams cover individual index rolls in depth (see for example *Rolling to series 10: Markit changes the play*, 26 August 2008). Here we look at the question from a more empirical, systematic angle.

Specifically, we contrast two options:

- Rolling on-the-run protection selling: The investor sells 5yr protection on the on-the-run index, rolling the position to the new on-the-run every six months.

- Hold-to-maturity protection selling: The investor sells 5yr protection and does not roll, allowing the contract to shorten in duration and eventually expire.

Before exploring the empirical analysis of these strategies we consider in Figure 21 the theoretical distinctions. We note that some of the effects mentioned in the table are time-varying: we have seen a definite increase in the liquidity available to trade off-the-run indices, with a corresponding reduction in transactions cost.

Figure 21: Rolling versus hold-to-maturity – investment grade indices

Factor	Rolling on-the-run	Hold-to-maturity
Default risk	Minimised through the refresh effect – weaker credits fall out of the new index series at each roll	Increases through time as the static set of names that is referenced experience downgrades
Maturity	Roughly constant through time	Falls through time
Spread sensitivity	Roughly constant through time	Falls through time
Liquidity	Excellent	Progressively poorer as contract rolls down
Trading costs	Small transaction costs associated with roll events	Transaction costs associated with defaults
Key risk	Risk of downgrades to sub investment grade – losses are crystallised on each roll to a new series	Defaults – on a hold-to-maturity basis only defaults will cause actual losses

Source: Barclays Capital

Crystallising P&L of exiting names in the rolling strategy

The last row in Figure 21 highlights the main difference between these two strategies. P&L due to spread changes in the names that exit the index on each roll are systematically crystallised in the rolling strategy. Names typically leave on-the-run indices for a variety of reasons, including:

- **Drop in liquidity:** A name no longer features in dealers' assessments of liquidity. This will typically not have a bias toward spread widening or tightening.

- **Downgrade to sub-investment grade:** Investment grade index rules state that at the roll date, names need to be rated above BBB- and Baa3, respectively, by S&P and Moody's. Names falling to sub-investment grade should – in theory – suffer spread widening during their time in the index.

- **Acquisition or orphaning:** Names are removed due to an acquisition or the retiring of reference debt. This typically would lead to spread tightening in a name.

- **Credit event:** Typically causes spreads to widen.

The last two events will affect the return on the hold-to-maturity strategy but the first two will not. The mark-to-market of names that remain in the index will equally affect the rolling and the hold-to-maturity strategies.

Below we look at a framework for assessing default and downgrade risk on a more quantitative basis. However, it is also informative to look at some examples of these events and the impact that they have on P&L of strategies. In Figure 22 and Figure 23 we analyse the CDX IG rolls in March 2008 and October 2008 between series 9 and 10 and 10 and 11, respectively. In each case we:

- Run through each of the names that exited the index, noting the reason for exit and the spreads at the beginning and end of the six month on-the-run period.

- For each name, we calculate the impact on total mark-to-market of selling protection on the index for the two cases of a strategy where we intend to roll and the strategy which does not roll. In both cases, we assume the strategy was initiated at the beginning of the on-the-run period considered. The approximate P&L effect does not take into account carry.

- We then sum up the crystallised P&L for all the exiting names – this will be the total mark-to-market impact on the rolling strategy. We compare this with the sum of only those exit events which would affect the hold-to-maturity strategy as a comparison.

Note that the calculations here are approximate, based on available data and information. They are intended to be illustrative of different single-name events on indices and should not be viewed as definitive mark-to-market effects on positions.

Figure 22: Names that exited CDX IG 9 on 20 March 2008 roll

	Ratings (Moody's/S&P)		Reason for exit	Spreads		Approx P&L impact (bp)
	20 Sep 07	20 Mar 08		20 Sep 07	20 Mar 08	
Belo Corp	Baa3/BBB-	Ba1/BB	Downgrade	408	387	0.6
Centex	Baa2/BBB	Ba1/BB+	Downgrade	430	516	-2.4
Ctrywde Home Lns	Baa3/A-	Aa2/AA	Acquired	277	522	-6.9
IAC InterActive	Baa3/BBB-	Ba3/BB	Downgrade	569	220	10.7
Jones Apparel	Baa3/BBB-	Ba1/BB+	Downgrade	317	423	-3.3
Lennar	Baa2/BBB	Ba1/BB+	Downgrade	772	716	1.2
Pulte Homes	Baa3/BBB-	Ba1/BB+	Downgrade	247	415	-5.2
				P&L impact to rolling strategy		-5.2
				P&L impact to maturity strategy		-6.9

Source: Bloomberg, Markit, Barclays Capital

Figure 23: Names that exited CDX IG 10 on 2 October 2008 roll

	Ratings (Moody's/S&P)		Reason for exit	Spreads		Approx P&L impact (bp)
	20 Mar 08	02 Oct 08		20 Mar 08	02 Oct 08	
Washington Mut Fin	Baa3/BBB-	Caa2/D	Credit event	604	8583	-32.9
Alcan	A3/BBB+	A3/BBB+	Low liquidity	74	44	1.2
Brunswick	Baa1/BBB	Baa3/BB+	Downgrade	293	414	-3.9
Fannie Mae	Aaa/AAA	Aaa/AAA	Credit event	55	37	0.7
Freddie Mac	Aaa/AAA	Aaa/AAA	Credit event	55	38	0.7
Liz Claiborn	Baa3/BBB	Baa3/BB+	Downgrade	436	400	1.1
MeadWestvaco	Baa3/BBB	Ba1/BBB	Downgrade	192	176	0.6
Radian Group	A2/A-	Ba1/BB+	Downgrade	1161	2365	-11.4
Rohm & Haas	Baa1/BBB	Baa1/BBB	Low liquidity	101	38	2.5
Sprint Nextel	Baa3/BBB	Baa3/BB	Downgrade	624	396	6.3
				P&L impact to rolling strategy		-35.3
				P&L impact to maturity strategy		-32.9

Source: Bloomberg, Markit, Barclays Capital

The results of this are quite surprising, perhaps due to the extreme period of the credit market in which this analysis is done. A number of points are worth mentioning:

- In most cases the P&L impact of the downgraded names is minimally negative, or even positive. This essentially shows that the market had priced in a downgrade in some of these names well in advance of rating agency action. This may or may not be a systematic pattern.

- The impact of market movements is apparent in some of the numbers. Although the acquisition of Countrywide by Bank of America resulted in a rating upgrade, spreads actually widened over the period in question causing a loss to both the rolling and hold-to-maturity strategies[1].

- The CDX IG 10 index witnessed a period of extreme defaults compared with historical precedent. Clearly, the WaMu default dominates the return impact for both strategies.

In theory, the main risk that rolling investors take on versus hold-to-maturity investors is that of downgrade risk rather than default risk. Anecdotally, the examples above show that this "risk" can actually be a positive for P&L as well as negative. It is relatively straightforward to calculate the implied breakeven default rate for an index from the market spread levels (see *Index breakeven spreads – a default perspective*). Rolling investors in investment grade indices might be better considering the expected loss due to rating downgrade. Unfortunately, this is a much more difficult number to estimate, and, like expected default rates, is highly time-varying.

Defaults are typically fairly rare, but the cost to the protection seller is high. Downgrades occur much more frequently, but cost less on a mark-to-market basis. It should be possible to estimate an expected downgrade rate based on six-month rating transition data for a given portfolio. Linking this together with data on spread moves for given rating transitions should allow a "pricing" of downgrade risk. Then, rather than comparing historical to implied default rates, a rolling investor might compare historically implied transition costs to the six months of premium earned in an on-the-run period. We leave this interesting analysis for future research.

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[1] *Note that at the time of writing we were unable to ascertain the exact timing of the exit as far as mark-to-market effects on CDX IG 9 are concerned.*

As a specific example of this kind of analysis, the Barclays Capital European Investment Grade strategy team have carried out an in-depth assessment of migration risk in iTraxx Europe – please see *Itraxx Main at 200? Or 20?, 2 May 2008*.

In the next section we turn to a more empirical analysis of returns, albeit over a predominantly low default rate period.

Hold-to-maturity beta strategies

Originally published in iTraxx strategies through the cycle, *European Alpha Anticipator*, *22 August 2008*.

Indices live longer than six months

Indices tend to be forgotten once they roll from being on-the-run to off-the-run. While many index investors choose to roll their positions at the start of each new index, there are substantial positions left outstanding in the old series, with a reasonably active secondary trading market. In this section, we analyse off-the-run series for the purposes of hold-to-maturity strategies.

Figure 24: The life of a credit index – spreads of an iTraxx-like index* formed in March 2001

QCX iTraxx Series 1: Initial maturity 5.25 years
QCX iTraxx Series 1: Initial maturity 10.25 years

Roll-down effects are swamped out on the 10y index during the credit crunch thanks to a mix of spread widening, curve flattening and increasing dispersion in credit quality

The differential - or curve - steepens markedly in the latter years of the 5y contract

The 5y index rolls down to zero quickly, post the 2002 bear market

Note: *Using the QCX index rules. Source: Markit, Barclays Capital

The credit market is, without doubt, going through significant changes. While we find historical analysis valuable in assessing trading patterns, we comment throughout on factors that may lead to differing behaviour in the period ahead. The most significant of these is the rise of idiosyncratic risk, possibly to levels not seen since 2001-02. Idiosyncratic events will affect off-the-run series more dramatically than on-the-run series, since the latter benefit from credit-quality 'refresh' effects.

Figure 24 shows our calculations of what the 5yr and 10yr spreads on an iTraxx-like index started in March 2001 would look like, held to maturity in the case of the 5yr, or till present for the 10yr. The index is constructed to mimic the iTraxx rules from single-name data using our QCX rules – see the following boxed section.

A number of points stand out from this unusual chart. First, the one example of roll-down is made apparent in the 5yr index as it approaches maturity, with the spread converging

to zero and the differential from the 10yr – ie, the 5s10s slope – increasing. However, we see a different picture with the 10yr index which, despite having only three years left to maturity, widens dramatically in the credit crunch, to similar levels as the on-the-run series 9. This can be explained by a combination of the flattening in curves and the gradual deterioration in credit quality of index constituents: for instance, our constructed QCX iTraxx Series 1 contains names like Carlton, Kingfisher, Heidelberger, British Airways, Rhodia and Nielsen, all of which are now in iTraxx Xover Series 9.

Figure 25 presents a snapshot of all the spread data for 5yr indices, both real indices and our proxy QCX indices.

Figure 25: Overlapping iTraxx and QCX iTraxx 5yr series, from inception to date or to maturity
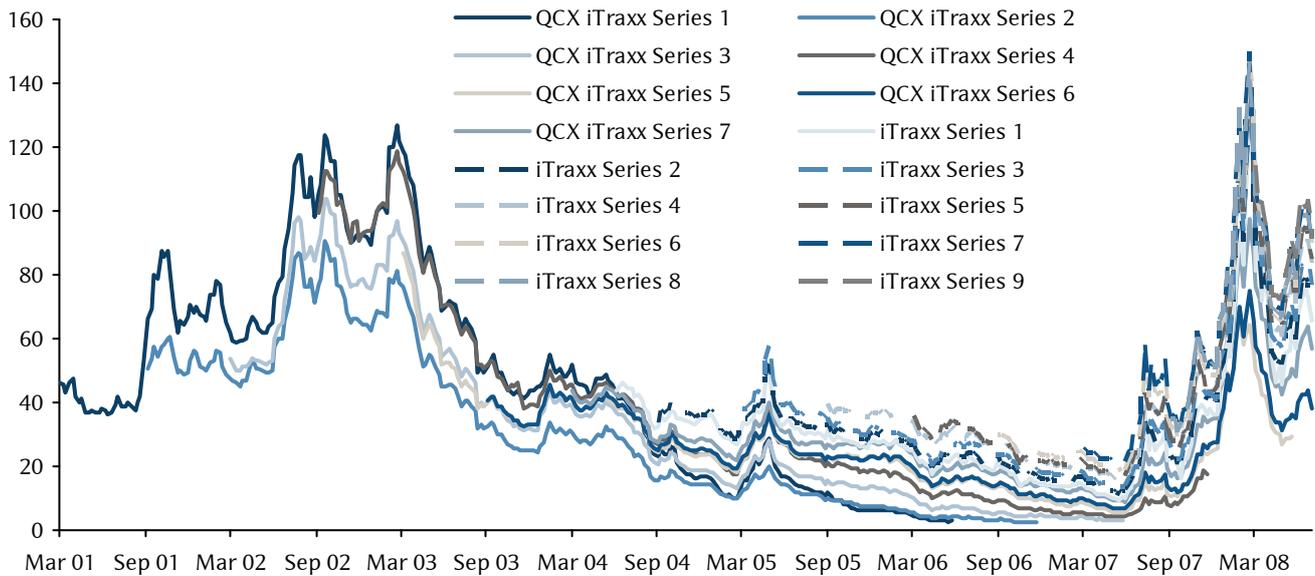
Source: Markit, Barclays Capital

For the majority of analysis presented here, we move from spreads space to returns space, since the important questions involving long holding period strategies inevitably revolve around P&L and mark-to-market volatility. All the returns are calculated using non-compounded cumulative total returns defined as:

Total return between 0 and *T* = Accrued fixed coupon + Upfront Payment (*T*)

- Upfront Payment (0)

As a benchmark for the analysis in this section, we first look at cumulative total returns from on-the-run indices.

Rolling on-the-run strategies

Most index analysis is carried out on the basis of 'rolling' on-the-run series. Figure 26 presents charts for iTraxx Main and iTraxx XO rolling on-the-run total returns from March 2001-July 2008, again using our QCX series to complete the dataset. These series are constructed by calculating the returns of holding each on-the-run index in turn and then rolling to the next. They are therefore constant 5yr maturity returns series.

These charts immediately present some interesting facts. For iTraxx Main, the effect of the 2001-02 downturn can be seen clearly with negative cumulative performance of around 200bp, before the 2003-07 credit bull market takes hold. Returns grow steadily during this period as spreads tighten, with a blip during the correlation crisis in May 2005. The final year of data shows the impact of the credit crunch, which wipes out all cumulative profits in a matter of months.

The chart for XO is noticeably different, with a more muted effect in 2001-02 and a more pronounced profitable period peaking around 40% cumulative returns by mid-2007. It is important here, however, to provide a caveat for the QCX XO on-the-run data for several reasons. Typical credit quality of our reconstructed XO series is actually much higher than today's XO constituents owing to a small universe of trading European high-yield CDS in 2001-03. Similarly, we believe defaults are underestimated in this period. A full discussion of this is given in *iTraxx S8 family: How wide and how flat can they go?* 19 February 2008. The result is that the losses in 2001-02 are probably underestimated.

It is interesting to note as well that the credit crunch has not yet had as dramatic an effect on XO, as the European default cycle is only now starting to pick up.

Figure 26: Rolling strategies on on-the-run iTraxx indices, total returns (bp)
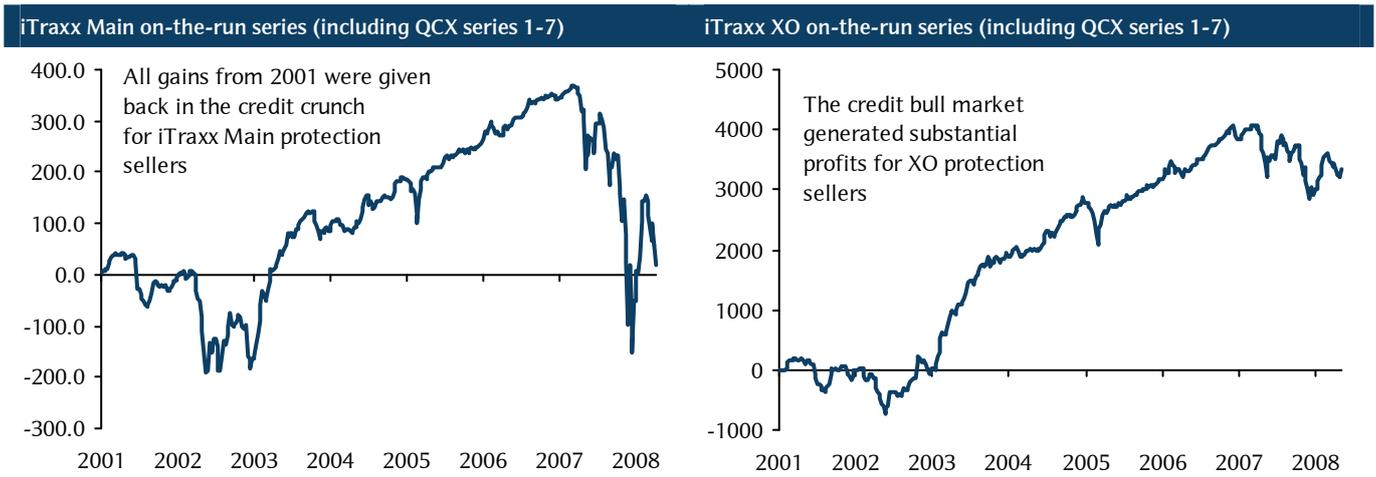
Note: Charts show cumulative total return (bp) of selling 5yr protection, including premiums   Source: Markit, Barclays Capital

We can also use our QCX CDX indices to compare the above charts to the US investment grade index. Note that the CDX Xover index is not directly comparable to the iTraxx Xover since the former does not include true high-yield companies. Instead, in Figure 27 we show CDX IG total returns with and without the Enron and Worldcom defaults. Although these firms were not included in the QCX series due to lack of data, we believe they may have been in the relevant on-the-run series on default. For simplicity, we take the recovery rate on each to be 15%. The combined cumulative hit to total returns is then 132bp. Both panels include the recent Washington Mutual default, although it is only marked on the second chart.

Figure 27: Rolling strategies on on-the-run CDX IG, total returns (bp) with and without defaults
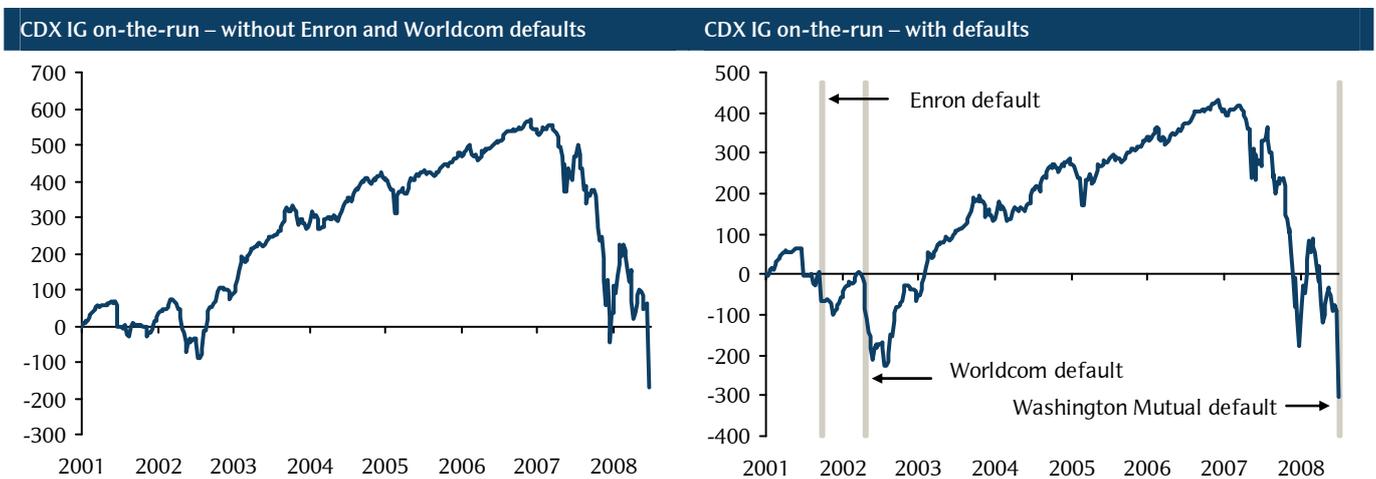
Source: Markit, Barclays Capital

Long-horizon strategies

We can now contrast these returns with long-horizon, static strategies on various indices, where we do not roll the contract and allow it to have decreasing maturity[2]. In practice, many index investors may use indices in this way to better match liabilities – for instance, when hedging a synthetic CDO portfolio, the maturity on the liability side is falling with time, so it makes sense to use a fixed maturity-date index to hedge this.

Figure 28 presents some example cumulative return series on different indices. Naturally, the performance varies tremendously, depending on at what point in the credit cycle the index is initiated.

In the left-hand charts we look at S1 and S7 5yr indices for iTraxx Main and XO. In both cases, S1 clearly benefits from the prolonged credit bull market, able to generate both carry and capital returns. S7, on the other hand, has no time to build up any cushion, and unsurprisingly performs very poorly in the credit crunch period.

In the right-hand charts, we examine our QCX reconstructed series to allow us to move further back in time. QCX S1, for both Main and XO, shows a similar pattern of initial underperformance before benefiting from the credit rally and then maturing in mid 2006. QCX S5 shows almost uninterrupted positive performance, and is not greatly affected by the credit crunch period given the very low duration by this point.

Figure 28: Example cumulative static position return profiles of different iTraxx series
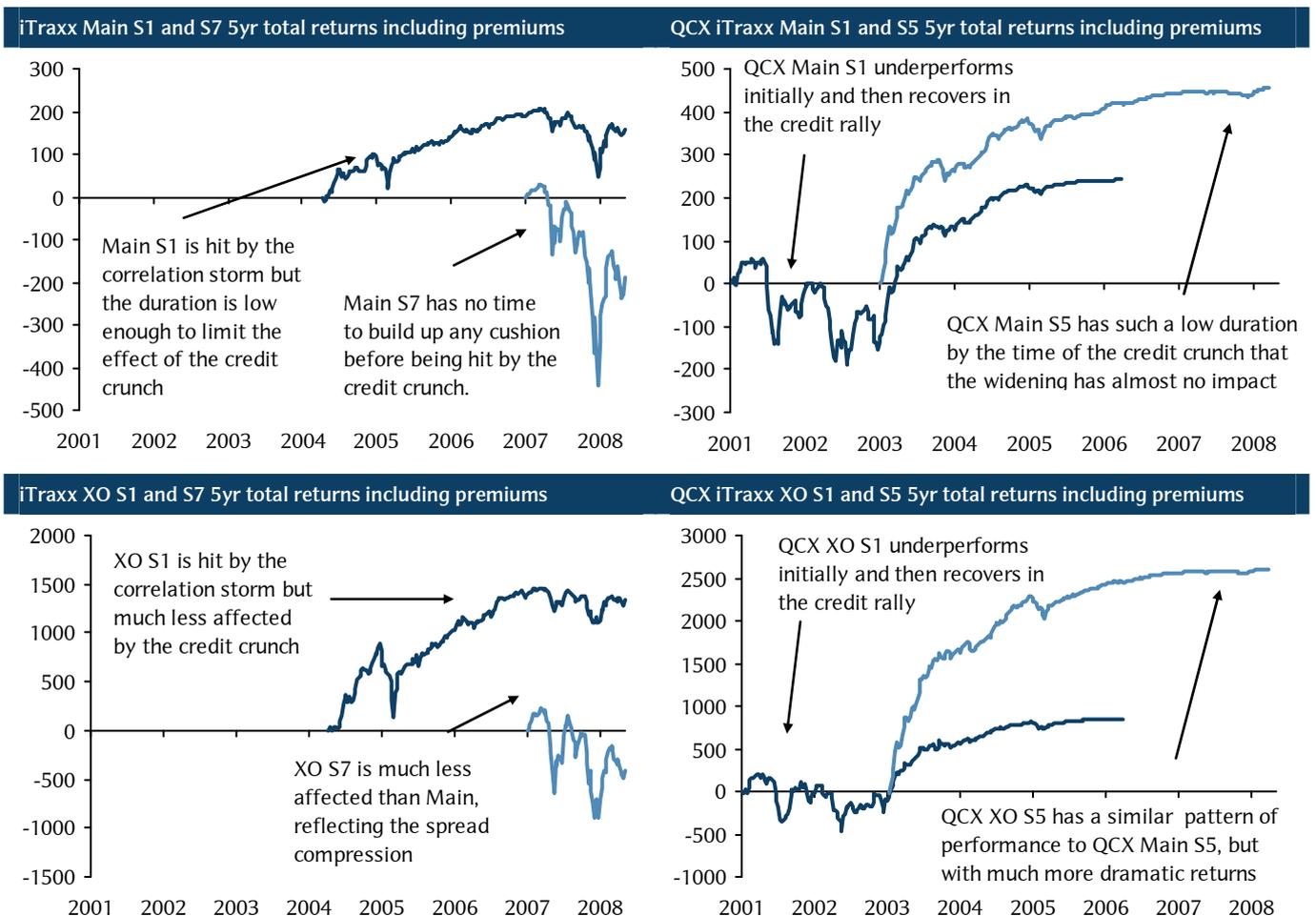
Source: Markit, Barclays Capital

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[2] We refrain from using the term 'Buy-and-hold' in this context. Although fitting, it may lead to confusion as we look at long credit risk strategies that sell protection and hold this position.

Figure 29 and Figure 30 show comprehensive summary statistics for the cumulative returns on all the indices, including the QCX series. The fields in the table are mostly self explanatory, but a short description of the less obvious fields is given here:

▪ Cumulative return: Total return from inception to maturity or marked-to-market at end-July 2008.

▪ Annual volatility: The annualised basis point mark-to-market volatility based off the standard deviation of weekly returns.

▪ Annual Sharpe ratio: The return per unit volatility.

▪ Second-half return and Sharpe Ratio: Dividing the sample period in two, we can check the performance in the second-half period.

The patterns of performance are mostly explained, as in Figure 28, by the starting and ending points of the index. Interestingly, the only indices showing substantial long-run positive risk-adjusted performance, as measured by the Sharpe ratio, are the QCX indices, which were able to benefit from the credit bull market, and iTraxx series 9' which captured the post Bear Sterns credit rally in March and April 2008.

The returns in the second half of each trading period also reflect the period in question, with strong performance on many of the QCX series. The purpose of including these second-half statistics will become clear when we switch to looking at curve effects in the next section.

Figure 29: iTraxx Main summary return, volatility and Sharpe ratios for static strategies

Series	Start date	End date	Cumulative rtn (bp)	Average annual rtn (bp)	Annual volatility (bp)	Annual Sharpe ratio	2nd half average annual rtn	2nd half average annual Sharpe ratio
iTraxx Series 1	Jun 04	Jul 08	156	38	68	0.6	-1	0.0
iTraxx Series 2	Sep 04	Jul 08	81	21	73	0.3	-13	-0.1
iTraxx Series 3	Mar 05	Jul 08	57	17	92	0.2	-42	-0.4
iTraxx Series 4	Sep 05	Jul 08	13	4	110	0.0	-80	-0.5
iTraxx Series 5	Mar 06	Jul 08	-46	-20	140	-0.1	-135	-0.7
iTraxx Series 6	Sep 06	Jul 08	-124	-67	193	-0.3	-109	-0.4
iTraxx Series 7	Mar 07	Jul 08	-187	-139	269	-0.5	-82	-0.3
iTraxx Series 8	Sep 07	Jul 08	-174	-211	344	-0.6	515	1.4
iTraxx Series 9	Mar 08	Jul 08	135	413	254	1.6	-359	-1.5
QCX iTraxx Series 1	Mar 01	Jun 06	243	46	93	0.5	44	2.0
QCX iTraxx Series 2	Sep 01	Dec 06	260	50	62	0.8	28	2.3
QCX iTraxx Series 3	Mar 02	Jun 07	283	54	67	0.8	25	2.1
QCX iTraxx Series 4	Sep 02	Dec 07	519	99	62	1.6	33	2.1
QCX iTraxx Series 5	Mar 03	Jun 08	456	87	40	2.2	27	2.7
QCX iTraxx Series 6	Sep 03	Jul 08	198	41	31	1.3	21	1.1
QCX iTraxx Series 7	Mar 04	Jul 08	178	41	39	1.0	7	0.2

Source: Markit, Barclays Capital

Figure 30: iTraxx XO summary return, volatility and Sharpe ratios for static strategies

Series	Start date	End date	Cumulative rtn (bp)	Average annual rtn (bp)	Annual volatility (bp)	Annual Sharpe ratio	2nd half average annual rtn	2nd half average annual Sharpe ratio
iTraxx Series 1	Jun 04	Jul 08	1334	326	337	1.0	106	0.4
iTraxx Series 2	Sep 04	Jul 08	1005	261	370	0.7	74	0.3
iTraxx Series 3	Mar 05	Jul 08	685	205	419	0.5	-67	-0.2
iTraxx Series 4	Sep 05	Jul 08	794	279	383	0.7	-264	-0.6
iTraxx Series 5	Mar 06	Jul 08	411	175	506	0.3	-409	-0.7
iTraxx Series 6	Sep 06	Jul 08	119	65	659	0.1	-115	-0.2
iTraxx Series 7	Mar 07	Jul 08	-402	-299	824	-0.4	-201	-0.3
iTraxx Series 8	Sep 07	Jul 08	-439	-531	802	-0.7	1193	1.8
iTraxx Series 9	Mar 08	Jul 08	327	1000	660	1.5	-1435	-2.2
QCX iTraxx Series 1	Mar 01	Jun 06	852	162	269	0.6	112	1.1
QCX iTraxx Series 2	Sep 01	Dec 06	1163	222	214	1.0	123	2.0
QCX iTraxx Series 3	Mar 02	Jun 07	1327	253	226	1.1	129	1.7
QCX iTraxx Series 4	Sep 02	Dec 07	2513	480	248	1.9	141	2.3
QCX iTraxx Series 5	Mar 03	Jun 08	2604	498	223	2.2	113	3.4
QCX iTraxx Series 6	Sep 03	Jul 08	1677	346	199	1.7	108	1.5
QCX iTraxx Series 7	Mar 04	Jul 08	1406	323	208	1.6	88	0.8

Source: Markit, Barclays Capital

Beta strategies using curves

Curve trades can provide directional credit exposure with differing risk reward characteristics from those of outright protection selling. In the following sections, we explore various ideas on this theme. In most cases we look at DV01-neutral steepeners as a way of being paid to take default risk, but typically with relatively low volatility. A full introduction into index curve trading is left to Systematic curve strategies. Our focus on actual curve trades here, rather than a choosing a preferred spot on the curve on which on takes directional exposure, stems from the limited liquidity of isolated trading points besides the 5yr in CDS indices. It is more common to see the 7yr trading implicitly in 5s7s curve trade than for it to trades as a 7yr spot trade. We argue that, by the end of the day, the default exposure that arises in a DV01 neutral curve trade is just a different way to take exposure to credit risk as one does in a 5yr spot trade.

Maximising carry per unit volatility

Originally published as Maximising carry per unit volatility, 24 April 2008.

The relative stability of index 5s10s curves, even through the recent volatility, make DV01-neutral curve trades attractive as a means of generating carry, in our view. Although we do not anticipate significant further steepening from current levels over the next twelve months, we show that the carry generated per unit of mark-to-market volatility is up to 3.5x greater on DV01-neutral index curve trades than for selling 5yr protection on the same index.

We analyse each of the five iTraxx indices and find the iTraxx Europe S9 to be the most attractive index in which to hold a steepener for carry purposes. In summary:

For investors needing to generate carry over a longer horizon (eg, 12 months) but wanting to minimise mark-to-market volatility and downside risk, we recommend a DV01-neutral 5s10s steepener on iTraxx Europe S9. Our analysis suggests the breakeven flattening of 6bp should adequately cushion against most bear market scenarios.

Although curves are directional in this environment, with steepeners tending to be a more bullish trade, we believe the carry per unit volatility argument dominates the directional sensitivity when considering long holding periods. Indeed, a strong view on actual curve steepening or flattening is not required to motivate this trade, but rather the knowledge of possible ranges of values and risk of inversion, which we discuss below. Current levels of iTraxx Europe S9 5s10s are, however, near recent highs, so for investors with shorter holding periods it may be worth waiting to see if entry levels improve in the coming weeks.

Comparing the properties of the indices using QCX

Our QCX versions of the iTraxx family allow us to analyse the trading and volatility profile of both curve trades and outright 5yr trades over the full credit cycle from 2001[3]. A summary of this analysis is given in Figure 31.

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[3] *See* iTraxx and CDX: Extending the horizon, *14 March 2007 and* iTraxx family: How wide and how flat can they go? *19 February 2008*

Figure 31: Contrasting indices in terms of attractiveness of 5s10s steepener versus outright short 5yr protection trade, 2001-2008

Index	Trade	Current levels (mids)	Historical trading range* (Mid-week values)	Current annual carry**	Annual MTM volatility** (1yr/7yr)	Carry/unit of MTM vol (1yr/7yr)	Breakeven 1yr widening/ flattening	Loss on 1 default, 20% recovery**
iTraxx Europe	Sell 5yr	81bp	20-147bp	0.81%	3.31%/1.52%	0.2/0.5	22bp	0.64%
	5s10s	10bp	6-25bp	0.46%	0.68%/0.51%	0.7/0.9	6bp	0.44%
iTraxx Sen Fin	Sell 5yr	68bp	7-147bp	0.68%	3.35%/1.47%	0.2/0.5	19bp	3.20%
	5s10s	6bp	-1-15bp	0.41%	1.85%/0.97%	0.2/0.4	6bp	2.23%
iTraxx Sub Fin	Sell 5yr	117bp	13-246bp	1.17%	4.92%/2.24%	0.2/0.5	33bp	3.20%
	5s10s	3bp	-8-31bp	0.75%	2.31%/1.12%	0.3/0.7	11bp	2.23%
iTraxx HiVol	Sell 5yr	152bp	39-274bp	1.52%	4.20%/2.37%	0.4/0.6	43bp	2.67%
	5s10s	15bp	-4-41bp	0.83%	1.08%/1.18%	0.8/0.7	12bp	1.72%
iTraxx Xover	Sell 5yr	466bp	152- >1,500bp	4.66%	9.03%/10.15%	0.5/0.5	137bp	1.60%
	5s10s	15bp	-150-107bp	2.13%	2.54%/4.08%	0.8/0.5	37bp	0.79%

*Note: Using 2001-2008 data, weekly observations, including QCX data. ** Expressed as percentage of 10yr notional in the case of the 5s10s steepener.*
Source: Markit, Barclays Capital

There is a wealth of information in this table. To select the most attractive index for a steepener we look for a number of properties:

A small trading range for the 5s10s curve, relative to carry. iTraxx Europe and Sen-Fin stand out on this metric. Unsurprisingly, the contrast with the 5yr trading range in each case is dramatic.

High carry per unit of mark-to-market volatility. The table measures this ratio both using a volatility calculated over the past 12 months and over the past seven years (all available data). On this metric, iTraxx Europe, HiVol and Crossover stand out with ratios in excess of 0.7. Note this number can be thought of as a form of Sharpe ratio. Among these, iTraxx Europe stands out due to its dramatic improvement over the 5yr outright trade (0.7 compared with 0.2 – a 3.5x improvement).

Low default exposure. iTraxx Europe stands out on this metric due to the larger number of names and hence smaller idiosyncratic exposures.

Further analysis and risk assessment

Some further comments on the relative attractiveness of the different indices for carry-generation through steepeners are given in Figure 32. We include a qualitative assessment of risk of curve technicals affecting the trade. For example, in iTraxx Europe we find that technicals on the curve itself are low but dynamics in the 5yr are significantly affected by technicals associated with the structured credit market.

Figure 32: Further qualitative considerations on suitability for steepener trades

Index	Liquidity	Curve technicals	Inversion risk assessment
iTraxx Europe S9	Greatest	Moderate	Risk of inversion low unless distress in many names (such as in CDX IG)
iTraxx Sen Fin S9	Poor	High	Risk of small inversion in the event that Sen-Fin trades wide of iTraxx Europe
iTraxx Sub Fin S9	Poor	High	Risk of significant inversion on further widening
iTraxx HiVol S9	Moderate	Low	Risk of significant inversion on further widening or distress/downgrades occurring
iTraxx Xover S9	Moderate	Low	Greatest risk of inversion over a longer horizon as default risk gets gradually priced in

Source: Barclays Capital

Figure 33 presents both the full time-series of iTraxx Europe on-the-run 5s10s and the full weekly returns distribution comparison between the 5yr sell protection and DV01-neutral 5s10s steepener trades.

Figure 33: iTraxx steepener – historical curve shape and weekly returns distribution

QCX/Actual iTraxx Main on-the-run 5s10s slope time series

Comparison of weekly mark-to-market distribution for 5s10s DV01-neutral steepener compared with outright 5yr position in iTraxx Main
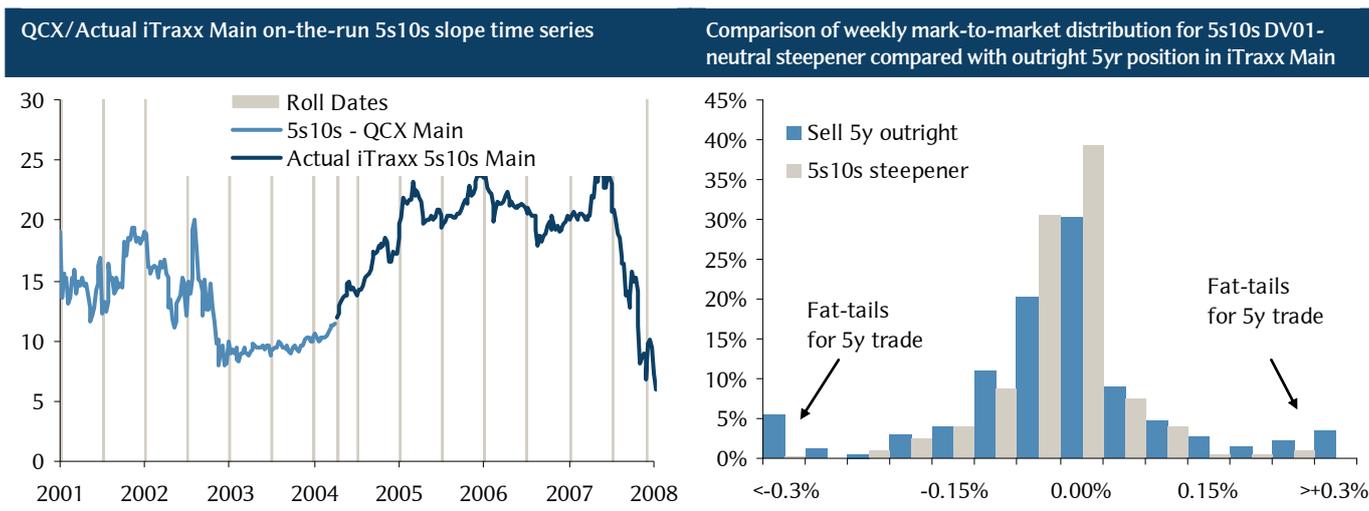
Source: Markit, Barclays Capital

Curve volatility: October 2008 update

Given the extreme volatility of the September – October 2008 period it is interesting to update the above analysis. For the first time, the iTraxx Main 5s7s and 5s10s curves have inverted, trading more in line with CDX IG (see *Systematic curve strategies* for more detail). A surge of front-end protection buying by loan books hedging drawn corporate liquidity facilities contributed to an unusually high period of curve volatility.

These developments immediately flag the question of whether the arguments of higher carry per unit volatility have continued to hold in this period. To answer this we look at performance of selling 5yr iTraxx Main S8 protection versus 5s10s DV01-neutral steepeners on the same index. We scale the two trades such that the carry earned on the steepener is equal to the carry earned on the outright 5yr position.

Figure 34 shows both the cumulative returns of these two strategies and rolling volatility of mark-to-market. In both cases, we see the steepener has outperformed the outright 5yr position – both on absolute returns, and on realised mark-to-market vol. However, in both cases the curve flattening of the last few weeks has diminished that outperformance substantially.

Figure 34: Comparing selling 5yr to carry-matched DV01-neutral steepeners during this period

Comparison of indicative cumulative returns during 2008

Comparison of rolling 12-week mark-to-market volatility during 2008
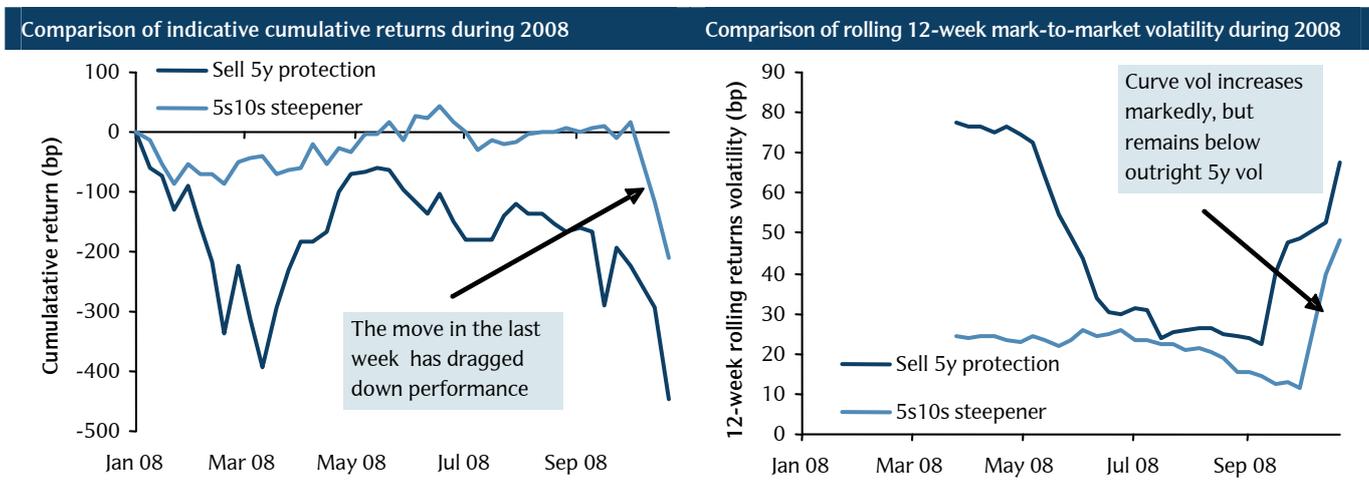
Source: Markit, Barclays Capital

Beta strategies using hold-to-maturity curves

Extract from *Off the run iTraxx trading*, *14 August 2008.*

In this section, we examine long-horizon strategies based on steepeners on the indices. Such strategies were extremely popular with investors during the credit bull market, but also led to substantial losses during the credit crunch. Frequently, investors use the on-the-run index to position a steepener trade. Figure 35 shows cumulative total returns of holding steepeners in a rolling strategy across the on-the-run series, using the following assumptions:

- 5s10s steepener initiated at the inception of each new index, weights set to be DV01-neutral at the beginning.

- Trade is unwound at the end of the six-month on-the-run series.

- We use the QCX iTraxx Main and XO series in the period March 2001-June 2004.

Overall, the on-the-run returns shown in Figure 35 closely resemble the 5yr outright on-the-run returns shown in Figure 26, but with modified scaling in terms of return magnitudes. This is in itself interesting as it empirically verifies the long credit-risk nature of steepeners. It is interesting to note, though, that despite significant curve steepening in Main during the 2003-06 period, the profits generated were small and easily wiped out by the flattening witnessed in H2 07 and H1 08. For XO, the carry and steepening profits during 2003-06 were much more substantial, building up something of a cushion against the collapse in curves at the beginning of 2008.

Figure 35: Cumulative returns for rolling on-the-run steepener strategies
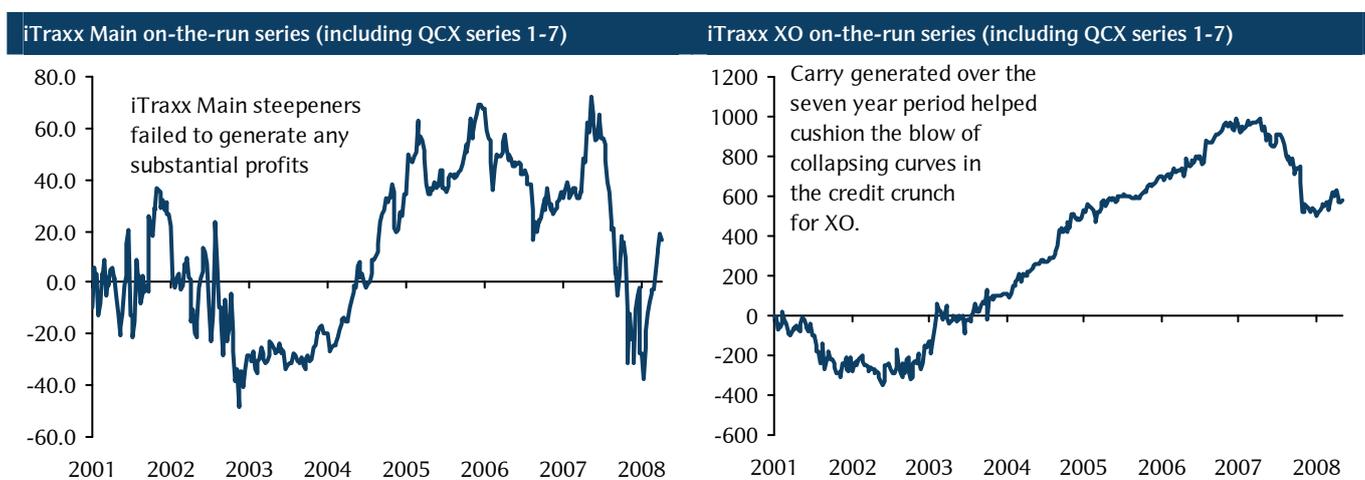
Source: Markit, Barclays Capital

Long-horizon strategies on curves

In a similar fashion to the previous section we can also investigate the properties and performance of steepener strategies held until maturity of the 5yr leg on each individual index. In the case of curves, this becomes a more complex strategy, because the decay in the DV01 sensitivities of the 5yr and 10yr contracts causes a fixed-weight strategy to become non-DV01-neutral over time. This will lead to the trade having a net long or short exposure in addition to the curve exposure, which may transform the intended trade.

Figure 36 shows the ratio of 5yr protection that needs to be sold per unit of 10yr protection bought to maintain DV01-neutrality (that is, P&L immunity to small parallel shifts in spreads) over the full life of a 5s10s steepener (up to the maturity of the 5yr leg). It is not practical to dynamically hedge this precisely, especially as we get closer to maturity.

For a discussion of DV01 weights and other curve topics please refer to the *CDS Curve Trading Handbook 2008*.

Figure 36: The ratio of 5yr protection to be sold against one unit of 10yr protection bought to maintain DV01-neutrality increases over time
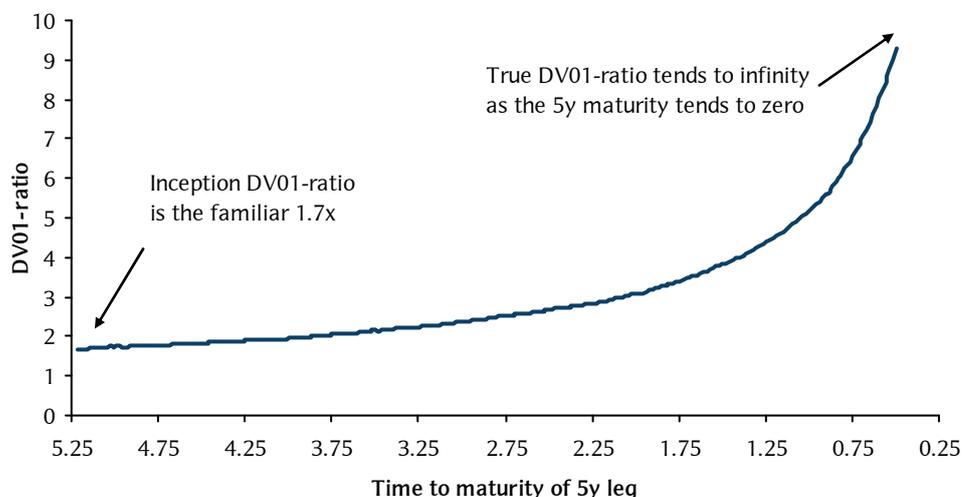
Source: Barclays Capital

As a solution to this problem we consider three options for weighting steepener strategies, detailed in Figure 37.

Figure 37: Weighting schemes for long-holding period steepeners

Weighting scheme	Advantages	Disadvantages
Fixed weights: Trade is set to be DV01-neutral at inception and kept fixed	Simple to implement, fixed jump-to-default exposure	As the trade progresses the position becomes increasingly net short credit duration
Dynamic weights: Trade is set to be DV01-neutral at inception and then delta-hedged every six months to maintain DV01-neutrality	Trade remains a true curve trade throughout, with limited net long or short duration	As the trade progresses, it requires more and more protection to be sold on the 5yr, increasing jump-to-default risk
Fixed-default exposure weights: A third option is to maintain DV01-neutrality, but scale the overall trade to have exactly one unit of jump-to-default exposure	Trade remains DV01-neutral and has fixed and manageable jump-to-default risk	More complex to implement, trade becomes gradually lower and lower beta to the market

Source: Barclays Capital

The fixed weights strategy is the simplest and probably most commonly implemented. Figure 38, however, highlights the risks associated with this strategy. The chart shows the net DV01 of the curve position – that is, the basis point mark-to-market loss incurred per 1bp parallel tightening in spreads. Towards the end of the trade, this grows to around 3bp, or, equivalently, approximately the DV01 of being outright long a 4yr index.

Figure 38: Fixing the DV01-ratio at inception results in the trade becoming increasingly net short credit risk over time
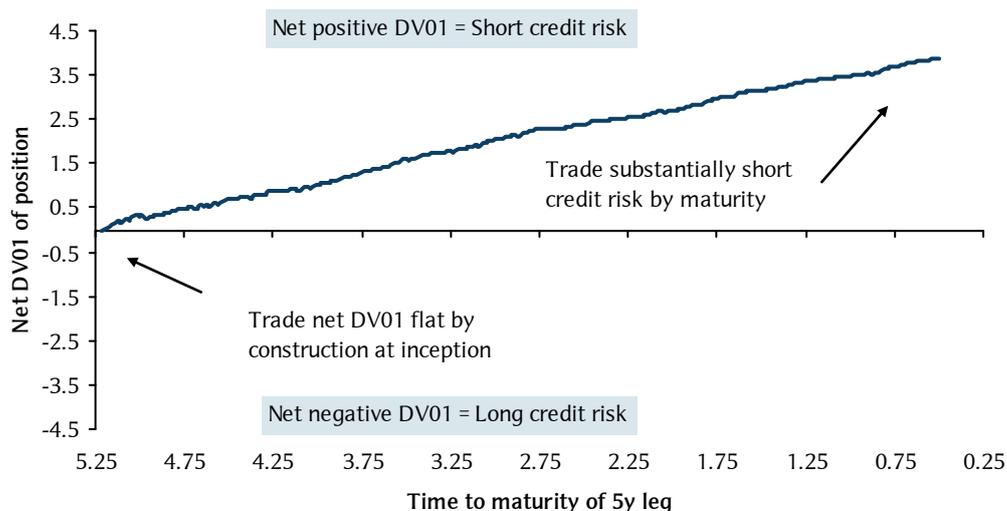
Source: Barclays Capital

The third option of fixed default exposure is possibly the most attractive, as it benefits from fixed risk in this sense, as well as DV01-neutrality. However, this strategy requires active rebalancing over time. Figure 39 illustrates the required weighting scheme through the life of the 5yr leg of the trade. In this example, we specify a fixed jump-to-default exposure of €10mn. In other words, the difference between the 5yr and 10yr notionals must always equal this amount. The notionals are then scaled so that they are DV01-neutral at each point in time.

The notionals start at around €25mn short protection on the 5yr and €15mn long protection on the 10yr. Over time these weights fall quickly. With one year remaining to maturity, the weights fall to around €13mn short protection on the 5yr and just €3mn long protection on the 10yr.

Figure 39: In the case of fixed jump-to-default (JTD) exposure of €10mn and DV01-neutrality, the required weights decrease through time
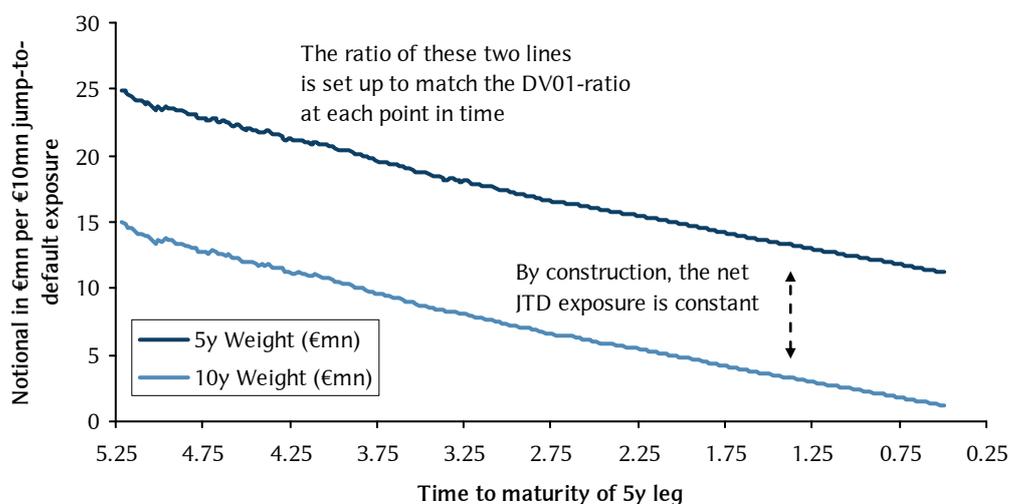
Source: Barclays Capital

It is useful to look at the performance of all three weighting schemes over long-holding periods. Example performance is given in Figure 40. The panel is divided into three rows. The first row shows performance under fixed weights, the second under DV01-

weights with constant 10yr notional and the third under fixed jump-to-default weights. For brevity, we report only iTraxx Main results here – in terms of the comparison of weighting schemes, the iTraxx XO patterns are similar.

In each chart we look at the cumulative returns of the 5s10s steepener versus the cumulative returns of simply selling 5yr protection on the same series. The left-hand charts use iTraxx series 1, which covers the full credit bull-market and credit crunch so far. The right-hand chart uses QCX iTraxx S2, showing returns up until unwinding at the maturity of the 5yr leg in December 2006.

For the dynamic strategies we use six monthly rebalancings, and we fix the maximum weight on the 5yr to 5x the weight on the 10yr. The bp total returns given in the following figures use the following conventions:

- Fixed weights: Total return expressed as basis points of fixed10yr notional

- DV01 weights: Total return expressed as basis points of fixed10yr notional

- Fixed JTD weights: Total return expressed as basis points of fixed difference in notionals, or jump-to-default exposure.

A number of interesting observations can be made from the charts in Figure 40:

- For the fixed-weights strategies, we find that the performance in the first half of the sample is somewhat correlated with the outright short 5yr protection position, but with a lower beta. In the second half of the sample the performance is largely driven by the net short DV01 exposure that evolves in the curve position. The result of this is dramatic in each case and leads to a negative correlation with the 5yr. In particular, the fixed weights strategy on S1 iTraxx outperforms dramatically in the credit crunch, while the QCX S2 underperforms in the credit rally.

- In the case of the DV01-neutral returns, the 5s10s returns are similar in the first half period but in the second-half period become quite volatile because of the large amount of notional protection sold on the 5yr. In both the case of S1 and QCX S2, the roll-down effects are dramatic in the second half, leading to outperformance versus the outright 5yr.

- The fixed JTD weights actually provide the most stable performance of the three. The first half period again shows similar performance, but the second half shows more stable positive returns in both cases. Here, the roll-down effects really benefit the steepener in the latter stages, and despite the falling notionals, returns still accumulate, but volatility and risk do not grow with time as for the other two weighting schemes.

Figure 40: Long-horizon 5s10s strategies – comparing cumulative P&L versus selling 5yr protection

Fixed weights: 5s10s benefit from net short-credit exposure in credit crunch

iTraxx S1

5s10s Cumulative returns
5y Cumulative returns

Fixed weights: 5s10s suffer from net short-credit exposure in credit rally

QCX iTraxx S2

5s10s Cumulative returns
5y Cumulative returns

DV01-neutral: 5s10s stronger performance but higher volatility in latter stages as notionals grow on the 5yr

iTraxx S1

5s10s Cumulative returns
5y Cumulative returns

DV01-neutral: 5s10s stronger performance but higher volatility in latter stages as notionals grow on the 5yr

QCX iTraxx S2

5s10s Cumulative returns
5y Cumulative returns

DV01-neutral and fixed unit jump-to-default: Steady performance throughout, with minimal volatility in latter stages

iTraxx S1

5s10s Cumulative returns
5y Cumulative returns

DV01-neutral and fixed unit jump-to-default: Steady performance throughout, with minimal volatility in latter stages

QCX iTraxx S2

5s10s Cumulative returns
5y Cumulative returns

Source: Markit, Barclays Capital

Overall, we find the properties and empirical performance of the fixed JTD weights to be most appealing for steepener strategies, despite the additional cost and complexity of dynamic re-weighting. Figure 41 presents full summary statistics for iTraxx Main steepener strategies using this weighting scheme, with the same fields as the table in Figure 29.

The point of including the second-half sample period results becomes clear here. As we saw from Figure 40, this period is often better for steepeners as the real kick from the roll-down effects may be felt. Although this will not always be the case – especially if the second-half period includes a higher default rate regime – it is nonetheless important to note. In particular, there is a marked contrast with the typical performance of off-the-run steepeners versus the rolling on-the-run steepeners we saw in Figure 35.

Figure 41: iTraxx Main summary return, volatility and Sharpe ratios for steepener strategies, using dynamic DV01-neutral, fixed jump-to-default weights

Series	Start date	End date	Cumulative rtn (bp)	Average annual rtn (bp)	Annual volatility (bp)	Annual Sharpe ratio	2nd half average annual rtn	2nd half average annual Sharpe ratio
iTraxx Series 1	Jun 04	Jul 08	224	55	77	0.7	33	0.4
iTraxx Series 2	Sep 04	Jul 08	269	70	73	1.0	60	0.7
iTraxx Series 3	Mar 05	Jul 08	161	48	64	0.8	69	0.9
iTraxx Series 4	Sep 05	Jul 08	151	53	65	0.8	89	1.0
iTraxx Series 5	Mar 06	Jul 08	58	25	82	0.3	67	0.6
iTraxx Series 6	Sep 06	Jul 08	50	27	73	0.4	13	0.1
iTraxx Series 7	Mar 07	Jul 08	15	11	95	0.1	8	0.1
iTraxx Series 8	Sep 07	Jul 08	-67	-81	126	-0.6	138	1.0
iTraxx Series 9	Mar 08	Jul 08	63	193	75	2.6	100	1.1
QCX iTraxx Series 1	Mar 01	Jun 06	222	42	96	0.4	35	2.4
QCX iTraxx Series 2	Sep 01	Dec 06	112	21	85	0.3	13	1.3
QCX iTraxx Series 3	Mar 02	Jun 07	123	24	45	0.5	10	0.8
QCX iTraxx Series 4	Sep 02	Dec 07	175	34	51	0.7	8	0.5
QCX iTraxx Series 5	Mar 03	Jun 08	248	47	30	1.6	36	1.2
QCX iTraxx Series 6	Sep 03	Jul 08	262	54	33	1.6	35	0.8
QCX iTraxx Series 7	Mar 04	Jul 08	274	63	42	1.5	53	1.0

Note: Returns are expressed as bp of the notional difference between 5yr and 10yr. Source: Markit, Barclays Capital

Figure 42 reports similar returns and statistics for the XO indices. Broadly speaking, the results and patterns we observe are similar. However, in this case, the additional benefit over rolling strategies is less pronounced.

Figure 42: iTraxx XO summary return, volatility and Sharpe ratios for steepener strategies, using dynamic DV01-neutral, fixed jump-to-default weights

Series	Start date	End date	Cumulative rtn (bp)	Average annual rtn (bp)	Annual volatility (bp)	Annual Sharpe ratio	2nd half average annual rtn	2nd half average annual Sharpe ratio
iTraxx Series 1	Jun 04	Jul 08	1280	313	368	0.8	100	0.4
iTraxx Series 2	Sep 04	Jul 08	1432	372	317	1.2	150	0.6
iTraxx Series 3	Mar 05	Jul 08	891	266	250	1.1	105	0.4
iTraxx Series 4	Sep 05	Jul 08	487	171	259	0.7	-24	-0.1
iTraxx Series 5	Mar 06	Jul 08	239	102	291	0.3	-246	-0.7
iTraxx Series 6	Sep 06	Jul 08	100	54	453	0.1	-494	-0.9
iTraxx Series 7	Mar 07	Jul 08	-560	-416	474	-0.9	-373	-0.6
iTraxx Series 8	Sep 07	Jul 08	-551	-666	560	-1.2	512	1.3
iTraxx Series 9	Mar 08	Jul 08	190	581	343	1.7	392	1.0
QCX iTraxx Series 1	Mar 01	Jun 06	500	95	263	0.4	92	1.7
QCX iTraxx Series 2	Sep 01	Dec 06	548	105	184	0.6	79	2.3
QCX iTraxx Series 3	Mar 02	Jun 07	737	140	258	0.5	49	1.2
QCX iTraxx Series 4	Sep 02	Dec 07	586	112	596	0.2	23	0.5
QCX iTraxx Series 5	Mar 03	Jun 08	1427	273	223	1.2	60	0.9
QCX iTraxx Series 6	Sep 03	Jul 08	1276	263	143	1.8	95	0.9
QCX iTraxx Series 7	Mar 04	Jul 08	1161	267	113	2.4	92	0.8

Note: Returns are expressed as bp of the notional difference between 5yr and 10yr. Source: Markit, Barclays Capital

Beta strategies using index forwards

As a final topic on beta strategies we look at using credit forwards to express directional views on the market. Forward protection trades, proxied by equal weight curve trades, do not take default risk at all until the forward start date, but do have credit spread directional sensitivity. In general we would expect to find the following results:

- Short forward protection strategies should outperform spot short protection strategies during periods of stress with elevated default risk, since default payments need not be made and curve flattening should benefit the trade.

- In more benign periods, short forward protection should underperform spot short protection strategies due to the lower carry earned and any curve steepening.

- Short forward trades should consistently have lower tail risk than short outright strategies.

Further explanations of these two points, as well as credit forward strategies in general, are discussed at length, both from a theoretical and strategy point of view, in *Trading CDS index forwards*.

Selling 5yr5yr forward protection as a long credit trade

Selling 5yr CDS protection 5 years forward (abbreviated as 5yr5yr) on a rolling basis is a trade which has zero direct default exposure but has negative DV01 – ie, the trade loses money as spreads widen (equivalently, makes money as spreads tighten). In the following charts we will compare systematically selling on the run 5yr5yr protection versus selling straight 5yr spot protection. All comparisons will be done on the basis of matched DV01 sensitivity. That is, we set up the forward trade to have the same net DV01 as the outright 5yr trade at the beginning of each index roll period. Figure 43 shows an example set up for iTraxx Main today.

Figure 43: Example iTraxx Main series 10 comparison trades with equal net DV01 exposure, 28th September 2008, 40% recovery assumption

	5yr notional	10yr notional	5yr DV01	10yr DV01	Net DV01	Value on default
Short 5yr protection	-€10,000,000	0	-€4,400	0	-€4,400	-€48,000
Short 5yr5yr forward protection	€14,000,000	-€14,000,000	€6,100	-€10,500	-€4,400	0

Source: Markit, Barclays Capital

Note that on a more tactical basis, buying forward protection can also make sense.

In Figure 44 we show the cumulative total return of selling 5yr protection 5 years forward on the iTraxx Main on-the-run series, rolling every six months. The broad performance patterns are very similar, justifying the claim above that the forward strategy has a positive beta to the market. We also see the relative out-performance/underperformance described. Naturally, this sample period is somewhat biased due to a lack of actual defaults.

Figure 44: iTraxx Main, rolling on-the-run cumulative returns
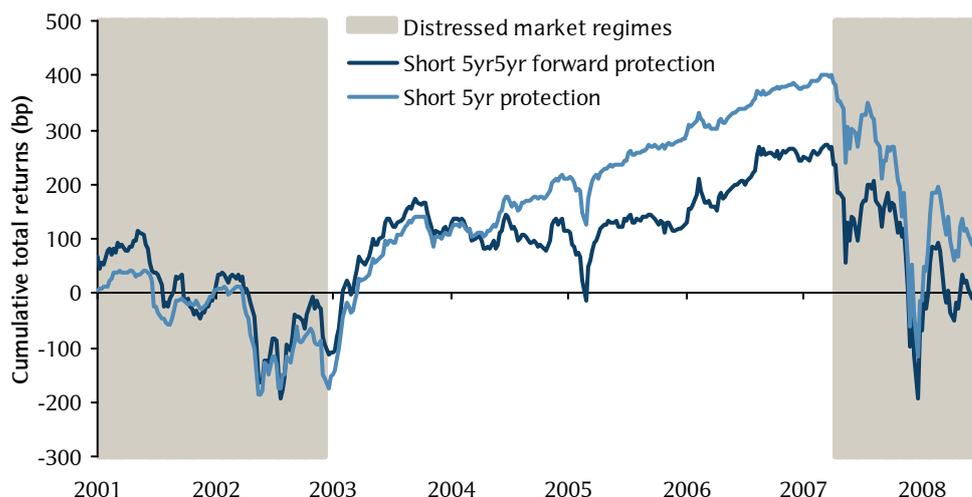
Source: Markit, Barclays Capital

Figure 45 provides a more detailed breakdown of performance, split benign and distressed credit market conditions.

Figure 45: Contrasting the performance across different periods, iTraxx Main
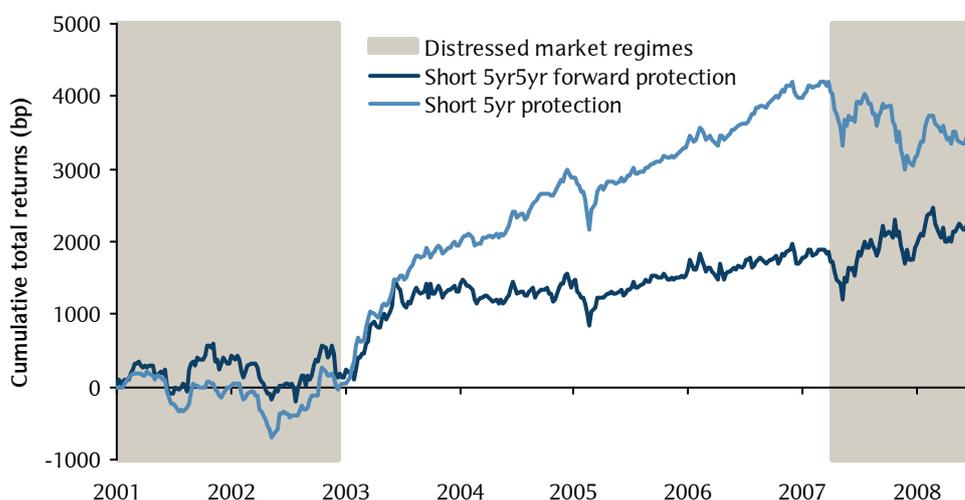
	Full period 2001-2008		Distressed market periods		Benign market periods	
	5yr spot	5yr5yr forward	5yr spot	5yr5yr forward	5yr spot	5yr5yr forward
Annual total return (bp)	-9	-23	-189	-154	123	72
Annual volatility (bp)	159	173	232	244	64	89
Sharpe ratio	-0.1	-0.1	-0.8	-0.6	1.9	0.8

Source: Barclays Capital

Figure 46 plots the analogous chart for iTraxx Xover. Broadly, the patterns are the same. However, interestingly, the outright 5yr underperformance on Xover has been much more muted during the current crisis so far. We would expect a much greater divergence as high yield default rates rise in the coming period. Note that the historical performance shown here before 2004 is using our original, rather than the more extreme rating-adjusted version introduced in the *Appendices*.

Running the analysis on the rating-adjusted series would demonstrate a far greater outperformance of the forwards strategy over the spot in the 2001-2002 period.

Figure 46: iTraxx Xover, rolling on-the-run cumulative returns

Source: Markit, Barclays Capital

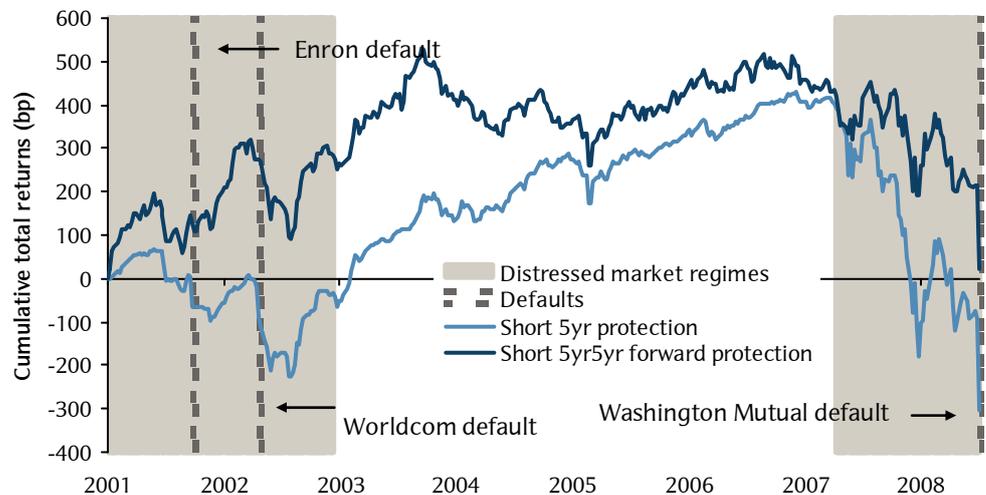Figure 47 summarises the performance stats for iTraxx Xover.

Figure 47: Contrasting the performance across different periods, iTraxx Xover

	Full period 2001-2008		Distressed market periods		Benign market periods	
	5yr spot	5yr5yr forward	5yr spot	5yr5yr forward	5yr spot	5yr5yr forward
Annual total return (bp)	426	264	-266	135	932	359
Annual volatility (bp)	552	643	674	768	432	536
Sharpe ratio	0.8	0.4	-0.4	0.2	2.2	0.7

Source: Barclays Capital

Our final comparison is on CDX IG – the only series to have experienced a substantial number of defaults in the 2001 to 2008 period. The chart in Figure 48 shows the two returns time-series along with actual default events marked out. We do not mark out the Fannie Mae and Freddie Mac defaults as these did not generate substantial returns.

Figure 48: CDX IG, rolling on-the-run cumulative returns

Source: Markit, Barclays Capital

Figure 49 shows results in tabular form with again the same patterns coming through from the other tests.

Figure 49: Contrasting the performance across different periods, CDX IG

	Full period 2001-2008		Distressed market periods		Benign market periods	
	5yr spot	5yr5yr forward	5yr spot	5yr5yr forward	5yr spot	5yr5yr forward
Annual total return (bp)	-41	3	-232	-37	99	32
Annual volatility (bp)	171	169	247	223	74	115
Sharpe ratio	-0.2	0.0	-0.9	-0.2	1.3	0.3

Source: Barclays Capital

Effect on returns distribution

A further analysis that is informative is the returns distributions of the outright short 5yr protection and short 5yr5yr forward protection strategies. Figure 50 shows these for the CDX IG series. We plot the frequency of weekly return observations in different buckets. The two profiles turn out to be surprisingly similar. There is a perceptible fatter tail, however, on the outright strategy, generated in part by the default events. We also record the 99% VaR (value at risk) calculations, verifying the fatter tails quantitatively.

Figure 50: Returns distribution, CDX IG, 2001 to 2008
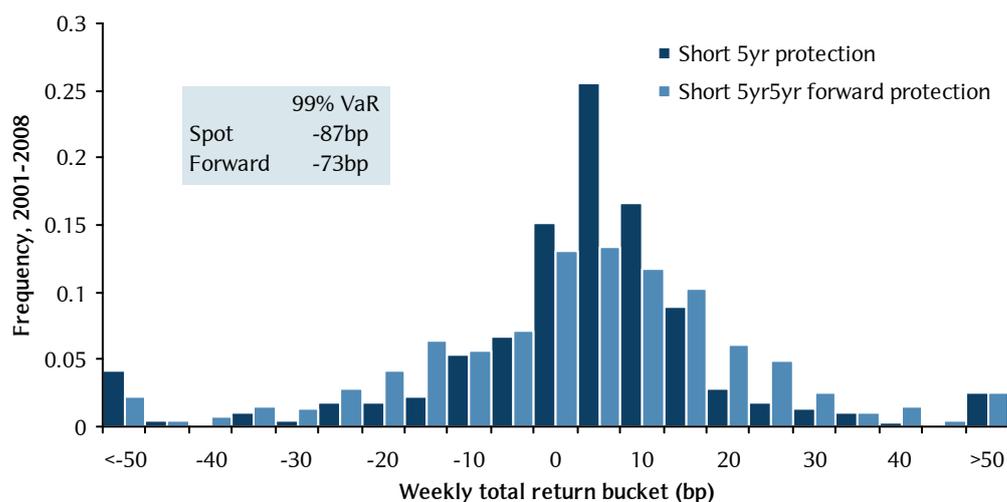
Source: Markit, Barclays Capital

It is worth noting that the benefit of the forward strategy in terms of reducing tail risk is less pronounced in the broad indices with 125 names, since the impact of an individual default is only small. A much greater difference in profile can be expected on the smaller indices – especially the Xover and HiVol indices which have riskier companies and fewer constituents.

Variable Default EXposure beta strategy– VDEX

For an investor who is required to have a positive beta to the credit market, but who wishes to avoid the severe credit downsides and participate when possible in the upside, it may be attractive to switch between the two strategies outlined above – selling spot or selling forward protection.

We now outline a simple implementation of such a switching strategy borrowing technology which will be introduced formally in the next section on macro credit modelling. A regime-switching model is estimated on historical default data generating, at each point in time, a probability of being in an increasing or decreasing default rate regime. Based on this probability we can then establish a weight between the forward and spot strategies.

Properties of VDEX strategy:

- The strategy is "long credit" in the sense that it has an approximately fixed credit spread DV01 – that is, it will always benefit from a parallel shift tighter in spreads by the same amount regardless of its state.

- However, default exposure is variable through time, depending on the estimated probability of being in a high default regime.

- The carry profile consequently also changes with time, with lower carry as default exposure falls.

- Likewise, curve exposure is also variable, with greater curve sensitivity as default exposure falls.

The strategy has a conservative bias towards early switching out of default risk, implemented by setting the threshold for switching into the 100% forwards strategy once the probability of high default regime hits 33%.

Specifically, weights are constructed as follows and are reset monthly:

% Notional on 5yr5yr forwards = MIN(3 x Prob(High Default Rate Regime), 1)

% Notional on 5yr spot   = 1 - % Notional on 5yr5yr forwards

Figure 51 plots the effective proportion of notional exposed to default through time and the regime default probabilities. The default exposure is zero from 2001 to mid 2002, and again from the end of 2007. Please refer to *RPARS: A time-series/risk premium curve strategy* for further details of the probability estimation. Note that the regime estimation is carried out in-sample. Although we believe the default rate regimes to be suitably well behaved that out-of-sample performance should not differ markedly, a full out-of-sample test would be required to develop VDEX further.

Figure 51: VDEX strategy default exposure and regime probabilities
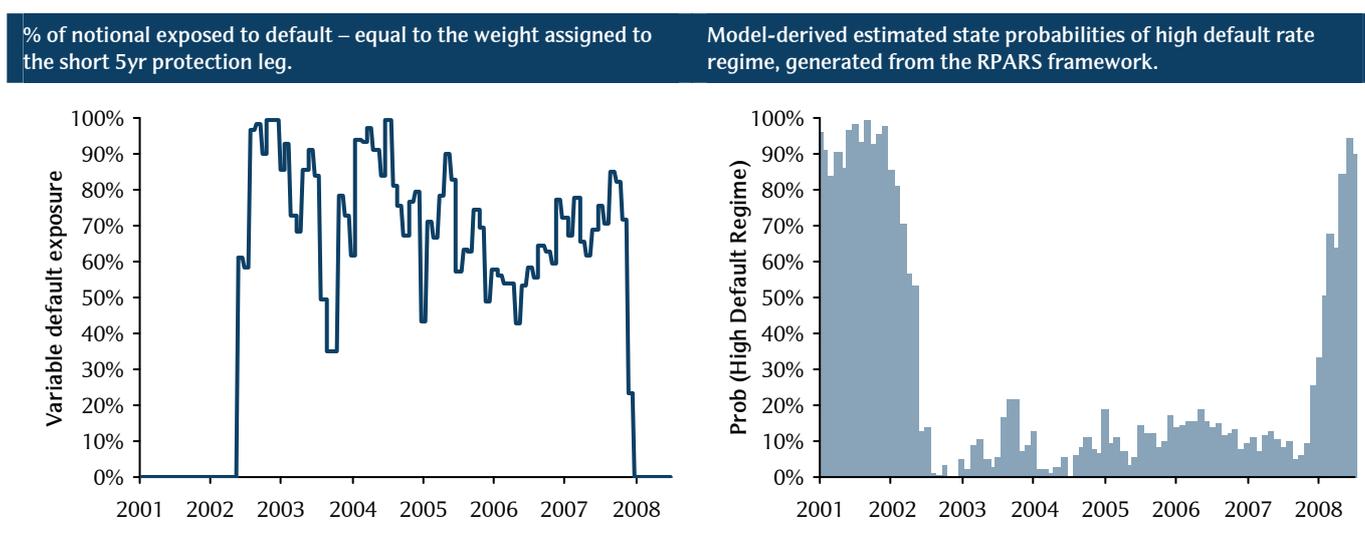
Source: Markit, Barclays Capital

Testing VDEX on CDX IG

We can compare the performance of VDEX with the two static component strategies. For these tests we use CDX IG as the base index, though we would expect to find broadly similar patterns for other indices. CDX IG, having experienced defaults, has possibly the most interesting historical returns profile.

Figure 52 shows the cumulative performance charts of VDEX versus the two separate strategies in the left-hand panel. VDEX clearly out-performs throughout the period, whilst retaining the long-credit profile as required. In the right-hand panel we show the returns differential with the outright short 5yr protection strategy. Not surprisingly, VDEX generates its out performance during the stressed credit regimes, and marginally underperforms short 5yr outright protection during the credit bull market period.

Figure 52: Comparing performance of VDEX on CDX IG with component strategies

| VDEX compared with short 5yr and short 5yr5yr forward protection | Cumulative differential between VDEX and short 5yr protection |
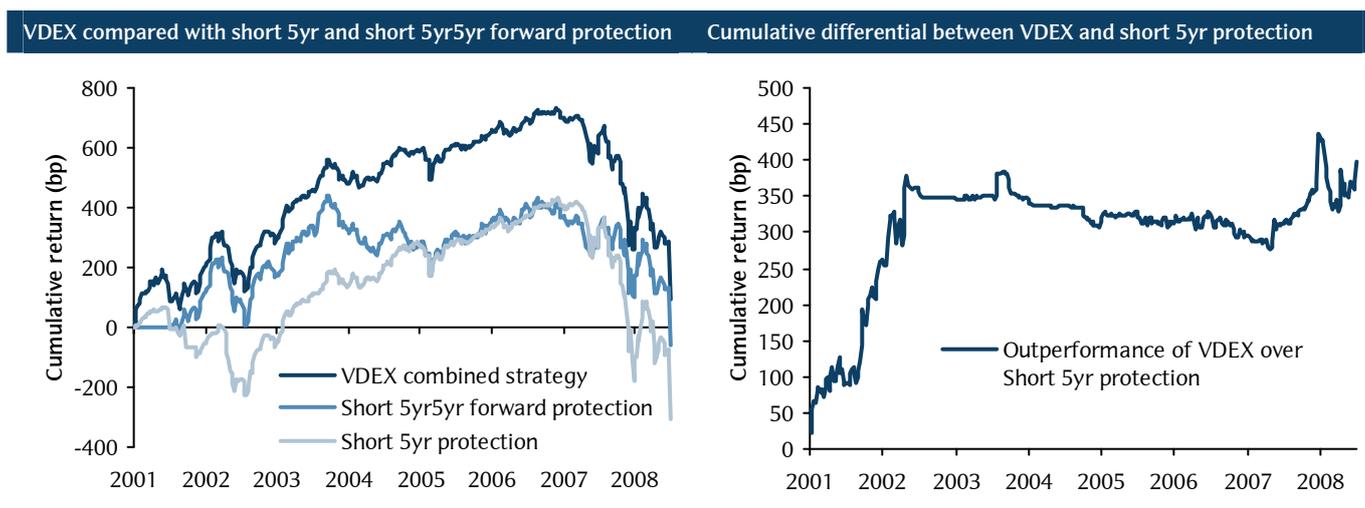
Source: Markit, Barclays Capital

Figure 53 provides more quantitative metrics of performance across the three approaches. Note first that the average DV01 (defined as the change in PV for a 1bp parallel tightening in the curve) is the same across all three – justifying the "long credit" claim of the VDEX strategy. Additionally, the returns correlation – or beta – with the underlying 5yr strategy is 91%.

The average carry generated by VDEX is between the carry generated by the basic strategies. Average annual performance has to be contrasted across strategies, where the VDEX strategy shows clear improvement over short 5yr and marginal improvement over short 5yr5yr forward protection. Due to the sample period involved, all the Sharpe ratios are close to zero.

The other measures of interest are the tail measures – specifically the 99% Value-At-Risk. VDEX shows a marginal improvement here over the other strategies. Average default exposure is a little over 50% of the notional assigned to the strategy. Clearly this sits in between the values for the two component strategies.

Figure 53: Comparing performance on different metrics on CDX IG

Strategy	Average annual return (bp)	Annual Sharpe ratio	Average DV01 (change in PV for 1bp parallel tightening)	Average annual carry (bp)	99% VaR	Average default exposure (% of notional)	Returns correlation with 5yr strategy
Short 5yr protection	-40.5	-0.2	+4.38	64bp	-87bp	100%	100%
Short 5yr5yr forward protection	3.2	0.0	+4.38	16bp	-73bp	0%	80%
Variable Default EXposure (VDEX)	12.2	0.1	+4.38	37bp	-72bp	53%	91%

Source: Markit, Barclays Capital

VDEX as an enhanced beta strategy

VDEX, even in this outline form, ticks many of the boxes to qualify as an enhanced beta strategy. In particular:

- VDEX is continuously equally long credit – in a spread duration sense – as outright selling rolling 5yr protection.

- Performance has a 90% correlation with selling rolling 5yr protection but lower tail-risk measures and higher average performance.

- VDEX takes default exposure in periods estimated to be low in default risk, and collects carry accordingly.

- VDEX zeros out default risk in higher default exposure periods.

# Macro positioning strategies with RPARS

We consider two distinct rules-based strategies for switching between long and short credit risk:

- Macro positioning (RPARS): We use fundamental macro credit inputs within a regime-switching model to dynamically allocate weight to a broad corporate bond index over a long time horizon. This strategy rebalances on a monthly basis.

- Micro positioning (NEMO): At the other end of the scale, NEMO is a high-frequency momentum strategy that rebalances at least daily. A full treatment of NEMO is given in the *High-frequency trading of CDS indices* section.

First we turn to algorithmic approaches to actually time the credit cycle itself. There is a very strong link, not surprisingly, between default rates and actual default rates, as pointed out in Figure 54. As a methodological note, we are considering the speculative grade default cycle here as that appears to be better in terms of the data set as well as its linkage to the economic cycle.

The graphs highlights how credit excess returns have tended to be negative as defaults are increasing. There is an important distinction here between "increasing" as opposed to "being at an elevated level". In fact, some of the biggest positive returns, cf. Q4 2002, have been staged in periods where default rates have been high, but importantly, decreasing.

Figure 54: US Bond index returns and speculative grade default rates
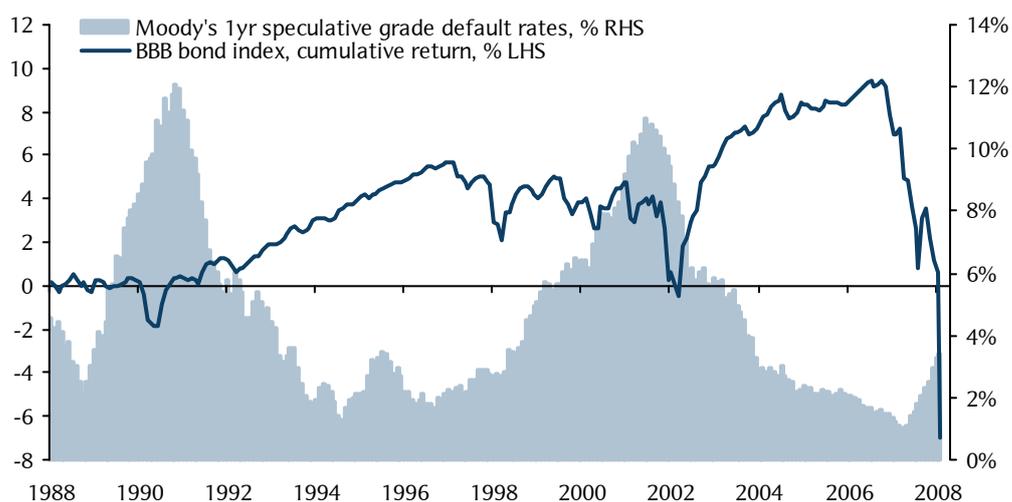
Source: Moody's, Barclays Capital

We have been analysing the corporate default cycle, and developing a quantitative framework to, more importantly, forecast it in a number of articles over 2006-2008. The box below provides links to some of the articles that we have written in this context. Figure 55 effectively summarises our forecasting framework, which largely is based on changes in lending conditions as reported by banks. The primary variable in this is the Federal Reserve's Senior Loan Officer's Opinion Survey (SLOOS). The SLOOS

reports quarterly results in terms of how banks are adjusting their lending standards on commercial and industrial (C&I) loans. Similar survey, but with much shorter histories, are available from the European Central Bank, Bank of England and Bank of Japan.

What comes out of the graph is clearly that banks' tightening of lending standards precedes moves in the corporate default cycle. Specifically, peaks in terms of how much banks have tightened standards have lead peak in the default cycle by around 12-18 months. This makes the SLOOS variable a strong candidate for ends of forecasting the default cycle.

Figure 55: C&I tightening and speculative grade default rates (with Barcap forecasts)
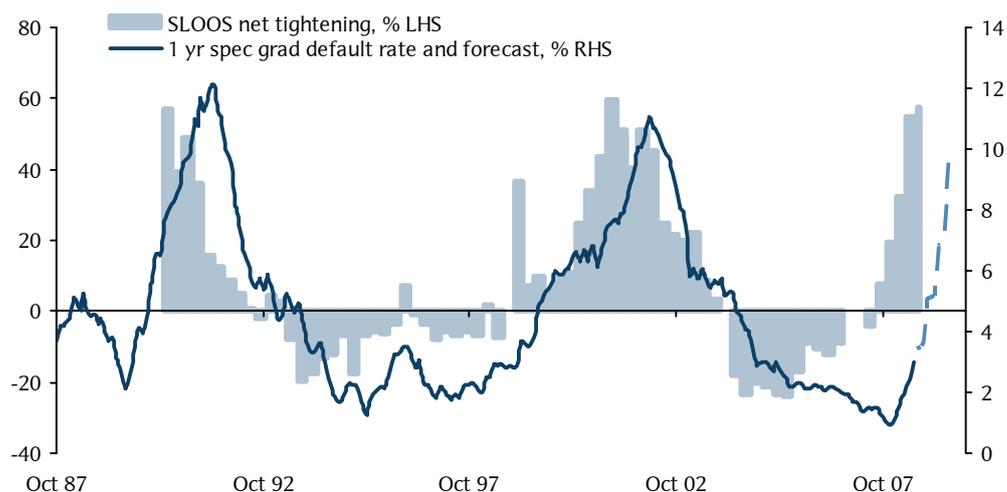
Source: Federal Reserve, Moody's, Barclays Capital

Systematic approaches on determining turning points in the credit cycle

For our macro quantitative analyses on the credit/corporate default/business cycle, see for example, The tale of two cycles – Credit and growth: a quantitative link, 8 October 2008; *Yield curve inversions, bank credit tightening and the credit cycle*, 8 February 2007; *Sub-prime volatility: Implications for the credit cycle turning point*, 30 March 2007; Default rate outlook 2008 in *Global Credit Market Strategic Outlook*, 12 December 2007; *Fed rate cuts and the default cycle: Assessing the empirical evidence*, 22 January 2008; and *The Crunch: Is it losing its bite?*, 2 May 2008. Please refer to *Lending standards – rate of tightening back to 2001*, 5 May 2008, for a comment on the Q2 SLOOS numbers.

There is also a strong link directly to valuations, as should be when we triangulate the links between credit excess returns/default rates/lending conditions. In Figure 56 we deploy 40 years worth of data in terms of lending conditions via the SLOOS and credit valuations. The figure is an excerpt from our early article, *Yield curve inversions, bank credit tightening and the credit cycle*, 8 February 2007. Although the imprecision in terms of the fairly coarse valuation data set makes exact inference difficult, one conclusion that we can draw both visually as well as quantitatively is that credit conditions tend to mover tighter (again, note the distinction between "move up" and "being high") in the run-up to valuations decreasing. In Figure 57, we plot the impulse response functions in terms of this, based on a fairly parsimonious Vector Auto-Regression. Please refer to the original article for full details.

Figure 56: Tightening in standards lending has led increasing yield differentials between BBB and AAA corporate bonds
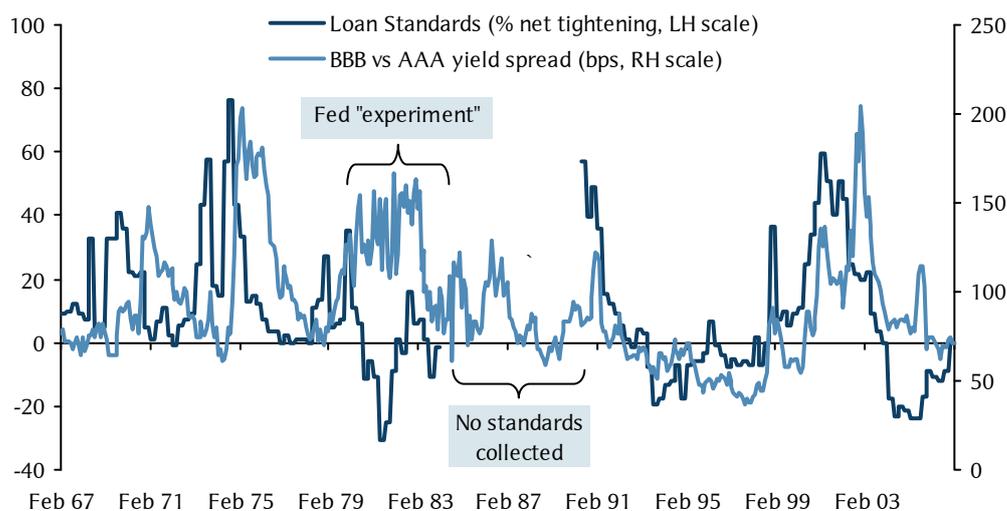
Source: Federal Reserve, Moody's Investor Services

Figure 57: Effects of tightening standards on the difference between BBB and AA OAS spreads (bps)
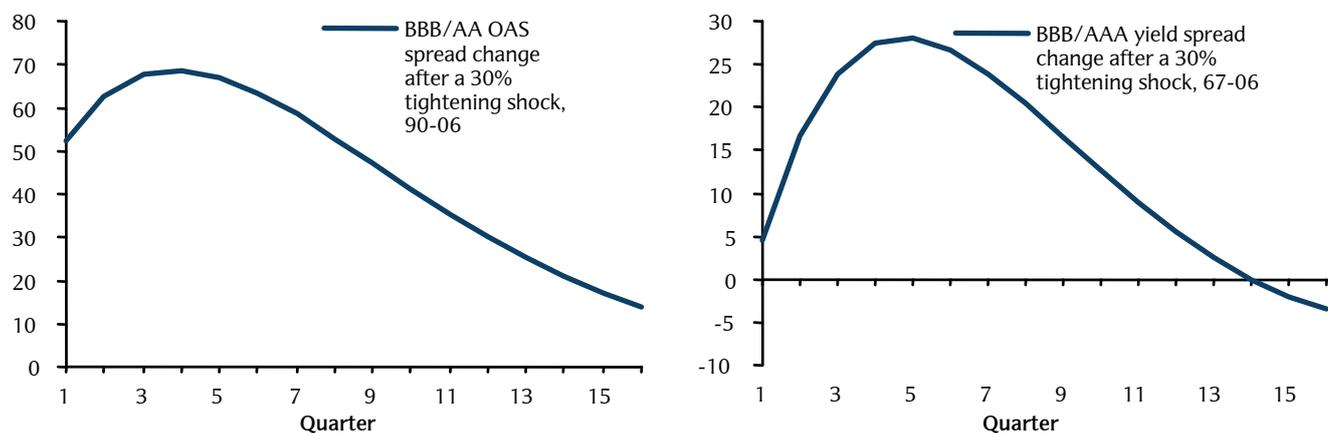
Source: The Yieldbook, Moody's Investor Services, Barclays Capital

Linking the macro framework to a trading strategy

By the end of the day, can we actually link these tentatively strong statistical linkages to a profitable trading strategy? We develop a dual approach to this, where the individual components are similar to the RPARS model. For ease of reference, this version of the model is denoted RPARS/ML (MacroLink). The trading strategy goes through the following steps:

▪ First, we apply a regime switching model to the default cycle itself, using the relationship shown in Figure 54. From this model, we derive probabilities that we are in either an increasing default rate regime, or a decreasing default rate regime.

▪ Second, we construct another regime switching model where the likelihood to transition from a positive return regime to a negative return regime is dependent on tightening of lending conditions. Hence, as illustrated in Figure 56, we deploy the forward looking power in the SLOOS data to infer the probability to switch into a weak regime. More detail on this procedure is available below.

Probabilities for either approach to determine if we are likely to be in a credit negative regime is available in Figure 58.

Figure 58: Probabilities to be in a credit negative regime according to the two macro approaches (versus cumulative excess returns on the intermediate bond index)
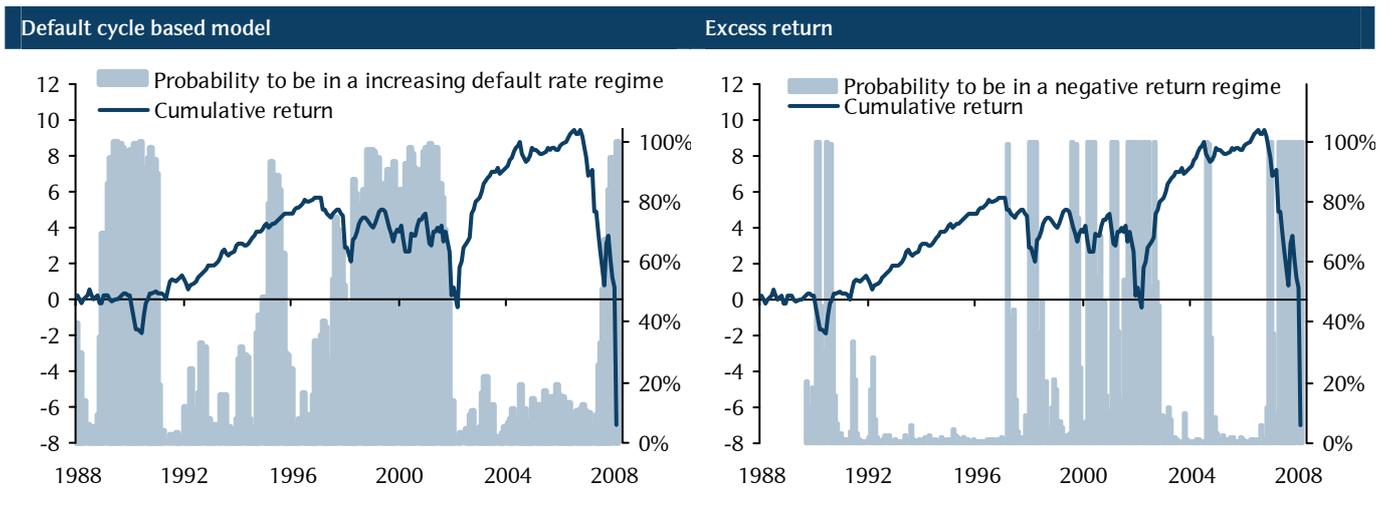
Source: Barclays Capital

Lastly, we note that due to the character of credit trading over the past 20 years, which has been in effect picking pennies in front of the steamroller, it makes sense to have a high propensity to switch into bearish mode fairly quickly in a downturn, even if this induces some short-term pain as carry is being leaked away. Based on this, we have the following allocation rule:

if **max [Prob(Increasing default regime at t+1);Prob(Negative return regime at t+1 based on SLOOS model)]** > 50% then short, otherwise be long (risk).

The positioning according to the RPARS MacroLink strategy, with ensuing cumulative return series is available in Figure 59. We can see that the strategy if fairly aggressive in terms of becoming bearish in the cycle, which is an effect well documented in our SLOOS based analytical framework (see specifically *Yield curve inversions, bank credit tightening and the credit cycle*, 8 February 2007, for an early warning of the 2007-2008 downturn in the credit cycle). It is also a fairly persistent signal, which is useful for trading purposes where you will naturally have to weight the frequency of trading and associated transaction costs versus potential alpha.

Figure 59: RPARS MacroLink allocation rule and cumulative returns
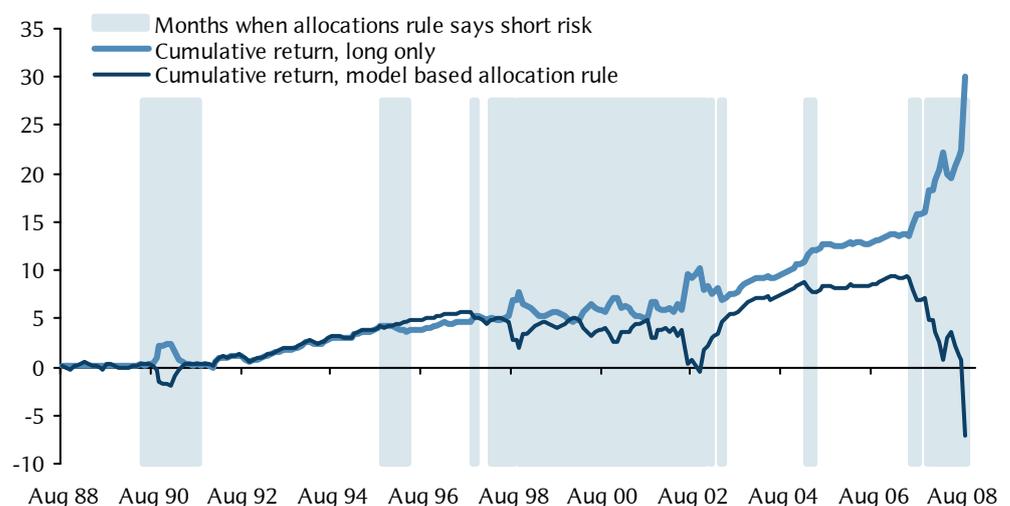
Source: Barclays Capital

In terms of returns, we must first confess the paltry numbers offered by the intermediate bond index in isolation. Cumulative (excess) returns over the period 1988 to date sums to -7.02%, with an extreme loss of 7% in September, 2008, pushing the cumulative return far into the negative. As late as October 2007, the index stood at a 7% positive, cumulative return. At that point the annualised Sharpe stood at 0.25.

Moving to RPARS/ML, numbers look more positive, as the allocation rule broadly appears to be going short/underweight in negative return periods. Cumulative returns are 29.8%/15.8% (Sept 2008/Oct 2007) with average monthly excess returns of 0.135%/0.075%. The associated Sharpe ratios are 0.64/0.59. So, despite a higher absolute performance once we include the last year, the risk-return ratio falls, as the magnitude of volatility has increased even more than the increase in returns over this year.

Figure 60: RPARS/ML benchmarked versus long index only

	RPARS/ML to Sept 08	RPARS/ML to Oct 07	Long index to Sept 08	Long index to Oct 07
Cumulative excess return	29.9%	15.8%	-7.02%	7.20%
Average monthly excess return	0.135%	0.075%	-0.029%	0.031%
Annualised Sharpe Ratio	0.64	0.59	-0.14	0.25

Source: Markit, Barclays Capital

The SLOOS based regime switching model

The model we apply is based on the following equation

$$y_t = \mu_1 \cdot \text{Prob}(S_t = 1) + \mu_2 \cdot \text{Prob}(S_t = 2) + \varepsilon_{t,Q_t} \tag{1}$$

where the coefficients μ_1, μ_2 are the average returns on the bond index in each of the respective regimes. We assume that $S_t = 1$ in the more positive return state, ie. $\mu_1 > \mu_2$. This is for notational simplicity and has no effect on the econometric results. The regime (or state) variable S_t is governed by a Markov process: for purposes of this expose, we note that the transition between one state to another is governed by a transition matrix $\mathbf{P}_t$, such that

$$\mathbf{P}_t = \begin{bmatrix} p_{11,t} & p_{12,t} \\ p_{21} & p_{22} \end{bmatrix}$$

In contrast to the model presented in REFERENCE TO RPARS, this transition matrix is time varying: we allow the probability to switch from the good state of the world into the bad state of the world (if you are a long bond investor) to be changing over time. Specifically, we use the following relationship:

$$p_{12,t} = (1 - p_{11,t}) = \frac{\exp(c + \phi SLOOS_t)}{1 + \exp(c + \phi SLOOS_t)}$$

This logistic specification forces the probability to be bounded [0,1], effectively mapping tightening of credit conditions, via the C&I net tightening data, to increasing likelihood to enter a low return state.

Micro-positioning strategies

At the other end of the spectrum of directional alpha strategies are micro/high-frequency approaches using intra-day data and trading rules. We dedicate the whole of the next chapter of this handbook to analysis of high-frequency strategies but provide here a short excerpt looking at the most developed of our rules-based systems, NEMO.

NEMO, standing for iNtra-day Exponential Momentum, is a trend-following strategy on CDS indices, using intra-day index quotes from multiple indices to construct trend filters and trading signals. Signals are generated on either a once-per-day or three times a day basis, depending on the application. The strategy therefore trades frequently to remain with the current trend direction.

The basic element of the NEMO trading strategy is straightforward: using a short-term and long-term moving average, we define a widening trend as when the short-term (ST) moving average is above the long-term (LT) moving average, and vice versa for a tightening trend. A depiction of this is given in Figure 61, where the light-grey/light-blue lines show the ST/LT moving averages.

Trading signals, as highlighted by the arrows in the figure, are then given at point of crossover between the ST and LT. In other words, when we switch from a widening to a tightening trend, as seen by the ST line crossing the LT line from above, we have a sell protection signal. We then hold on to that position of being long risk/short protection as long as the ST average stays below the LT average.

Figure 61: NEMO at work, 18-21 August 2008
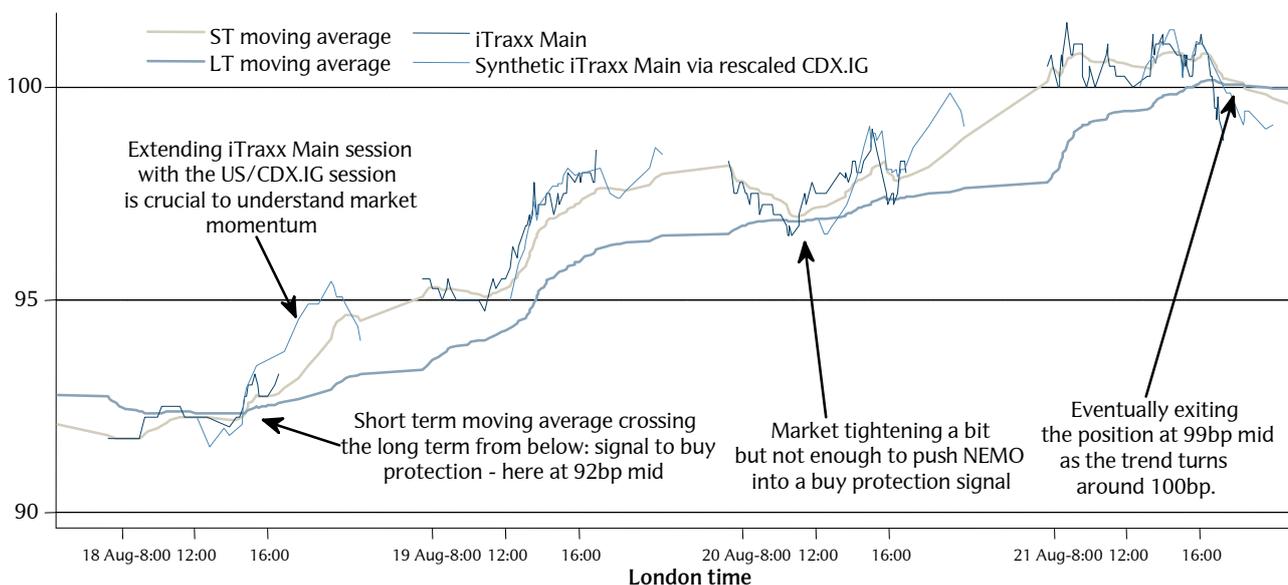
Source: Barclays Capital

Performance of NEMO

We provide some summary statistics in Figure 62 for the family of NEMO models suggested in this text. Performance has been in the range of 8-10% in terms of unlevered, excess return over the sample period

Figure 62: Summary statistics for NEMO strategies (post-transaction costs, 1 May 2007-22 October 2008)

	Cumulative return	Monthly avg return	Annualised Sharpe ratio	Number of trades	Cumulative transaction costs
NEMO/DT: iTraxx Main	9.4%	0.52%	1.7	127	2.8%
NEMO/DT: CDX.IG	10.8%	0.59%	1.6	110	4.6%
NEMO 8/12/16: iTraxx Main	8.2%	0.48%	1.1	247	5.9%
NEMO 8/12/16: CDX.IG	8.9%	0.52%	1.4	175	7.2%

Source: Barclays Capital

Performance of the NEMO/DT, CDX.IG is the strongest and most consistent on a post-transaction costs basis of all the investment grade NEMO strategies. Figure 63 plots cumulative returns and other diagnostics for this model. Performance is weaker in the July-October 2008 period, but still positive post-transaction costs. What we can see for the CDX version is that it had fairly modest returns in 2007, only generating 0.4% of return post transaction costs. The right-hand skew return distribution is even more protruding here compared to the 8/12/16 version, with two trades generating in excess of 2% of return each and the largest two losses in the 80-90bp range. The annualised Sharpe ratio reaches 1.6 versus 1.4 in the 8/12/16 strategy.

Figure 63: NEMO/DT for CDX.IG
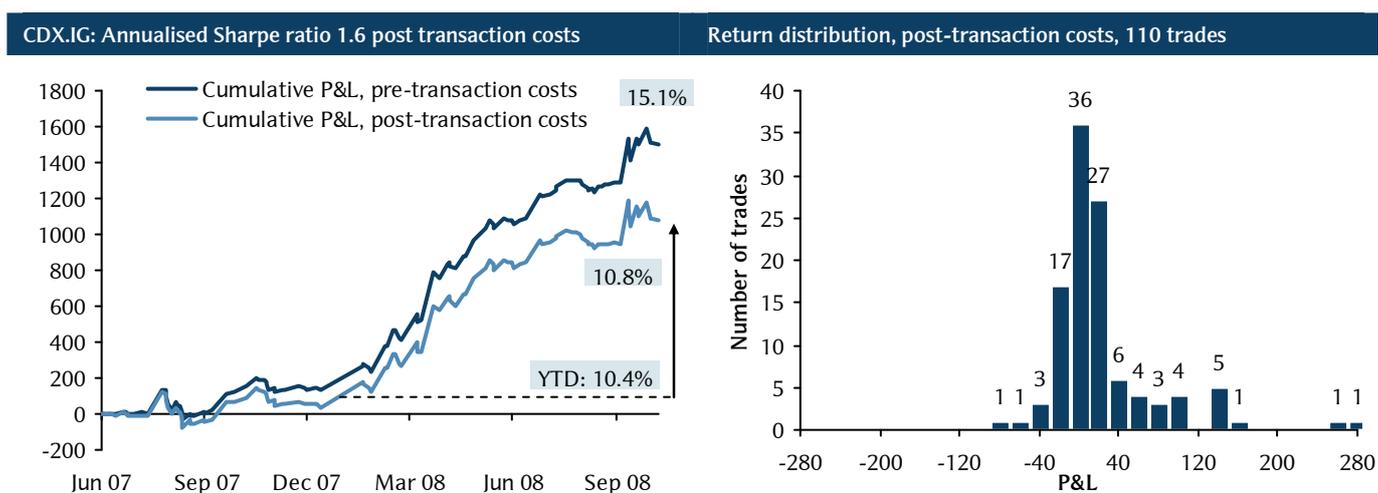
Source: Barclays Capital

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High-frequency trading of CDS indices

The turn of the credit cycle in 2007-08 very clearly highlighted that index strategies could not be based on monthly, weekly, or even daily data. A core issue of trading CDS indices is that of execution, which has been particularly apparent over the past year. Successful systematic index trading will have a significant execution component to add or subtract from the bottom line P&L. With intraday trading ranges in the IG indices up to 25bp, the notion that you can simply strike a trade at some aggregated end-of-day level is naïve at best. In such an environment, systematic strategies should be benchmarked versus actual trading levels.

But the intraday dynamics of spreads should be considered an opportunity rather than a difficulty. Whereas the spread moves between two trading days close-of-business (COB) levels may appear very jumpy, following them on an intraday basis makes it much easier to connect the dots. In this chapter, we dig deeper into the dynamics of CDS indices on an intraday level, thereby furthering the precision of the analysis, as well as giving us tools for systematic trading strategies. We divide the chapter into the following sessions:

- General analytics:

  ‣ We show how general trading strategies or typical target level type of trades can achieve higher precision both in terms of execution and testing the validity of other strategies.

  ‣ We analyse the challenges in a methodological sense to analyse intraday (tic-by-tic) data and look at the information that can be derived from it.

  ‣ We show how to make European, US and also Asian CDS index trading sessions less disjointed, both by using credit markets themselves and equity markets.

  ‣ We take a specific look at tail-risk event driven, during which spreads are in their most volatile state.

- High-frequency trading strategies:

  ‣ Event analysis with BEAM. We develop a framework to analyse and trade the impact of news flow and data releases on high-frequency CDS index moves.

  ‣ We show how the tic-by-tic momentum strategy NEMO in various forms has produced strong returns, not only over the credit volatility in 2007-08, but since inception of credit index trading.

  ‣ We analyse how NEMO can be interpreted as a long volatility strategy with similar characteristics to buying straddles, but at lower cost.

- General trading dynamics from an intraday perspective:

  ‣ How can Value at Risk (VaR) become more precise using intraday data? We show that intraday-based VaR gives a better description of tail risks, generally improving risk assessment around tail events. We also note that basing risk systems on intraday data can actually reduce the VaR of index positions.

  ‣ Impact of mark-to-market volatility. We show how static rather than dynamic, index trading can easily fall victim to tight mark-to-market constraints, even when directional calls are correct.

Intraday CDS analysis in practice

Pitfalls and opportunities in execution

An understandable, yet misguided, scepticism toward systematic strategies in credit can arise due to discrepancies between assumed execution levels and where one in practice can execute a trade. Even in our experience of recommending high-frequency trades within the NEMO framework, there is sometimes more imprecision than what one would ideally have, and this is in a system where the recommendation is out within a few minutes of a previously-quoted spread. In that sense, scepticism is well founded, but one has also to appreciate that intraday volatility can make for more attractive execution levels than a COB spread would indicate.

We illustrate this in Figure 64, where CDX.IG spreads are plotted for a few volatile sessions in September, 2008. The official closing levels of the index, as reported by MarkIT, are represented by dots in the chart. As we can see, they appear fairly accurate for a timing of 16:00 (EST) for the time at which they are contributed. What is more striking, however, are the trading ranges around these close of business (COB) levels, even on a very granular scale. On 16 September, for example, we see a trading range in excess of 45bp on CDX.IG between midday and after-market levels!

Figure 64: CDX.IG official closing levels versus spot trading ranges in volatile sessions
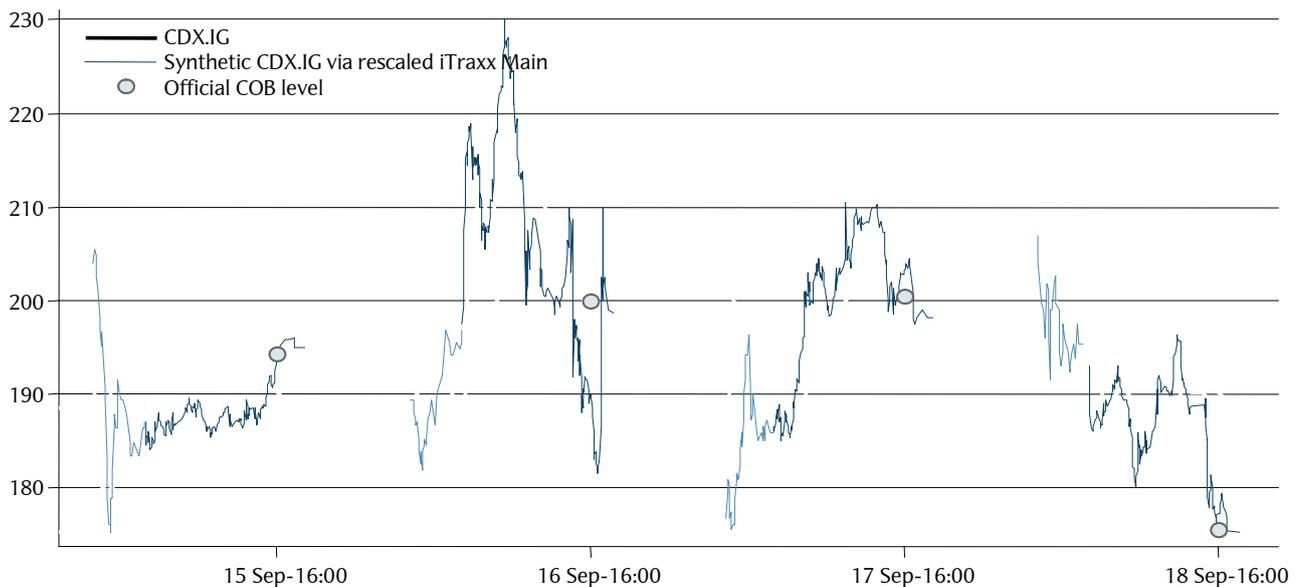
Turning to the European side, and with a more systematic approach, we find that the iTraxx Main and iTraxx Crossover have a trading range of 1.8%/1.2% of the COB spread between 15:00 and 17:00, with a significant time-varying component as illustrated in Figure 65. In other words, if the index is trading at 100 at the official close, we would expect the trading range to be between 98.2bp and 101.8bp on average. This suggests that any timing mechanism for entering a trade around the closing levels could have a substantial impact on bottom-line P&L.. Although the potential gain from improving execution around these times may seem small in isolation, we believe that for a systematic execution approach where there is frequency execution, this may add up to substantial amounts over time. One way to do this is to consider momentum in the market, which we discuss further below.

Figure 65: Trading range between 15:00-17:00 London time as a percentage of COB spread
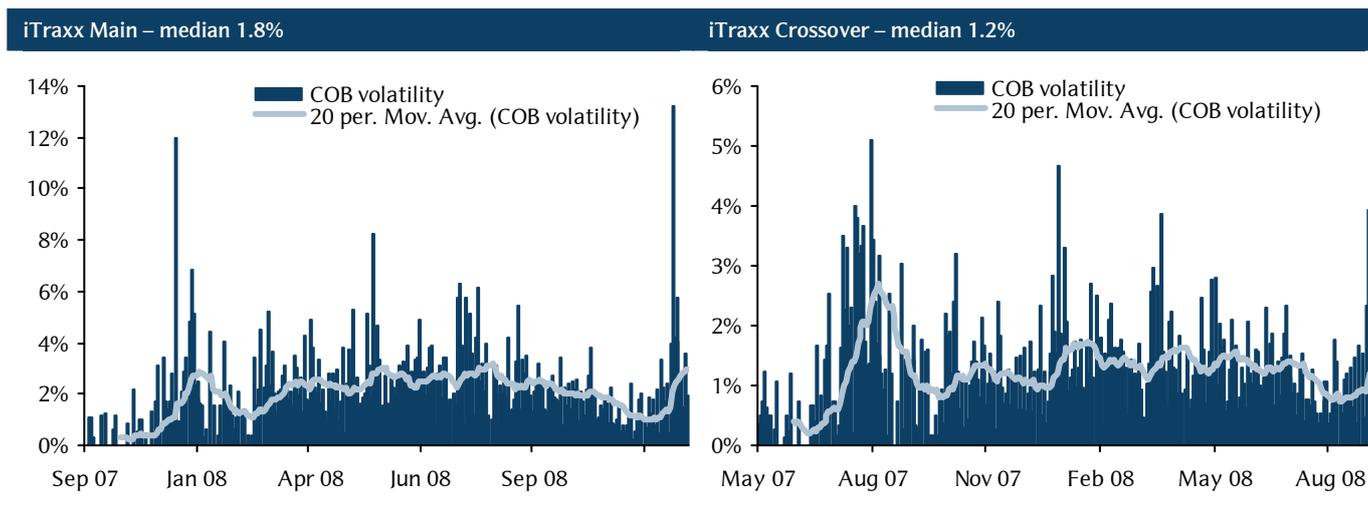
Source: Barclays Capital

Another point to make in terms of closely monitoring intraday data is to take the example of having certain target levels for a trade. Once the spread level hits that target, we want to exit the trade. In July, 2007, we might have wanted a target level of 100 on CDX.IG to take off a short, but this level was never reached if you look at the traditional data. On a tic-by-tic level, however, we reached 100bp mids for a brief period of time on 30 July and then started a very strong rally. Without the precision of the intraday levels, we would lose out on potential P&L in this example. So on aggregate, how much more precision can we get by using intraday execution data when doing a target level type of trade? We run the following illustrative experiment:

- We consider an investor buying protection in CDX.IG S10, or iTraxx Main S9.

- The investor has a target level of today's COB spread level +5bp.

- The investor closes out the trade when the measured spread (we will look at either COB reported spreads, or intraday spreads) has exceeded the target level.

- We discard all observations where the trade never hits the target level

Although this is a simplistic approach, it offers some very illuminating insights, as presented in Figure 66. First, we can see that for a non-negligible proportion of target levels, we would not execute at all if we relied solely on close-of-business (COB) levels. For roughly 6% of target orders, the potential trades did not execute unless tic data was used. In terms of the average time to execution, and hence to the P&L of the view was crystallised, it took on average twice as long for the COB orders to be executed. Lastly, in the average tracking error column, we measure how much above the preset target level the order actually executed. We see that the tracking error for the COB-based orders was between 4-6x the magnitude of the intraday-based tracking error.

Figure 66: Target level execution – large difference in tic-by-tic versus COB precision

Index	Type of data	Number of executed orders	Average time to execution (trading days)	Average tracking error (bp)
CDX.IG10	COB	85	11.4	2.7
	Intraday	90	7.5	0.4
iTraxx Main S9	COB	81	12.9	2.7
	Intraday	86	6.6	0.6

Source: Barclays Capital

This precision becomes even more important in relative value trades. Figure 67 takes a look at a few days of fairly large moves in spread differentials between iTraxx Main and CDX.IG. Over the course of this period where the differential ranged between 44-70bp, there was of course more or less opportune movements to put compression or decompression trades. The example goes to highlight the high speed at which even the investment grade indices changes in relative value for someone who considers putting on a macro-based US versus Europe trade. The same less applies to almost any type of index relative value trade, as discussed in *Systematic relative value strategies*. As these strategies are generally playing on relatively small moves, the difference between a few, or even fractions, of basis points in terms of strike levels can be crucial.

Figure 67: Looking at compression and decompression between indices with higher precision
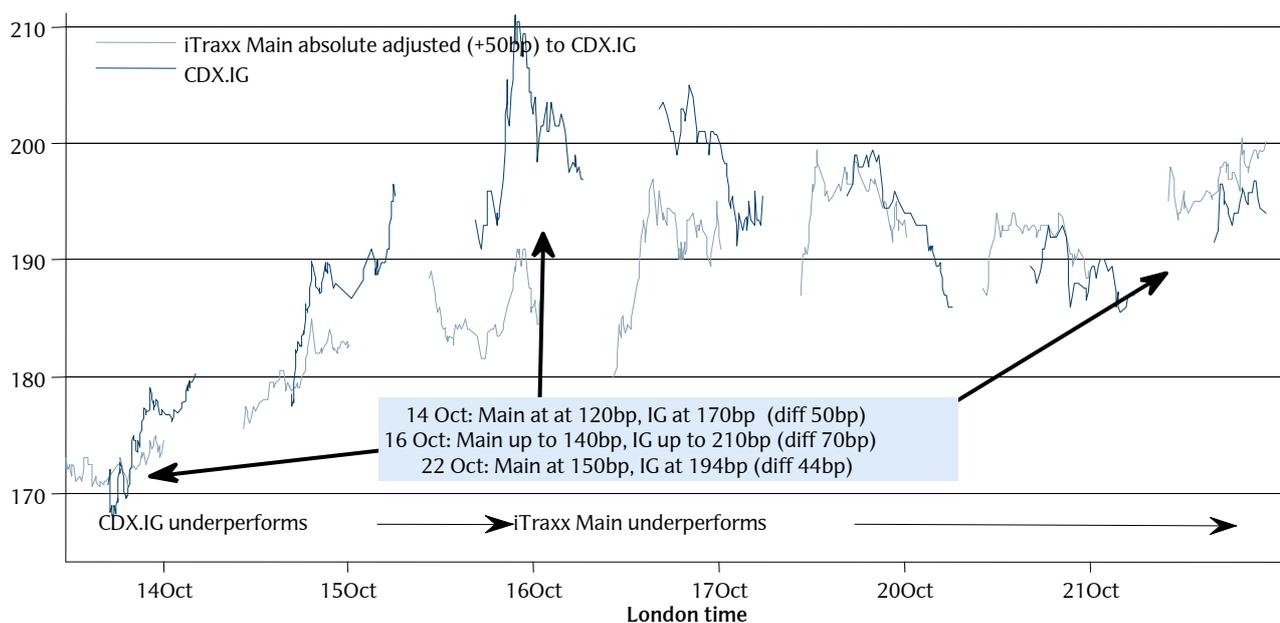
Source: Barclays Capital

Capturing cross-market spread moves

The credit crunch has highlighted the well-oiled transmission of shock waves between different geographies. For credit investors, the most obvious linkage is between the iTraxx Main and CDX.IG indices, which have been the primary battlefield for the systemic volatility in 2007-08. On a day-to-day basis, market makers and investors alike will likely monitor the 'other' indices continually to get indications of their local index' opening levels and/or dislocations. Can we recreate this process in a more systematic fashion than the usual rule of thumbs that market participant are using?

We first approach this link from the perspective of an iTraxx Main investor. From her perspective, the most important factor for where opening levels in Europe should be will be how CDX.IG has traded post Europe close the previous day. Usually some sort of spread ratio is used for this, but as we illustrated in Figure 67 above, there are risks in terms of compression/decompression of this ratio, and this becomes especially difficult in this case. COB Europe versus COB US effectively references different points in time, and hence can be severely skewed if, as often is the case, there have been substantial systemic moves between the two close-of-business points. Taking a simple spread ratio for two quotes in the simultaneous trading session of the previous day is more precise but this can be quite unstable due to intraday idiosyncratic variations between levels across markets.

In order to create artificial – or synthetic as we prefer to call them – levels for iTraxx Main post the European market close, we translate all CDX.IG quotes by normalising them via a more stable intraday-based spread ratio. An example of this can be seen in Figure 68. The procedure is as follows:

- Collect all the quotes from the simultaneous iTraxx Main/CDX.IG trading session (roughly 12:00-17:00 London time, highlighted in the box in Figure 68).

- Choose pairs of quotes where the quotes are the closest together in (absolute) time difference, and no more than X minutes apart. We let X be time-varying depending on market volatility. In a higher quoting frequency market, such as in the Fall of 2008, we would consider a time differential of 10 minutes to be a maximum between quotes.

- Calculate the average ratio between these quote pairs, so as to create an average spread ratio for the day. This is the conversion factor to divide/multiply CDX.IG spreads with once iTraxx Main has stopped trading.

An important feature of this procedure is that it is completely backward looking, and hence is applicable in real time. This should be a requirement for any procedure that is intended for strategy back-testing.

Figure 68: Simultaneous trading session ratios to create synthetic after-market spread levels, iTraxx Main
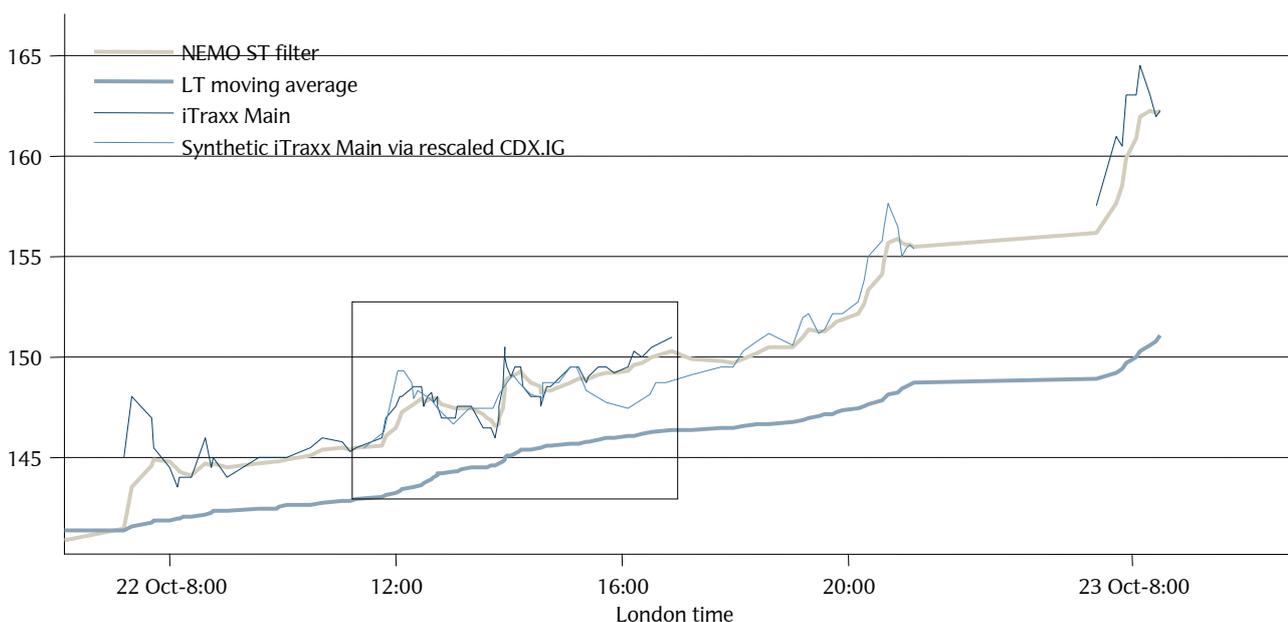
Source: Barclays Capital

For the CDX.IG investor, the problem is slightly different. They can observe iTraxx Main levels prior to open, but have two components working against them. First, they have no updated intraday based spread ratios, but would have to rely on the previous day's intraday spread ratio. Second, they have a partially unobserved gap between the close of CDX.IG and the opening of iTraxx Main. Any differential between the implied synthetic iTraxx Main levels (via CDX.IG) at US close to the actual opening levels of iTraxx Main can come either from new overnight information (such as Asian market moves) or from imprecision and/or (de)compression in terms of the conversion factor between Main and CDX.IG. As a results it is harder to pinpoint where CDX.IG should open based on iTraxx Main early morning (EST time) levels.

We prefer the following real-time approach in order to proxy pre-market CDX.IG moves via iTraxx Main trading. This approach is useful for determining momentum of pre-market moves, something which is explicitly used in the NEMO trading strategy (see below).

- At the first quote of the CDX.IG trading session, or a set of the first quotes within a specified time-frame from the first tic of the day, create the actual spread ratio between CDX.IG and iTraxx Main at that point in time.

- Using this spread ratio, convert earlier in the day iTraxx Main levels into synthetic CDX.IG spreads. In this way, we can recreate the directional moves in the index before market open.

This approach, as said, is useful for understanding the directional dynamics in pre-CDX.IG markets, as illustrated in Figure 69. It is, however, not useful for inferring opening levels on CDX.IG as it requires us to actually observe them before running the procedure. To understand opening levels, for the movement, we prefer to use the previous day's intraday-based conversion factor as outlined above, at the same time continuing to research better ways, where not only the conversion factor from iTraxx Main is used, but also one based on Asian index moves as well as overnight equity futures dynamics.

Figure 69: Pre-market conversion of iTraxx Main into CDX.IG spreads
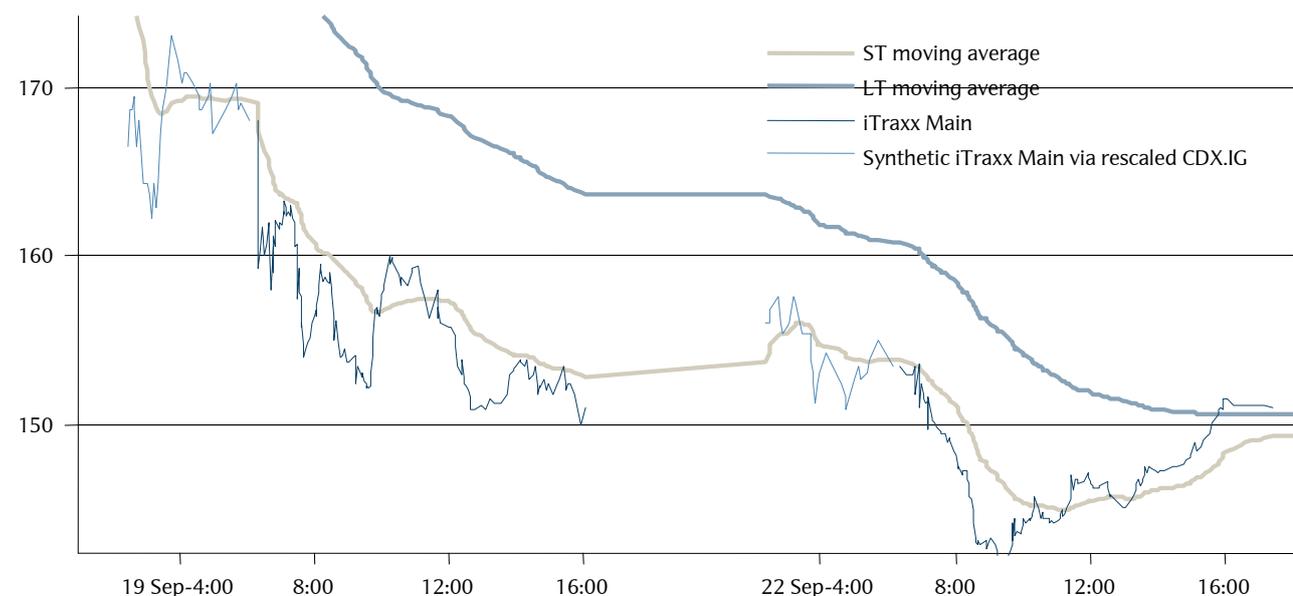
Intraday equity market correlation

In the context of inferring overnight moves in the indices, one could also, as we hint at above, utilise equity market information. For starters, some of the equity futures, such as for the S&P500, trade almost around the clock, except for brief periods of clearing and system upgrades.

Two basic issues arise around linking future moves to credit index spreads: directional correlation and volatility magnification. First, correlation, or the tendency for spreads to move wider/equities move lower on a tic-by-tic basis has been highly time-varying and in a not insignificant number of cases it has moved to zero or even been negative. Second, volatility magnification refers to how much a delta in the equity futures dimension should translate into credit spreads. This is also something which has been highly time-varying, for some periods a 1% move down in equity futures have implied a 3-4bp widening in iTraxx Main/CDX.IG. But toward the autumn of 2008, this volatility magnification effect has been reduced almost to one for one, meaning that a 1% move down in equities would translate into a 1bp move in the IG indices.

Despite the methodological challenges, we believe that there is a wealth of information to capture in terms of translating around the clock equity futures trading into credit dynamics. In Figure 70 and Figure 71, we plot the results of the preliminary version of our modelling framework for this, which clearly shows how you can imply credit spread levels from how the futures are trading.

Two important features come across from these graphs. First, which was the main motivation, they extend the trading hours significantly, giving us some directional indication before, and after the credit market trading session. Second, equity future tic data are more granular, and can provide a source of market direction movements when no such information is coming out from credit markets. This can be especially relevant in times of important news flow, for example as considered in the BEAM model below.

Figure 70: Equity futures model of CDX.IG spreads, 28 July 2008
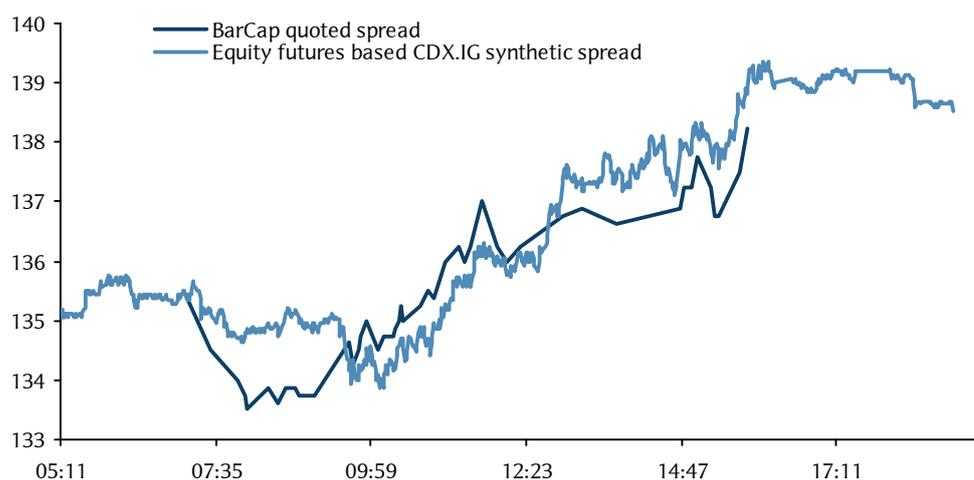
Source: Barclays Capital

Figure 71: Equity futures model of Main spreads, 11 September 2008
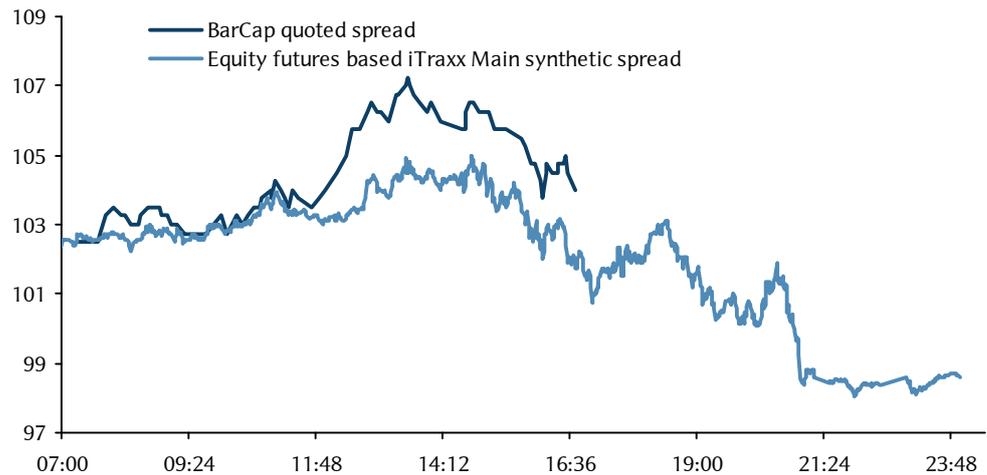
Source: Barclays Capital

Intraday analytics: Using information in quoting frequencies

A foundation for the mainstream statistical analysis is the assumption of regularly spaced time intervals between observations. The spread change between Tuesday and Wednesday COB has occurred under the same time frame as the spread change between COB Monday and Tuesday. Hence, the same amount of information should on average have passed through the market on these two different data points. This allows us to do a number of common operations, such as computing moving averages, realised volatility and conduct ordinary regression analysis without being in breach of any of the basic statistical assumptions.

At the tic level, as we consider it here, the equal/regularly spaced time interval assumption between observations is null and void from the beginning. This makes analysis less straightforward, at least from an econometrics perspective. But it also gives us an advantage in that the spacing between tics is informative in itself. Let's go back to the interday/COB data case: irrespective if we are in a four-year drag tighter in the index, with moves of 1/8bp on average a day, or if the very foundations of the world as we know it is under threat and we trade +/-10bp in an hour, we will still only have one quote a day.

Put this way, regularly spaced data kills information that one can very easily retrieve if one looks at intraday data. For an illustration of this, we run the following exercise to evaluate if quoting frequency is telling us anything about the market:

- Split the trading day into two sessions: 8:00 to 16:00.

- For each separate session, measure the number quotes in that session, and the volatility of the sessions as:

  Session % volatility = abs[min(spread) – max(spread)]/average(spread)

Figure 72 plots the relationship between the number of quotes and spread volatility resulting from this analysis. The relationship is fairly clear from the graph, and possesses very high statistical significance. For example, in a session where we have seen 30 quotes (note that this is based on a sole trading desk) spread volatility has been around 5%.

Figure 72: Quote frequency increases as spread volatility goes up
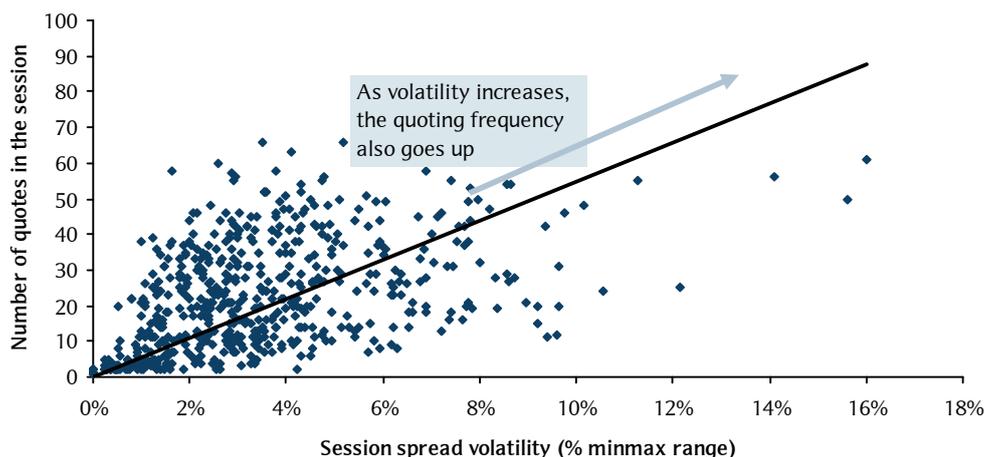
Source: Barclays Capital

Although these conclusions may appear trivial, of course there are going to be more quotes as volatility is higher, it is an important piece of information for constructing systematic strategies on the index. In the NEMO strategy, for example, quote intensity is explicitly built into how the trend signals are generated. It is also a component in most contemporary academic market microstructure models of intraday trading. As an example, the credit market's OTC structure makes any type of order flow analysis difficult, but one can use quote intensity as a proxy for this.

What is volatility? Intraday spread ranges and traditional vol

Next is the question of how to measure realised volatility. For clarity, what this usually refers to is the squared measure of daily spread moves. This approach really only works in very large samples. A small sample suffers from the adverse effect of spreads closing at or near the same level as the previous day, generating zero volatility in the measurement. Hence, realised volatility as we know often understates 'true' volatility.

With intraday data in hand, one can get much closer to the continuous-time representation of volatility that would be as close as statistically possible to the true, unobserved volatility. We take a much simpler approach, by looking at the following measure:

Realized intraday volatility = abs (high spread of the day – low spread of the day)

This specifies the trading range on a single day, which gives a much better sense of the tails of spread movements. Figure 73 shows the relationship between observed realised volatility (measured as the absolute spread change COB to COB) and the intraday-based measure. Note that our intraday-based measure does not account for any overnight moves and hence should the spread range given in this high-low volatility calculation is a minimum of what would be given if the overnight move was included.

We superimpose a 45-degree line to show the division between where intraday volatility exceeds realised volatility (dots above the line) and where the realised volatility is greater than the intraday measure (dots below the line). It is clear from the graphs that, in a majority of the cases, realised vol in the traditional senses underestimates the actual width of the trading range to a significant degree.

Figure 73: Trading range measure of volatility versus traditional realised volatility
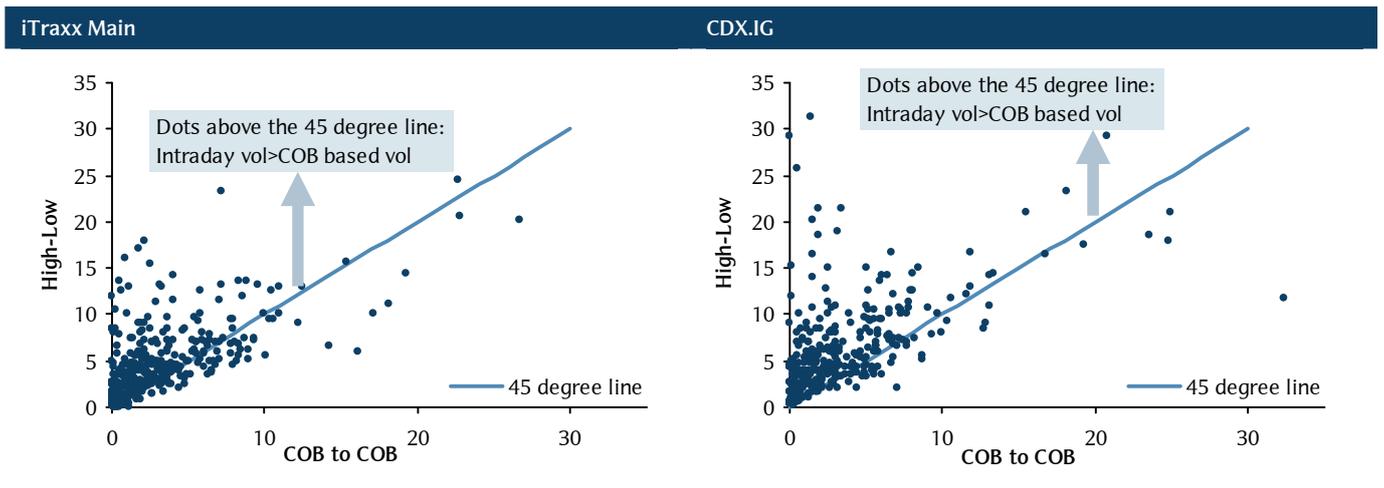
Another way to see this is to see how indices have been behaving in the run-up to two different spread wides in iTraxx Main. We can see highlighted by the rectangles in Figure 74 how the widening out to 166.5bp in Main in February and March 2008 was in a fairly non-volatile fashion, at least compared to the widening seen in September and October. In the latter case, the time-series plot makes it quite clear that intraday volatility was several magnitudes greater than earlier in the year. This, to some extent, casts some doubt on the traditional equivalence put on higher volatility equalling wider spreads. We could even see more refinement to deciding what volatility really is. Even when normalising for the spread range that has been traded, some sessions appear more volatile on the basis of a 'spread distance travelled' measure. For example, a trading day where we oscillate several times in a 10bp range could be considered more volatile than one where we only cover the trading range once.

Figure 74: Periods of spread widening, but with different types of volatility, 2008
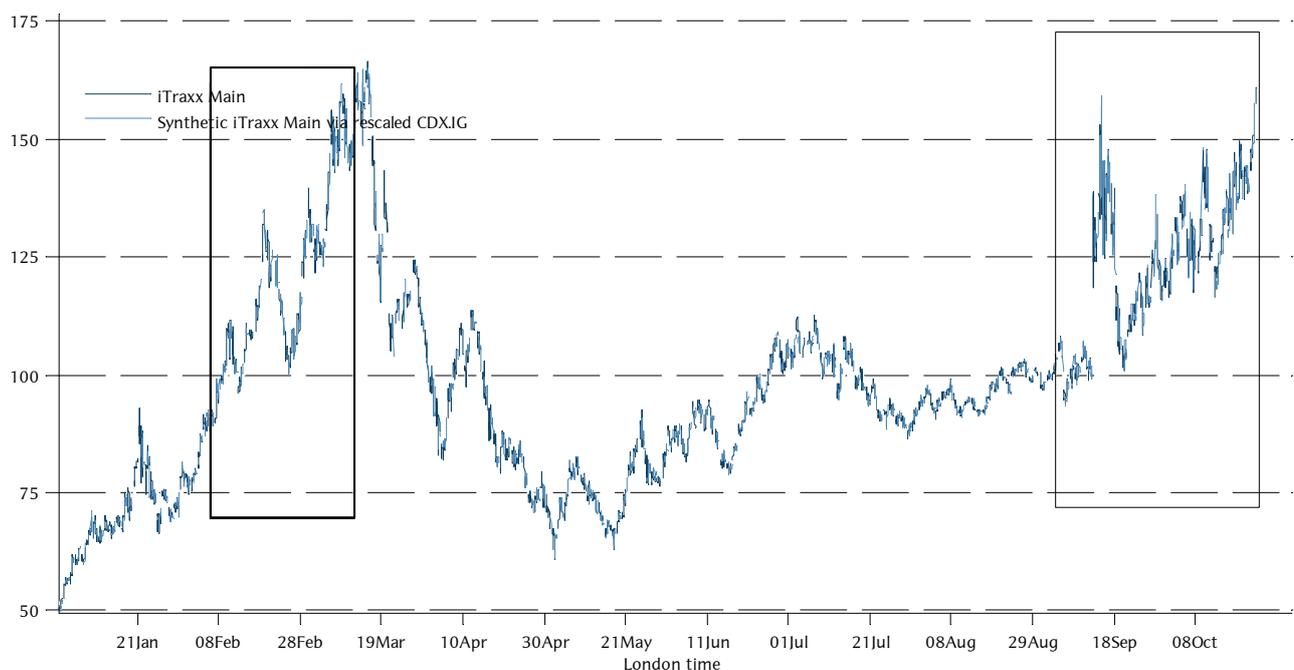
One important thing to remember here is also that the intraday-based volatility index can be computed in real time, whereas a traditional realised volatility measure will not show up until after COB. Needless to say, this can have practical implications in situations where news flow drives up volatility very quickly. In the next section, we analyse further some spread movements seen on the intraday level due to large surprises hitting the market.

Extreme event index moves

Students of fat-tailed distributions have had a heyday in 2007-08, with a number of events unfolding that have pushed credit spreads very far in a very short time. In the graphs below we highlight some events and the dynamics around them as an illustration of how indices can behave around significant news flow.

Figure 75: FOMC announcement of surprise 100bp rate cut, 22 January 2008
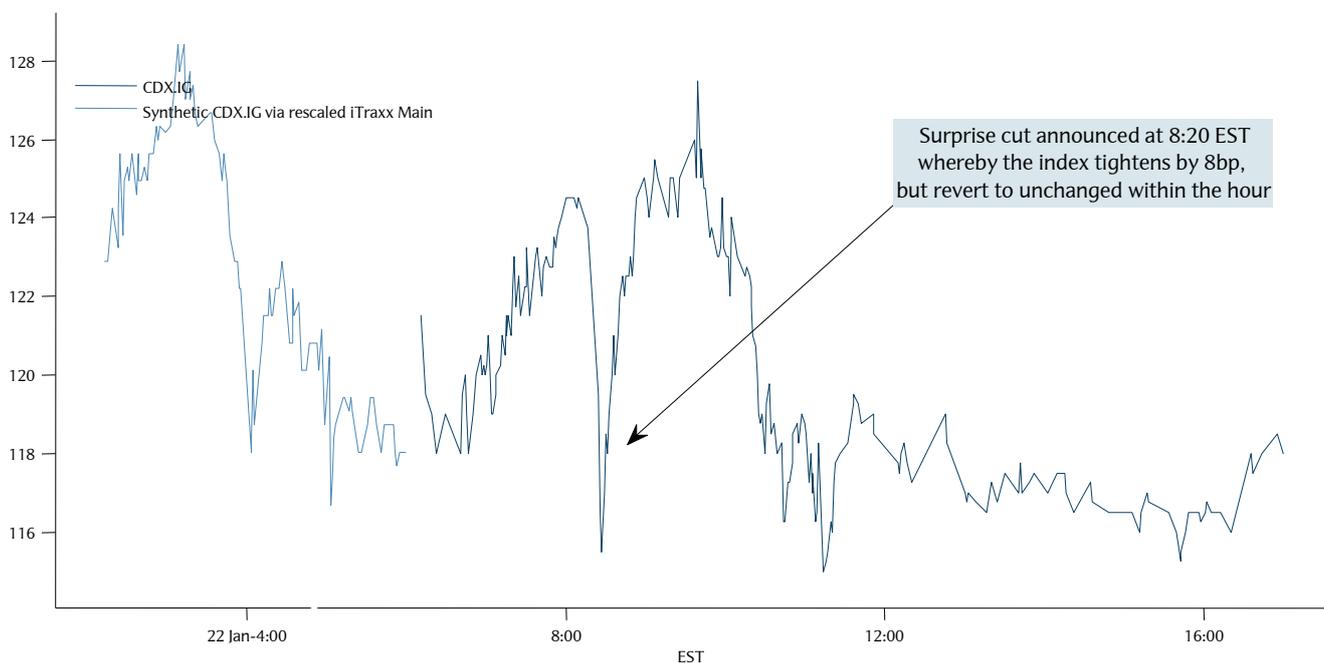
Source: Barclays Capital

One interesting feature of all the graphs is that the initial move appears to have overshot and has even been entirely nullified within a fairly short time. See for example Figure 64 for the spread moves around the first surprise rate cut in 2008. On 22 January 2008, the Federal Reserve cut rates by 50bp in an unanticipated way (for an at-the-time account of this, please refer to *Fed rate cuts and the default cycle: Assessing the empirical evidence – 1988-2007, 22 January 2008*). At the time, CDX.IG tightened by 8bp very quickly, as the market took this as a very positive signal. With time, however, and we speak a time-frame of a few hours here, the reasoning behind the rate cut started to strike a chord with credit investors, and CDX.IG soon trade back to exactly the level before the news hit the tape.

Figure 76: Bear Sterns distress, 14 March 2008

Strong positive session until BSC news start hitting the tape. After that, the index widens by 20bp temporarily but reverse some of this, and eventually close the day just 3bp wider from opening levels
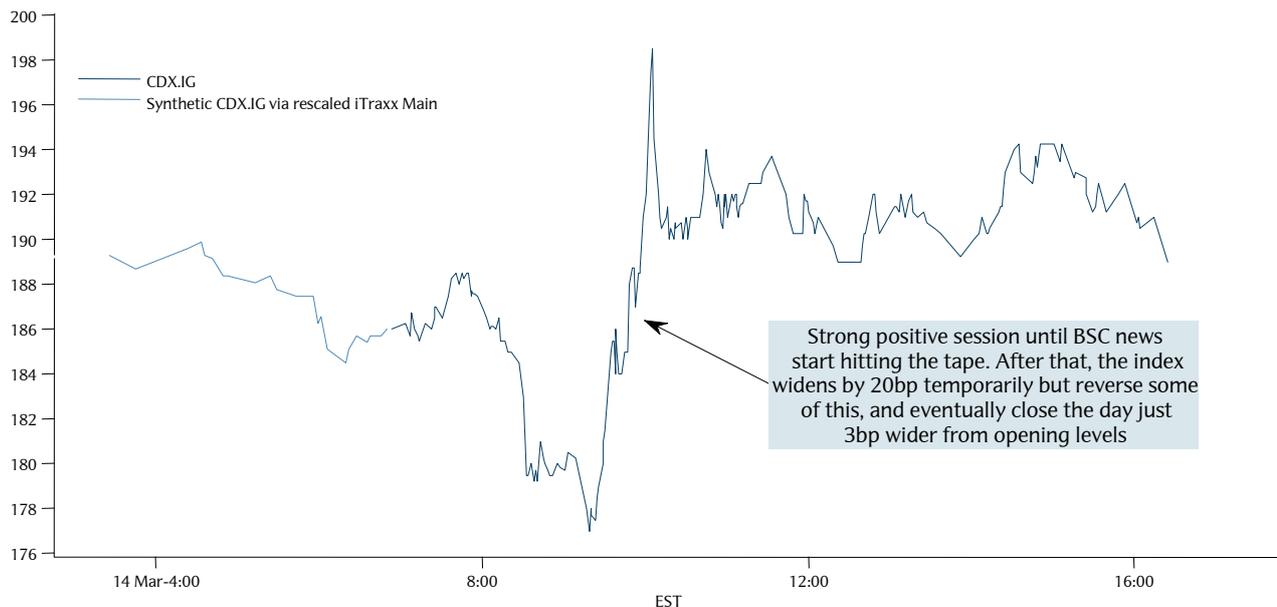
Source: Barclays Capital

On 14 March 2008, we hade the inverse situation as the Bear Sterns distress story unfolded. Up until then, we had traded in a very positive session (see Figure 76) coming to tights in the CDX.IG S9 index of 177bp. In the following hour, however, we moved more than 20bp north. Again, we saw some of this revert in a whiplash way, with the index eventually settling at the 190bp level.

Lastly, we show in Figure 77 how markets reacted to a concerted rate cut on behalf of the Federal Reserve, the ECB, the Bank of England and the Riksbank. An unprecedented event that just months prior to when it actually happened would have been an equity investor's sweet dream moved iTraxx Main 7bp tighter for around 1.5 hours, but the trading session eventually closed wider from when the rate cut was announced. By this time, the inconvenient discrepancy between the long-term effect but short-run implications of expansionary monetary policy (see 'Rate cuts: A bearish signal for credit?' *European Alpha Anticipator,* 25 January 2008) seemed definitely to have hit home.

Figure 77: Concerted rate cut to counter the credit crunch, 8 October 2008

Concerted rate cut at 12:00 London time, iTraxx Main tightens 7bp in an instant but gives this up in less than an hour
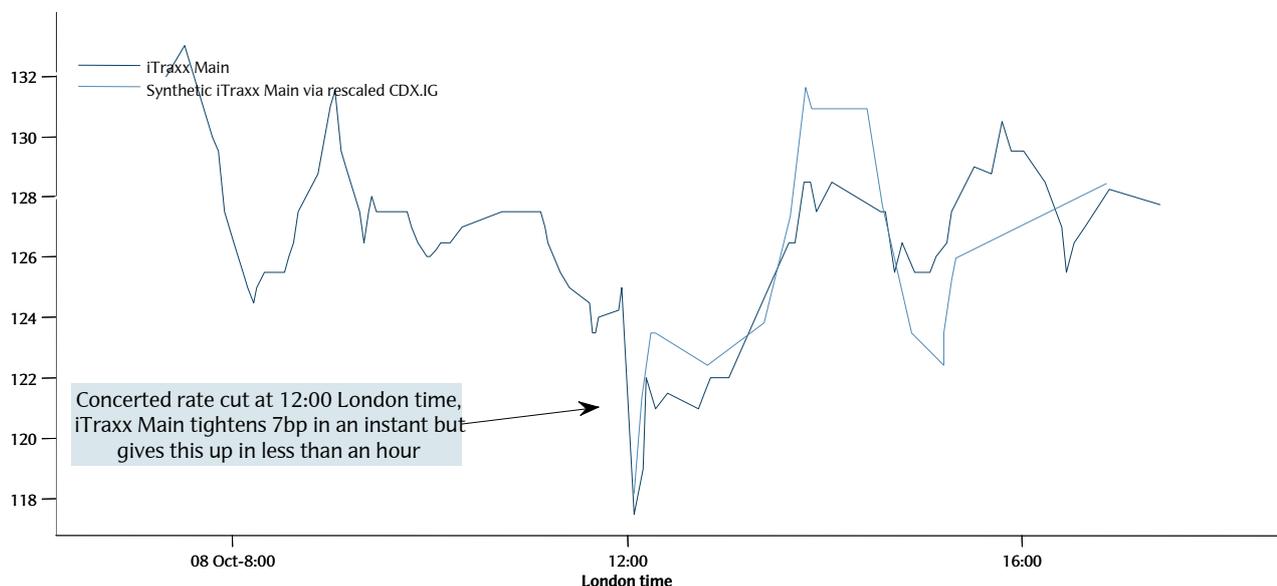
Source: Barclays Capital

These few events offer some anecdotal evidence on the dynamics of extreme events with their tendency to overshoot. We firmly believe these dynamics garner more systematic research to see whether our initial observations hold under scientific scrutiny. From a trading standpoint, we note that this seemingly predictable behaviour does not necessarily reflect tradable moves as bid/offers may become prohibitively large around surprise movements. Nonetheless, systematic strategies in event trading could prove a fruitful avenue for systematic index strategies, as illustrated in the next section.

Trading strategies

Credit, at least until mid-2007, remained a fairly long way behind other asset classes in terms of utilising intraday data for trading purposes. The plethora of statistical arbitrage models and funds were nowhere to be seen in credit land. Part of this superficial conservatism has been due to a simple trade-off between volatility and transaction costs. The amount of alpha that you could potentially generate via high-frequency trading in CDS indices was just too low relative to the amount of transaction costs that you would have to pay out. The new regime of credit volatility in 2007-08 has definitely changed that. We showed in Figure 7 in the introduction how the gearing between volatility and transaction costs have very clearly shifted up, with average bid/offer spreads being only a small fraction of intraday trading ranges today.

Given the paradigm shift in the potential alpha/transaction costs ratio, developing trading strategies based on high-frequency positioning or signals has started to make sense. In this section, we introduce two general frameworks/strategies:

- The Barclays Event Arbitrage Model (BEAM): This is a framework in which we take positions around regular data releases such as jobless claims or payroll numbers releases. The positions are entered into within 15 minutes of the actual data release if some conditions are fulfilled whereby the model deems that spread levels post the release have overreacted. Positions are exited within the next few hours either on the basis of realised mean-reversion, as a stop-loss or due to the end of the trade timing window having been reached.

- The iNtraday Exponential Momentum (NEMO) strategy: This strategy goes long or short the index based on tic-by-tic-based trend indicators, where we also utilise the quoting frequency (see above) to form the trend indicators. We look at a few different implementations along the dimensions of execution frequency and different indices.

Data release trading with BEAM

Active market participants in the CDS indices have become increasingly addicted to following the periodical macro data release over 2007-08. But, even after the event, it is sometimes hard to explain the spread dynamics around data releases. Subjective views on which data has what effect abound, making a systematic approach empirically verifying these views desirable.

Figure 78: Data releases coincidental with initial jobless claims, May 2007-August 2008

Data release	Number of occurrences	Comment
Initial Jobless Claims	71	Data itself
Continuing Claims	71	Always identical release time
Core PCE q/q	12	Periodically identical release time
GDP Price Index	12	
Personal Consumption	12	
GDP Annualized, GDP q/q (Annualised)	6	Coincidental releases
Durable Goods Orders, Durables Ex Transportation, Trade Balance	5	
Import Price Index (m/m), Import Price Index (y/y)	4	
Advance Retail Sales, Building Permits, Housing Starts, Nonfarm Productivity, PCE Core (m/m), PCE Core (y/y), PCE Deflator (y/y), Personal Income , Personal Spending, Retail Sales Less Autos Unit Labor Costs	3	
Consumer Price Index (m/m), Consumer Price Index (y/y), Consumer Price Index NSA, CPI Core Index SA, CPI Ex Food & Energy (m/m), CPI Ex Food & Energy (y/y), Empire Manufacturing, Employment Cost Index, PPI Ex Food & Energy (m/m), Producer Price Index (m/m)	2	
Average Hourly Earnings m/m, Average Weekly Hours, Change in Manufact. Payrolls, Change in Nonfarm Payrolls, Unemployment Rate	1	

Source: Bloomberg, Barclays Capital

We seek to provide a systematic approach to this, constructing the BEAM framework for trading around events. Below, we show as an example a fairly simple form of the framework, where we look for mean reversion around data releases on jobless claims numbers. However, the approach is easily extendable to other types of data releases. We also discuss the avenue around an integrated approach to trading around events, where one would be able to trade on information linking together a multitude of data releases as well as current market dynamics.

We take the view that the content of data releases themselves, although important from a long-run point of view, are not necessarily very useful in isolation. With a large array of economist data forecasting more or less precisely the actual levels that are going to come out on a GDP data release, the market should have priced in the expectation already. What becomes more interesting is how different the actual data are compared to the expectation, and how revisions to previous data releases look. We define the surprise factor in the following way:

$$\text{Surprise index for event } X_t^l = \left[\frac{\left(X_t^{Actual} - X_t^{Survey}\right) + \left(X_{t-1}^{revised} - X_{t-1}^{prior}\right)}{X_t^{revised}} \right]$$

This surprise index becomes a percentage number of the total change in the data release at hand versus the previous revised data release.

Other considerations for event studies on CDS indices

First, when conducting an event study type of analysis on indices for trading purposes, we require tic-data to get the granularity required to actually gauge the impact of data releases on the index. In order to mould this type of data into something that can be used in our statistical framework, we discretise the time intervals prior and post a data release, as shown in Figure 79. Without such a discretisation, the dimensionality of an event study can quickly explode. What we now will look at is the predictability of spread moves in the periods T+1 to T+4, given the information available at time T.

Figure 79: Time intervals chosen for event study

Time code	Time interval covered
T-1	Pre-data release period: we sample spreads as close as possible prior to the data release, we discard any event where we do not see a firm spread level in the X minutes prior to the actual data release
T=0	Exact time of data release
T+1	0-5 minutes post the release
T+2	5-20 minutes post the release
T+3	20-60 minutes
T+4	60-180 minutes

Source: Barclays Capital

Multiple data releases at the same time: On a 'data-heavy' trading day, each individual data release is likely to have less of an impact on the market. It may also distort some of the statistical analysis. For example, if we are observing data such as jobless claims numbers at 13:30 London time, and then have payrolls numbers coming in at 15:00 London time, the T+4 window in Figure 79 should probably be excluded from the analysis. Likewise, a trading position opened due to the jobless claims release awaiting some specific dynamics should be closed before T+4 as it will otherwise be more about taking positions on payrolls.

Adjusting for volatility:

Spread changes around events will most likely tend to be dependent on market volatility and/or spread level. We do not necessarily have a prior take on which way this will go; one can argue in favour of a bad data release on a volatile day having either a larger or smaller impact than on a less volatile day. For example, if we are in a trading session where min/max type of volatility is high (ie, a trending market), a poor/good number may struggle against technical pressures in the markets. This becomes pronounced in periods like March 2008, where technical pressures would supercede actual macro news flow. On the flip side, in sessions where directionality is low, new macro data may very well prove to be the tipping point in either direction.

Discounting for current market dynamics

A weak jobless number at the same time as the financial world order has just been saved may not have as much of an impact as one where markets have been distinctly directionless. Hence, it seems reasonable to weight the impact of a macro surprise on how strong the market dynamics are at the moment of the data release.

Trading around Initial jobless claims/continuing claims numbers with BEAM

The BEAM framework provides a generic approach for event trading, and although we focus on jobless numbers below, the framework can be applied to many different types of data releases/events.

The initial jobless claims numbers are released at 13:30 London time each Thursday. These numbers have been quite high profile a number of times over the past year, as Figure 78 highlights. They have also been fairly interesting over this period in terms of signalling a cyclical downturn, see Figure 81.

Figure 80: BEAM in action – spread dynamics around 31 July 2008, jobless claims surprise of 13% (above survey) and continuing claims +4%.
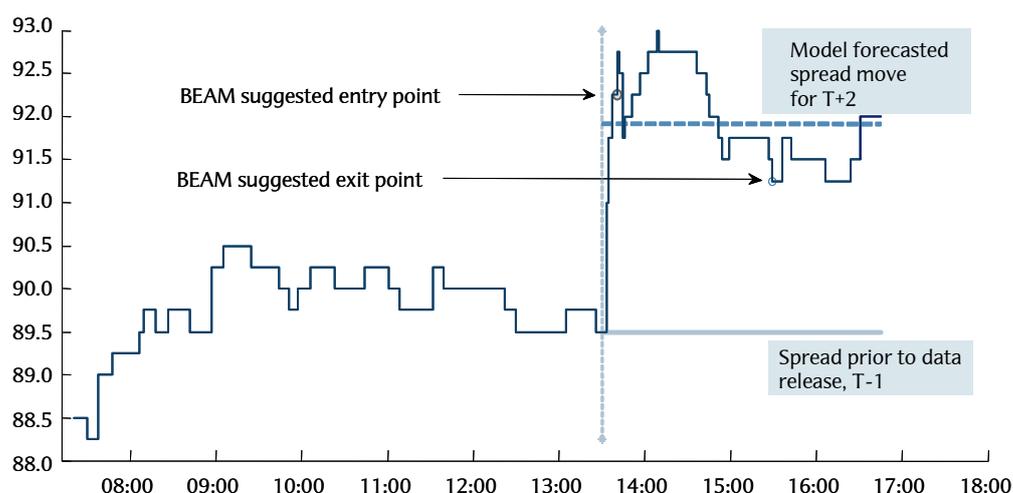
Source: Barclays Capital

Figure 81: Continuing claims, realisations and surprises
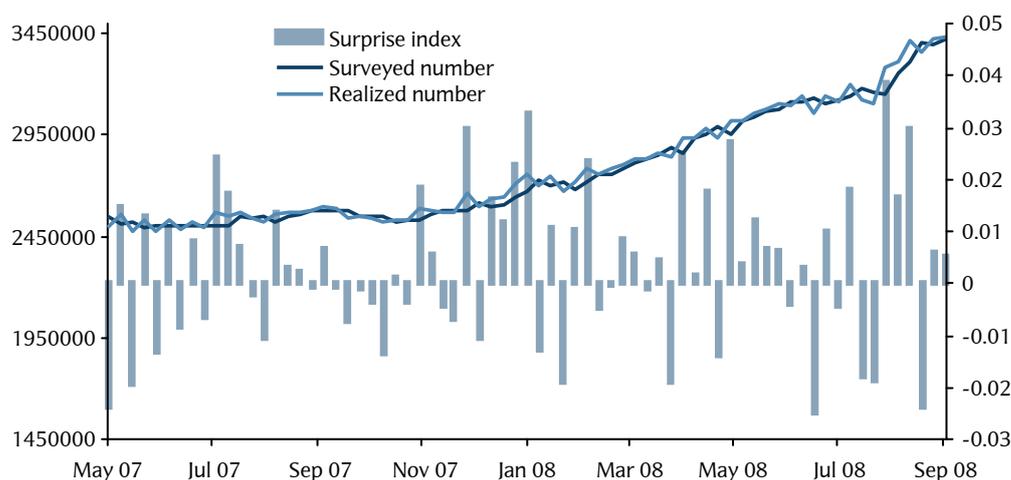
Source: Bloomberg, Barclays Capital

One problem with frequent data such as jobless claims is that, in many trading sessions, their impact will be swamped by other market movements. As long as we have a systematic way of screening out such sessions, this need not be a problem other than there being fewer opportunities to trade. Figure 78 shows a set of other data releases that have occurred at the same time as the jobless releases, and the frequency at which this has happened. We note that some data releases always happen at the same time, but at a lower (monthly) frequency, such as the Core PCE numbers that have been in focus as inflation was a major concern in the first half of 2008.

A model for expected market impact

We follow a straightforward route in terms of whether the current data release has an impact on the market or not:

▪   We observe if the index moves in the directions suggested by the surprise index, by looking at the first tic that comes out after the data release.

- If the tic, or rather the delta of this tic, is in the expected direction (wider if the jobless surprise is negative) then we proceed, otherwise the data release is removed from the sample (and not considered to be relevant for trading purposes).

For a sample of total 50 observations, we have 20 remaining after this screening.

The next step is to relate a statistical linkage between the magnitude/dynamics of the surprise and the actual realised data. We use the following set of equations to estimate this:

$$\Delta\%CDS_{n,t+1} = \underbrace{\left|S_t^{Jobless} + S_t^{Continuing}\right|^{\gamma}}_{\substack{\text{Absolute magnitude of the surprise}\\ \text{amplifies the magnitude of the expected}\\ \text{move}}} \cdot \left(\beta_1 S_t^{Jobless} + \beta_2 S_t^{Continuing}\right) + u_{n,t+1}$$

$$u_{n,t+1} \sim N\!\left(0,\sigma_t^2\right); \qquad \sigma_{t+1}^2 = \alpha + \underbrace{\phi \cdot MinMax_t}_{\substack{\text{Volatility of the regression}\\ \text{error is dependen on the volatility}\\ \text{of the current trading session}}}$$

This set of non-linear equations is estimated via maximum likelihood. The β_1, β_2 parameters measure the individual impact coming from jobless versus continuing claims. γ works as an amplifier for how much the absolute value ($|\circ|$ denotes absolute value) of the surprise has an effect on the predicted CDS move. Lastly, in order to achieve a proper statistical fit, we allow a GARCH like dependency of the CDS move on the trading range earlier in the day. We estimate the model via maximum likelihood.

Results of estimating this model are presented in Figure 82. We achieve a strong statistical fit in terms of explaining the average spread in the window T+2, with the parameters all having their expected signs. Interestingly, we have much less of a fit in terms of the T+3 window, and eventually even less in T+4. How should we interpret this deterioration of fit?

We believe that these results actually document an effect that sometimes has been apparent from watching these events unfold in real time. The effect of the data release is significant in the first short period of the data release, but then spreads tend to mean-revert fairly quickly. An example of this is provided in Figure 80 above.

Figure 82: Parameter estimates on the jobless event model – T+2/+3 impact of data releases

	T+2		T+3		T+4	
Parameter	Coefficient estimate	Probability value	Coefficient estimate	Probability value	Coefficient estimate	Probability value
β_1	0.04	0.00	0.01	0.00	0.01	0.45
β_2	0.11	0.00	0.09	0.05	0.34	0.00
α	0.34	0.00	0.67	0.00	0.92	0.00
ϕ	266.4	0.50	557.9	0.50	206.9	0.5
γ	1.60	0.00	1.88	0.29	n.a.	n.a
Statistics	R2 = 62.6%	LogL: -14.92	R2 =14.1%	LogL: -33.11	R2 = 12%	LogL: -33.35

Source: Barclays Capital

This actually suggests a viable trading strategy. We develop the following trading algorithm around jobless data releases.

- Await the data and the first tic to receive confirmation of if the model is 'on'.
- In the period T+2, await the first quote that fulfils the following two conditions:

1) The quoted spread is beyond what is predicted by the model.

2) The quote in question is higher/lower than the previous quote, in the direction that we expect the mean-reversion to occur (ie, we await the first sign that the spread level is starting to retrace post the data release induced moved).

3) We strike our trade at the first (chronologically) quote that fulfils 1)-2). If, for no quote in T+2, the conditions 1)-2) are not fulfilled, then we do not trade.

▪ In T+3, we are looking to unwind the trade. We will unwind in either of the following situations:

1) If a quoted level arrives that is 2% in the money, ie, where there has been a 2% spread move from the strike level to the current quoted.

2) We have reached the end of the T+3 window.

We run this trading strategy over our intraday sample on iTraxx Main, spanning May 2007 to August 2008. Summary statistics are provided in Figure 83. We can see that these results look fairly promising. We would have traded on 10 data releases, with the average return being 3bp with a hit ratio of 71%.

Figure 83: BEAM example performance

	Average return per traded data release	Trade hit ratio	Trade return standard deviation
BEAM – Jobless/Continuing claims	2.97	71%	6.53

Source: Barclays Capital

This performance looks promising, but we believe that just trading one data release in isolation is likely to be less attractive than a system where we allow ourselves to trade on every important data release with significant surprises. Also, this should be in an integrated way where the model used to forecast the trajectory of spreads should take all data released at one point in time into account. A system like this could extend to trading around extreme, unexpected events, such as discussed in the previous section. And, as hinted at before, one could improve the T+1 confirmation signal to be driven by equity market moves that tend to show new prices much more quickly after the event compared to credit markets. So, although individual (post-transaction costs) hit ratios for trading on data releases or events could be marginal, the fact that they provide relatively frequent trading opportunities could mean a potential for a stand-alone trading system.

As a final point, we believe that high-frequency execution, such as in the NEMO strategy, should take the nature of data releases into account. For example, if we believe the market is overshooting one direction in a way that provides a signal for a reversal of the current trend, then we should wait and see rather than jump into this potentially very short time trend.

Trend following

We have documented the existence of index momentum in a number of publications in 2008-08, see for example *Intraday movements of the iTraxx Xover*, 3 August 2007; *European Alpha Anticipator: Index trading strategies*, 24 August 2007; *High-frequency trading of iTraxx Series 8 indices: Trading with NEMO after roll*, 18 October 2007; *The CDS index rollercoaster*, 7 March 2008; *Extreme index momentum, really*, 18 April 2008, and *NEMO anniversary*, 2 September 2008.

Some of the momentum runs have been spectacular. For example, between February and April 2008, CDX.IG /iTraxx Main traded from around 80bp to 165bp and back to the low 60s (see Figure 84). During this period, the consistency in the rule 'if we are tightening/widening, we will continue to tighten/widen' was exceptional, and the volatility around these trends was quite modest. We discuss the technical reasons around the trend stability during 2007-08, and even prior to that, below.

Figure 84: Trending markets in spring 2008

Source: Barclays Capital

Our iNtraday Exponential Momentum (NEMO) strategy was designed to take advantage of such trending markets and it had a commensurately strong performance in 2007-08 in periods such as February through April. We provide some summary statistics in Figure 62 for the family of NEMO models suggested in this text. Performance has been in the range of 9.2-10.4% in terms of unlevered excess return over the sample period. Considering that these returns are based on trading the most liquid credit instruments available, and that the constituents are investment grade, we find these numbers quite impressive.

Figure 85: Summary statistics for NEMO strategies (post-transaction costs, 1 May 2007-27 October 2008)

	Cumulative return	Monthly avg return	Annualised Sharpe ratio	Number of trades	Cumulative transaction costs
NEMO 8/12/16: iTraxx Main	9.4%	0.55%	1.4	248	5.9%
NEMO 8/12/16: CDX.IG	9.2%	0.54%	1.6	177	7.3%
NEMO/DT: iTraxx Main	10.4%	0.58%	2.1	128	2.9%
NEMO/DT: CDX.IG	10.2%	0.60%	1.8	115	4.7%

Source: Barclays Capital

Why trends in CDS indices?

There are some natural explanations for this. We find that persistence in spread changes in the index can partly be attributed to investors having to hedge exposures once the index has moved far enough against them. Consequently, the hedging activity itself propagates the initial spread movement. Three factors appear to be driving this: sentiment-driven trading; correlation book gamma-hedging/other structured credit-related forces; and risk limits/stop loss strategies.

Sentiment-driven trading

Spread dynamics through the credit crunch so far have reflected changes in sentiment and risk tolerance much more than fundamental credit concerns. This tends to create trends as widening spreads generate fear and further buying of protection and so on. When the market turns as sentiment changes, market participants can find themselves in a very overcrowded traded (particularly, so far, on the short-risk side) leading to a capitulation.

Correlation book gamma-hedging/other structured credit-related forces

Correlation book activity is also a natural source of trend propagation, as many desks have been left very 'short gamma'. That is, the index notionals required to delta-hedge CDO positions increase as spreads widen, requiring further protection to be bought and vice-versa when spreads tighten. A second effect has been fear over the unwind of structured products such as CPDOs. Whether or not fears were warranted was irrelevant as investors went increasingly short as protection against unknowns.

Risk limits/stop loss strategies

With the inception of the credit crunch last summer, and the carnage that followed on many credit books, the aversion to losses has been a fundamental force in credit markets. As we showed in 'Tactical index positioning: Days of the opportunist', *European Alpha Anticipator*, 11 April 2008, of which an excerpt also is available below there is a large asymmetry in how investors with either risk-limits or loss-tolerance levels are actually getting knocked out of trades when the mark-to-market of their positions get far enough underwater. In our empirical investigation, we find that an investor with one month perfect foresight of the future index level would still have to crystallise negative P&L in around 20-25% of all possible trades! There appears to be much less of this in terms of investors crystallising their upside in P&L.

Over the course of 2008, it appears that the first factor (sentiment-driven trading) has become a more dominant factor than the latter two. Correlation books have become much better at keeping a low net gamma exposure, and CPDOs have mostly been unwound. We also note that the risk limit arguments have become slightly weaker as more investors have become risk constrained, keeping their net index exposure at flat.

Momentum trading with NEMO

So how do we actually judge when to enter and exit the trends? First, we argue that the swings on an intraday basis will be crucial to capture in order to both deduce the trend direction as well as implement trend-following trades as close as possible to the turning points. Secondly, with systemic movements driving the lion's share of index volatility, capturing systemic moves across both EUR and USD, and potentially Asian markets, will be necessary to establish a true, systemic trend.

Our iNtraday Exponential Momentum (NEMO) model and trading strategy implements both these two themes. In the following sections, we go through the following sections:

- The basic NEMO strategy and NEMO/DT

- Performance summaries for the various NEMO formats and implementations on different indices

- Benchmarking NEMO versus outright positions

The basic element of the NEMO trading strategy is straightforward: using a short-term and long-term moving average, we define a widening trend as when the short-term (ST) moving average is above the long-term (LT) moving average and vice versa for a tightening trend. A depiction of this is given in Figure 61, where the light-grey/light-blue lines show the ST/LT moving averages.

Trading signals, as highlighted by the arrows in the figure, are then given at the point of crossover between the ST and LT. In other words, when we switch from a widening to a tightening trend, as seen by the ST line crossing the LT line from above, we have a sell protection signal. We then hold on to that position of being long risk/short protection as long as the ST average stays below the LT average. This first stage of the trading rule of NEMO is likely to be one of the most frequently used 'technical' or 'chartist' trading rules out there. However, there are complications aplenty – as well as a couple of equations under the hood – that disqualify NEMO from being chartist and move it firmly into the field of a quantitative strategy.

Figure 86: NEMO at work, 18-21 August 2008
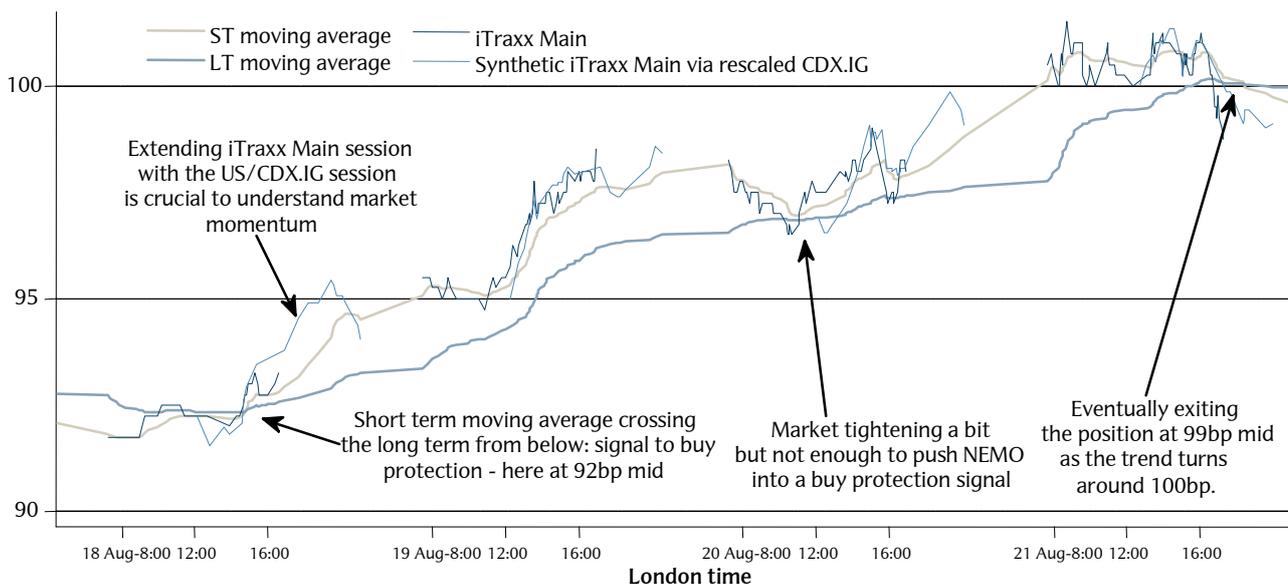
Source: Barclays Capital

We already saw that the basic trading signal is given when there is a crossover between the ST and LT moving averages. In order to accommodate some liquidity features of the credit market, avoid overly frequent trading, and have practical implementation of NEMO, we suggested that we only allow the strategy to trade three times a day at fixed times. Our 8/12/16 trading rule, where the numbers refer to the (London) hours at which we trade, was originally suggested in *A simplification of the NEMO trading strategy*, 30 April 2008, and has been actively implemented since then.

A key feature of the strategy is its discipline and focus on where it thinks the index is heading, rather than how its current position will fare if the index goes in that direction. This means that **the strategy will at times reverse a position once or even twice a day. After the fact, this may appear meaningless. Before the fact, however, we never know whether we are legging into a trade that will stay for four hours or four days.** It is important to understand this trade-off between sensitivity of getting into trends early versus going into trades that are very brief. How should the trade-off be done? We argue that empirical analysis is the best way, taking into account actual historical index dynamics as well as actual transaction costs.

Creating the ST and LT moving averages from intraday data

To revert to the first complication above – how do we manage intraday data? – NEMO runs on a real-time system that captures trader tic data as it comes through on the Bloomberg screen. This ensures, as far as possible, that the pricing going into the model is actually reflecting market pricing. It is also worth noting that the implication of this tic data is that quotes are not equally dispersed in time. Admittedly, this sounds like a mind-numbingly boring topic to explore, but unfortunately it is also a crucial element in the workings of NEMO. If you do not accept that quote dispersion will make ordinary moving averages give strange results in a tic-by-tic setting, then please refer to the discussion in the fact box below.

> In a traditional moving average set-up, for example, on daily equity prices, we have closing levels from each day, and each data point is at an equal (trading) time distance from each other. Hence, taking a straight average of the observations will give you something that represents the 'true' average. But consider now the case where, on the first day, you are actually given two data points that are both at, or close to, the closing time. Then your moving average will actually over-emphasise the first day, as you have twice as many observations on that day. The way to remove this bias is to start weighting observations so that the observations on the first day actually only carry half the weight of any of the other data points. Extend this further to the credit tic-data, and it becomes apparent that a straight average over the past two days, for example, can give rise to effects where old pricing carries much larger weight than recent pricing.

In order to capture the dispersion of quotes and also have a system where we put more weight on recent observations than on historical ones, we use the following weighting function:

$$w(T-t,\lambda) = \frac{1}{e^{(T-t)\div\lambda}}$$

T is the current time, t is the particular time of the quote for which we want to find the weight. λ is a parameter that decides how much more weight we should put on recent versus older data points. Figure 87 shows how the weighting would work for 20 data points equally spaced over a period of 30 hours (the x axis). We can see for the short-

term NEMO average (λ = 100) that the tic received right now accounts for 65% of the total weighting, and anything received earlier than six hours ago has a weighting of very close to zero. For the LT NEMO average (λ = 600), the current observation has only a 14% weight in the average which is being calculated, whereas, for example, a quote 15 hours ago has a weighting of 3%. The actual mathematical formula for calculating the moving average, given a recent history decay factor λ, is:

$$MA(\lambda) = \frac{\sum\limits_{t=T-i}^{T} w(T-t,\lambda) \cdot Spread_t}{\sum\limits_{t=T-i}^{T} w(T-t,\lambda)}$$

where *i* is how far back you look in terms of your history of quotes. An attractive feature of this approach is that it becomes insensitive to the look-back window, as long as you set *i* to be large enough (we use 15 days). If we have a look-back of more than 30 hours in the example in Figure 87, the changes in the actual moving average becomes very marginal as the weights on those observations are miniscule anyhow.

Figure 87: Decay of weights in moving average calculation
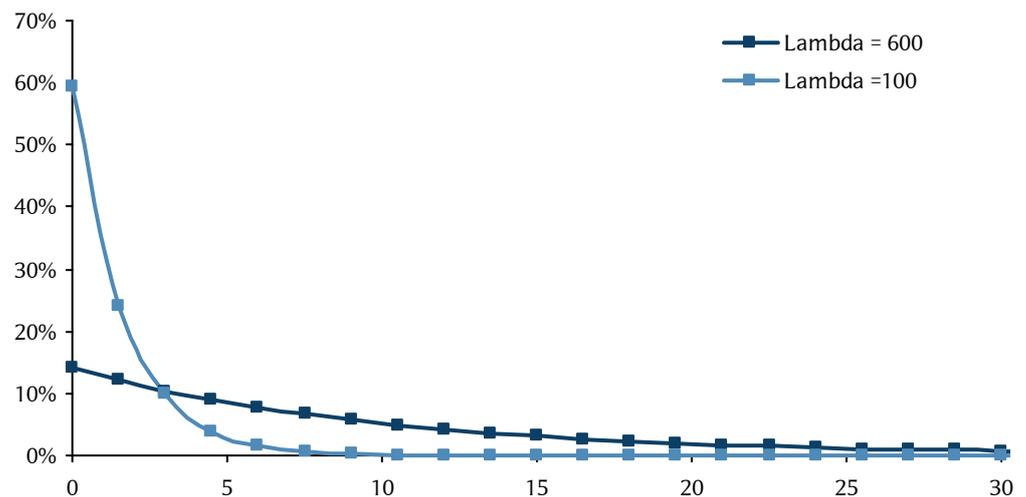
Note: X-axis is in hours, with t measured in minutes. Source: Barclays Capital

Incorporating intermarket momentum

A crucial part of the NEMO strategy is to incorporate the momentum of the credit market around the clock than rather only the traded index's own session only. Similarly to all momentum-based strategies, a time series with large gaps will provide weaker momentum signals than one where the gaps are smaller.

In the NEMO strategy we apply the synthetic index methodology described earlier in this chapter, and exemplified in Figure 68 and Figure 69 among other places. In effect, we allow the synthetic spreads generated based on these procedures to be treated exactly as the quoted index spreads themselves, as far as the signal generation is concerned. We do not, at this stage, allow for actually trading on the synthetic levels. However, this could be a very interesting avenue to follow for the NEMO technology as many market momentum moves would have benefited from being able to switch in and out of the strategy irrespective of which market currently is open.

Evolving NEMO

This material on enhancing NEMO was published in original form in *NEMO anniversary*, 2 September 2008.

A drawback component of the NEMO strategy has been a weak handling of intraday cyclicality as observed in the markets around the turn of the year 2007/08, as well as in July 2008. These markets, exemplified in Figure 89 below, tend to generate signals to buy protection around intraday peaks, and to sell around intraday tights. This obviously has a detrimental effect on performance: if we do not break out of the range, then we are not capturing momentum but rather victimising the strategy of mean-reversion patterns in the data.

To minimise this drawback, we have constructed a new version of NEMO in which we use a sophisticated filtering technique for the short-term moving average, rather than the exponential momentum function used in the first version of NEMO. We provide a flow diagram of the new NEMO operation in Figure 88. The effect of this adjustable smoothness short-term filter in terms of performance can be seen in.

Figure 88: Schema of the Enhanced NEMO strategy
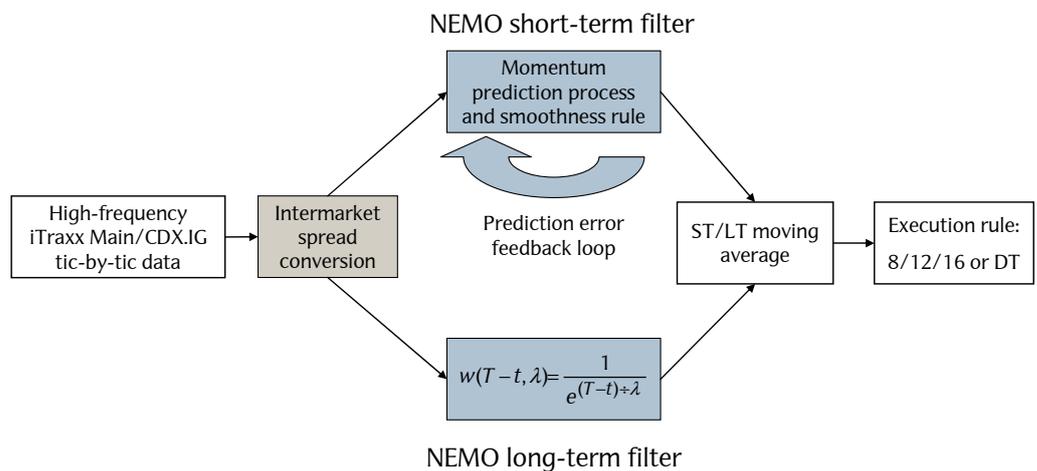
Source: Barclays Capital

As stated above, the enhanced NEMO differs in how it computes the short-term moving average. We replace the old exponential momentum computation with a state-of-the-art filtering technique for the short-term part of the model.

The filter incorporates its own prediction dislocation in terms of how it handles incoming data. If recent spread moves are more volatile away from the predicted momentum direction, the filter will put more weight on recent data point to form the short-term moving average. For example, this will happen in situations of high intraday cyclicality. We will then see the short-term trend being quicker to adapt and it will look less smooth in a graph compared to the original NEMO short term. An illustration of this can be seen in the graphs in Figure 89.

Conversely, if there is a higher degree of predictability in the spread dynamics, a longer memory will be used and the short-term moving average will be smoother, looking quite similar to the NEMO function with λ =100. This will lead us to retain the strong trend following capacity of the baseline NEMO version that has served it well in the momentum markets that have characterised 2007-08, but also allow a higher adaptability in periods of less momentum.

Figure 89: 26 August intraday cyclicality – Comparing NEMO versus the enhanced NEMO

Original NEMO

- ST moving average
- LT moving average
- iTraxx Main
- Synthetic iTraxx Main via rescaled CDX.IG

Intraday trading cycles with peaks around 101 and troughs around 100bp

Enhanced NEMO

- NEMO2 ST filter
- LT moving average
- iTraxx Main
- Synthetic iTraxx Main via rescaled CDX.IG

Short term moving average reacting faster to spread moves when cyclicality is high
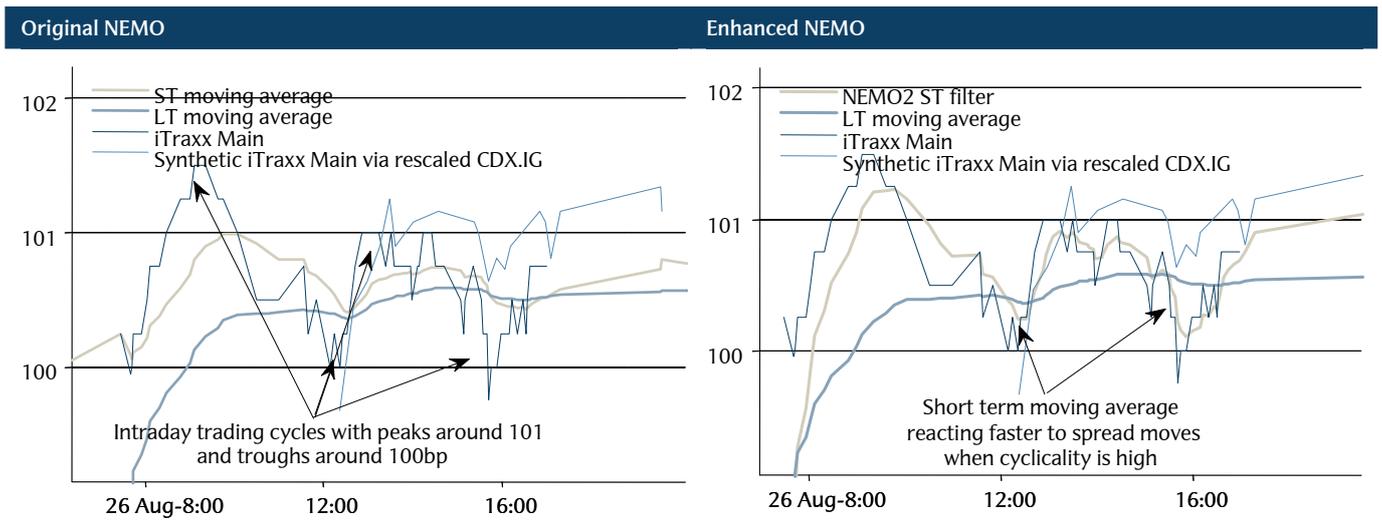
Source: Barclays Capital

So how does the enhanced version compare to the original version? We plot the post-transaction cost cumulative P&L differential between the two versions in Figure 90. Over the first 12-13 months of the sample, there were clear improvements with the new short-term file, but this took a rapid turn down as intraday volatility entered a new regime in September 2008. Cumulative outperformance went from 3.5% to 0.5% during this period. In October, however, this turned around again, and in mid-October the number is up to 2.4% again.

Our conclusions from this enhancement are two-fold. First, it illustrates the sensitivity of adding more complexity to the framework in the face of structural changes. By this we mean that the additional complexity introduced also had untested consequences once the environment the strategy operated in changed. Still, after this fairly rough road test of the new framework, it shows itself to still generate a substantial advantage over time versus the original model.

Figure 90: Outperformance of the enhanced short-term filter versus the original NEMO formulation

Source: Barclays Capital

Performance summary for NEMO strategies

The momentum trading landscape has definitely changed over the course of 2007-08. We noted the peak of strong trending in CDS markets so far in the March-April 2008 period (see for example *Extreme index momentum,* 4 April 2008). We first take a look at performance with NEMO in the baseline format, where trades are executed at 8am, 12pm and 4pm local time (London time for iTraxx users, Eastern time for CDX indices). This format was originally suggested in *A simplification of the NEMO trading strategy,* 30 April 2008, on the grounds of practicality but with actually an improved performance versus the earlier format.

NEMO for iTraxx Main

Cumulative P&L series from iTraxx Main are available in Figure 91. iTraxx Main generates 15.4%/9.4% of return pre/post transaction costs since 3 May, 2007, when our data-set begins, all calculated as non-accrued excess returns. [4] The 2008 year-to-date performance is 5.7% with strong performance in the first six months, and a negative performance in July, September and October. We note here that transaction costs remove 41% of the returns, where the transaction cost assumptions are available in Figure 93. Post transaction cost, the Sharpe ratio of the strategy on an annualised basis is 1.4.

Besides the strong cumulative performance, considering that these are performance numbers based on a levered strategy in the most liquid credit asset available, the strategy also exhibits a highly right-skewed return distribution. The right-hand panel of Figure 91 shows this. Whereas the two largest individual losses are in the 60-70bp range, the three biggest winning trades were in the 110-120bp range. This is a function of how the strategy operates: if a trade starts to go against you, it will be because of the spread trend has moved the other direction, which will, in turn, make the strategy switch into the new directional trend.

Figure 91: NEMO 8/12/16 on iTraxx Main
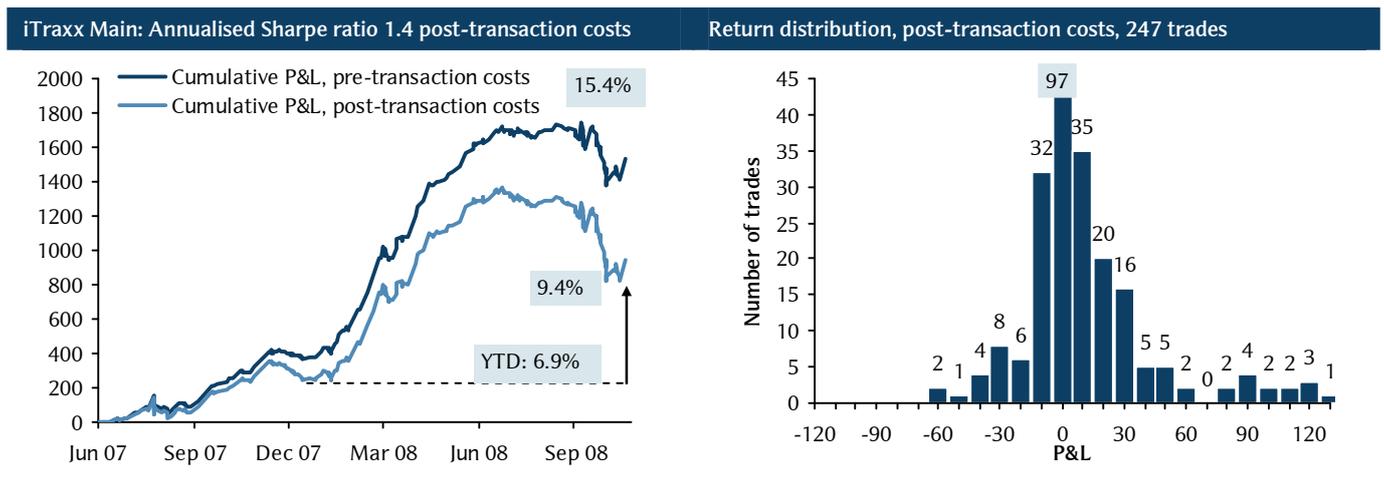
Source: Barclays Capital

Hence, the strategy (and any momentum following strategy) has the nature of an automatic stop-loss order. So we will expect the return distribution to follow the pattern in the chart, where the right-hand tail is longer than the left-hand tail. This is

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[4] *From here on throughout the NEMO performance section, all return numbers will be assumed to be post transaction costs, unless stated otherwise.*

considerably more attractive than the traditional credit return distribution, which usually exhibits many small positive returns and a few large but negative ones.

We have already mentioned the reasons why NEMO has appeared to work quite well in most of 2007-08, but we now try to understand what actually did not work well. From a pre-transaction cost standpoint, gauging the model's signalling power, performance held up until the start of the September, but after that performance deteriorated on a pre-transaction costs basis as well. In Figure 92, we plot the intraday moves over three trading sessions in iTraxx Main/CDX.IG on 16-20 October 2008. The graph shows a negative macro-trend with iTraxx Main widening in the 5-10bp region during these trading days. The intraday variations around this trend are very large, however. We highlight these with the arrows in the chart where four extremely volatile trading periods are shown through the arrows. These periods saw spread velocity (directional move per unit of time) of around 5bp an hour. The morning of the 17 October was the direst, where the index moved 17bp wider from open at 7:20am to 10:50am London time. As a consequence, the sampling frequency, in the sense where we allow the NEMO baseline strategy to trade, of 8:00, 12:00 and 16:00, is simply too coarse. To react to such rapid intraday moves, one has to decrease the intervals between the trading points in order to reposition for the new market momentum as soon as possible. Alternatively, one instead trades much more infrequently, such as in the NEMO/DT framework below, so that these intraday variations, or whiplash effects, become less accentuated.

By the end of the day, which direction one chooses – continuously trading in and out, or actually downsampling to trade less frequent – must be evaluated on alpha/risk-appetite grounds. The high-frequency trading approach can potentially capture more alpha, if execution costs are low, and will also minimise the mark-to-market risk of the strategy. In the less-frequent trading approach, there are fewer operational and transaction costs, but one has to sustain more risk if the current position's mark-to-market moves significantly against you.

Figure 92: Whiplash patterns in iTraxx Main, 16-20 October 2008
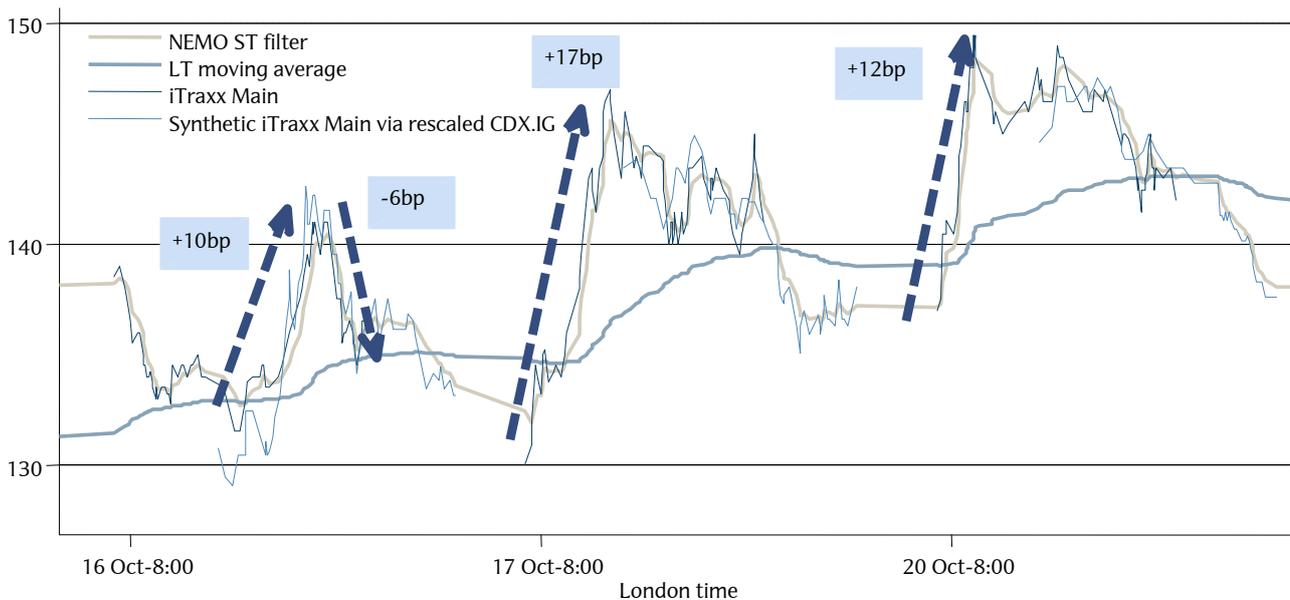
Source: Barclays Capital

Notes on transaction cost assumptions

Obviously, transaction costs are an important point in NEMO. In our assumptions (Figure 93 for iTraxx Main, Figure 94 further below for CDX.IG) we have tried to reach a balance in how penalised the strategy should be in terms of the trading frequency. For someone who follows the trading strategy exactly, they will carry the full cost and the bid/offers presented may seem on the low side compared to what one usually sees on a single Bloomberg run. We believe that, for a repeated user trading 200+ times a year, just looking at one dealer's full bid-offer from the runs may in the end be too conservative.

Figure 93: Transaction cost assumptions, iTraxx Main

Lower bound of spread (>=)	Upper bound of spread (<)	Transaction costs assumption
1 May 2007- 30 March April 2008		
0	40	1/8bp
40	50	1/4bp
50	80	1/2bp
80	-	1bp
1 April 2008-		
0	40	1/8bp
40	60	1/4bp
60	120	1/2bp
120	170	1bp
170	-	2bp

Source: Barclays Capital

Figure 94: Transaction cost assumptions, CDX.IG

Lower bound of spread (>=)	Upper bound of spread (<)	Transaction costs assumption
0	50	1/4bp
50	100	1/2bp
100	150	1bp
150	-	2bp

Source: Barclays Capital

NEMO for CDX.IG

We have not previously covered a NEMO implementation on CDX.IG specifically and hence we provide some detail here on the calibration of this model. There are a few features that are different in the implementation of NEMO on CDX.IG.

- Trading costs in CDX.IG appear higher than in iTraxx Main, with a commensurate penalty on frequencies that trade too often. We show our CDX.IG transaction cost assumptions in Figure 94. [5]

- The momentum captured from overnight trading becomes more significant as it will have a direct impact on the NEMO signals in the early hours of CDX trading. This means that imprecisions in the calculation of synthetic CDX spreads will be relatively important compared to the iTraxx Main case.

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[5] *From a calculation standpoint it is also harder to compute the returns series on CDX.IG switching between different versions of the index in Series, due to credit events Washington Mutual, Fannie Mae and Freddie Mac. We account for these by switching into the newest version of the index at the earliest date when we trade again. Rolls are conducted at 08:00 on the roll date, and at the quoted costs for rolling to the on-the-run index at that time.*

- There is a more pronounced drop in activity toward the end of the CDX trading session compared to the European session. Interest in trading European contracts from the US can keep activity up despite having far passed normal trading hours. For the US market, there is little external influence to keep volumes up once the domestic market starts wanting to go home. This should move the last time of the day that you allow trades on back somewhat, in order to have similar liquidity conditions to iTraxx Main.

Given these factors, we believe that it makes sense to have a different calibration of the NEMO parameters in the CDX.IG version, particularly for the more transaction cost-sensitive 8/12/16 version. We conduct a calibration in the following way:

- We set a historical date at which the optimisation is conducted to get the optimal combination of the short-term and long-term filter sensitivities. Specifically, we set this date to 31 October 2007, to have enough data to calibrate on (six months) but also retain a significant out-of-sample testing period (12 months).

- We find a fairly strong negative effect of trading as late as 4pm New York time, mostly due to a lack of good data that late in the day. Hence, we compress the trading window by one hour, so that the strategy trades at 8am, 11.30am, and 3pm.

- On the in-sample period (1 May 2007-31 October 2007), we calculate the pre- and post-transaction cost P&L for a discrete set of combinations of lambdas.

- Using a weighting matrix, we calculate the average return for combinations of lambdas close to one particular lambda, which in effect works as a smoother/moving average in two dimensions. Specifically, we weight the central point at 4x, any adjacent P&Ls at 2x and elements two positions in the matrix at 1x their actual P&L. A result of this procedure can be seen in Figure 95.

- We choose our optimal combination of lambdas according to the global maximum in the (smoothed) P&L surface, ie, the highest point on the grid in Figure 95.

Figure 95: P&L surface, 31 October 2007, for NEMO 8/12/16, CDX.IG
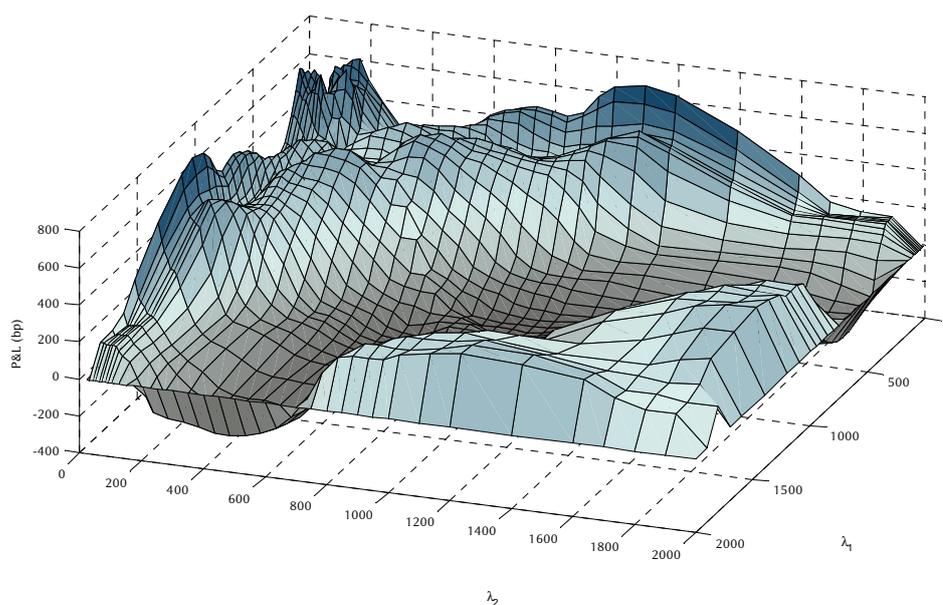
Source: Barclays Capital

As we can see in the figure, even the task of choosing an optimal lambda combination when using the smoothing procedure is non-trivial. There appears to be two areas where P&L is fairly high, one where the lambdas are relatively small (between 70 and

200 for both lambdas) and one where the short-term sensitivity is high (lambda1 < 50) and the long-term lambda is much less sensitive (between 900 and 1,500). In the end, our algorithm picks the [30,1100] combination. We check the stability of this estimate and find it remarkably stable even as we shift the end date of the calibration period.

Performance analysis

Given this combination based on the first six months of data, we apply the enhanced NEMO methodology (see previous section on 'Evolving NEMO') on the full set of CDX.IG data. Results are available in Figure 96. We see a similar performance to what we saw in iTraxx Main, with cumulative performance of 16.5%/9.2% pre/post transaction costs, and a year-to-date performance of 7.9% post transaction costs. The annualised Sharpe ratio stands at 1.6 post transaction cost. The right skewed return distribution is again apparent, as shown in the right-hand panel of the figure. For example, whereas we see the three biggest losing trades in the -60 to -70bp bucket, there are 12 trades that generate returns in excess of 70bp.

We note two differences in the CDX.IG performance numbers. First, the differential between the pre- and post-transaction cost number is larger, with 44% of the returns diluted to trading costs, but not distinctly so from the 41% in iTraxx Main. Trading costs are, as we noted, higher in CDX.IG, but we also have a reduction in the number of trades in the CDX.IG calibration from 247 in the iTraxx Main version to 177 in CDX.IG.

Second, the nature of the underperformance post June 2008 looks slightly different. Over this period, pre-transaction cost performance has been actually marginally up, whereas the post-transaction costs returns are falling in a fairly gradual fashion, until September. Thereafter, we have seen both September and October as positive return months. Closer analysis suggests that the difference between Main and CDX.IG in this period stems partly to idiosyncratic factors, such as news flow before or after either of the strategies has taken a position, and partly due to a more systematic factor: information flow during this period has been backloaded into the US afternoon, when the Main strategy has not traded.

Figure 96: NEMO 8/12/16 on CDX.IG
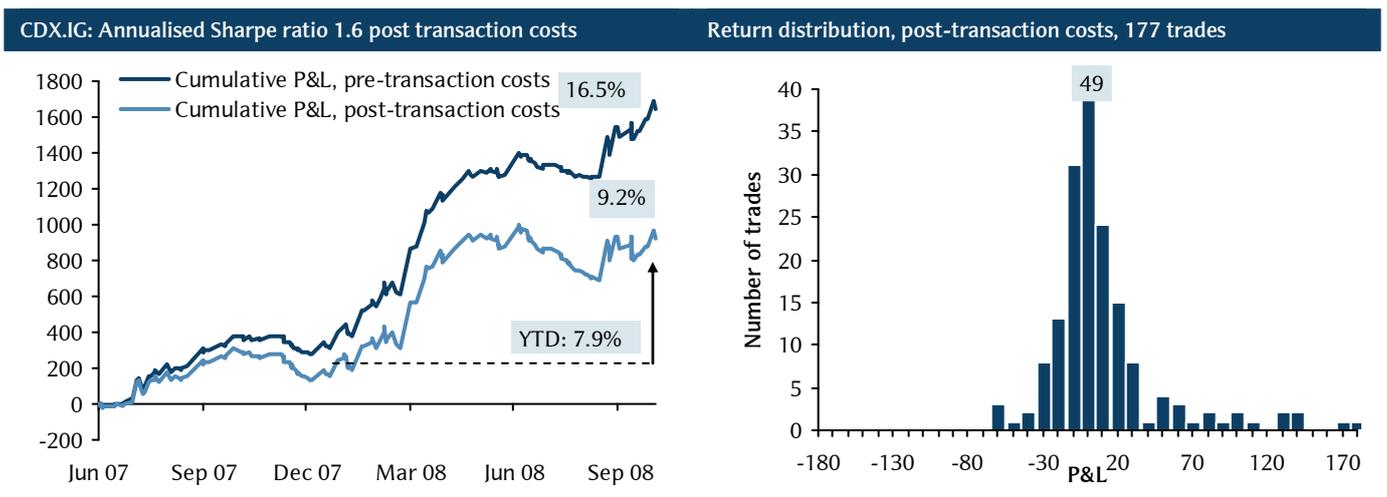
Source Barclays Capital

NEMO/DT (Daily Trading)

For many investors, trading at an intraday frequency may not be applicable due to practical constraints. Cognisant of that, we introduced a NEMO version denoted DT (for Daily Trading) in *NEMO – Three signals a day, or just one?* 3 July 2008. This version was

calibrated to have the responsiveness of the moving average filters suited for a lower trading frequency. The calibration procedure is described in the section below and was conducted with iTraxx Main in mind. The methodology was similar to what we used to calibrate the CDX.IG trading strategy presented in the previous section as well.

We apply the resulting lambda combination found at for the iTraxx Main NEMO/DT mode (equivalent to a short-term lambda of 60 and a long-term lambda of 750) for this strategy. We allow the strategy only to trade at 2pm Eastern time, as it has historically been a much lower liquidity/quoting frequency from 3pm and onwards. Setting the signal at 2pm allows us to retain the data-set fairly intact. It also allows interested European investors to partake in the strategy without having to stay at their desk too late in the evening.

Performance of the NEMO/DT, CDX.IG is the strongest and most consistent on a post-transaction costs basis of all the investment grade NEMO strategies. Figure 63 plots cumulative returns and other diagnostics for this model. Performance is weaker in the July-October 2008 period, but still positive post-transaction costs. What we can see for the CDX version is that it had fairly modest returns in 2007, only generating 0.4% of return post transaction costs. The right-hand skew return distribution is even more protruding here compared to the 8/12/16 version, with two trades generating in excess of 2% of return each and the largest two losses in the 80-90bp range. The annualised Sharpe ratio reaches 1.7 versus 1.6 in the 8/12/16 strategy.

Figure 97: NEMO/DT for CDX.IG
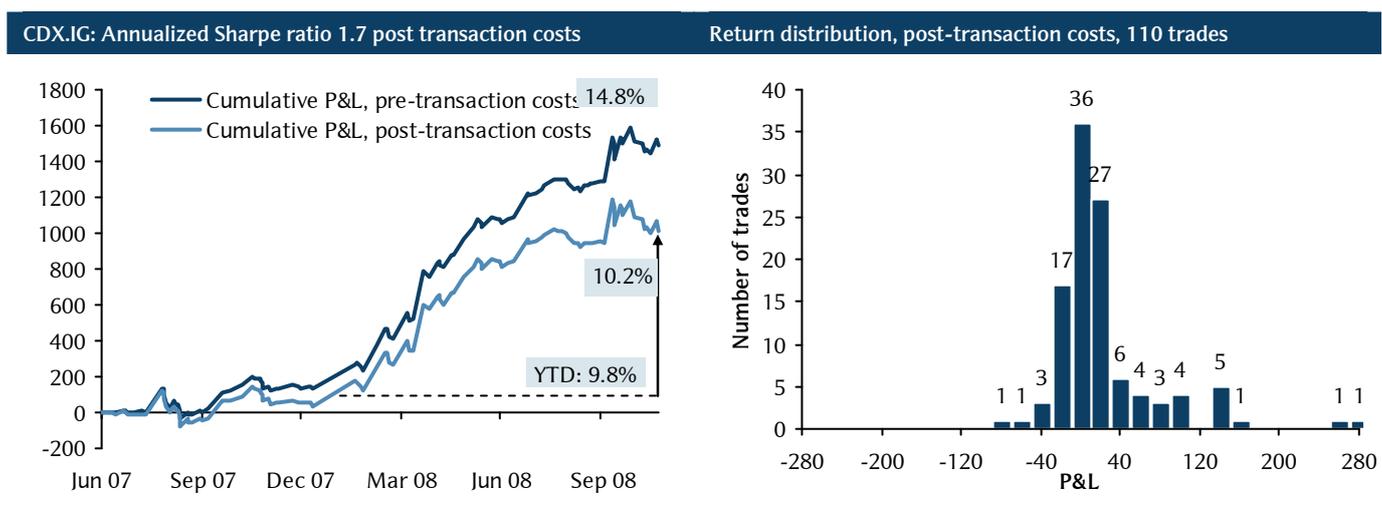
Source: Barclays Capital

Turning to the NEMO/DT for iTraxx Main we see a substantial improvement vis-à-vis the 8/12/16 trading rule. Cumulative return hits 13.3%/10.4% before/after transaction costs, with the Sharpe ratio reaching 2.1 post transaction costs. Compared to the higher frequency version, the DT version benefit from much less trading in a less trending environment in September-October 2008 and is essentially flat P&L-wise throughout this challenging period. Similar to the CDX.IG version, there is a pretty extreme right-hand tail in the return distribution, stemming from going long the market close to the peak of spreads in March 2008 and exiting that position a few weeks later when the market was much tighter.

Figure 98: NEMO/DT for iTraxx Main

| iTraxx Main: Annualised Sharpe ratio 2.1 post transaction costs | Return distribution, post-transaction costs, 127 trades |
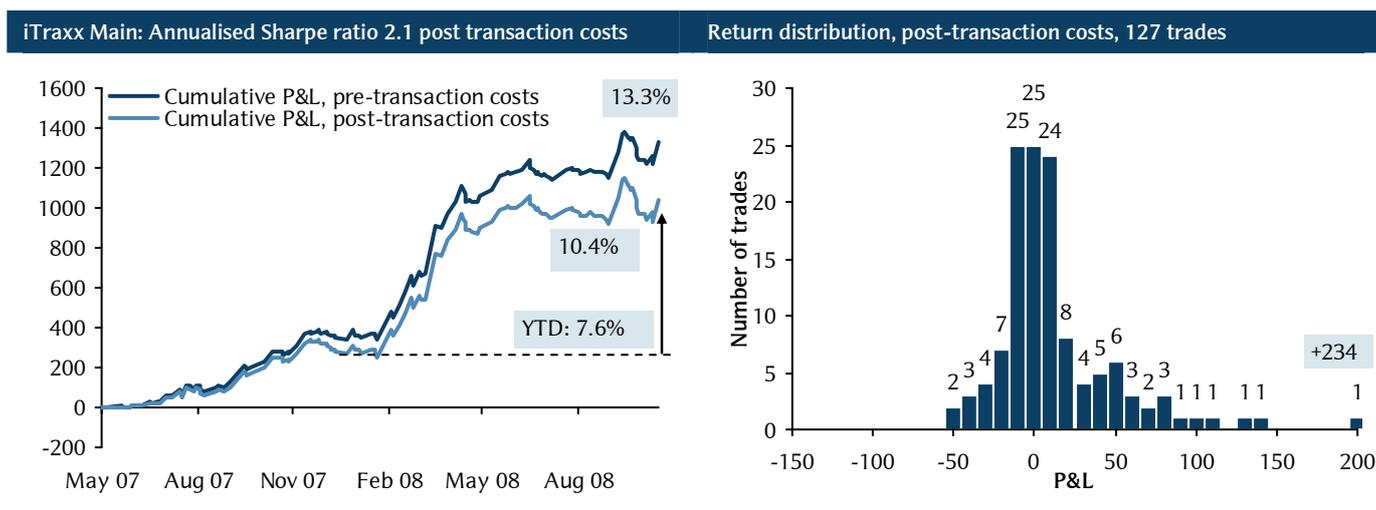
Source: Barclays Capital

Lessons from trading NEMO 8/12/16 versus NEMO/DT and further avenues of research

What can we learn from the performance benchmarking of the NEMO/DT strategy versus the 8/12/16 version? We would like to summarise our findings as:

- Relative performance: Although it has become obvious from the above benchmarking that the DT models have had a strong cumulative performance, this has not been the case in earlier evaluations. In previous research pieces, for example *NEMO – Three signals a day, or just one? 3 July 2008*, we have consistently found the 8/12/16 version to be ahead of the DT version.

- Transaction cost/execution cost sensitivity: Pre transaction costs, we still find the 8/12/16 version around 1-2% ahead of the DT version. Hence, execution improvement will have proportionally bigger effects on the 8/12/16 version with its larger number of trades.

- Tail-risk exposure and risk reduction: We note that the NEMO/DT strategy will give rise to some fairly high negative mark-to-markets, as highlighted in Figure 92. Here, one could argue for a system that actually goes away from fixed execution time and starts to react faster to large spread moves.

We believe that one of the more promising avenues of research in the NEMO domain would be to look at dynamic execution times, as suggested in the last bullet point. This would be a less practicable solution than the current one, but could provide substantial improvements in performance.

Another possibly fruitful extension would be to allow for overnight trading via whichever index is open at the time. This requires a more complex trading structure in order to net non-identical index positions, such as going from long in iTraxx Main to implementing the next short (and hence having to offset the previous Main position) in CDX.IG, if signalled so by the model.

Optimising trend extraction for the 16:00 trading rule

Extract from *NEMO – Three signals a day, or just one?* 3 July 2008

We recommended a thrice daily signal update convention for the NEMO (iNtraday Exponential Momentum) trading strategy in *A simplification of the NEMO trading strategy*, 30 April 2008. Although the performance since this change has more than met expectations, we acknowledge that for some investors the trading frequency is still too high.

From a technical standpoint, optimising lambdas entails conducting a grid search for the possible combinations of lambdas to identify those that generate the highest P&L, or whatever sort of target function we are looking to optimise. Figure 99 shows the post-transaction costs P&L surface based on the possible combinations of lambdas. Dark blue colours indicate the highest performance in the sample. The dark blue areas are concentrated around the [150,200] and [100,700] points, indicating that combinations of alphas around these areas appear optimal for maximising post-transaction cost P&L.

We are cognisant that looking for just one point to generate the greatest P&L in a grid search such as this can be misleading, as an isolated point of very strong performance that is not really stable could emerge. We apply a matrix smoothing technique to find the most stable, high post-transaction cost P&L combination of lambdas. In the end, we arrive at the lambdas [60,750] as the optimal combination for the 16:00 hours strategy. With this in place, back-testing performance increases from 8.65% to 10.11% over the sample period.

Figure 99: Optimising trend smoothness for the 16:00 rule
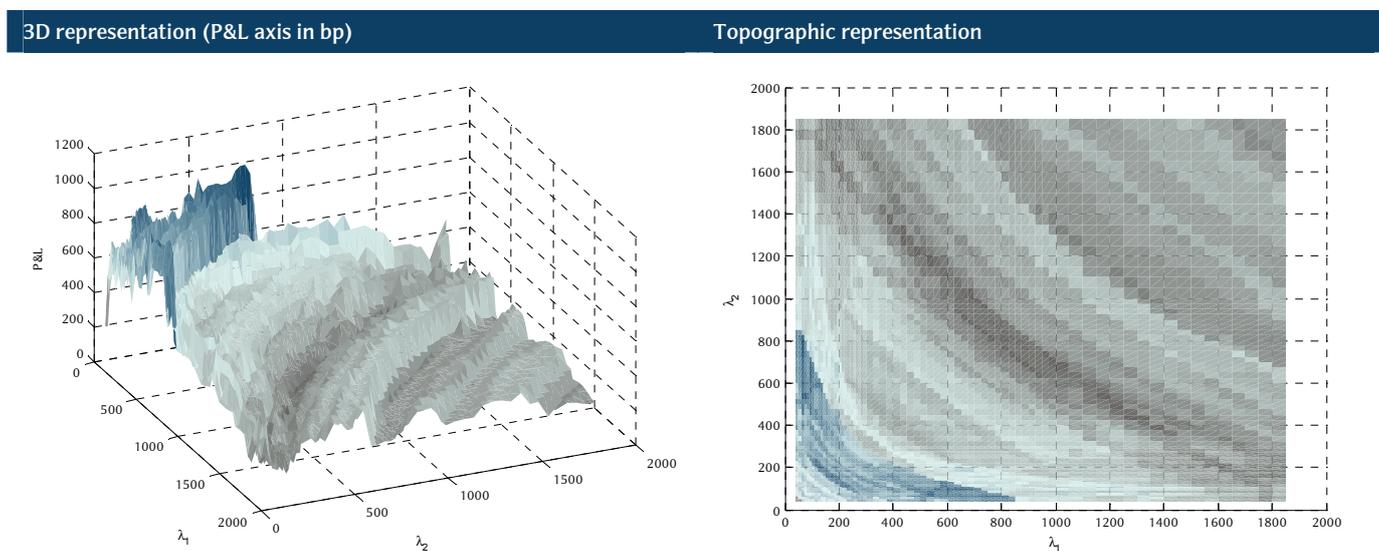
Source: Barclays Capital

NEMO: How would it have done pre-credit crunch?

Extending testing to the pre-credit crunch era

NEMO has, as we see above, proved effective in the generally volatile credit conditions of the past year. What some NEMO followers are asking is how it would perform in a return to a quieter, lower-spread regime, such as that seen in the pre credit-crunch period of 2004 to mid-2007. Although we do not expect any near-term return to such a regime, it is nonetheless a valid robustness question for any algorithmic strategy. In particular, some users have expressed concern that a much tighter trading range may lead to performance being paid away in transaction costs due to excessive flipping of positions.

An immediate problem with any extension of back-testing, however, is data availability. NEMO uses intra-day quotes to compute the trend signals which trigger trading. We have been actively collecting and monitoring this data from June 2007, but before this there is no reliable source. Instead, we do have end-of-day iTraxx data back until June 2004 when the indices were launched, and our QCX indices (see *Appendices*) which further extend this back to 2001.

It is possible to approximate the NEMO trends using end-of-day data alone. As with the full version of NEMO, exponential weighting can be used to emphasise more recent quotes and put less weight on older quotes. Example long-term (LT) and short-term (ST) trends based on end-of-day data are given in Figure 100.

Figure 100: Long-term (LT) and short-term (ST) NEMO exponential trend series based on end-of-day data on iTraxx Main

Source: Markit, Barclays Capital

Back-testing using end-of-day data

Using end-of-day data we can formulate trends as shown in Figure 100 and establish long or short trading signals on a daily basis, similar to the full version of NEMO. Naturally, this extended back-test will allow trading only once per day, similar to the NEMO D/T version.

There are a number of important caveats to the use of end-of-day data:

- The full trending behaviour and volatility of index levels cannot be captured by end-of-day pricing alone.

- We use Markit composite mid-market quotes. As trimmed averages, these do not truly represent tradable levels, in contrast to the live quotes we use for full NEMO back-testing.

- We assume a transaction cost schedule as shown below.

- Additionally, in the versions shown here, we are unable to effectively include information from the CDX IG market outside iTraxx hours – this is a significant contributor to actual NEMO signals.

Despite these points, we have set the exponential weighting functions that generate the trends shown in Figure 100 in such a way as to best approximate the actual NEMO trends in the credit crunch period where both are available. We assume the following transaction costs, based on observed patterns.

Figure 101: Assumed iTraxx Main bid-offers

5yr spread range (bp)	Bid-offer (bp)
0-50	0.25
50-80	0.5
80+	1

Source: Barclays Capital

Figure 102 shows charts of the cumulative total returns in basis points on the NEMO-style strategy using end-of-day data from June 2004 to August 2008. There are a number of observations to make on this back-testing performance:

- The average annual total return over this full period is 220bp, post transaction costs. The Sharpe ratio is 1.26. Over the period up until June 2007, the average annual total return is 76bp, with a Sharpe ratio of 1.4.

- Overall, performance in the pre-credit crunch period is weaker than during the credit crunch. However, the performance is still positive over this period, with low volatility and minimal drawdown periods (that is sustained periods of losses).

- Performance picks up markedly in the credit crunch period, in line with spread volatility.

- Trading costs do not swamp performance – there is only a mild divergence between the pre- and post-transaction cost cumulative performances. This also shows that the frequency of trading is reasonable.

- The pattern of performance during the credit crunch is similar to that of the full NEMO D/T strategy (see the previous article), but the magnitudes of returns are smaller. This is comforting in that our approximate NEMO end-of-day-based trends are providing broadly similar signals, and the high-frequency version does, however, add significant extra value.

Figure 102: Strategy performance based on daily trading signals using end-of-day trend series on on-the-run iTraxx series, June 2004 to Aug 2008
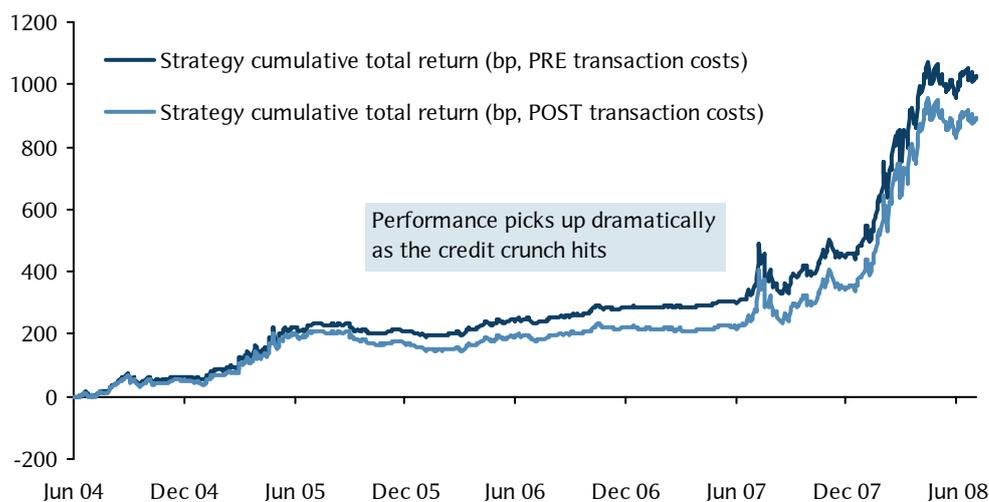
Source: Markit, Barclays Capital

Bounding performance using different trend speeds

In the extended back-test above we selected weighting parameters to construct the NEMO-style trends so that they were visually similar to the actual NEMO trends during the credit crunch period. It is informative to consider other weighting schemes as a way of ascertaining the robustness of the back-testing. In this section we look at a very sensitive, fast moving, long-term trend and an insensitive, slow moving trend. In a sense, the performance of any NEMO-style strategy should be somewhere between these two extremes.

In a first example, we consider a very sensitive long-term trend shown in Figure 103. This fast moving trend tracks the spot spread quite closely, leading to fast trading signals when there is a momentum change. Naturally, trading frequency will increase.

Figure 103: Fast moving long-term (LT) trend model
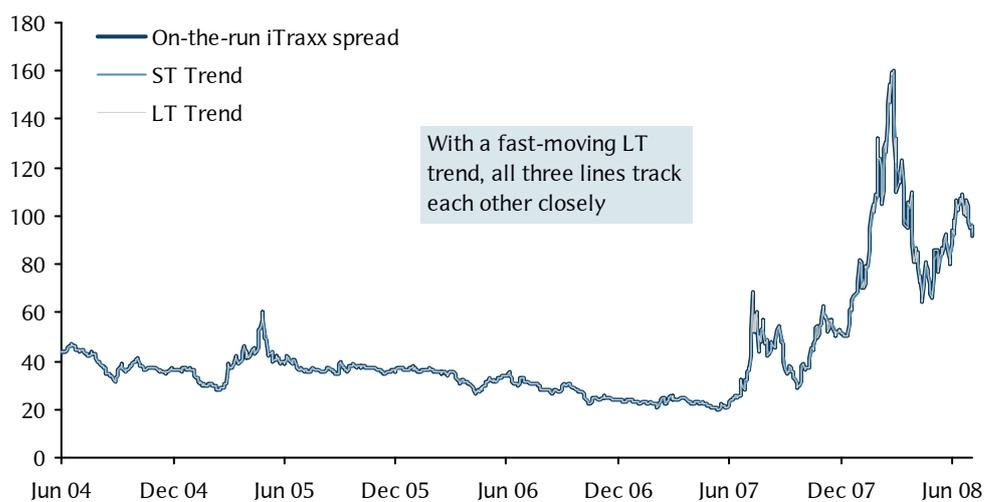
Source: Markit, Barclays Capital

Figure 104 shows the performance of the NEMO strategy using this fast moving LT trend. Pre-transaction costs, performance is strong and approximately in line with the first test we ran. However, due to dramatically increased trading frequency, the post-

transaction cost performance diverges significantly. A little under half of the performance is given up in trading costs.

Figure 104: Strategy performance with fast moving LT trend
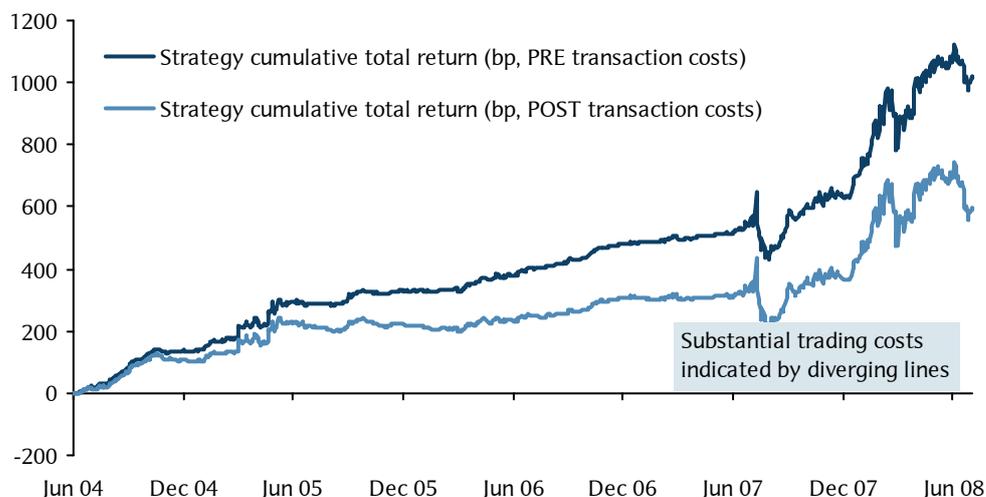
Source: Markit, Barclays Capital

As a second example, we consider the opposite extreme of a very insensitive, slow moving long-term trend. Figure 105 shows the charts of these trends. The LT trend is very slow to react to spread moves, resulting in dramatically less trading.

Figure 105: Slow moving long-term (LT) trend model
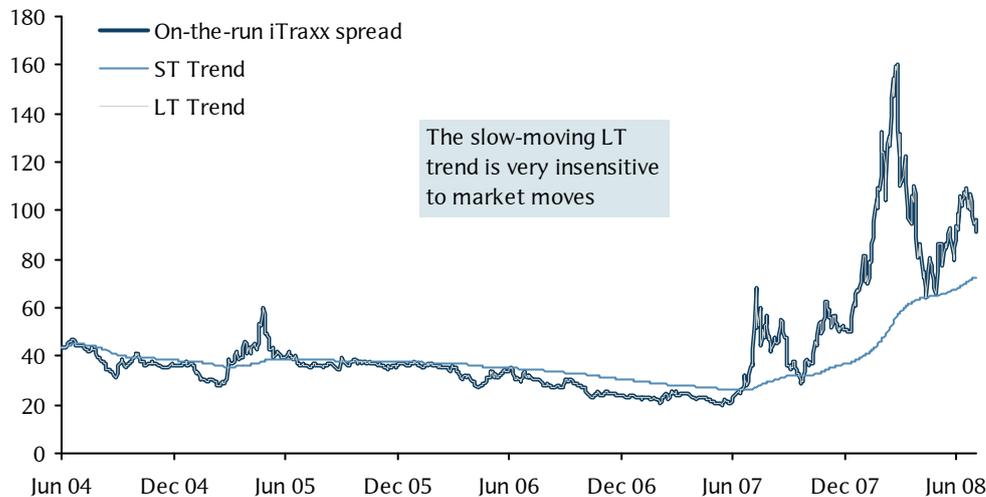
Source: Markit, Barclays Capital

The performance using the slow moving LT trend is shown in Figure 106. The overall pattern resembles closely the graph of spreads themselves shown in Figure 105, as the model stays long or short for extended periods. There is correspondingly very little performance give-up in terms of trading costs, shown by the minimal divergence of the pre- and post-transaction cost lines.

Figure 106: Strategy performance with slow moving LT trend

- Strategy cumulative total return (bp, PRE transaction costs)
- Strategy cumulative total return (bp, POST transaction costs)

Performance mimics the spread series, with little divergence between pre and post transaction costs
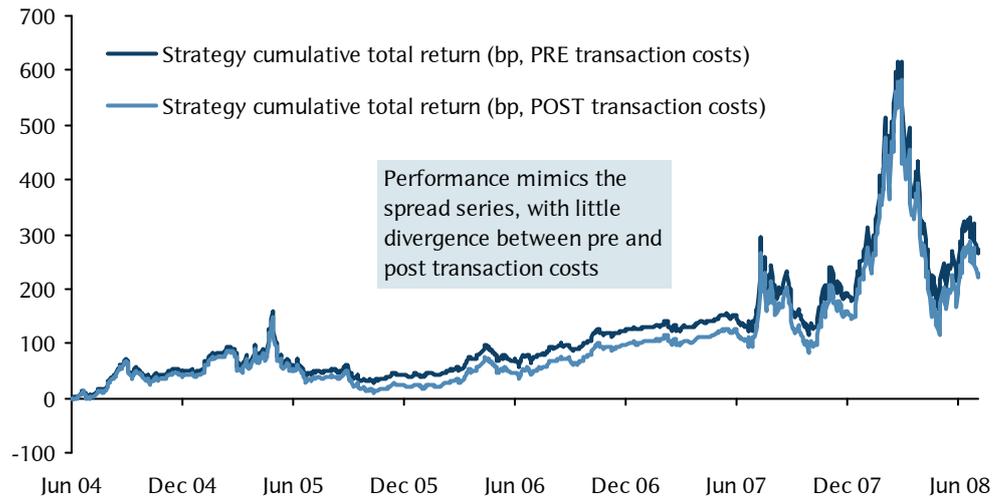
Source: Markit, Barclays Capital

Full sample test, using QCX and NEMO-DT

A final extension is to use our QCX end-of-day data which go back to 2001. Although this includes a further volatile period in 2001-02, we do not have the intra-day based signals available. In Figure 107 we show the cumulative and summary performance of the end-of-day NEMO test from 2001 to mid-2007, switching to actual NEMO-DT performance from mid-2007 onwards. Naturally data quality is more of an issue in the early part of this sample, but the patterns are broadly consistent with the rest of NEMO history.

Figure 107: NEMO-DT extended testing back to 2001

Average annual return: 2.77%
Annual Sharpe ratio: 1.6

End-of-day NEMO test

NEMO- DT (Intraday signals)
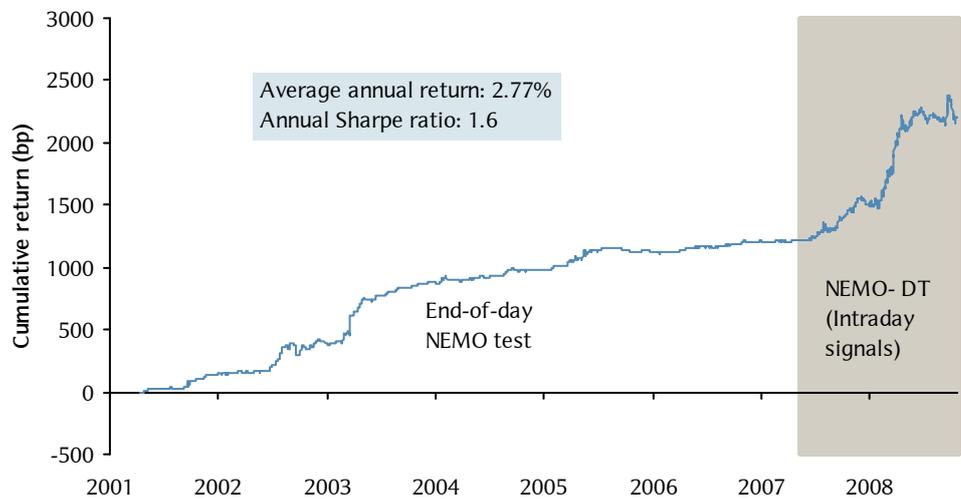
Source: Markit, Barclays Capital

NEMO: A volatility interpretation

NEMO has been shown to have a performance link – both conceptual and empirical – to credit market volatility. In the following extract we attempt to characterise and quantify this effect by comparing NEMO performance with that of some standard long-volatility option strategies.

The analysis in the full article (from which the following extract is taken) extends to the testing of a strategy which systematically invests in NEMO and sells short-dated delta-hedged straddles. This strategy has many appealing properties, strengthening the performance of NEMO at the expense of increased complexity. Option strategies are beyond the scope of this handbook and we encourage the reader to follow this reference.

This is an extract from *Credit volatility: the cheap and the expensive*, 15 October 2008.

Soren Willemann, Matthew Leeming, Ulf Erlandsson, Graham Rennison

We compare three methods of buying volatility:

1) **Buying straddles**. Buy ATM spot straddle and hold until expiry.

2) **Buying gamma through delta-hedged straddles**. Hedge option daily until expiry.

3) **Investing in NEMO**. Daily rules-based momentum trading.

These three strategies benefit from two principal kinds of volatility: directional, where spreads move significantly in either direction and rangebound, where spreads change without momentum.

- The correlation of applying these strategies consistently through time is positive, about 30%. However, iNtraday, iNtermarket Exponential Momentum (NEMO) has the best average performance of the three, and buying gamma the worst.

- Straddles benefit from wide ranges but can underperform when option premiums are high. Correlation of P&L with the realised range is 42%. Correlation with the volatility risk premia is -41%.

- Buying gamma benefits from non-directional realised volatility, but is expensive. Correlation with realised volatility is 39%, but the average return is substantially negative over long sample periods.

- NEMO relies on directional volatility and is not affected by the volatility risk premia. The P&L has an 83% correlation with the realised spread range.

- Volatility generated in NEMO is cheap: NEMO has a historical Sharpe ratio that is consistent with having bought straddles with a 35% lower implied volatility.

Relative performance of volatility trades

We tally the outright performance of the three different ways of buying volatility in Figure 108. NEMO has highest Sharpe ratio by far, with an annualised figure of 1.66 and the smallest tail risk, with a monthly 99% VaR of -€37k. Buying straddles outright has a Sharpe ratio of 0.17, followed by buying delta-hedged straddles with a negative average return and a Sharpe ratio of -0.93.

Historically, NEMO has had a VaR lower than that of buying straddles. However, it is important to note that the VaR of buying straddles can never be higher than the price of the options. VaR is thus strictly bounded. For NEMO, it is theoretically bounded only by how much spreads can move from close to close over two days, conditional on NEMO being caught of the wrong side of the spread movement. Historically, this has not resulted in very high VaR levels, but in theory there is no upper limit to the NEMO VaR.

Figure 108: Annual return statistics (€000s for €10mn invested)

	Buy delta-hedged straddle	Buy outright straddle	NEMO
Average	-53	21	394
Std	57	120	238
Sharpe ratio	-0.93	0.17	1.66
99% monthly VaR	-53	-84	-37

Source: Barclays Capital

The Sharpe ratio as shown in Figure 108 covers significant time variations, as shown in Figure 109, Panel A. Here, we show the Sharpe ratio calculated over three months (of overlapping 1mth trades). There is a general tendency for the ratios to follow each other, albeit at different levels. Of particular interest is that in the current volatile period and (in retrospect) quiet periods of 2005, the NEMO strategy has prevailed with the highest Sharpe ratios (even if negative in late 2005).

Sharpe ratios and VaR measures are not perfect, giving information only about the first and second m/ments and a crude measure of downside. To complete the picture, Figure 109, Panel B show the historical distribution of monthly P&L of the three volatility trades. It sums up what we have learned about the three types of volatility trades.

Figure 109: Rolling window Sharpe ratios and historical P&L distribution for competing strategies

Panel A: 3mth rolling window Sharpe ratio of 1mth horizon trades | Panel B: Historical distribution of monthly P&L (€k for €10mn invested)
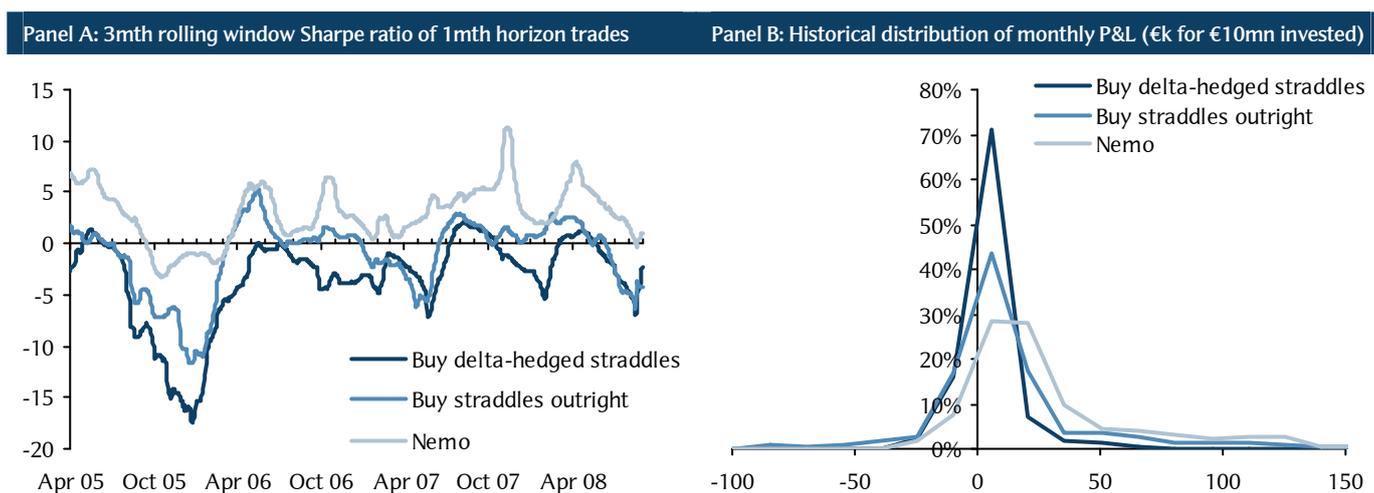
Source: Barclays Capital

Drivers of performance

In Figure 110, we characterise the performance of the three ways of trading volatility. Over a given period, we calculate the percentage realised volatility, the implied volatility at inception, the implied volatility minus the realised volatility (premium) and the range of spreads (highest minus lowest). See the notes to the figure for details. We then calculate the correlation between these characteristics of the period with the P&L of the respective trades. We also show the correlation of P&L between the trades:

- All volatility trades show a positive, albeit low, correlation in the low 30s. That is, as in Figure 109, the three trades tend to have a drop/increase in profit at the same time.

- Buying delta-hedged straddles shows a strong and negative correlation with the volatility premium: when options are expensive relative to the volatility being realised, the trade underperforms.

- The P&L of NEMO has a strong correlation with the realised range of spreads: NEMO profits from very large swings in the underlying.

- Buying straddles has a P&L profile positively correlated with the realised range and negatively correlated with the volatility premium. Both make intuitive sense: buying straddles profits if spreads move significantly (the range is large), while the strategy will suffer if the implied volatility premium is large – options being expensive relative to the actual volatility. Note that long straddles, as such, do not benefit from realised volatility over the period, they benefit only from the absolute difference between spreads at inception and spreads at expiry being large.

Figure 110: Correlation matrix – performance of volatility trades versus characteristics of spread movements

	Realised	Implied	Premium	Range	Buy Gamma	Straddle	NEMO
Realised	100%						
Implied	64%	100%					
Premium	-65%	18%	100%				
Range	81%	70%	-34%	100%			
Buy Gamma	39%	-18%	-68%	25%	100%		
Straddle	32%	0%	-41%	42%	32%	100%	
NEMO	61%	50%	-28%	83%	35%	32%	100%

Note: We define realised volatility as the annualised log-volatility of daily spread changes incurred over a given period. Implied volatility is the 1mth ATM implied volatility observed at the beginning of the period. Premium is the difference between 1mth implied volatility at the beginning of the period less realised volatility over that period. We define the range as the difference between the highest and the lowest spread levels observed over a given period. Source: Barclays Capital

The price of volatility in NEMO

NEMO has similar characteristics to buying straddles: both trades make money if spreads move a lot in either direction, and both tend to lose money if spreads do not move much.

However, as shown in Figure 108, the Sharpe ratio of the NEMO strategy is higher than that of buying straddles. This beckons the question: to the extent that NEMO has a higher Sharpe ratio than buying straddles, how much cheaper would straddles have had to be historically for the Sharpe ratios to be identical?

We answer this question in Figure 111, Panel A. The NEMO strategy has a Sharpe ratio of approximately 1.7. For the strategy of buying straddles to expiry to have the same Sharpe ratio, implied volatility would have needed to be 35% lower than actual levels. In a sense, then, NEMO allows the investor to buy 'directional' volatility at a price that has historically been 35% below that seen in the market.

Figure 111: Comparing buying straddles to investing in NEMO – Sharpe ratio and 99% VaR

Panel A: Historical Sharpe ratio of straddle trade assuming various shifts to actual level of implied volatility vs Sharpe ratio of NEMO	Panel B: VaR for strategies at different VaR thresholds

-35% implied correlation: buying straddles same Sharpe ratio as NEMO

Straddle
NEMO

Change in implied volatility

NEMO
Straddle (actual implied volatility)
Straddle (-35% implied volatility)

VaR threshold

Source: Barclays Capital

As noted before, investing in NEMO has a higher Sharpe ratio and less tail risk than buying straddles. Figure 111, Panel B shows that the lower tail risk in NEMO is not solely related to the fact that it generates 'cheap volatility', as discussed above. Even if we assume a 35% lower implied volatility, the straddle trade still generates marginally more tail risk than the NEMO strategy.

In Figure 112, we show the historical distribution of monthly P&L for NEMO, buying straddles, and buying straddles had implied volatility been 35% lower. We note that in the last case, the straddle trade would have shown a historical return distribution much more similar to NEMO than is actually the case. We also see that, even taking into account that straddles appear expensive relative to NEMO, the straddle trade still has more downside risk than NEMO and less potential upside.

Figure 112: Historical distribution of monthly P&L for NEMO and straddle trade for actual and -35% implied volatility

NEMO
Straddle (actual implied volatility)
Straddle (-35% implied volatility)

Monthly PnL (bp of invested notional)
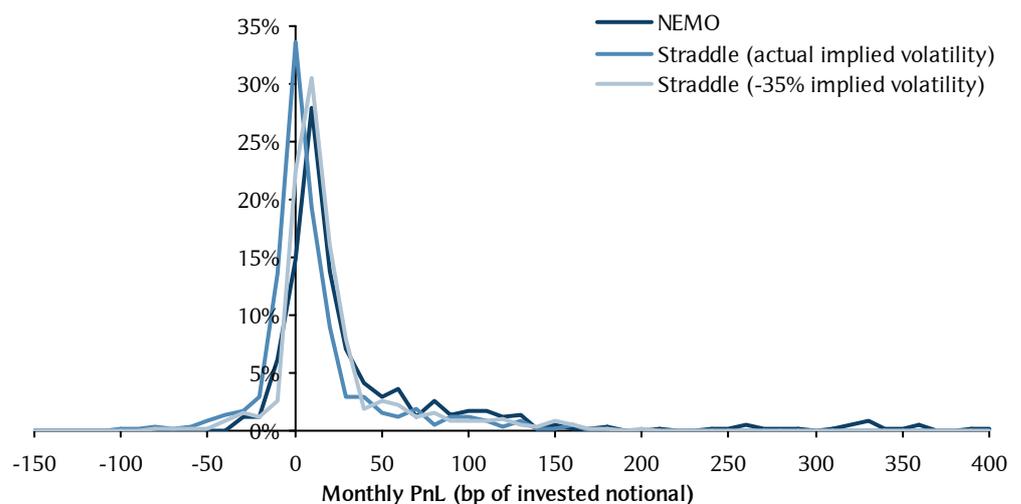
Source: Barclays Capital

Our analysis thus highlights that historically, the NEMO strategy has generated a long-volatility investment at a 35% lower implied volatility than achievable through buying straddles, at the same time as having a more attractive behaviour in the tail –in terms of both up- and downside.

Mark-to-market implications of high index volatility

This is an excerpt from 'Tactical index positioning: Days of the opportunist', *European Alpha Anticipator*, 11 April 2008.

Index markets have traded wider and moved faster between highs and lows than ever before over the past couple of weeks. In market conditions like these, we see compelling advantages of playing the indices opportunistically, rather than overly relying on point forecasts of future index levels. These forecasts, even when right, often get overrun by very large index fluctuations and adverse mark-to-market when applied in a trading setting. We draw the following conclusions, with our focus being on the iTraxx Main

- In the current market, even with perfect forecasts of future index levels, loss tolerance/risk limits on how far the mark-to-market of a position may slip can kick in and create frequent unwinds at substantial loss-making levels;

- For example, even with perfect foresight, 10-30% of Main trades put on with a one-month horizon would have been unwound, given a loss tolerance of -50bp in mark-to-market return.

We suggest solutions to this along two dimensions:

- Investing in the index tactically/opportunistically – for example by following momentum. This has worked well, as evidenced by our intraday-based momentum strategy which has generated 7.8% of return, post transaction cost, since the start of the volatility last year. The momentum strategy could be applied either for active trading strategies, or to decide on entry and exit points in the indices;

- Alternatively, we suggest investors implement longer-term fundamental views through trading the index curves. We show that they have a stronger link to fundamentals and much lower mark-to-market volatility, making forced unwinds less likely.

Tap, tap, I know you're right but…

Risk management and awareness has come to the forefront in the current environment. As a practical implication for index trading, risk limits are most likely to have been constrained, at the same time as volatility has increased manifold, see Figure 113. Anecdotal evidence suggests that the occurrence of 'taps on the shoulder', whereby investors are forced to close out positions due to the mark-to-market breaching some lower threshold, has increased manifold in this period. Moreover, the propensity to stay in a loss-making position seems to have diminished; even though the fundamental view stays the same, a trade may have become too risky to keep once it is far enough under water.

This increases the complexity of index trading. Let's presume that we have perfect foresight of what the index level will be in a month's time.[6] In a simple world, this would allow us to exactly monetise profit and loss via the change in spreads and duration and the carry components, and we would be indifferent to what happened in the meantime (barring defaults).

In reality, however, there is a non-zero probability that we will not monetise the profit and loss, as we may: 1) at some point breach a risk limit, ie, seeing the mark-to-market go below our loss tolerance threshold, and be forced to unwind the trade; or 2) deem the position as too risky once it is deeply out-of-the-money as we question the reliability of our foresight. In both cases, we would choose to exit the position.

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[6] *By perfect foresight, we mean that we know what the index level will be at the future date, but not in the period between today and that future date. 'Perfect' means we know exactly what the index level will be.*

We refer to a level of loss that we can sustain before 1) or 2) kick in as the 'risk limit' or 'loss tolerance' interchangeably. They are interconnected, as an investor approaching a formal risk limit may choose to exit the position before hitting the limit to avoid potentially adverse execution conditions when forced to unwind.

In either case, when the mark-to-market of an index position breaches the loss tolerance level, we suddenly incur a large loss. With this, in our perfect foresight world, we move from a 100% probability of generating profit to 100-X% probability to generate profit and an X% probability of suffering a loss. The variable X is simply the probability that the mark-to-market go below the loss tolerance that we have.

Several factors will affect the probability X that the investor will need to exit a position:

- Index volatility – the higher the volatility, the higher likelihood that the mark-to-market value of the position at some point will hit the risk limit;

- Investment horizon – the longer horizon you have foresight on, the more likely that the position at one point will breach the loss tolerance threshold;

- Risk limit – the more conservative the risk limit, the more likely it will be that the position knocks out at some point;

- Marking-to-market frequency – the higher the sampling frequency, the more likely that the position will hit the risk limit (on an intraday basis, for example). On the flip side, the economic gain of higher mark-to-market gains will improve the efficiency of the risk-limit system.

Figure 113: iTraxx Main Series 7/8/9 intraday movements
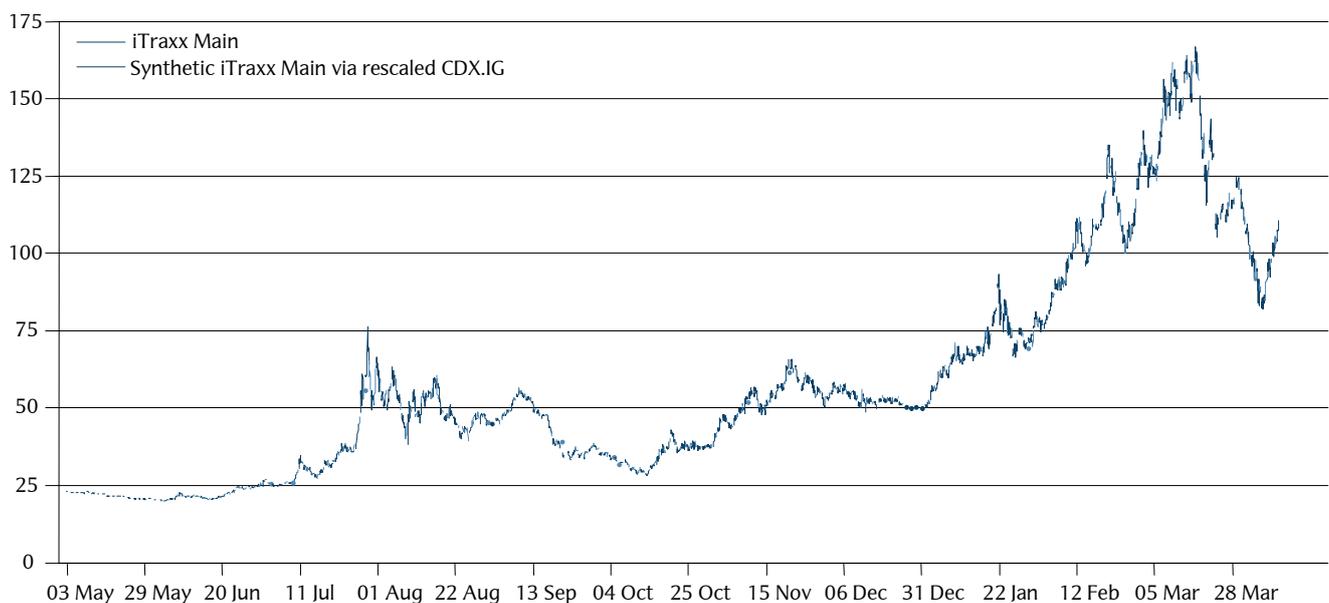
Source: Barclays Capital

Note that we are taking the perspective of perfect foresight here. If we assume that the index investor does not have perfect foresight, then the dynamics of these factors change. It is important to note that risk limits only have economic costs if you have perfect foresight. As we rarely are so fortunate, this type of risk management will kick in to avoid structural faults with the forecast or in plain language when we are simply wrong. In those cases, the limit is designed to contain losses due to lack of foresight. Whether this actually works is another complex question we leave aside for now.

Perfect forecasts with and without loss tolerance limits

So how relevant are the risk limits really? To see this, we observe how often the mark-to-market of positions that we know eventually are going to make money actually

breaches some maximum loss level. We do the following simple, yet powerful, empirical evaluation of how often an index investor would be forced to unwind trades, even when their view always is realised.

- We start out with an investor buying protection in the iTraxx Main whenever he/she knows that the index is going to widen over the next month. In other words, the investor has perfect foresight/a perfect forecast.

- We look at trading the index at each point in time where there is a Barclays Capital Bloomberg index run (a total of over 6,000 quotes from May 2007 to date).

- With no risk limits, the final value of any trade will always be above zero (we ignore carry costs); the 'no risk limit' case. We exclude transaction costs from these calculations.

- In the 'knock-outs included' case, the investor chooses, or is forced, to crystallise mark-to-market losses whenever the mark-to-market loss on the position exceeds the risk limit. For example, with a risk limit of 50bp, this will happen roughly when the index has tightened by more than 11-12bp.

Using this procedure, we can gauge the economic impact of risk limits in an ideal world. Figure 114 shows the results, plotting the fraction of trades (y axis) that achieve a certain level of P&L (x axis) under the risk-limit/no risk-limit approach. In these calculations we assume that the risk limit is 50bp.

The graph reads as follows: For example, in point (a) we measure the frequency of trades that generate more than a certain level of P&L, specifically 150bp. Reading the y axis, we see that around 23% of trades (100-77%) have managed to do so in the 'no risk-limit' case. For the risk-limit case, the corresponding number is 19% (100-81%).

Turning to point (b), we just affirm that we are looking at perfect foresight. We see that in the no risk-limit case, all trades generate positive returns. But the really crucial point is going to be (c), where we see how many trades actually knock out as the mark-to-market of the trade goes below the risk tolerance point. For this case, we see that roughly 10% of trades would knock out. So the conclusion is that, although you know exactly what the index level would be one month ahead, adverse mark-to-market of the position would, via the risk limit, force you to unwind and induce losses in 10% of trades!

Figure 114: P&L profile, buy protection with perfect forecasts of a horizon of one month, with and without a 50bp (loss) risk limit
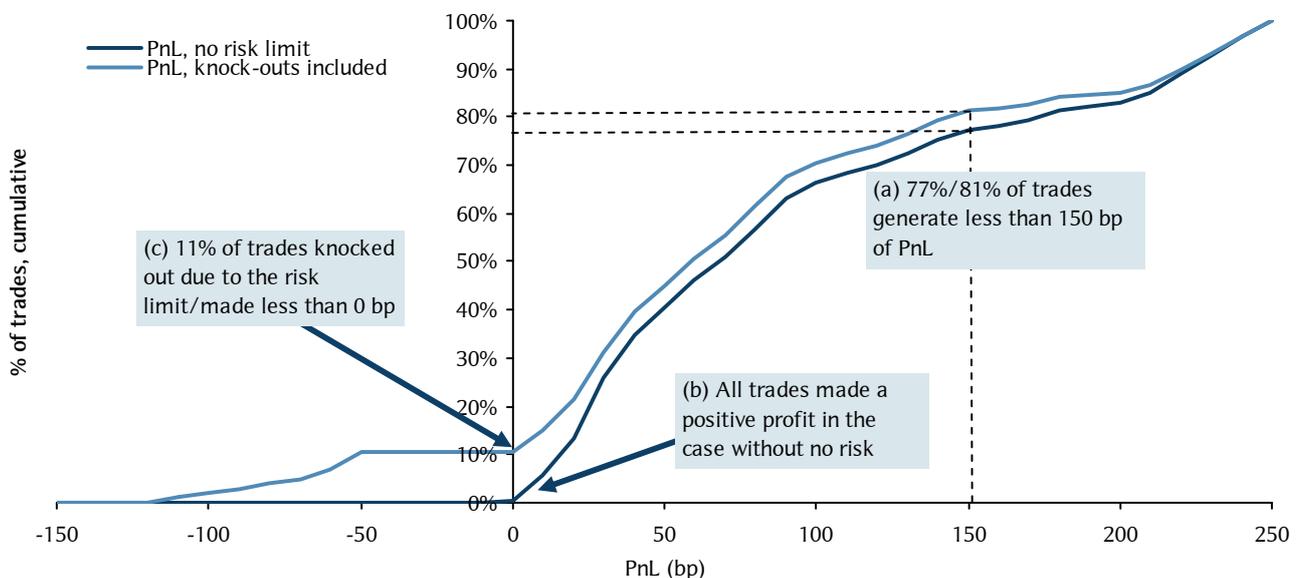
Source: Barclays Capital

Changing the loss tolerance limit

Naturally, different investors will have different risk limits and will apply different leverage to their positions. In Figure 115, left-hand panel, we chart how many trades would have knocked out when different risk limits have been applied for the short protection case. Setting the unwind threshold at a loss of 10bp would have knocked out more than 60% of the trades whereas a limit of 100bp of negative mark-to-market would force unwinds in 2% of the trades.

In the right-hand panel of Figure 115, we plot how the Sharpe ratio of the trades decays as the risk limits get more conservative. Again, note that this is the perfect foresight case, where any constraints on the strategy by definition results in a trade that is away from the optimal, baseline trade. In our case, the maximum Sharpe ratio is 1.24 and the imposition of limits will make that ratio fall. In the case of a 50bp risk limit, for example, we see the Sharpe ratio deteriorate to 0.88 (the average return per trade goes down from 101bp to 83bp, with a 15% increase in vol).[7]

Figure 115: Percentage of trades that knock out given varying risk limits, long protection case
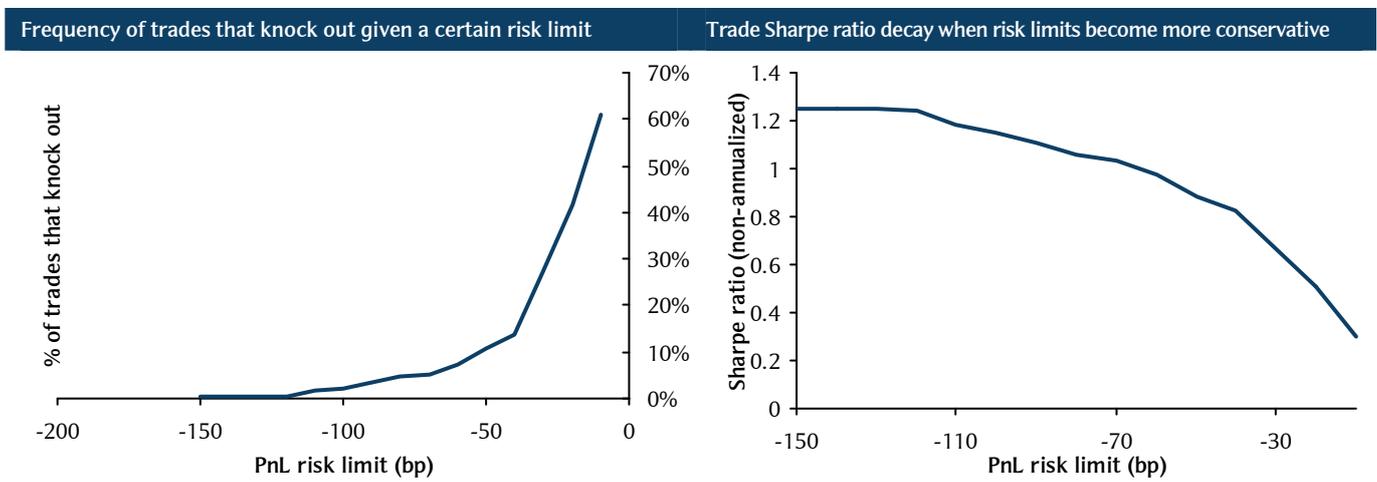
Source: Barclays Capital

Long risk positions: TKO

So far, the analysis has only considered the perspective of someone buying protection in the index. Given that the iTraxx Main spread has widened from 20bp in May 2007 to heights of more than 160bp in March this year, having been short protection, was obviously the right call on average. Having perfect foresight in the long risk trades should thus be more of an uphill battle, and indeed it is, as we show in Figure 116. Approximately a third of all trades would have been unwound prematurely with the 50bp loss tolerance. This certainly tells you a bit about how difficult it has been – even when you have been right in calling for the market to tighten.

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[7] *The Sharpe ratio is calculated assuming that the unwind is possible to execute exactly at the risk level limit. Including actual costs of executing the loss tolerance unwinds at below threshold levels will push down Sharpe ratios.*

Figure 116: Perfect foresight in sell protection positions
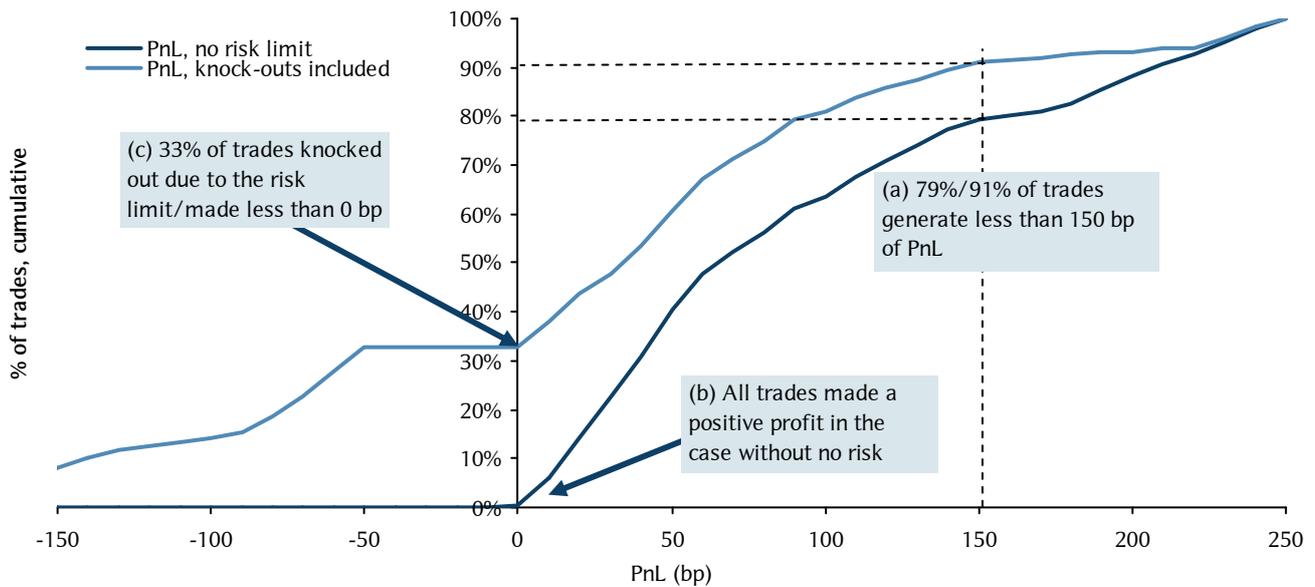
Source: Barclays Capital

We also take a look at changing the risk limits with regards to the long risk trades (Figure 117). Even for a maximum negative mark-to-market of 100bp before the trades are pulled, we see 15% of trades getting knocked out. The Sharpe ratio for the optimal strategy is 1.28 and it drops quickly even for quite liberal risk limits. When we reach a 50bp tolerance, the Sharpe ratio is down to 0.49.

Figure 117: Percentage of trades that knock out given varying risk limits, short protection.
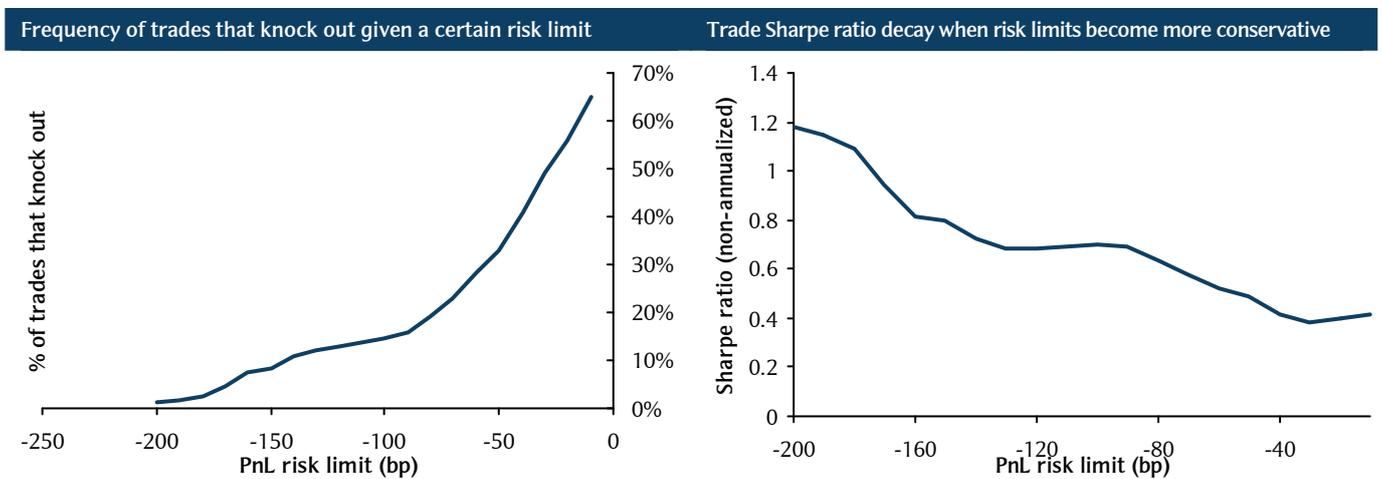
Source: Barclays Capital

Conclusions on index trade mark-to-market and risk limits

It is difficult to put a positive spin on these results. In our view, index positioning via a forecast of the future level of the index will be significantly adversely affected if there is mark-to-market sensitivity in taking that position. Any forecast based trade has a high probability of going so deep out-of-the money that you decide to cut it before the actual level actually is realised.

One could argue that a knock-out ratio of 11% for the buy protection positions is fairly low. However, there are three caveats to this. First, there is a directional bias in this 11% number. We would expect the knock-out rate from long and short risk to converge, making this number potentially closer to 20%.

Second, we are talking about knock-outs in terms of perfect foresight trades. With errors in the forecast, we will still see the same number of forced unwinds at a loss, but also a number of trades where the trade does not knock out, but instead just goes slightly the wrong way and generates losses that way. In essence, being right is hard, and not when you are right it's a safe haven.

Third, our analysis has been focused on the period of June 2007 to date. Some of these risk tolerance breaches appear to have been more frequent in the later period, especially after January, 2008. Going back to Figure 113, we see some of the largest movements and highest volatility in this period. Hence, with potentially similar levels of volatility one would expect knock-out rates towards the higher end of our numbers.

In the two next sections, we discuss two ways to avoid these difficulties in current index market trading. First, one of the drivers behind our results is the extreme degree of momentum we currently see in the indices. Rather than letting that knock you out of a trade, one can take advantage of it via tactical trading. Second, to attain greater mark-to-market stability and a stronger fundamental connect, we argue that medium- to long-term investors should be using index curves rather than 5yr points to implement views.

Improving precision in Value-at-Risk for CDS indices

This is an excerpt from *The CDS index rollercoaster*, 7 March 2008.

In this section we consider two uses of high-frequency data to understand the risk in CDS index positions:

- Empirical value-at-risk

- Overnight gap risk

Empirical value at risk

Another interesting exercise is to look at the probability of large losses within one trading day. To do this, for each quote, we calculate the profit or loss generated by trading back the position at any index level later in the day. This gives us a distribution of potential daily profits and losses. In the traditional way, we can then easily derive the level of losses incurred for any given probability level: we can, for example, infer that there is a 5% probability we will lose more than 25bp.

An example of this can be seen in Figure 119 where we plot the empirical daily VaR of selling protection on iTraxx Main. There is a 1% probability we will lose more than 28bp on any randomly selected position in Main.

In the right-hand panel, we show the probability of large moves expressed as a percentage of the initial spread level. For example, if we are trading at 100bp, there is a 5% probability that the index will trade below 100bp * (1- 5.5%) = 94.5bp at some point during the trading day.

Figure 118: Empirical intraday VaR from selling iTraxx Main protection

Main – profit-and-loss distribution	Main – percentage move based on initial spread

VaR 10% = -11.9bp
VaR 5% = -17.3bp
VaR 1% = -28.6bp

VaR 5% = -5.5%
VaR 95% = 4.4%
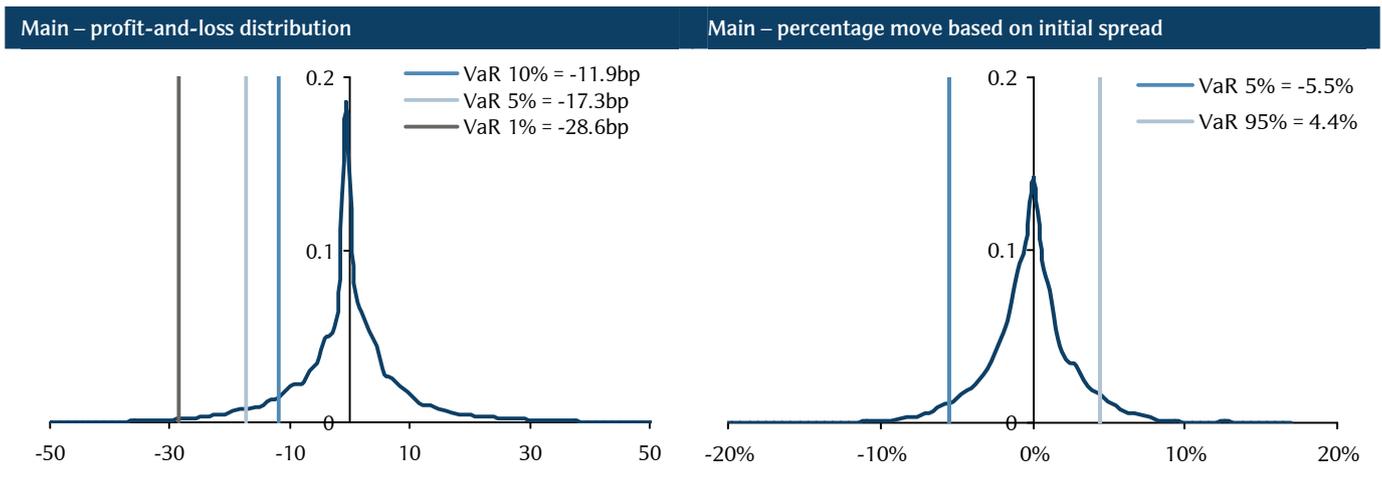
Source: Barclays Capital

Interestingly, we find that the percentage VaR measure for Crossover is considerably tighter than for Main. A full 90% of Crossover positions will change only between -3.6% and 2.6%, compared with -5.5% to 4.4% for Main. This reinforces the narrative of Main replacing Crossover as the more volatile index in connection with strong technical drivers in the investment-grade space.

Figure 119: Empirical VaR from selling Crossover protection

Crossover – absolute spread moves	Crossover – percentage move based on initial spread

VaR 10% = -44.4bp
VaR 5% = -59.7bp
VaR 1% = -94.7bp

VaR 5% = -3.6%
VaR 95% = 2.6%
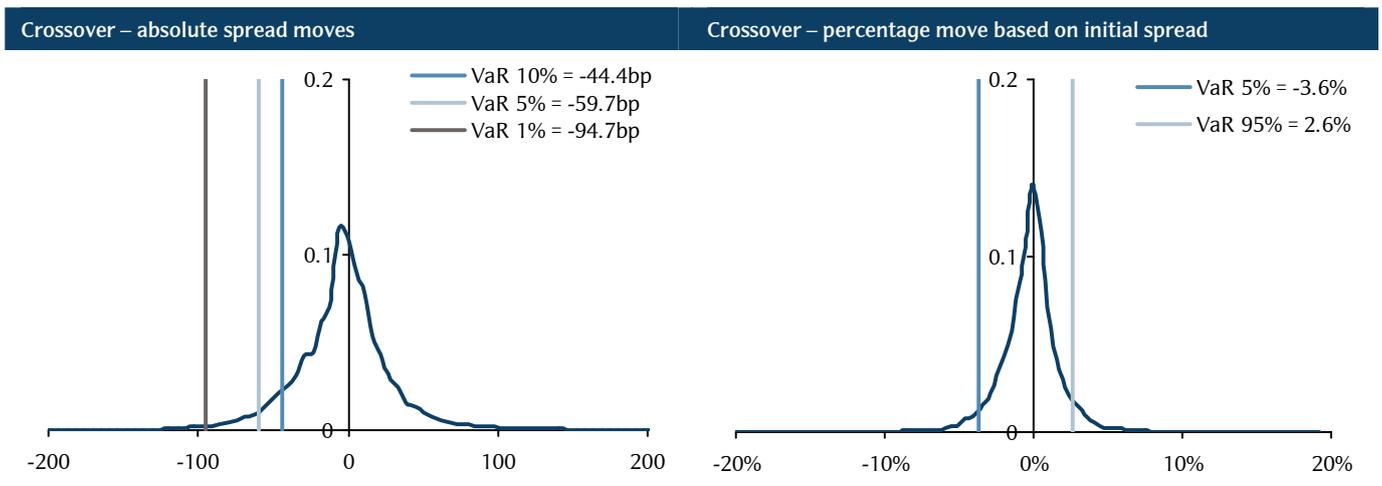
Source: Barclays Capital

The natural extension of this exercise is to fit the empirical distributions to the statistical ones. The drawback of the purely empirical approach is that it will not sufficiently take into account the likelihood of seeing larger moves/profit and losses than those we have seen historically. With a statistical distribution, we can start inferring the likelihood of even larger losses than we have seen in the data.

This seems to be especially relevant for the data in question. Kurtosis, which is a measure of how much risk is allocated in the tails of the distribution, ranges between six and eight for the indices. In contrast, a normal distribution is four. So we see a significant divergence between the empirical distribution and what would be assumed in a (log)normal setting. We do not travel further on this route, as there are several advanced statistical issues that are linked with using trading-based data such as this (for example, our distributions are very pointy due to their tendency of not moving quotes at all if there are only small fundamental movements).

High-frequency trading of CDS indices

Overnight gap risk

An important part of risk in these volatile times comes when a book is closed non-flat on the day, giving rise to overnight gap risk. In the graph below, we highlight the time series of overnight gap risks in the indices, where we define the overnight gap as the absolute difference between the last quote of the preceding day and the opening quote on the next day. We also conduct a similar empirical VaR analysis, looking at the probability distribution of overnight gap risk and delineating the 95% cutoff point.

As we can see, the July/August moves of last year on an interday basis were distinctly larger than what we have seen recently, especially in the Crossover index. The latter likely stems from the tendency of credit investors to have used iTraxx Main rather than Crossover as a hedge during the recent spate of volatility.

The empirical distributions indicate an unconditional 5% probability of seeing overnight gaps in excess of 6.9/25.2bp for the Main/Crossover index.

Figure 120: Overnight gap risk
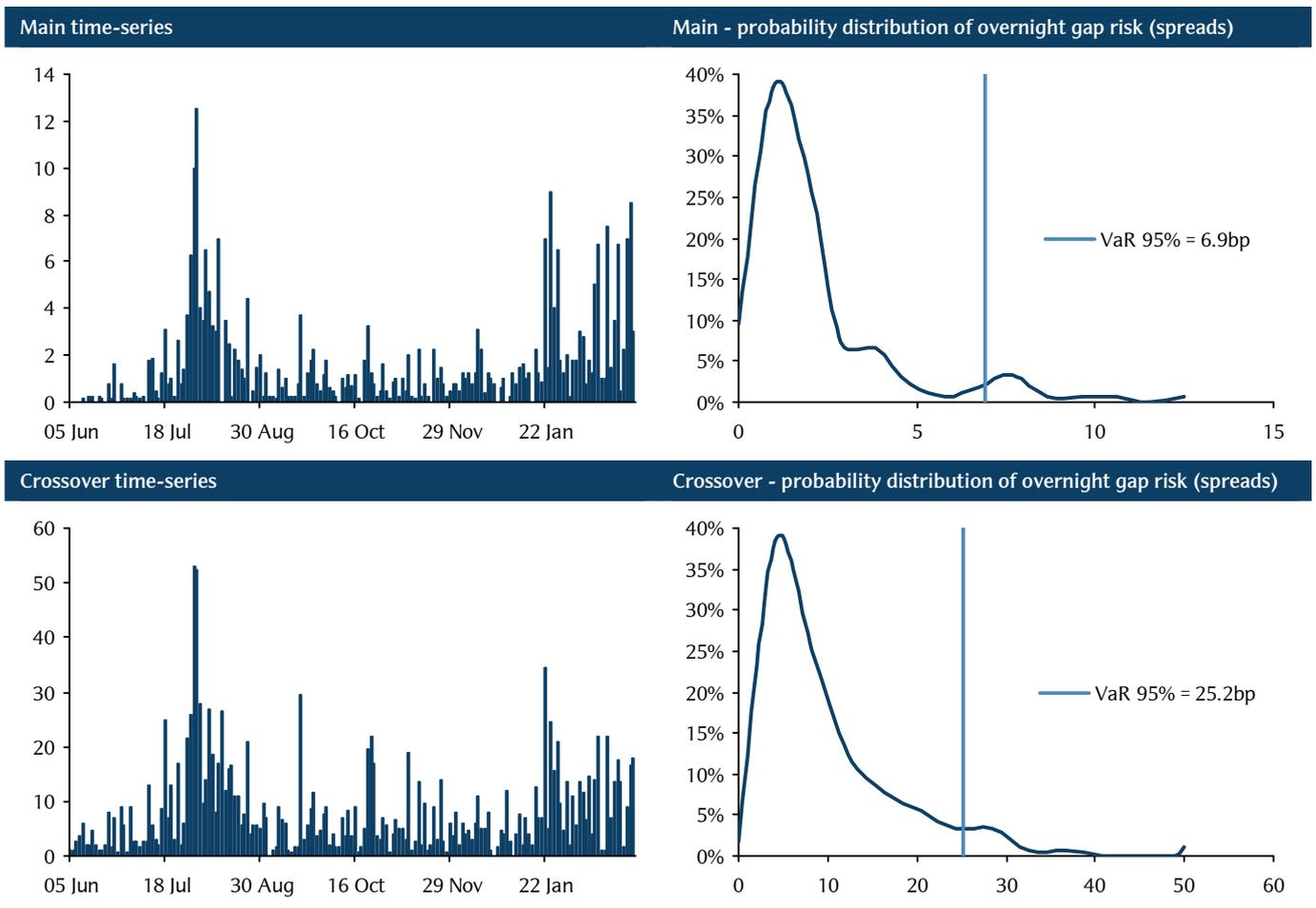
Source: Barclays Capital

COB data and intraday data: A comparison

Finally, the direct advantages of the intraday data in terms of precisely quantifying the risk in the intraday trading versus the overnight gap risk are fairly obvious. Less clear is how intraday precision will benefit VaR in an 'apples-for-apples' comparison between the two potential data frequencies. For example, how much more precision do we get with intraday data when we compare the empirical VaR distributions for positions put on at day 0, COB, and then held until the next trading day?

If we have only the COB data available, that would be the same as looking at the empirical day-to-day return distribution. For the intraday data, we look at the final quote of the first day and then study the distribution of returns based on the removal of the position at any of the quoted levels the next day. We plot the two return distributions for the COB data and the intraday data in Figure 121.

Interestingly, we see fairly strong overlap between the two distributions. The intraday data are clearly smoother and more regular in their estimation of the distribution compared with the COB data, but the general shapes correlate strongly. To us, this indicates that the COB data work fairly well in approximating this type of value at risk at a broader scale. But, taking a closer look at the tails, which in the end is the more relevant part of the VaR, we see that the COB data provides a pretty inaccurate description of what is shown by the more granular data (see the right-hand panel of Figure 121).

We furthermore stress that the benefits of the intraday are primarily based on the ability to separate overnight gap risk from intraday trading risk. This can have significant implications: traders who end their books flat will be grossly penalised in their VaR limits if the VaR is based on the traditional COB data, as the intraday trading VaR is just a fraction of total VaR.

Figure 121: Value at risk for position held COB to the next trading day, iTraxx Main long risk returns (bp)
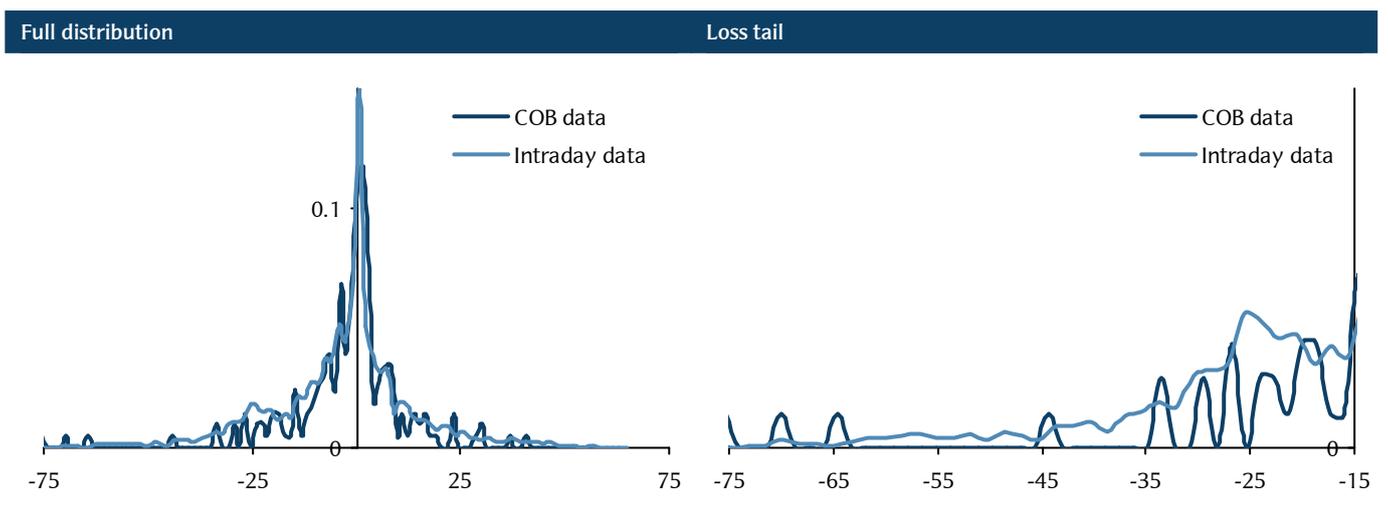
Source: Barclays Capital

Systematic relative value strategies

This section contains a collection of strategies and frameworks for trading indices against each other in various formats. A brief summary of the section is outlined below.

- *Trading ratios and differentials: We analyse the historical trading patterns of indices against each other, both on a ratio and differential basis.*

- *Momentum in Index Relative Performance (MIRP): A rules-based long-short strategy on different indices.*

- *Relative value in iTraxx financials: A framework for understanding senior versus subordinated index spreads.*

- *Ratio strategies: We consider trading on the ratio of indices and introduce a rules-based strategy for dynamically trading the sub:senior ratio (FIRRE).*

- *Skew strategies: We develop a robust screening approach for trading relative value between off-the-run indices, with promising results.*

- *Strategies using equity signals (iDIEM): Our Dynamic Indicator of Equity Momentum (DIEM) framework turns out to be effective for index relative value.*

- *Cross market strategies: We discuss the potential for relative value strategies involving CDS indices versus instruments from other asset classes.*

Properties of spread ratios and differentials

We begin by analysing the time-series properties of both the spread differential and spread ratios between different indices, and then move on to exploring strategies for exploiting relative value. The focus in this section is on iTraxx Main, HiVol and Xover together with CDX IG. In a later section we also consider the iTraxx senior and subordinated financials relative value. In each case, the comparison of indices reflects some fundamental factors:

- **Relative value linked to credit quality:** iTraxx Main versus HiVol or Xover effectively compares instruments of differing credit quality within the same region.

- **Relative value linked to region:** The comparison of CDX IG and iTraxx Main compares similarly rated portfolios across the two key credit market regions.

- **Relative value in financial recovery values:** We show in a later section that the comparison of iTraxx financials senior and subordinated constitutes an assessment of relative recovery rate expectations.

In practice, of course, the actual relationships will also be driven by technical factors that may, at times, overwhelm fundamental arguments.

In each case we use our QCX data to extend analysis back to 2001 for on-the-run series. An important factor to take into any analysis is the effect of varying constituents between series. In theory, since one series may contain different names than the next, it makes no sense comparing, for example, that ratio of iTraxx HiVol to iTraxx Main spreads across series. In practice, the constituent differences are limited enough that the impact graphically is limited, however we return to this point when considering trading strategies.

Figure 122 shows charts of the 5yr series of iTraxx Main and HiVol and, in the right-hand panel, the ratio of spreads through time. The comparison of Main and HiVol is perhaps the most meaningful of those that we consider, since HiVol itself is a subset of Main. The two series track each other fairly closely and the ratio remains in quite a tight range of 1.2-2.2x throughout the period. In the early part of the sample, we see significant discontinuities across several roll dates.

A further interesting analysis would be to consider LoVol versus HiVol where LoVol is defined as Main ex HiVol.

Figure 122: iTraxx Main versus iTraxx HiVol, 2001-08
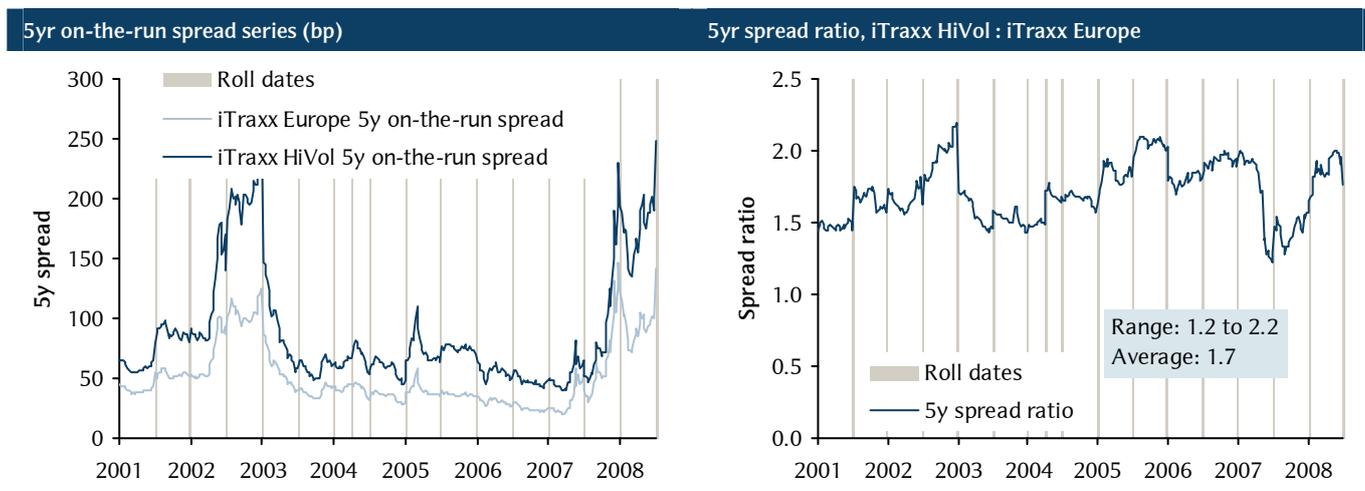
Source: Markit, Barclays Capital

Figure 123 shows equivalent series for iTraxx Main and Xover. Here, we use our standard (non-adjusted) version of the QCX Xover data. These two series have a far more erratic relationship with a spread ratio that varies from 3.3-10.4x through the sample. In this case, the discontinuities between series are also more striking in 2002 as extreme underperformers breach upper spread limits.

Figure 123: iTraxx Main versus iTraxx Xover, 2001-08
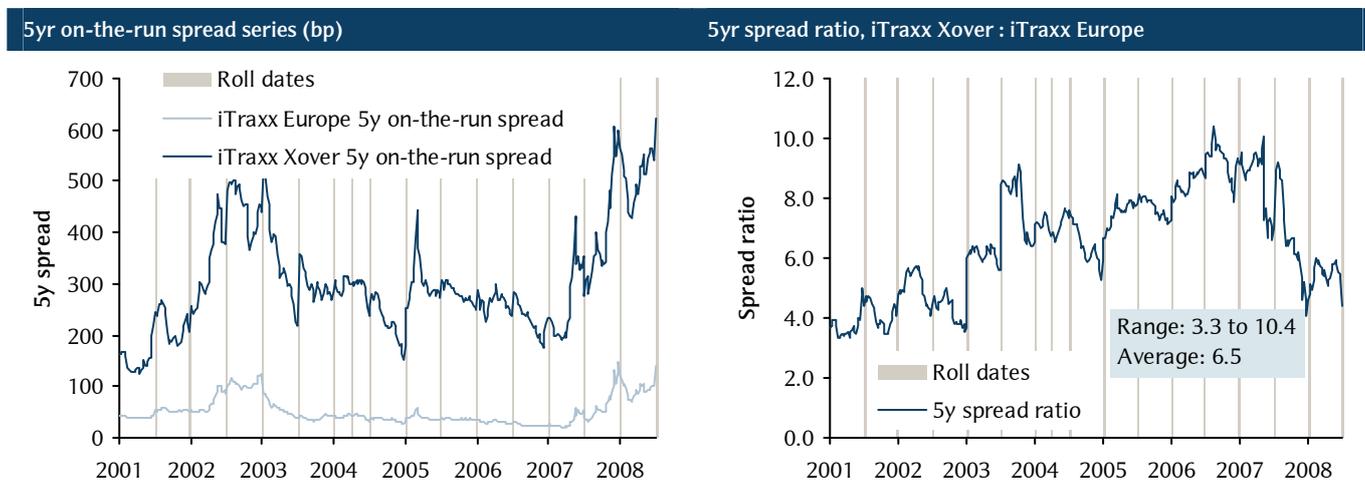
Source: Markit, Barclays Capital

Figure 124, finally, compares iTraxx Main and CDX IG. These two series, being both 125 investment grade names, track each other fairly closely in terms of absolute spread levels, with a substantial differential developing in the very recent period. On a ratio basis, the series are quite erratic in the first half of the sample, with strong trending behaviour followed by a sizeable discontinuity at the inception of the real CDX IG indices in June 2003. Following this date the ratio has been well behaved in a range of 1.2-1.8x.

Figure 124: iTraxx Main versus CDX IG, 2001-08

5yr on-the-run spread series (bp)	5yr spread ratio, CDX IG : iTraxx Europe
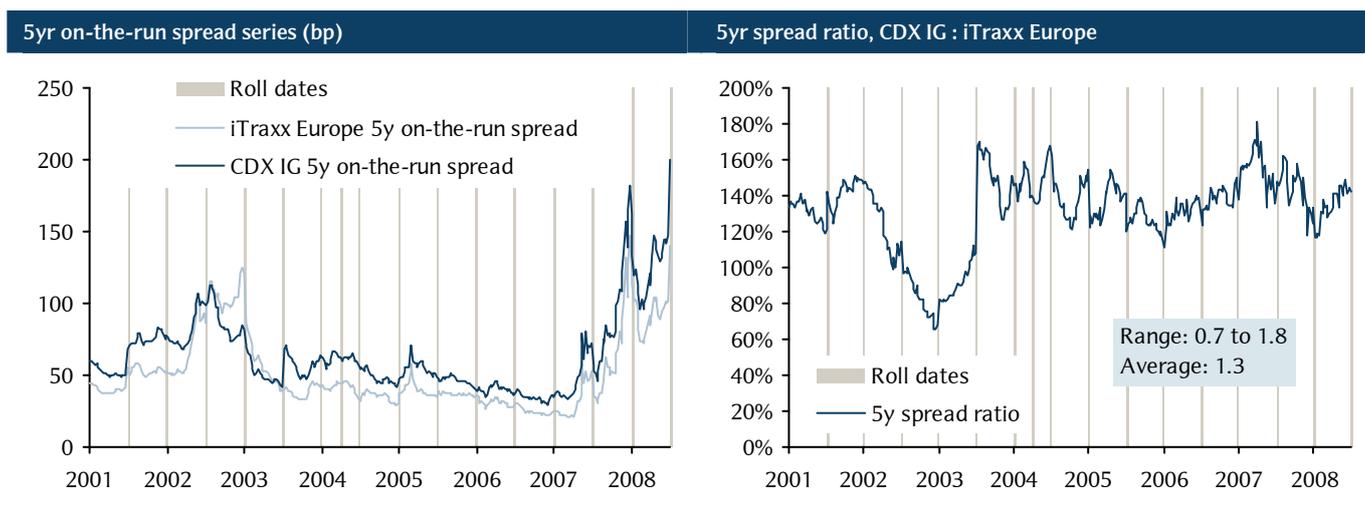
Source: Markit, Barclays Capital

Momentum in Index Relative Performance (MIRP) strategies

The behaviour of the differential in spreads in the above charts appears to be broadly persistent and trending in some cases. Fundamentally, the differential between spreads in each case reflects differing risk profiles on a rating basis (in the case of Main versus HiVol or Xover) and on a geographical basis (in the case of Main versus CDX IG). In principle, we could argue that such relative value is not changing day to day and that it will follow broad trends linked to the business cycles in each region. Additionally, we discuss, at length, evidence of general momentum in credit in *High-frequency trading of CDS indices*. For these reasons, it seems plausible that momentum-based strategies may be profitable between pairs of indices. In the following tests we introduce a framework termed Momentum in Index Relative Performance (MIRP), which should be viewed as the outline of a potential rules-based strategy.

Defining MIRP

MIRP is a straightforward returns momentum method and operates as follows. Index A, for convenience, refers to the index with lower spread in the pair.

- At a pre-specified frequency (the 'trading frequency'), the performance, including carry, of selling 1 unit of protection on index A and buying 1 unit of protection on index B over an agreed number of preceding weeks (the 'momentum window') is calculated.

- Where the momentum window includes a roll date, the performance of closing the old contract and opening a new on-the-run contract is included in the calculation.

- When the difference in performance is positive, the MIRP signal is to sell 1 unit of protection on index A and buy 1 unit of protection on index B (decompression).

- When the difference in performance is negative, the MIRP signal is to buy 1 unit of protection on index A and sell 1 unit of protection on index B (compression).

- MIRP does not have a neutral state in this implementation.

MIRP is intended to be an outline strategy and, as such, we ignore transaction costs in the analysis. Clearly, with such a straightforward system, there is scope for many avenues of potential improvement, which we leave for future research.

Testing MIRP: iTraxx Main versus iTraxx HiVol

Figure 125 shows details of MIRP's performance on Main versus HiVol. The left-hand chart shows cumulative performance with summary statistics. MIRP requires two key parameters, the momentum window and trading frequency, as defined above. In the test shown we fix both of these at four weeks. Performance is reasonable throughout the period, with stronger returns during the more volatile market conditions of 2001-02 and 2007-08. Average performance is 0.98% per year over an average of seven trades.

The right-hand panel is an example of a parameter stability map, which we define in the box below. The map shows that the strategy is somewhat stable in the lower region. This corresponds to a relatively high trading frequency (at least every four weeks).

Figure 125: iTraxx Main versus HiVol, MIRP indicative performance and parameter stability
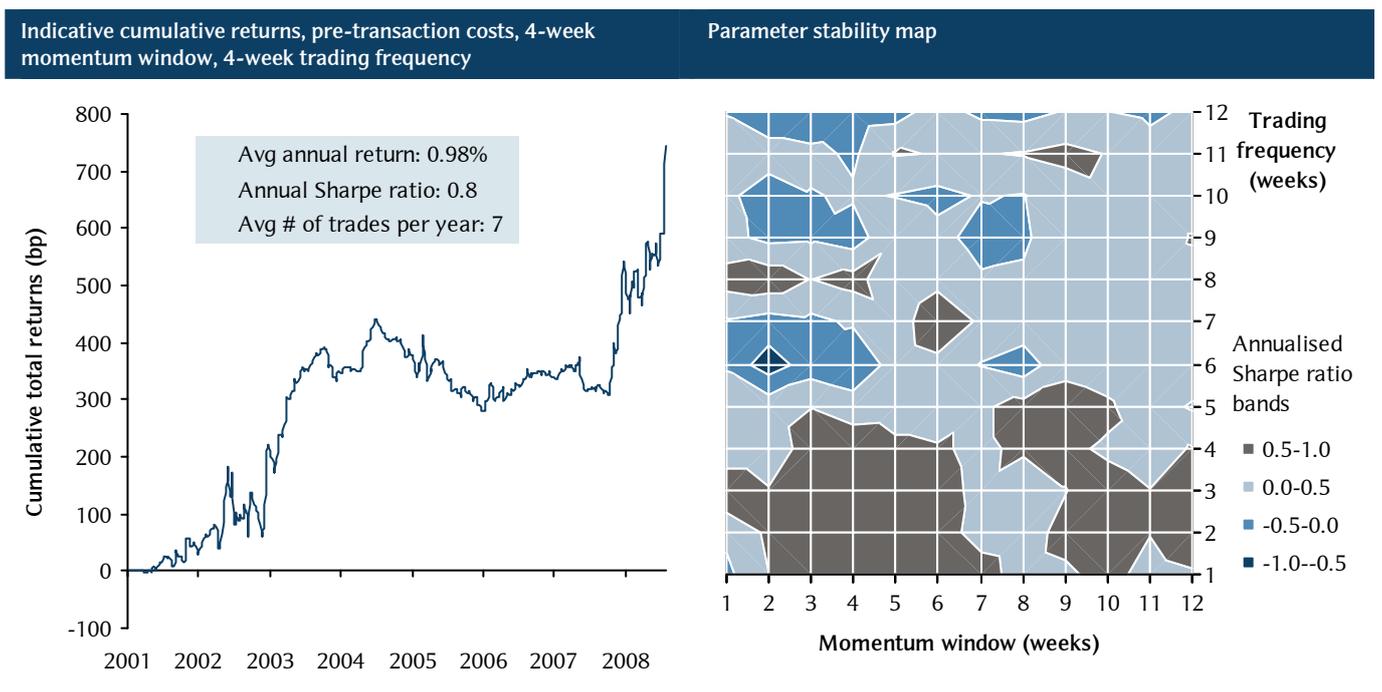
Source: Markit, Barclays Capital

Reading parameter stability maps

The chart shown in the right-hand panel of Figure 125 is an example of a parameter stability map. The map is on two axes representing parameters of the model in question. The shading at each point categorises the Sharpe ratio of testing the strategy with these parameters over the full sample period. The Sharpe ratio is always bucketed into four sets:

- -1.0 to -0.5 – actually includes values less than -1.0 (although these are rare);

- -0.5 to 0.0;

- 0.0 to 0.5; and

- 0.5 to 1.0 – actually includes values greater than 1.0 (although these are also rare).

The map is used to test the stability of parameter settings, to avoid 'data-mining'. In theory, we could simply optimise across this grid in-sample and generate the best possible performance. This would clearly not be stable, in general, out-of-sample. The stability map helps to find sensible regions of performance where altering parameters does not drastically change the Sharpe ratio.

In general, a strategy is more convincing if it is stable across large regions of the map. We would happily sacrifice absolute performance of the peak combination in favour of a stable parameter region.

Testing MIRP: iTraxx Main versus iTraxx Xover

Figure 126 shows the same charts for Main versus Xover. Here we find that the momentum window and trading frequency need to be lower to generate attractive returns. The left-hand chart shows performance for the 1-week, 1-week combination. The high annual return of 2.59% is diminished somewhat by the high volatility, giving a mediocre Sharpe ratio of 0.6 over an average 22 trades per year. This strategy took a substantial hit in the September/October 2008 volatility.

The parameter stability map looks reasonable only in the lower region again.

Figure 126: iTraxx Main versus Xover, MIRP indicative performance and parameter stability
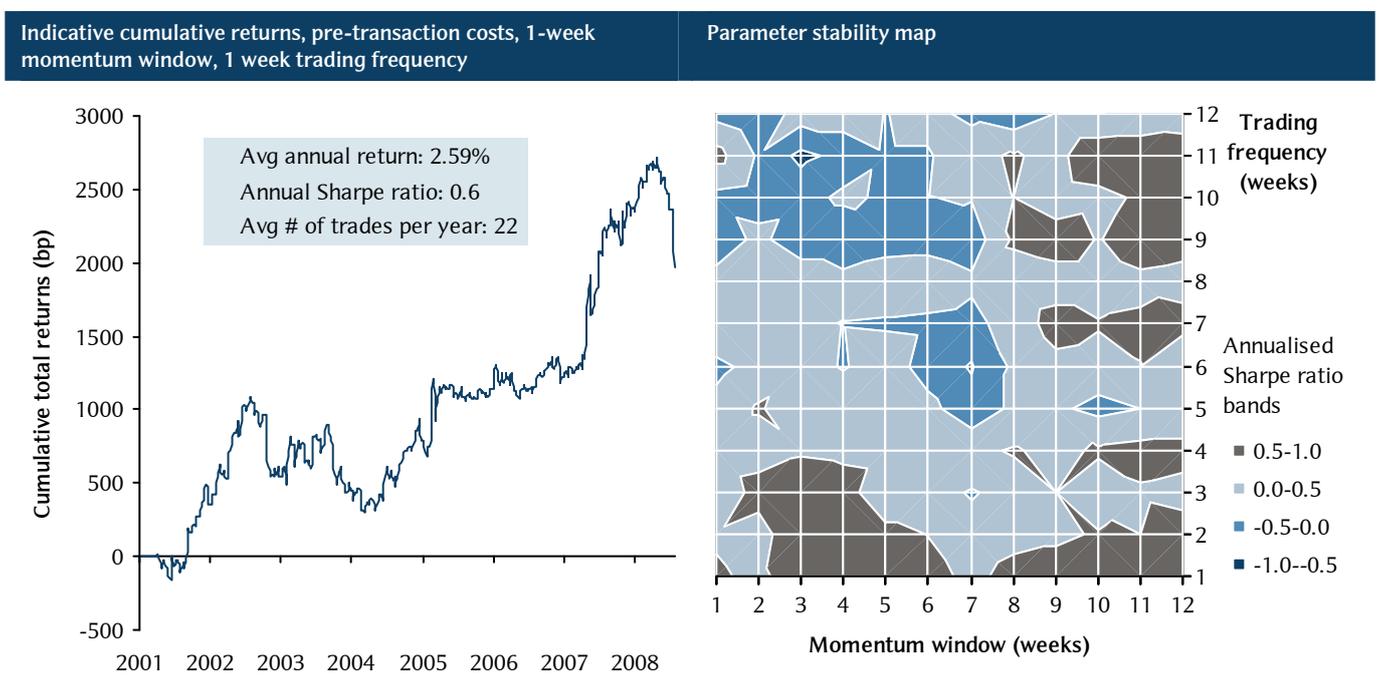
Source: Markit, Barclays Capital

Testing MIRP: iTraxx Main versus CDX IG

Our final test is based on iTraxx Main versus CDX IG. Performance of this strategy is somewhat weaker than the other two. We show the 4-week, 4-week combination which has an annual return of 48bp. The parameter stability appears ok, but there are only limited regions of significant outperformance.

Figure 127: iTraxx Main versus CDX IG, MIRP indicative performance and parameter stability

Indicative cumulative returns, pre-transaction costs, 4 week momentum window, 4 week trading frequency	Parameter stability map

Avg annual return: 0.50%
Annual Sharpe ratio: 0.6
Avg # of trades per year: 7
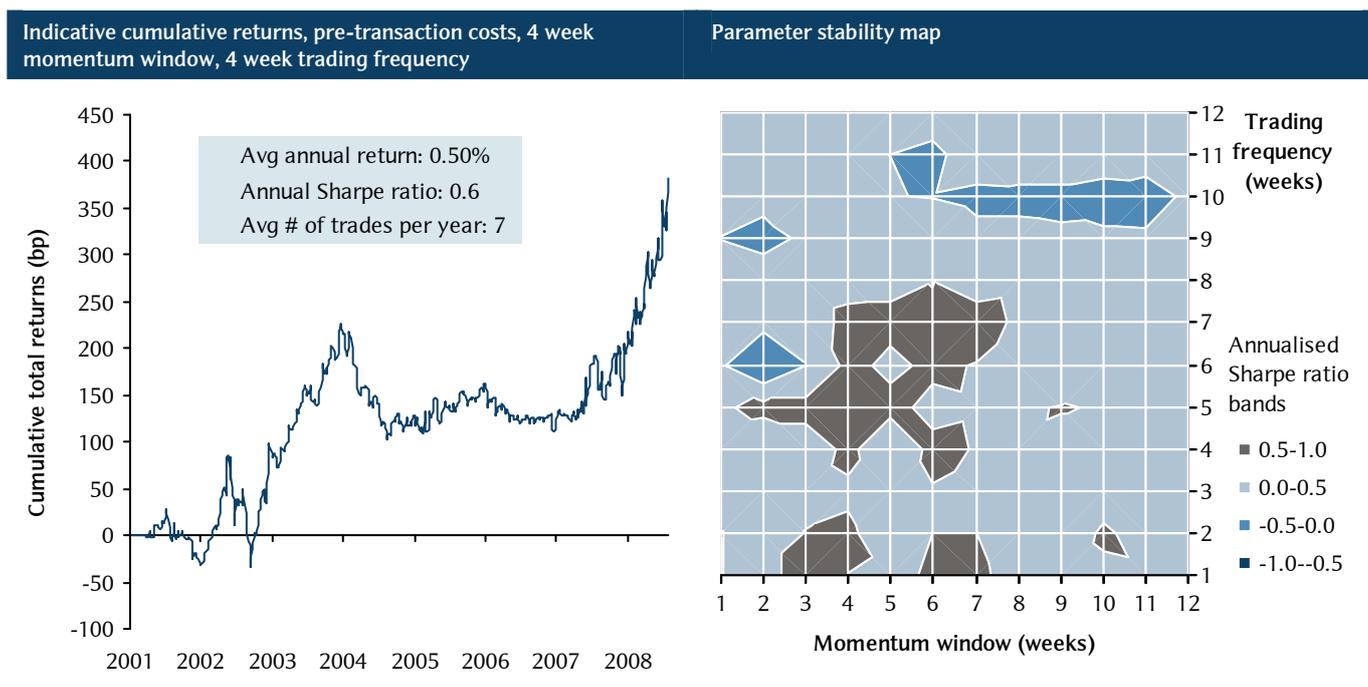
Source: Markit, Barclays Capital

MIRP – A summary

The Momentum in Index Relative Performance strategies show some potential, although absolute performance metrics are somewhat on the weak side. The parameter stability maps indicate that performance is not attributable to local data mining, although they also show that regions of significant performance are small. MIRP may provide the basis for more sophisticated strategies in future research.

Relative value in iTraxx financials

Originally published as *Making sense of iTraxx financials sub vs senior, 19 September 2008*.

Dynamics of the iTraxx senior and subordinated financials indices have been closely watched through the credit crisis and used both as hedges and as convenient directional tools. The relative value between the two is often considered on a ratio basis between 5y spreads since the absolute difference is very correlated with overall spread levels. Here we review the empirical ratio behaviour together with the theoretical ratio implied by varying recovery assumptions.

Figure 128: iTraxx financials on-the-run 5yr sub:senior ratio, 2007-08
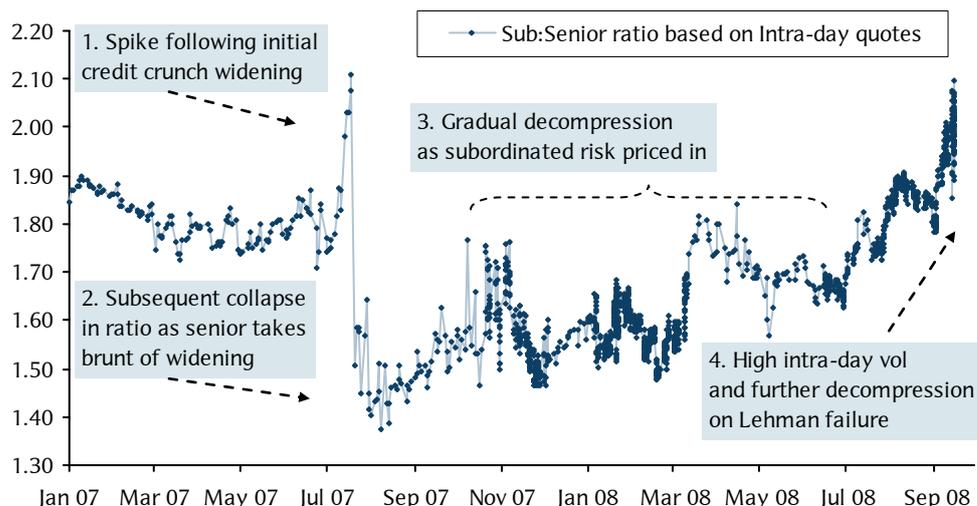
Source: Markit, Barclays Capital

Figure 128 presents the time series of the ratio of the iTraxx financials subordinated to senior 5yr spreads through the credit crunch, based on intra-day trading quotes. We use our high-frequency dataset to gain greater granularity of analysis and more realistic trading levels than end-of-day data. We present more information on the use of high-frequency index data in *High-frequency trading of CDS indices.*

The extreme events of the credit crunch period have driven sometimes unusual behaviour in the ratio, which tends to be mean-reverting over a medium time-scale. The trading range over the past two years has been from around 1.5-2.2x, which turns out to be consistent with our longer time-series analysis below. However, strong technical factors – including proxy hedging of subordinated debt and even Tier 1 by some investors – have led to the recent decompression momentum.

With the tumultuous events in financials during this week, and the now very real prospect of actual defaults, we believe it makes sense to review the theoretical pricing arguments that should determine the relative pricing of sub and senior CDS based on expected recovery values.

We first investigated the sub-senior trading patterns in the *European Alpha Anticipator*, 1 February 2008, where we argued that decompression trades positioning for an increase looked attractive around the 1.5x level.

Long time-series perspective

Using our extended time-series versions of the indices (the QCX indices – see *CDS Curve Trading handbook 2008*, p145 for details) we can analyse the iTraxx senior and subordinated financials series back to 2001 to investigate the consistency of the relationship. Two charts are shown in Figure 129. The left-hand chart shows the 5yr index series and the ratio on the right-hand axis, while the right-hand chart shows the 5yr index series with the differential between the two.

Figure 129: Long time-series of iTraxx financials using QCX series from 2001-04

Sub and Senior spreads together with the ratio on the right-hand axis	Sub and Senior spreads and differential on the right-hand axis
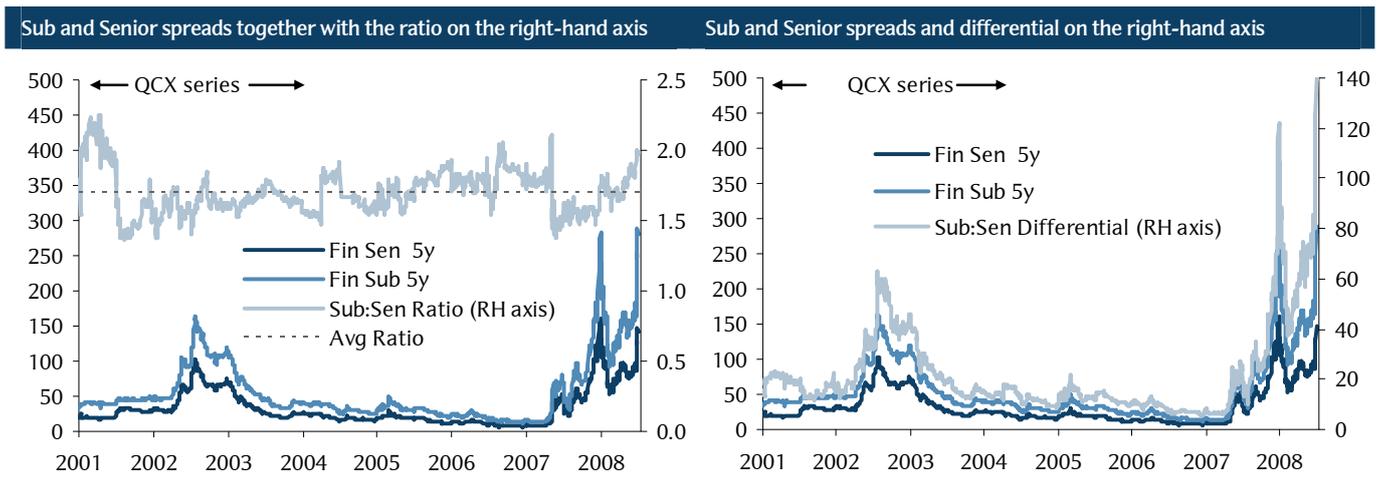
Source: Markit, Barclays Capital

What is immediately evident in both charts is the correlation between sub and senior through time. This correlation manifests itself in a tight range of around 1.5-2.2x for the 5yr spread ratio of the two indices, shown in the left-hand chart. Even in 2001-02, we find that the ratio is largely within this range[8].

It is hard to conclude any consistent time-series patterns for the sub:senior ratio from these charts. In a later section we return to the long time-series data to examine the relationship between senior spread level and the ratio and differential of sub:senior.

Analysing the theoretical sub:senior relationship

It is possible to derive a theoretical relationship between the subordinated and senior CDS in the instance of default, by considering possible recovery scenarios for the two debt groups. Although there is – so far – little precedent in terms of European financial defaults with significant tiered debt outstanding, we can make assumptions based on a strict subordination rule for recovery values. That is, subordinated recovery can only be greater than zero in the event of senior recovering very close to 100%.

Figure 130: Implied sub:senior ratio for different scenarios, in the case of strict priority of recovery
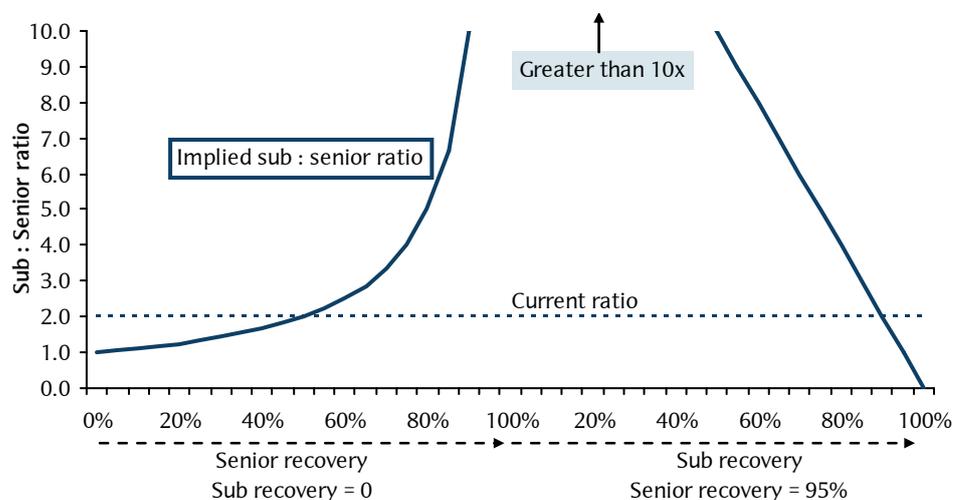
Source: Barclays Capital

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[8] This is particularly interesting; due to limited (quantity and quality of) data, we expect the range and ratio-volatility to be over-estimated in this period.

A full derivation of the relationship is given in the final section. Figure 130 presents a schematic of sub:senior ratios for different recovery scenarios. On the horizontal axis, the total recovery increases from left to right. For calculation purposes we allow the senior recovery to vary from zero to 95%[9]. The subordinated recovery is assumed to be zero up until this point, after which it varies from zero to 95%, but assuming that senior recovery stays at 95%.

The current level of 2x is represented by a dashed line. Recovery scenarios with 50% senior and 0% sub give an implied ratio of 2x. Less than 50% senior recovery would give lower ratios. As senior recovery increases, the ratio rises –in extreme scenarios of very high senior recovery and zero sub recovery the ratio could be greater than 10x. However, as sub recovery increases (with senior recovery held constant at 95%) the ratio falls again, linearly this time.

What scenarios are most likely?

Not all points in Figure 130 are equally likely. However, with limited empirical experience, we can only hypothesise which scenarios are most probable. Figure 131 looks at some specific example outcomes and the implied ratio in each case.

Figure 131: Sub-senior ratio scenarios based on recovery assumptions

Assumption	Recovery values	Sub:senior ratio
Based on pricing conventions, using Moody's historical (corporate) recovery rates – we argue this is not a realistic outcome in an actual default and this is not included in the above chart.	Sub 20% Sen 40%	1.33x
Disaster scenario, in which total recovery is close to zero. Possible in distressed times when all asset values are depressed.	Sub 0% Sen 20%	1.25x
Low recovery outcome where institution defaults in distressed period but assets retain some value.	Sub 0% Sen 50%	2.00x
High recovery outcome where a workout results in positive sub recovery	Sub 50% Sen 95%	10x
High recovery outcome where no workout for sub.	Sub 0% Sen 95%	20x

Source: Barclays Capital

Directionality of the sub:senior ratio

The chart in Figure 130 highlights that there is no monotonic relationship between total recovery and implied ratio. The ratio can be low for either extreme. Therefore, we would expect theoretically for there to be little directional relationship between the ratio and the level of spreads.

To formalise this, we look empirically at ratios and sub:senior differentials versus spreads in Figure 132. In the left-hand panel we find that the ratio and spread levels do indeed show no clear relationship. Ratios appear to be depressed for intermediate spread ranges, but this is hard to justify fundamentally. In contrast, the spread differential is highly directionally dependent, especially at lower spread levels, as shown in the right-hand panel.

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[9] *We do not allow recovery greater than 95% for simplicity of calculations. If the loss on the senior CDS is too small, the theoretical sub:senior ratio becomes undefined.*

Figure 132: Analysis of spread directionality of the sub:senior ratio and differential

iTraxx sub:senior ratio for different levels of senior spread   iTraxx sub:senior differential for different levels of senior spread
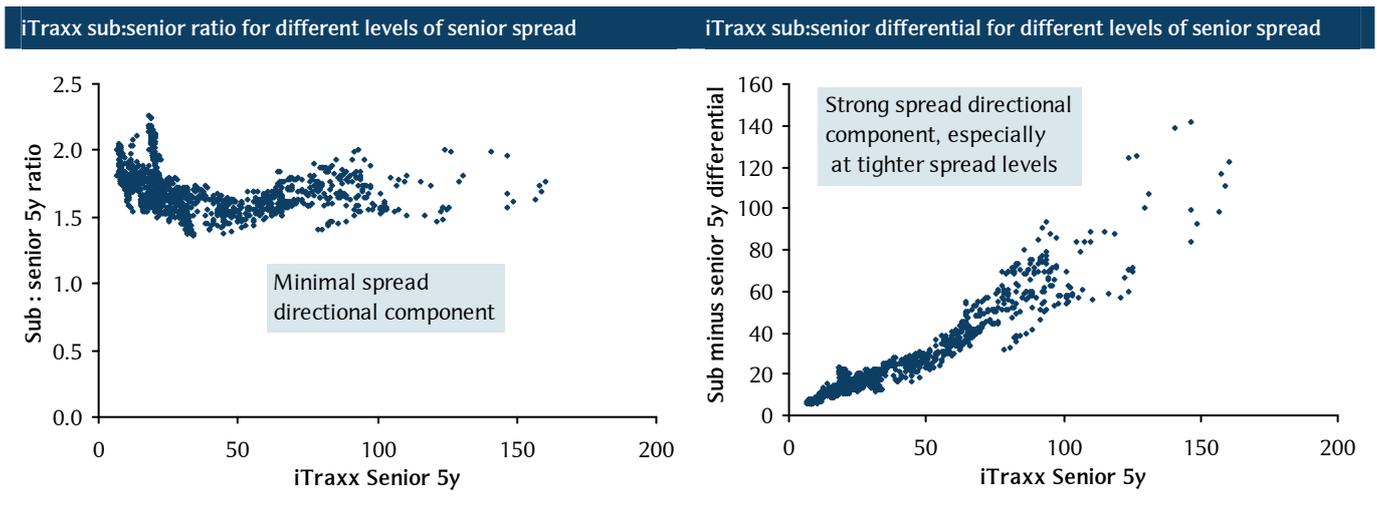
Source: Markit, Barclays Capital

How do ratios behave on single-names?

We can also drill down to the 25 individual constituent CDS in the iTraxx financials series 9 index. Figure 133 summarises the current levels and ranges of ratio for each name, with the vertical bar showing the minimum to maximum since the beginning of 2007 and the horizontal bar showing the current level.

Clearly, there is a great deal of variation across names, although current levels are near the top of the range in most cases. The differences across names may be explained by a number of factors, including:

- debt profile of the company;
- technical factors relating to hedging;
- the spread level of the CDS; and
- the market conditions.

We investigate the last two of these below.

Figure 133: Trading ranges and current levels of sub:senior ratio
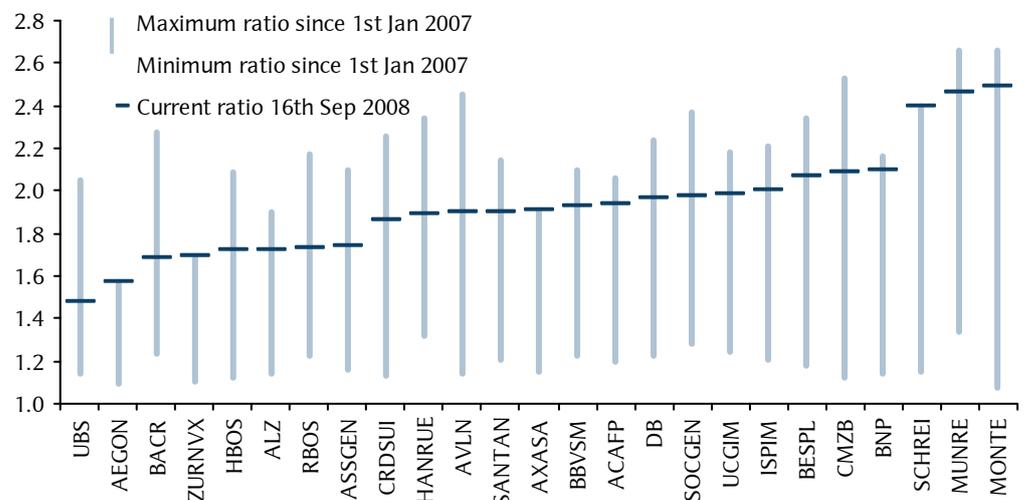
Source: Markit, Barclays Capital

Figure 134 shows the current cross-section of European bank CDS in the iTraxx financials Series 9. Here we exclude insurers for clarity, although the relationship is similar. There is a clear downward relationship between spread level and ratio. The fitted line (logarithmic fit) is actually pulled up by HBOS, which stands out as an outlier.

Overall, an interpretation of this relationship is that higher spread names have lower total recovery outcomes being priced in distressed periods such as now. This would make sense fundamentally since the wide spread may be due to concern regarding asset quality – and lower asset quality would lead to poor recoveries in distressed markets.

Figure 134: Cross-section of bank CDS, spread versus ratio, 17 Sep 2008
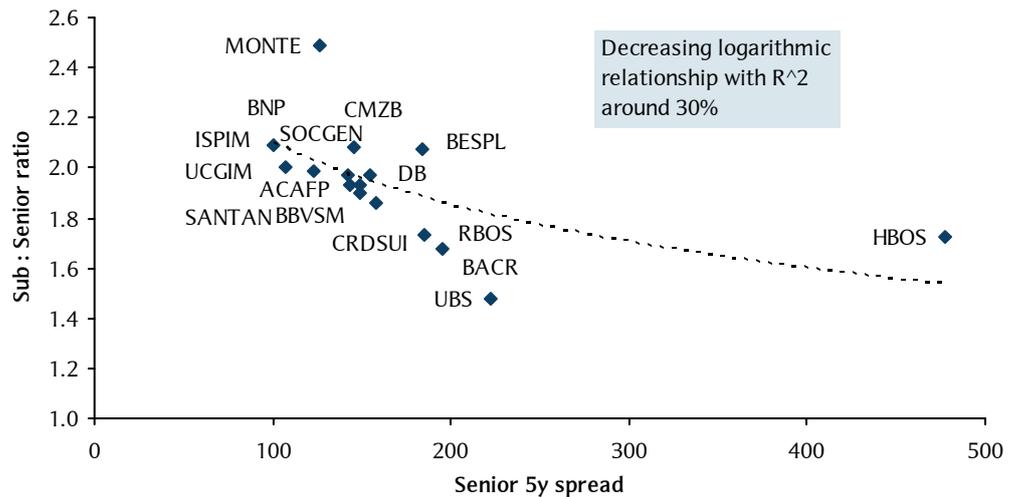
Source: Markit, Barclays Capital

How does this relationship change with the market conditions? We can compare Figure 134 with Figure 135, which shows the same cross-section chart for the iTraxx financials Series 7 index on 30 May 2007, before the credit crunch took hold. Clearly, the relationship is much weaker in this chart and even shows a marginal increasing slope. The r-squared is just 5% for the 20 May example versus 30% for the 17 September one. Clearly, in more benign markets, recovery considerations are not as relevant since default is perceived to be far off.

Figure 135: Cross-section of bank CDS, spread versus ratio, 30 May 2007
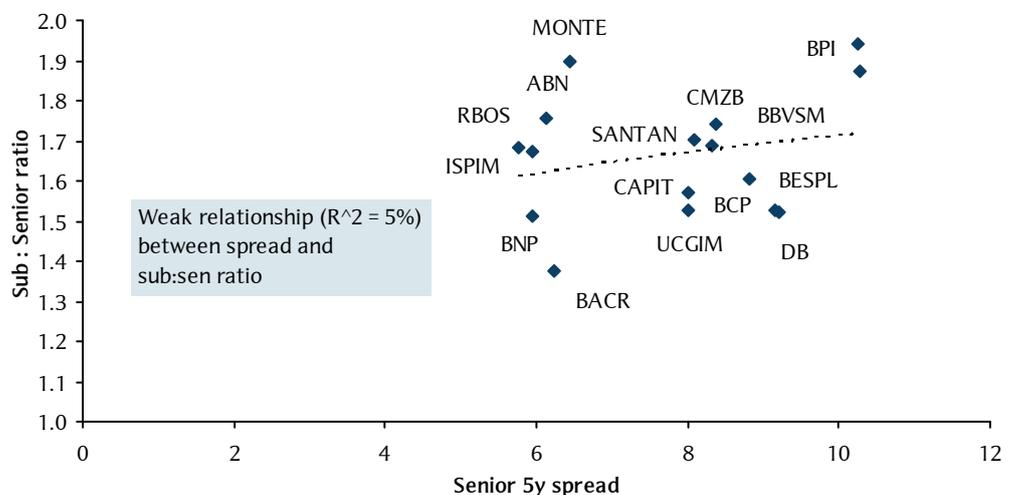
Source: Markit, Barclays Capital

High-frequency dynamics

Investors considering trading the spread ratio can benefit from also analysing the very micro behaviour using intra-day data. Although a detailed investigation is left to future research notes, Figure 136 presents interesting charts of intra-day trading patterns and ranges during September 2008. In particular, we can see that, even when the ratio itself is trending or stable on end-of-day data, it can vary substantially intra-day giving scope for potentially profitable (or painful!) trade timing.

Figure 136: High-frequency analysis during the September 2008 volatility
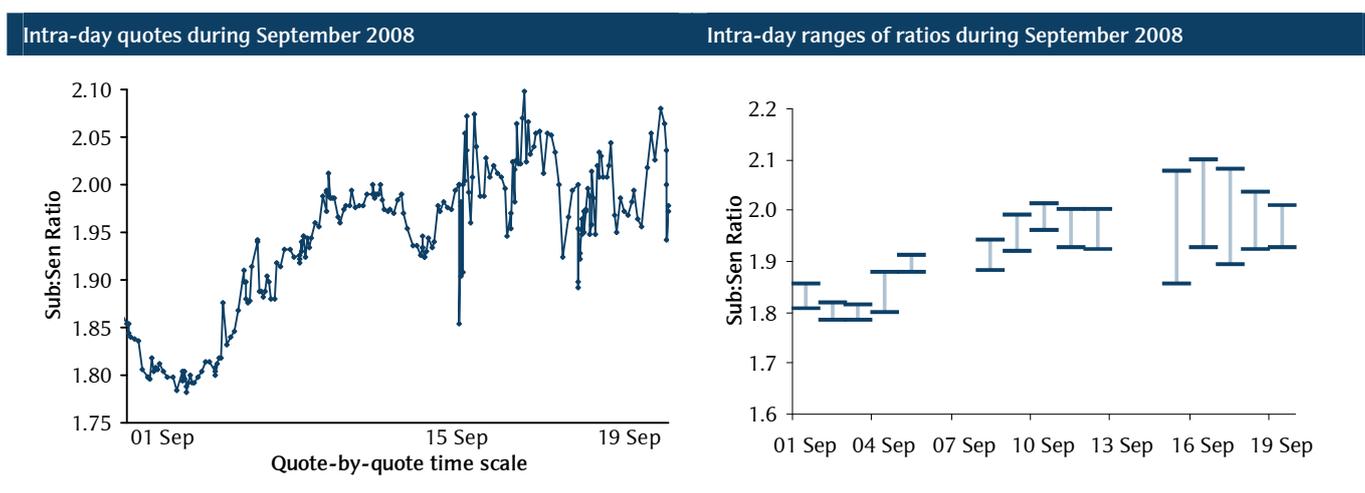
Source: Markit, Barclays Capital

Derivation of the theoretical sub:senior ratio

Although highly technical in its dynamics, the ratio of sub CDS to senior CDS is a fundamentally motivated quantity in that it relates directly to relative implied recovery rates on the two types of debt.

We can derive a simple approximate relationship for the sub and senior spreads of a single company based on CDS pricing as follows. Equating the premium leg on the left-hand side to the protection leg on the right-hand side,

$$Spread_{5y}^{Sub} \times DV01_{5y}^{Sub} \approx \Pr(Default) \times \left(1 - \mathrm{Re\,cov}^{Sub}\right) \quad (1)$$

$$Spread_{5y}^{Sen} \times DV01_{5y}^{Sen} \approx \Pr(Default) \times \left(1 - \mathrm{Re\,cov}^{Sen}\right) \quad (2)$$

Noting that the probability of default is the same (it is the same company) and the DV01s can be assumed to be approximately the same. Dividing equation (1) by equation (2) gives:

$$\frac{Spread_{5y}^{Sub}}{Spread_{5y}^{Sen}} \approx \frac{\left(1 - \mathrm{Re\,cov}^{Sub}\right)}{\left(1 - \mathrm{Re\,cov}^{Sen}\right)}$$

Because the probability of default cancels, the trade has no theoretical directional component. Note that, in the case of the differential trade, we take equation (1) minus equation (2) – this difference still contains a factor of the probability of default.

Systematic ratio strategies

An alternative to trading the differential between indices in a simple, equal-weighted long-short setup is to position for a change in the ratio itself. This should, in theory, remove some of the market directional component of the returns. However, tempting as it is, we argue that trading the ratio only makes sense where there is some fundamental basis to the relationship. One such example is with the Financials indices, trading the subordinated versus senior contracts, as described in the above section. Here there is a fundamental link between the two which should motivate trading strategies. Before outlining an example of such a strategy, we first review some technical points regarding trades constructed on ratios.

Trading the ratio

Positioning for a change in the ratio is possible through a ratio-weighted trade. For example, in September 2008, the ratio of 5yr iTraxx sub financials to 5yr iTraxx senior financials was 2x, close to historical highs. An investor wanting to express the view that the ratio is too high and will fall could, for example, sell protection on the sub index and buy protection in the senior index with a weight of 2x on the senior leg. Such a trade would be carry-neutral by construction. The trade should then profit when the ratio falls and lose money when the ratio widens. However, due to marginal differences in DV01, and convexity the trade is not precisely flat when the ratio is unchanged.

A critical and subtle feature of such a trade, however, is the directional dependence of the magnitude of P&L. Figure 137 shows P&L profiles of a trade struck at a senior spread of 127bp and a sub spread of 254bp with an initial ratio of 2x. The lines show the P&L on the trade in basis points of sub notional for different final spread and final ratio outcomes. A few points stand out in the chart:

▪ When the ratio falls, the compression trade makes money – but the amount of money made increases with spread level.

▪ When the ratio increases, the compression trade loses money – but the amount of money lost increases with spread level.

▪ The payoffs are slightly positive convex for the compression trade. A decompression (positioning for an increase in ratio) has a slightly negatively convex profile.

Figure 137: P&L profiles of compression trade for different final sub:senior ratios at various spread levels. P&L in bp of notional on the sub leg
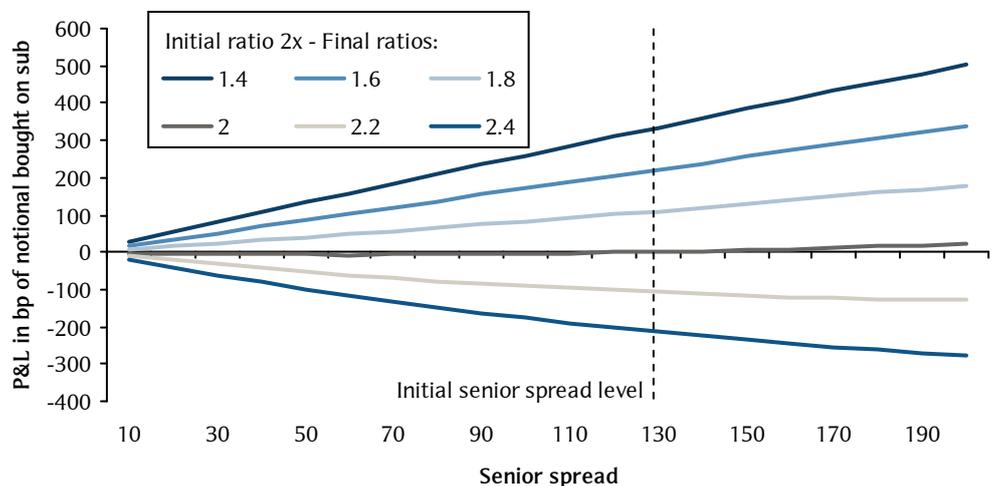
Source: Barclays Capital

Financials Index Ratio Reversion (FIRRE) strategy

In an earlier part of this chapter we described a framework for understanding the sub to senior relationship in iTraxx financials. This, together with empirical evidence over the past eight years, motivates the search for a mean-reversion strategy on the index. The Financials Index Ratio Reversion strategy (FIRRE) is an example of such a model. FIRRE operates by estimating the cointegrating relationship between the two indices, and monitoring deviations from it. Specifically, we estimate:

$$Spr_t^{Sub} = \beta \cdot Spr_t^{Sen} + \varepsilon_t \text{ where } \varepsilon_t \sim N\left(0, \sigma^2\right)$$

We monitor residuals at each point in time by forming the error signal as

$$\text{Error signal} = \frac{\varepsilon_t - \hat{\varepsilon}}{\hat{\sigma}^2} \text{ where } \hat{\bar{\varepsilon}} \text{ is the sample mean of the residuals.}$$

Large error signals indicate that the relationship between sub and senior has deviated significantly from the long-run stable level.

This process requires numerous parameters. For robustness, we again use the parameter stability maps to guard against over-fitting. In our standard implementation we use a six month (24 week) rolling window for the estimation and error-signal computation. We use an error-signal threshold of ±0.5 and a trading frequency of once every two weeks. Figure 138 shows the actual time series of the ratio of 5yr spreads of sub to senior, together with the estimated beta parameter. The beta essentially acts as a moving average value. At the bottom of the chart, we show the trading signal generated from the errors according to the above process. The model switches between three states:

- Decompression: the current ratio is substantially below the long-run ratio

- Neutral: the current ratio is broadly in line with the long-run ratio

- Compression: the current ratio is substantially above the long-run ratio

The trading signal is reasonably stable throughout this period with only a few periods of erratic trading.

Figure 138: Sub to senior 5yr spread ratio and FIRRE trading signals
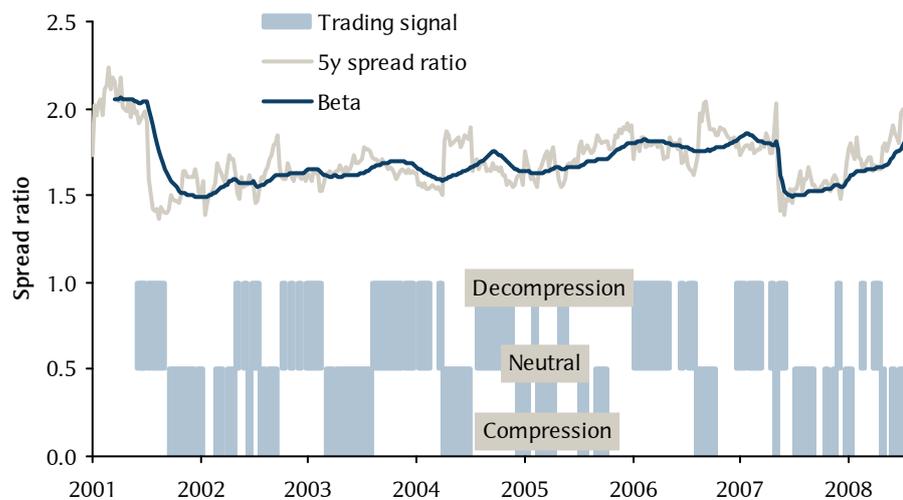
Source: Markit, Barclays Capital

Figure 139 reports the performance of the FIRRE strategy as described. The left-hand chart shows cumulative returns over the 2001-08 sample which average 78bp per year, with a Sharpe ratio of 1.0 over roughly 11 trades per year.

The strategy is clearly susceptible to sustained periods of deviation from historical levels. This has occurred in periods in 2002, 2004 and recently over the summer of 2008. Usually the strategy makes enough money on the eventual reversion to recoup any losses made. To analyse this more precisely we show, in the right-hand chart, the drawdown analysis. Here, we find the worst drawdown was in mid-2002 causing a cumulative loss of around 80bp over about one month. However, the strategy pulled back to flat within a further month of this drawdown.

Figure 139: FIRRE strategy returns and drawdown analysis
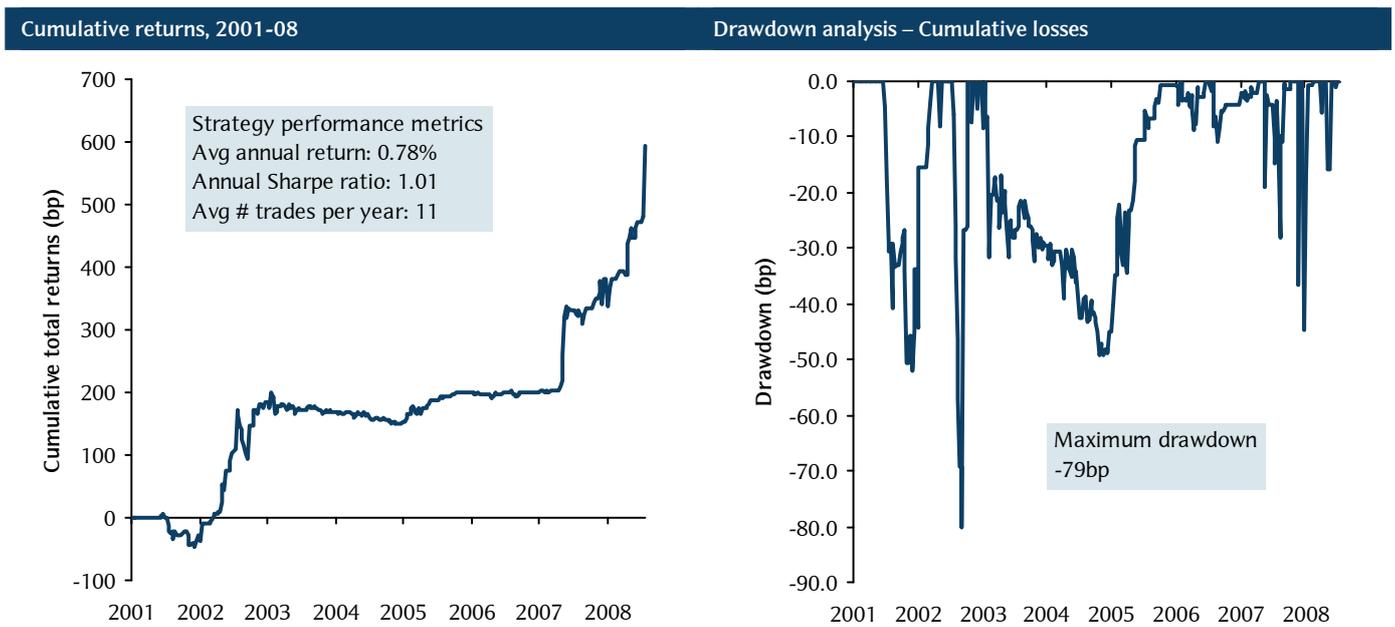
Source: Markit, Barclays Capital

Figure 140 shows the all-important parameter stability. Again, since this is a parameter-dependent strategy, we view robustness checks like this as essential. There are three parameters in the model: i) trading frequency; ii) estimation window; and iii) error-signal cut-off values. The left-hand chart analyses the first two, and the right-hand chart the latter two. Both charts show very convincing stability. We find that the strategy is optimal at a relatively high trading frequency of one to two weeks. We choose two weeks to help minimise the number of trades executed. The error-signal and estimation window parameters appear very stable, with strong performance throughout the right-hand grid.

Figure 140: FIRRE parameter stability analysis, 2001-08
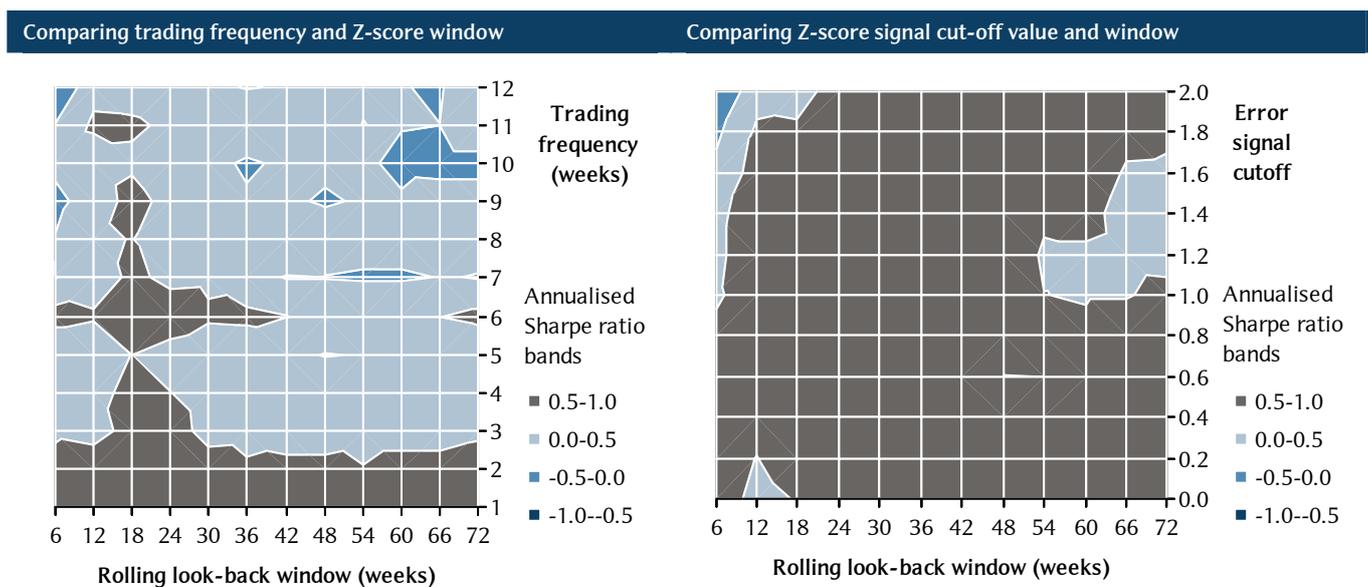
Source: Barclays Capital

A note on transaction costs

Transaction costs are not included in the FIRRE strategy results as they are intended to be indicative only, at this stage. Clearly, a trade-off needs to be reached in terms of the number of trading signals generated and the performance of the strategy. Transaction costs on the iTraxx Financials indices are quite variable through time and would take a substantial portion of any profits made.

Trading other ratios

The FIRRE strategy suggests some potential for mean-reversion style strategies on index ratios. However, as mentioned in the introduction, we prefer to consider such strategies only where the ratio has some theoretical meaning.

Many investors have experimented with the iTraxx Main to Xover 5yr spread ratio. Figure 141 shows a chart of this ratio through time. Two points are immediately clear in this chart:

- The Main: Xover ratio is highly non-stationary and not obviously mean reverting.

- Because of substantial changes in constituents, some correction needs to be made across roll dates.

The second point can be addressed by constructing 'roll-adjusted' ratio series, also shown in the chart. At each roll date, the ratio of the new contract to the old is calculated and all future quotes of each new series are rescaled according to these roll-adjustment factors. The adjustment factors are cumulative across subsequent rolls.

Figure 141: iTraxx Xover 5yr to iTraxx Main 5yr on-the-run spread ratios
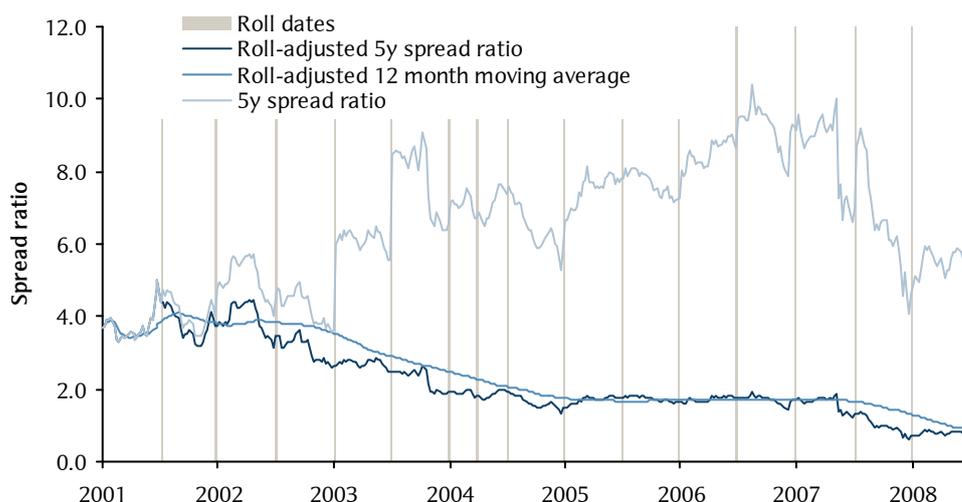
Source: Markit, Barclays Capital

Despite this adjustment, we find little evidence of any meaningful systematic ratio-relationship between the other indices. We believe that non-theoretically linked ratios such as Main: HiVol and Main: Xover should instead be traded on a fundamentals basis depending on the underlying names and market environment/technicals. As an example of such a trade, the next short section illustrates a combined fundamentally/quantitatively motivated index relative value trade.

US and European High Yield index relative value

Originally published as *CDX HY vs iTraxx Xover opportunities in the volatility, 11 June 2007*.

During the late-February credit sell-off, the US market reacted more negatively than the European market, but this pattern has been reversed during this week's rout, with the European Crossover moving much wider on a percentage basis than the US HY index (Figure 1). Our cointegration model is also pointing to a disruption of the normal statistical relationship. Although the tone in the US market is firmer today we believe next week's PPI and CPI numbers could surprise to the upside, creating another round of market volatility that the CDX indices in particular are not fully pricing in. This leads us to recommend going short the US and long Europe via the CDS indices.

We have recommended CDX HY versus iTraxx XO trades in the past. For further in-depth analysis of these trades please see *US Alpha Anticipator, February 1 2007*, Flow and Structured Strategies for a High Yield Pullback.

Recommended Trade:

▪ Sell 10y iTraxx XO series 7 protection and buy 5yr CDX HY series 8 protection. We suggest a carry-flat weighting of 0.9:1. This format is approximately beta x DV01 neutral (for example, calculating betas to XO 5yr).

Trade entry points:

▪ At the time of writing the markets are moving around substantially. According to our statistical analysis, we find that entry points around 310bp, or wider, for iTraxx XO 10y and 270bp, or tighter, for CDX HY 5yr work.

Trade format rationale:

- We recommend selling 10y iTraxx XO series 7 rather than 5yr. We believe this has a better risk profile in the case of a more substantial sell-off due to convexity effects and an anticipated relative flattening of the iTraxx curve.

Figure 142: Our statistical model anticipates the gap between XO 10y and HY 5yr to close
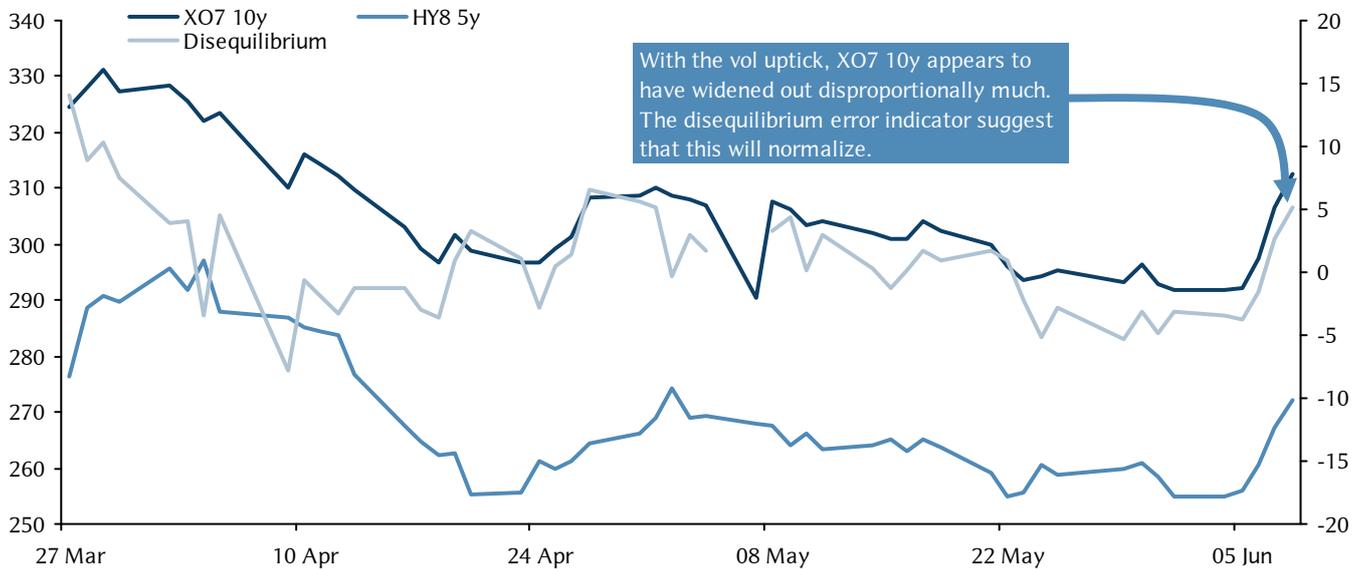
Source: Markit, Barclays Capital

The econometric indicator

We use a cointegration model to determine that (i) the XO and HY indices have a 'true' statistical relationship and (ii) the recent volatility has put the indices out of sync with each other.

The statistical model calculates a 'disequilibrium' error, as highlighted in Figure 142, which indicates the likelihood of a relationship between two variables to mean-revert. On the back of recent volatility, the error has switched from negative to positive, meaning that the ratio between the iTraxx XO 10y spread looks too wide in comparison to the CDX.HY 5yr spread.

The model results are based on the following statistical framework:

$$\begin{bmatrix} \Delta XO_t \\ \Delta HY_t \end{bmatrix} = \begin{matrix} \alpha_1(XO_{t-1} - \beta_1 HY_{t-1}) + A_1(L)\Delta XO_t + u_t \\ \alpha_2(XO_{t-1} - \beta_1 HY_{t-1}) + A_2(L)\Delta HY_t + v_t \end{matrix} \qquad (1)$$

where A(L) denotes a lag polynomial and greek letters indicate parameters to be estimated. The terms within the parentheses gives us the structural relationship between the two indices and is called the equilibrium relationship, which is the time-series plotted in Figure 142. This structure, when estimated with fairly complicated methods, can be used to avoid spurious relationships where no mean-reversion occurs.

Skew strategies

Originally published as *iTraxx skew strategies*, European Alpha Anticipator, 12 September 2008.

Using off-the-run indices to monetise skew

Certain credit market participants including bank prop desks and hedge funds are active in arbitraging the index skew, defined as the difference between the market spread on the index and the theoretical price of protection implied from the single names[10]. While attractive in theory, execution is complex and trades frequently fail to complete on liquidity grounds.

Off-the-run indices may present an alternative way to trade the skews. We can monitor the skew on different indices to find discrepancies – for example, where simultaneously one series trades with a positive skew and another with a negative skew. In order to truly arbitrage this kind of anomaly, the full replication trade would be necessary. However, we find it can be profitable to construct a long-short position in the two indices and ignore the single-name legs. While not a risk-free trade, it is plausible that such discrepancies will tend to revert, especially as index-arbitrageurs get to work.

To identify such trades, an accurate index intrinsic model is required, as well as screening tools such as the examples shown in Figure 143 and Figure 144. These tables, based on 9 September closing values, look for anomalies across series and terms on iTraxx Main. Large differences in skews for similar indices may be trading opportunities.

This note revisits and updates ideas introduced in *iTraxx off-the-run trading*, 14 August 2008. Naturally, series 10 will offer a further instrument to compare in the screen when it begins trading next week.

Figure 143: Example skew monitor for iTraxx Main, based on 9 September data

Term	Series 3	Series 4	Series 5	Series 6	Series 7	Series 8	Series 9	Maximum difference
5yr	-4.1	-4.0	-3.1	-4.1	-3.8	-2.4	-1.2	3.0
7yr	-6.5	-6.0	-2.2	-2.9	-4.2	-5.5	-6.1	4.3
10yr	-7.3	-7.8	-6.6	-7.8	-6.6	-7.6	-7.0	1.3

Source: Markit, Barclays Capital

Figure 144: Matched maturity skew monitor for iTraxx Main, 9 September 2008

Maturity	Jun 2010	Dec 2010	Jun 2011	Jun 2012	Dec 2012	Jun 2013	Jun 2015
Index 1	Series 7 3yr	Series 8 3yr	Series 9 3yr	Series 7 5yr	Series 8 5yr	Series 9 5yr	Series 9 7yr
Index 2	Series 3 5yr	Series 4 5yr	Series 5 5yr	Series 3 7yr	Series 4 7yr	Series 5 7yr	Series 3 10yr
Skew 1	-3.9	-2.4	-4.0	-3.8	-2.4	-1.2	-6.1
Skew 2	-4.1	-4.0	-3.1	-6.5	-6.0	-2.2	-7.3
Difference	0.2	1.7	0.9	2.7	3.7	1.0	1.2

Source: Markit, Barclays Capital

Simple skew screens

Figure 143 is a screen based on iTraxx Main only and highlights, for each maturity/term, the minimum and maximum skews at any one point in time. For example, in the 7yr off-the-runs on 9 September, the S3 skew was estimated to be -6.5bp, while the S5 skew was estimated to be -2.2, a difference of 4.3bp. A possible

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[10] *For details of the calculation of the skew, please refer to the CDS Curve Trading Handbook 2008, p149.*

trade could be formed by selling 7yr S4 versus buying 7yr S7. In this particular case, the differential is not large enough to be compelling after transaction costs, but keeping track of these differentials regularly leads to more substantial anomalies.

As an example, Figure 145 shows iTraxx Main S4 5yr and S8 5yr spreads during July 2008. On 9 July, the skews on the two indices differ substantially. The S4 skew is about -1bp while the S8 skew is around -7bp, suggesting selling S4 protection and buying S8 protection. After one week, the skew on the two indices converges, as do the indices themselves, leading to a potentially profitable trade. We will test the validity of such a strategy more formally below.

Figure 145: Example skew trade on iTraxx Main 5yr S4 and S8, July 2008
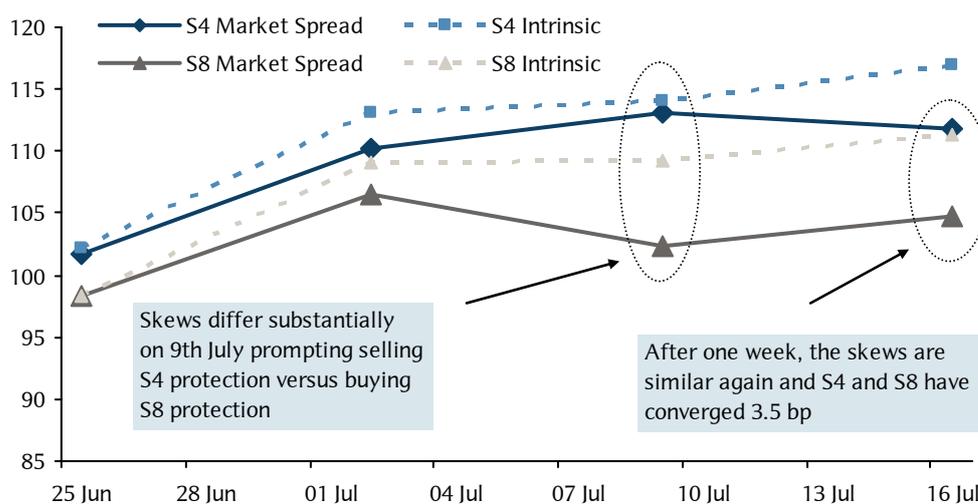
Source: Markit, Barclays Capital

Trade risks

There are several risks to such a skew strategy:

- Idiosyncratic risk – as we are trading two different series, idiosyncratic events in non-overlapping names may cause unexpected spread moves.

- Curve risk – as the two indices have different remaining times to maturity, there are implicit curve risks.

- Transaction costs – full bid/offer costs may knock out a fair chunk of any profits on such a trade.

The first two points indicate that it is attractive only to hold such trades for relatively short horizons. While skews empirically tend to revert relatively quickly, there is no guarantee that this will always happen.

Measuring performance of a skew strategy

Using our extensive dataset, we can run a more formal test of the above strategy. The test is carried out as follows:

- Every week we calculate skews on all indices, terms and series. We exclude 3yr indices because of limited liquidity.

- We use a screen like the one in Figure 143 to find the maximum and minimum skews.

- Setting a threshold of 5bp; if any pair of indices has a skew differential exceeding this, we set up the convergence trade and hold for one week.

Figure 146 shows the performance of these strategies, measured over January-July 2008. The chart shows one line per index and term. The vertical line shows the range of weekly P&L values for trades carried out on the index and term. The horizontal bar shows the average weekly return of trades.

As an example, iTraxx Main 10yr shows an attractive distribution of returns, with an average of 43bp, a worst trade of 13bp and a best trade of 141bp. HiVol 7yr and 10yr, and Crossover 10yr also show good performance. Main 5yr and Crossover 5yr have the worst performance, possibly owing to the greater visibility and liquidity on these series.

We do acknowledge that, generally, the lower the liquidity in the series the greater the trading performance. This does suggest that the strategy is capturing an illiquidity premium. With this in mind, performance numbers here are intended as indicative and do not take into account bid/offer costs, which may be substantial. The purpose is to illustrate that even relatively simple strategies can generate possibly attractive returns.

Figure 146: Skew strategies – average, max and min weekly returns, January to July 2008
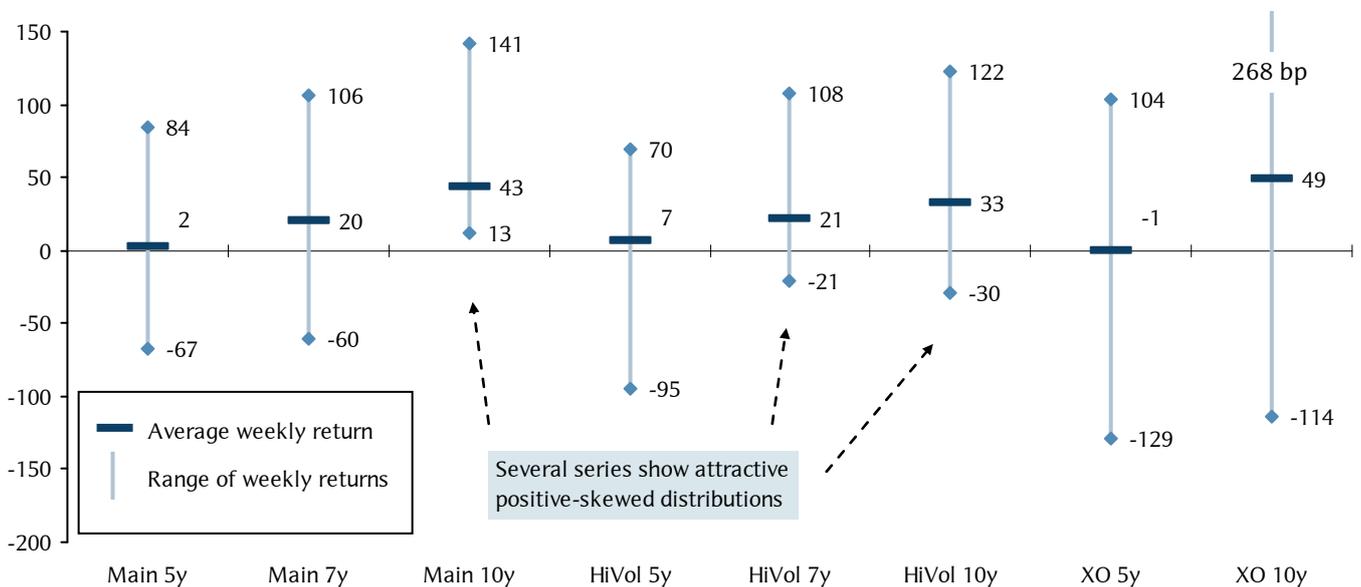
Source: Markit, Barclays Capital

Matched-maturity skew strategies

The second screen shown on the first page, Figure 144, is an example of a matched-maturity monitor. This time we only allow trading in indices with the same final maturity date. For example, we can monitor Series 9 5yr skew versus Series 5 7yr skew – both indices have five years remaining until maturity, so there is no curve risk. Trades based on this monitor will neutralise the second of the trade risks identified above – curve risk.

The screen in Figure 144 is split by final maturity date, and the respective indices are shown in the second two rows. We then analyse the difference in skews and look for large absolute values of this difference for trading opportunities.

We can test the performance of these strategies in a similar way to those above. These tests average performance across all the different series for Main and then for HiVol (Crossover does not have enough term structure points for this strategy), allowing multiple trades at each time point if more than one pair of skews is substantially different.

Figure 147 shows the results for Main in the left-hand panel in the form of a returns histogram. The latter shows the number of trades falling into each returns bucket, plus the average weekly return of 16.3bp on the strategy.

Systematic relative value strategies

The right-hand chart acts as a robustness check. We have set a threshold of 5bp as the minimum difference in skews to warrant a trade. This chart demonstrates that the strategy performance is actually robust to this number and varies predictably. The line shows the number of trades for each given threshold. As expected, the higher the threshold, the fewer the number of trades but the greater the average return.

Figure 147: Returns distribution and robustness of maturity-matched iTraxx Main skew strategies
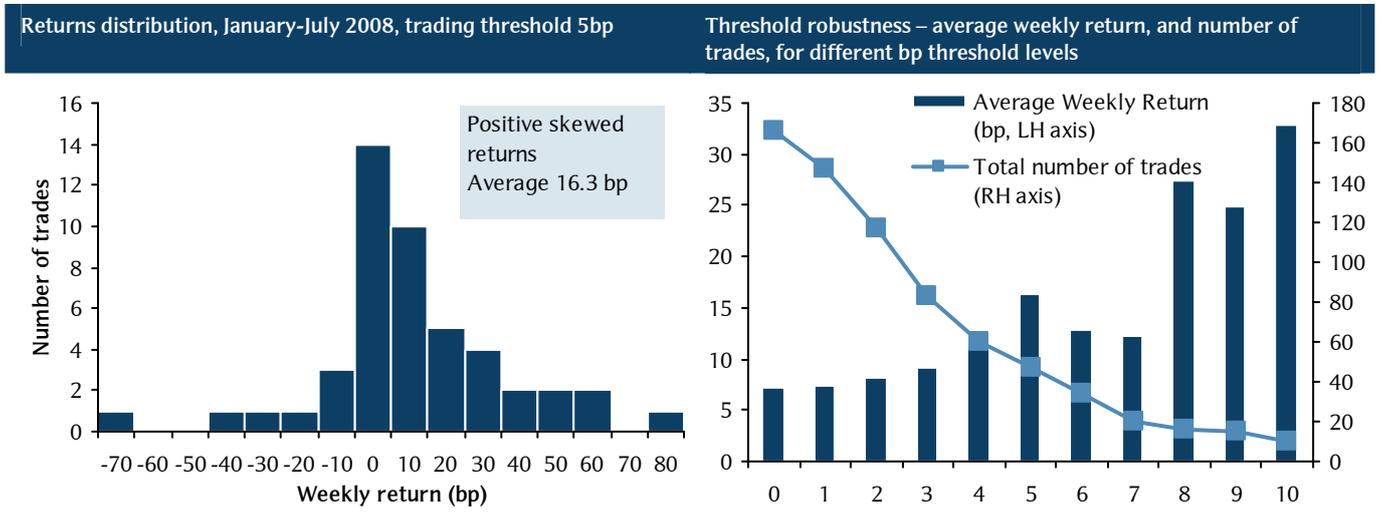
Source: Markit, Barclays Capital

Similarly for the HiVol indices, Figure 148 presents the returns distribution and robustness test. Overall performance is very similar but slightly weaker than for iTraxx Main, with an average weekly return of 10.7bp for the 5bp threshold test. Actually, liquidity in HiVol is much weaker than for Main, however, and we would view these results more as a valuable robustness check than an actionable strategy.

Figure 148: Returns distribution and robustness of maturity matched iTraxx HiVol skew strategies
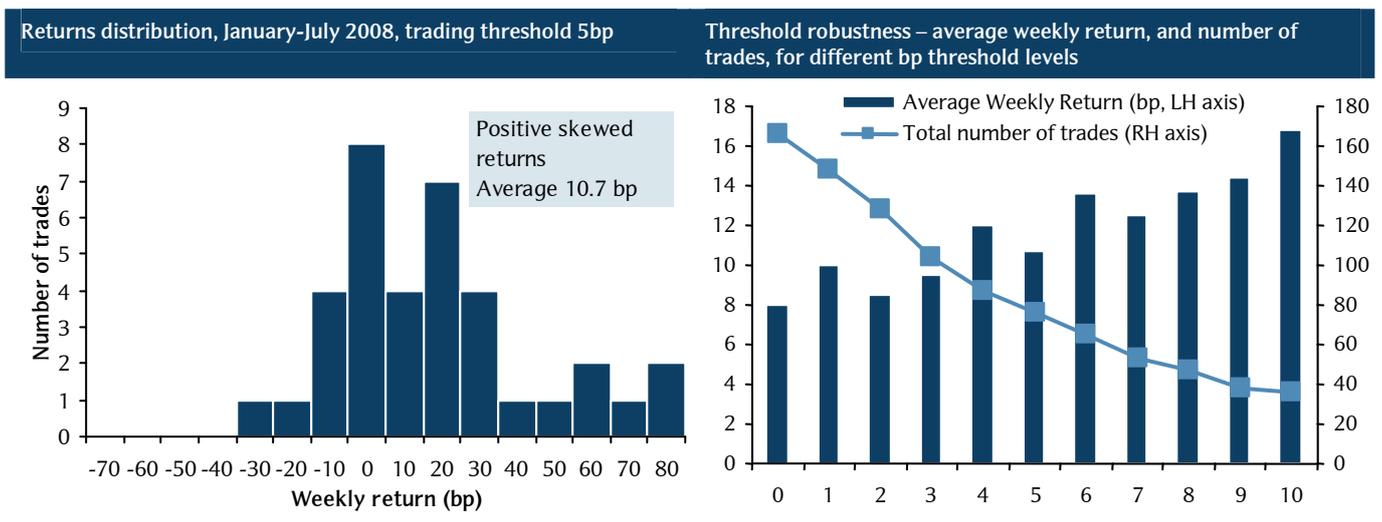
Source: Markit, Barclays Capital

Patterns in off-the-run skews

It is also interesting to look at broader patterns in the skew on off-the-run series. Figure 149 presents details of the skew on off-the-run series versus on-the-run series based on data from January to July 2008. The figure is divided into four panels. The top two charts show the skew on iTraxx Main 5yr and 5s10s slope. Each chart shows both the average value

(horizontal line) over this period and the range of values (vertical line). The skew on Main has a relatively small range of around -8bp to 6bp. This is because the single-name constituents typically trade with a bid/offer around 5bp, meaning that skews beyond this range can be monetised. Similarly, the skew on 5s10s (that is, the difference between 10yr and 5yr market spreads minus the difference between 10yr and 5yr intrinsic spreads) has a small range, reflecting the reasonable curve liquidity in investment grade credits.

The HiVol and Crossover skews have a notably greater range of values, reflecting both the reduced liquidity and higher transaction costs of the underlying names. Overall, the off-the-run skews tend to be in a similar range to the on-the-run skews.

Figure 149: Comparing skew trading ranges and averages across series and indices
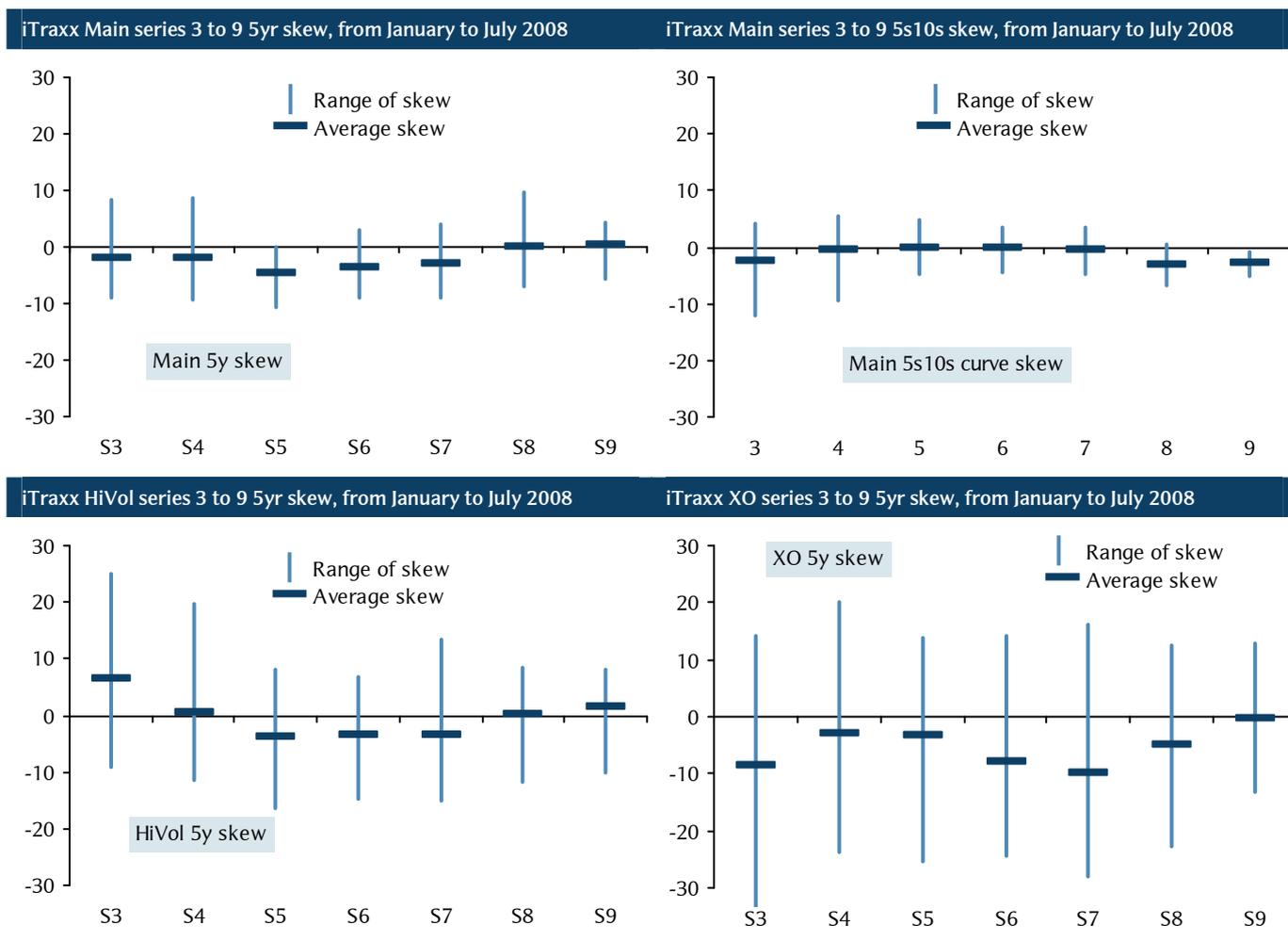
Source: Markit, Barclays Capital

Figure 150 digs a little deeper, now considering the dynamics of the skews on the indices. The charts show, this time just for Main and Crossover, the correlation of the skew on the off-the-run index with the skew on the on-the-run index. A consistent pattern is present where the more recently off-the-run index skews trade somewhat in line with the on-the-run, while older series skews show less of a relationship. This effect is not surprising as the lower liquidity in the further off-the-run series means they will not react as quickly as the more recent ones, leading to a very low contemporaneous correlation.

Figure 150: Comparing skew over time with the on-the-run skew for each series, Jan-July 2008

| Correlation of iTraxx Main 5yr skew with on-the-run skew | Correlation of iTraxx Crossover 5yr skew with on-the-run skew |

Off-the-run skew is more correlated with on-the-run skew for more recent series

Older series skews show little relation to the on-the-run skew
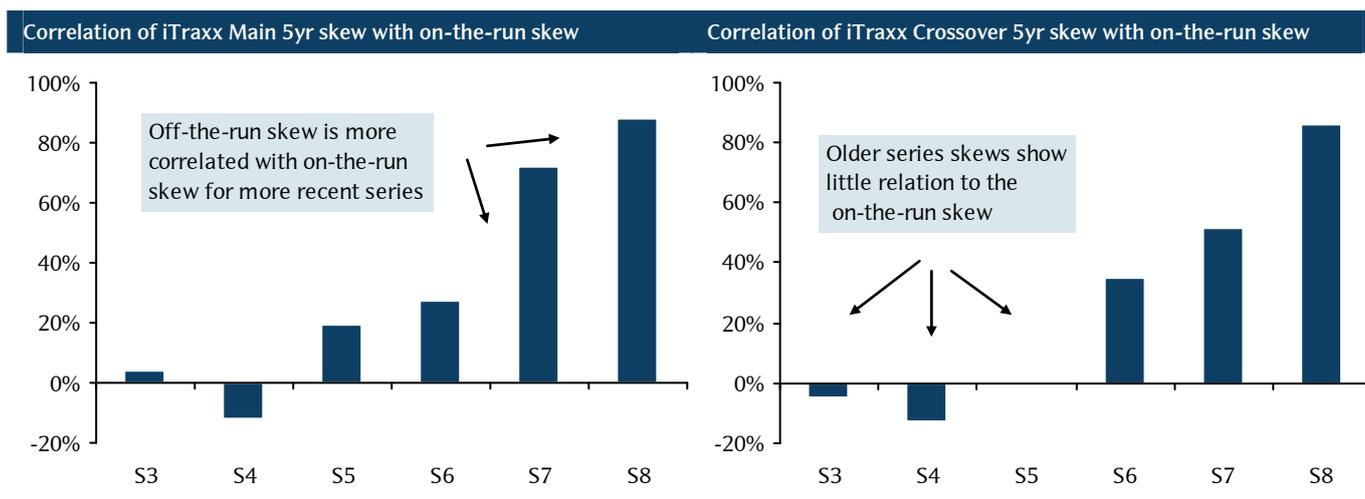
Source: Markit, Barclays Capital

Bottom-up signals from the equity market

An extensive area of quantitative credit research revolves around capturing information from the equity market. Merton-style structural models have often been a popular means of doing this. We have steered more towards empirical approaches such as our Dynamic Indicator of Equity Momentum (DIEM) credit selection model that uses equity momentum effects to select long and short credit candidates. DIEM is introduced in *Alpha generation in volatile times*, 23 January 2008 – a brief summary is given later in this section.

In this section we look at ways of extending this type of analysis to the index level, with the aim of generating relative value trading signals. At the single-name level it is straightforward to identify the stock and equity options that link to a particular CDS issuer. For a CDS index, however, it is less clear how to map to an appropriate equity index, as reasonable matches in terms of constituents, weightings and numbers are hard to find. For this reason, we focus here on bottom-up methods where we use the aggregated linked equity data of each individual constituent issuer to establish quantities at the CDS index level. The only downside of this method (other than the cumbersome task of linking data) is that the aggregated values are not tradable. In order to generate cross-market signals we have to live with the index mismatches – an example of such a trade is given at the end of this section.

Naturally a constraint on generated bottom-up signals is the existence of listed stocks for the constituents of the indices. It turns out that the majority of constituents are indeed listed, although the universe of names with listed options is much smaller. We return to the latter issue below, but in Figure 151 and Figure 153, we report the exact proportion of each index and each series that have listed equities. For CDX IG and iTraxx Main the coverage is very high. iTraxx Xover, however, shows a reduction over time in the proportion that are listed as the index started being increasingly populated with newly privatised LBOs.

Figure 151: Percentage of index constituents that have listed equities, by series (including QCX)

CDX IG

Series	Percentage
S11	98%
S10	98%
S9	98%
S8	98%
S7	98%
S6	98%
S5	98%
S4	97%
S3	97%
S2	95%
S1	96%
QCX S6	96%
QCX S5	96%
QCX S4	97%
QCX S3	98%
QCX S2	98%
QCX S1	98%

iTraxx Europe

Series	Percentage
S10	98%
S9	98%
S8	98%
S7	97%
S6	97%
S5	97%
S4	94%
S3	95%
S2	97%
S1	96%
QCX S7	98%
QCX S6	98%
QCX S5	98%
QCX S4	94%
QCX S3	93%
QCX S2	93%
QCX S1	92%
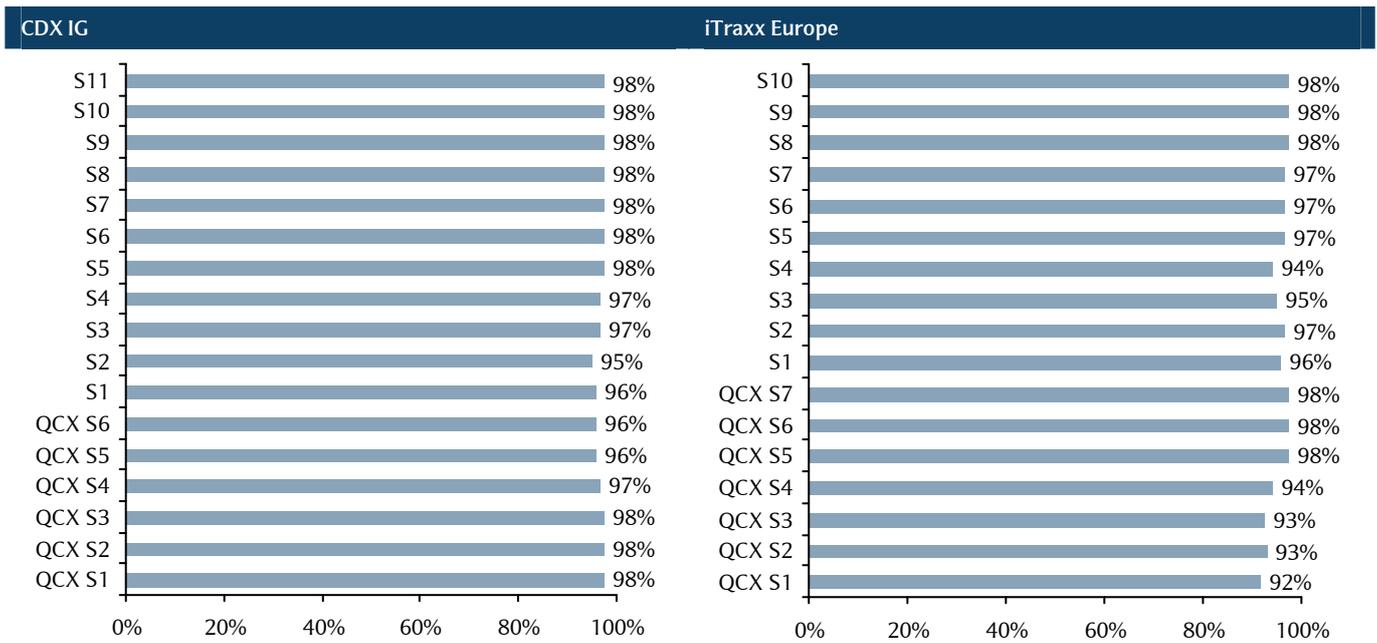
Source: Markit, Barclays Capital

Figure 152: Percentage of index constituents that have listed equities, by series (including QCX)

iTraxx HiVol

Series	Percentage
S10	97%
S9	97%
S8	97%
S7	97%
S6	97%
S5	93%
S4	87%
S3	87%
S2	93%
S1	93%
QCX S7	97%
QCX S6	100%
QCX S5	93%
QCX S4	97%
QCX S3	90%
QCX S2	84%
QCX S1	80%

iTraxx Xover

Series	Percentage
S10	64%
S9	60%
S8	60%
S7	62%
S6	62%
S5	67%
S4	78%
S3	80%
S2	90%
S1	100%
QCX S7	93%
QCX S6	97%
QCX S5	100%
QCX S4	87%
QCX S3	93%
QCX S2	93%
QCX S1	93%
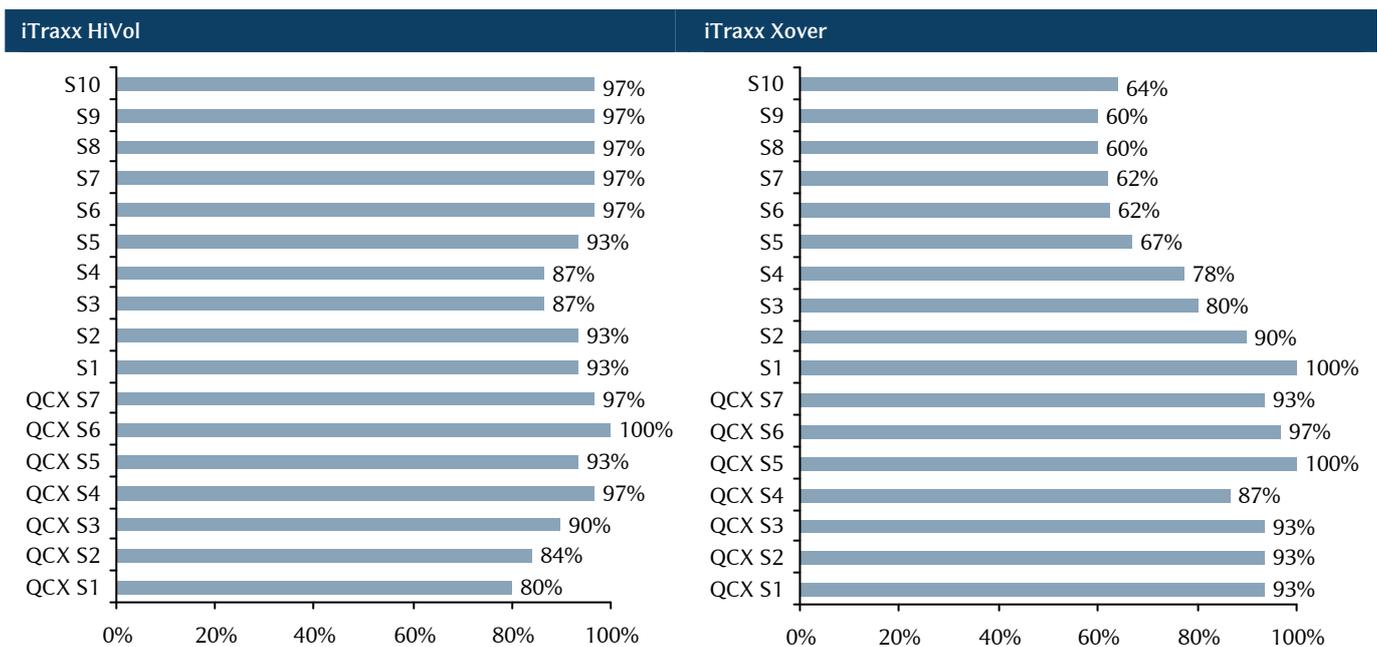
Source: Markit, Barclays Capital

Of these listed equities, a much lower number have listed option data. We can get around this by using projected implied equity volatilities generated from our cross-section volatility model (described in the box below).

The implied volatility projection model

In order to proxy what an implied volatility for a stock would be if there is not an equity option trading, we take an econometric approach based on realised volatility, recent stock performance and peer-group relationships. When applying a cross-section technique, we are able to estimate rather than guess what weight should be put on

short horizon realised volatility versus longer-term realised volatility within a peer group where implied volatilities are observable, and then use these weight for the names in the group where we want to proxy implied volatility.

For the names on which we have six-month implied volatility and which fulfil the following criteria:

- Implied volatility is between 10% and 60% per annum,

- Realised volatility at the two-month to one-week horizon is also between 10% and 60%,

we run the following regression:

$$\sigma_i^{ATM6M} = \alpha + \beta_{1S}\sigma_i^{RL2M} + \beta_{2S}\sigma_i^{RL1M} + \beta_{3S}\sigma_i^{RL1W} + \\ + \chi_S \Delta r_t^{1M} + \varepsilon_i; \quad i \forall S \tag{1}$$

where σ_i^{RLkM} denotes the realised annualised volatility at time horizon k for company i, and Δr_t^{1M} denotes the change in the stock price over the last one-month period. The coefficient β_{1S} measures the sensitivity of implied volatility to the realised volatility at the two-month horizon and so on for the coefficients β_{2S} and β_{3S}. In this way, at periods of time when short-term realised volatility is more correlated with implied vol, the short-term coefficient β_{3S} will carry a heavier weight than β_{1S} and vice versa.

By introducing the sensitivity χ_S of implied volatility to recent stock performance, we target the empirically established asymmetry of implied volatility, being higher when a stock underperforms than when it outperforms.

Sectors, denoted S in equation (1) above, are based on the Bloomberg GICS breakdown at the top level, numbering 10. Companies where a sector is not available are pooled into an 11th sector. When estimating equation (1), we do this on a sector-by-sector basis to capture sector-specific shocks that may make the relation between realised vols and implied vols different for a specific sector than what it may be in the rest of the universe of names.

Aggregate index implied volatilities

Using this data, we can form aggregate implied volatility values for individual indices. Figure 153 shows the simple average of the projected volatilities of on-the-run iTraxx Main and Xover constituents from 2001-08. We add in the VStoxx index, which measures implied volatility on the EuroStoxx 50 equity index. A couple of points stand out from the chart:

- Xover projected volatility is consistently higher than Main projected volatility, which makes sense given the riskier nature of the constituents.

- The VStoxx index and the aggregate volatility series are clearly correlated, but with VStoxx trading lower than the aggregate values over the majority of the sample. This is consistent with equity index volatility generally being lower than the average single-name equity volatility, due to the positive correlation between equities. VStoxx spikes above the aggregate volatilities; however, in the most extreme market conditions, reflecting surges in risk aversion.

Figure 153: Average projected implied equity volatilities on iTraxx, compared with VStoxx. Xover has consistently high vol than Main

Vstoxx is generally lower than average constituent volatility, reflecting generally positive equity correlation
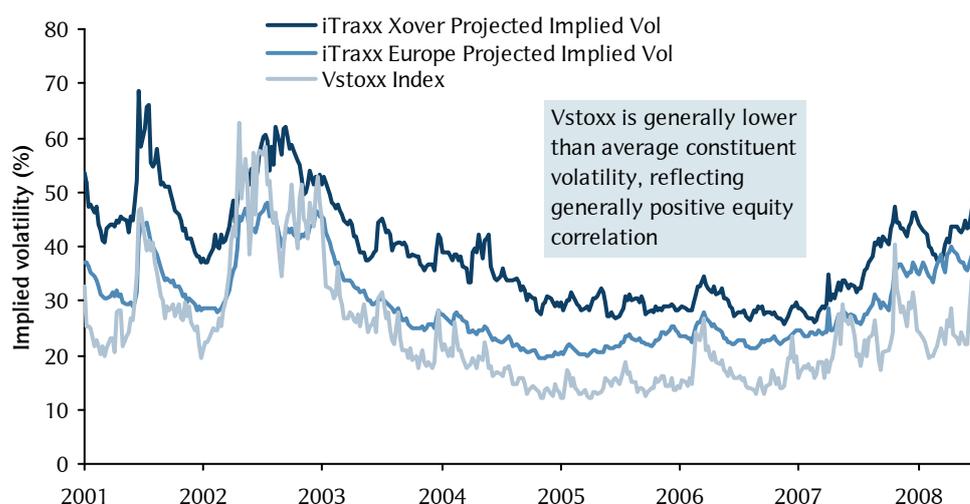
Source: Markit, Bloomberg, Barclays Capital

Figure 154 shows analogous series for CDX IG, CDX Xover and the VIX index. Broadly similar patterns are present as with the European series. The VIX index trades considerably lower still, compared with the aggregate series, than VStoxx does in Europe. This can be attributed to the very broad underlying universe (S&P 500) versus the comparatively small CDS index universes.

Figure 154: Average projected implied equity volatilities on CDX, compared with VIX. Xover has consistently high vol than IG

Similarly VIX is typically substantially lower than the CDX indices' average constituent vols
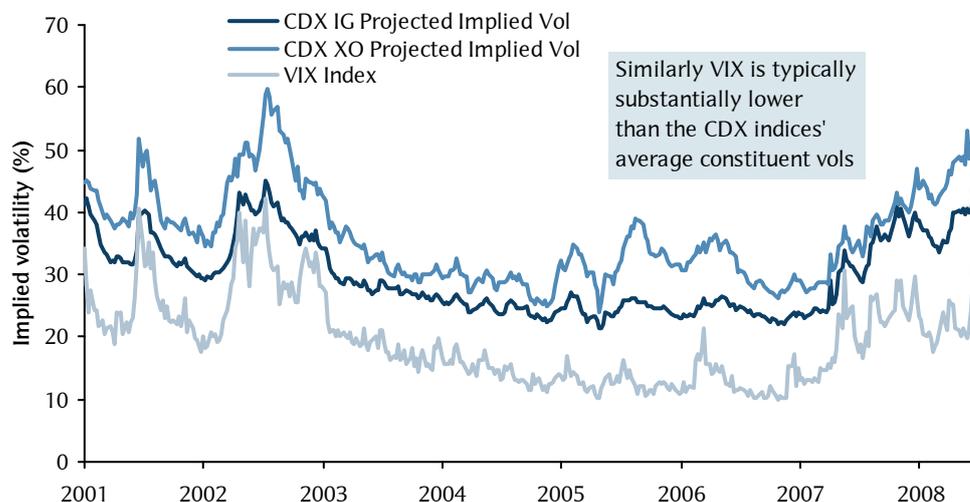
Source: Markit, Bloomberg, Barclays Capital

It is also interesting to compare these aggregate series with credit volatility. Figure 155 shows realised spread volatility of iTraxx Main versus the aggregate equity volatility series. There are numerous periods of spectacular disconnects between the two, most notably during the earlier parts of the credit crunch, but also in the correlation storm of May 2005.

Figure 155: iTraxx Main aggregate projected implied volatility versus realised 60-day spread volatility
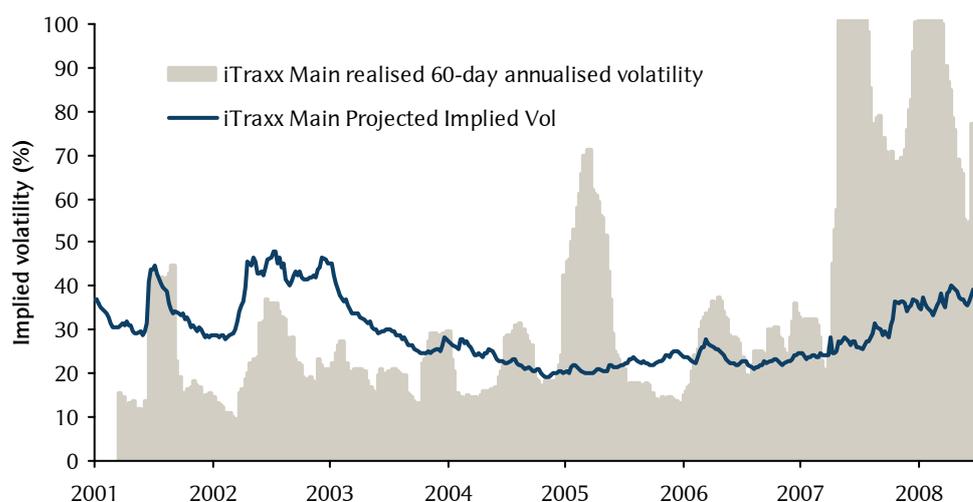
Source: Markit, Barclays Capital

Measuring equity momentum of an index

A similar aggregation approach can be used to generate index level equity momentum signals, similar to those used in DIEM. These may produce useful relative value signals between indices. As an example, we can consider trading iTraxx Main versus CDX IG based on the relative equity momentum. According to the premise of the DIEM model, the index with the stronger equity momentum should tend to outperform the one with the weaker momentum.

Specifically, we can run the following test which we will refer to as the iDIEM strategy:

- The DIEM indicator is calculated for each constituent name in an index (DIEM indicator is defined below).

- The iDIEM indicator for an index is taken to be the simple average of the constituent indicators.

- The strategy goes long the index with the greater average iDIEM indicator and short the other index.

The strategy is set to rebalance quarterly, in line with the single-name DIEM framework. Figure 156 shows a time series of the iDIEM indicator differential, together with trading signals as defined. Here, decompression corresponds to buying CDX IG protection and selling iTraxx Main protection.

Figure 156: CDX IG versus iTraxx Main relative equity momentum
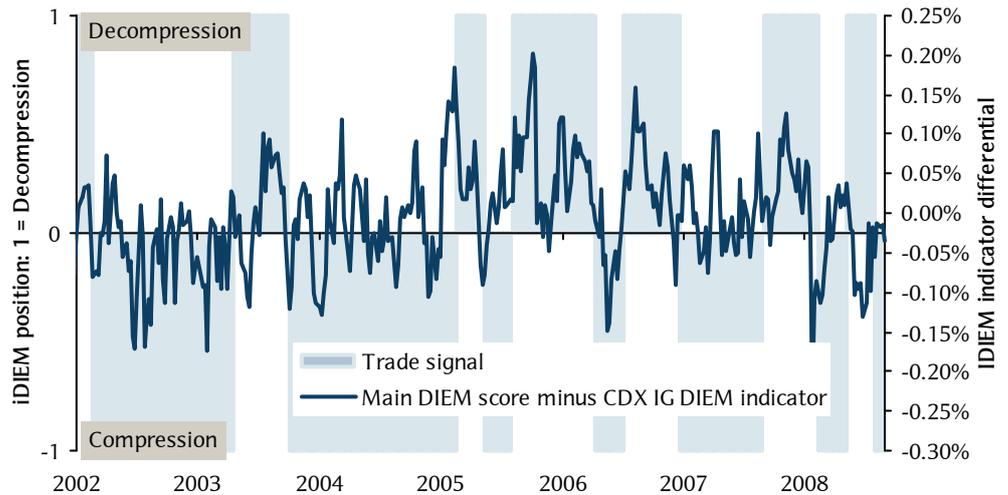
Source: Markit, Barclays Capital

Unfortunately, the performance of this strategy is not especially strong and is summarised in Figure 157. Returns are consistent in the first half of the sample and then become fairly erratic for the second half of the sample. The right-hand chart shows a one dimensional parameter stability chart, focusing on trading frequency. The shading used is the same as that in the previous parameter maps. We see that the strategy is at least stable across different frequencies.

Figure 157: CDX IG versus iTraxx Main iDIEM test – weak performance in second half of sample
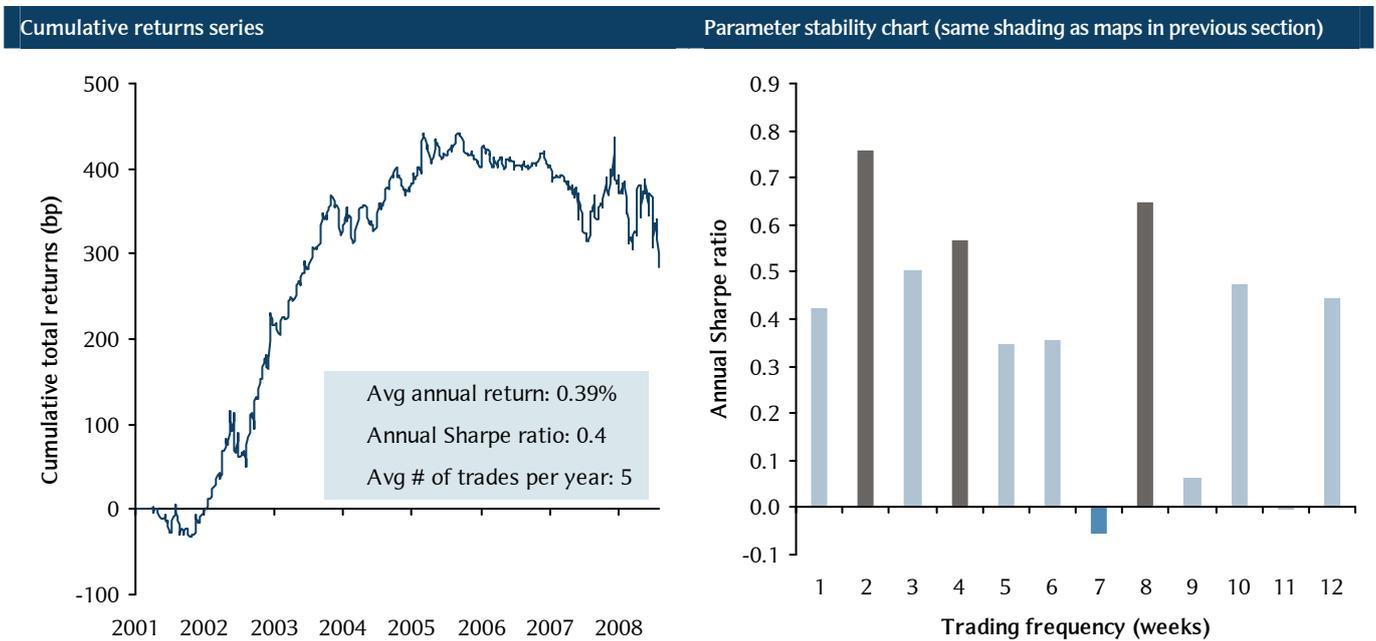
Source: Markit, Barclays Capital

Testing iDIEM on iTraxx HiVol versus iTraxx Main has a similar performance profile, although stability is weaker. We present an example below of a more ad-hoc trade idea using this approach published at the beginning of 2008.

Figure 158: iTraxx HiVol versus iTraxx Main iDIEM test – reasonable performance in periods

Cumulative returns series	Parameter stability chart (same shading as maps in previous section)

Avg annual return: 0.63%

Annual Sharpe ratio: 0.5

Avg # of trades per year: 4
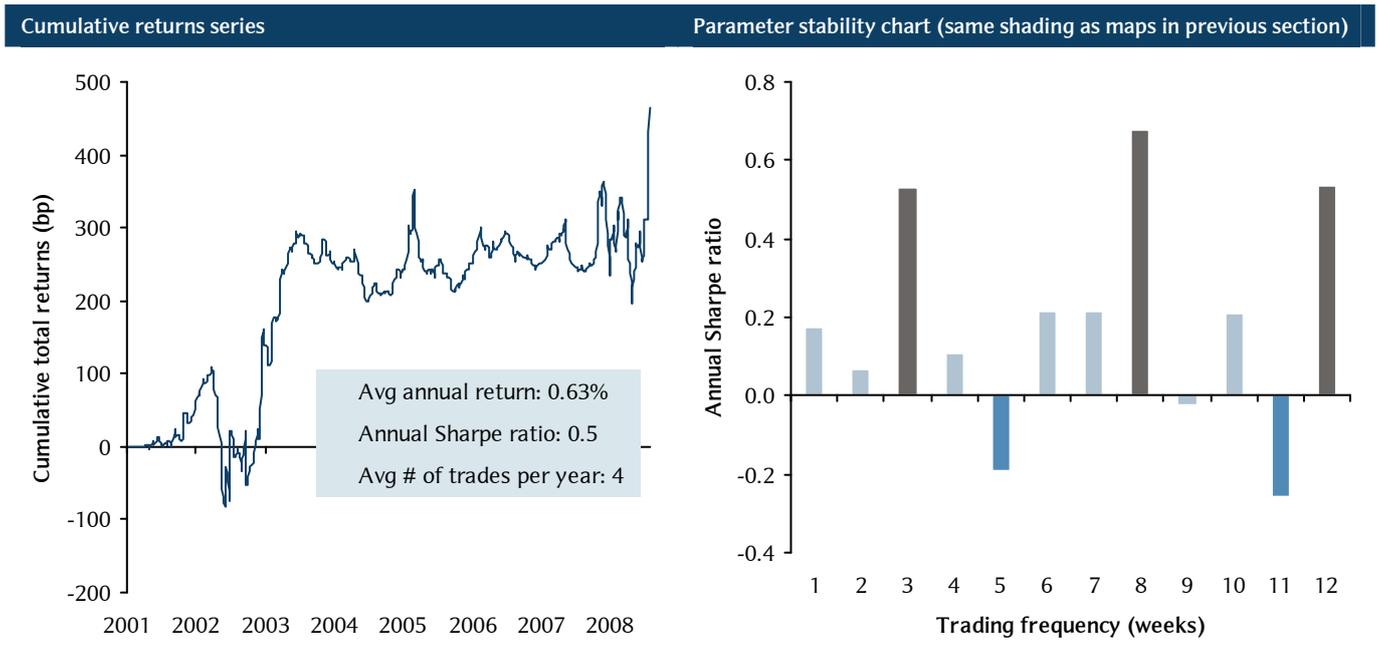
Source: Markit, Barclays Capital

Testing iDIEM on iTraxx Main versus iTraxx Xover turns out to have more promising historical performance with reasonable returns and a very stable profile. The strategy has underperformed in the most recent six months, which drags down overall performance, but average annual returns come out at 3.46% with a Sharpe ratio of 0.8 based on just four trades per year. Figure 159 and Figure 160 present the trading signals over time and the returns performance.

Figure 159: iTraxx Xover versus iTraxx Main relative equity momentum
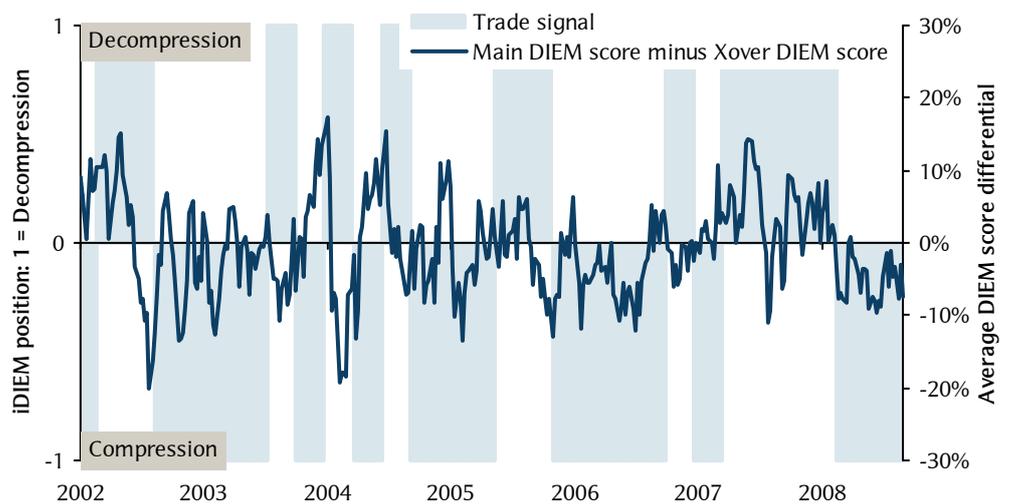
Source: Markit, Barclays Capital

Figure 160: iTraxx Xover versus iTraxx Main iDIEM test – good profile, except most recent period

Cumulative returns series	Parameter stability chart (same shading as maps in previous section)

Avg annual return: 3.46%

Annual Sharpe ratio: 0.8

Avg # of trades per year: 4
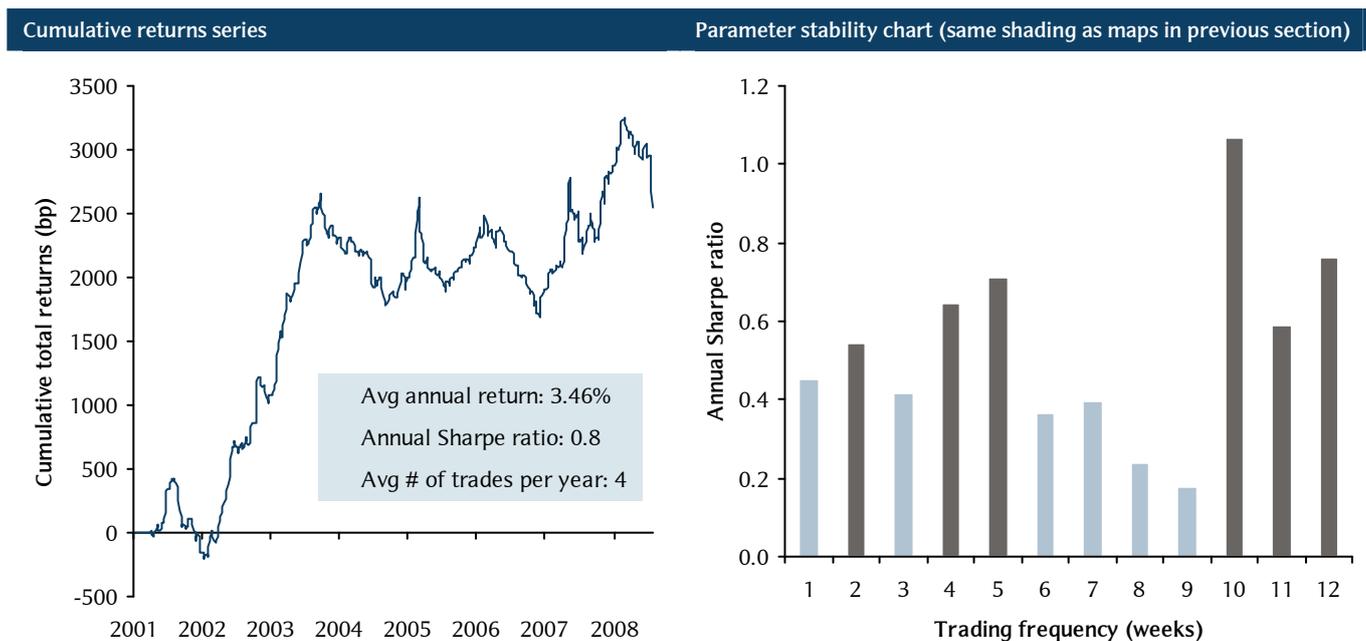
Source: Markit, Barclays Capital

Overview of Dynamic Indicator of Equity Momentum (DIEM)

Our DIEM equity momentum model captures relative strength in equity price trends, on a volatility-adjusted basis, to create relative value signals in credit space. A credit with stronger-than-trend equity performance, measured in equity volatility units, will achieve a more credit positive signal compared with a name with less strong performance/higher equity volatility given similar CDS spread levels.

Our Dynamic Indicator of Equity Momentum (DIEM) model is built around the following baseline equation:

DIEM Indicator = (Percentage deviation in equity price from 2-month trend) ÷ (Expected/implied volatility)   (1)

Volatility is taken from our projected implied volatility model described above. In order to get a relative value signal, we look at a given universe of CDS and rank names with 'similar spread', as obtained via a nearest neighbour approach, according to their DIEM indicator. The signal is then along the scale -2 (sell risk/buy protection) to +2 (buy risk/sell protection) according to which percentile the indicator belongs to. The top 20% indicators for a given spread range will have a +2 as they have the strongest relative equity momentum and analogously for the lower quintiles.

HiVol versus Main using iDIEM – An example

Originally published as *Quantitative trade ideas: iTraxx HiVol RV using DIEM, 8 January 2008.*

Our models indicate a relative value opportunity between selected iTraxx HiVol S8 single-names and iTraxx Main S8 index. We recommend either implementing in spot format, or using forwards.

- Buy €10mn 5 yr protection on any of the following iTraxx HiVol S8 credits, versus selling €10mn iTraxx Main 5 yr protection (per name): Accor, Adecco, St. Gobain, GKN, Marks and Spencer, Next, PPR, Valeo and Vinci

- Forwards format, buy equally-weighted 5s10s steepeners on the above credits versus equally-weighted 5s10s flatteners on Main. GKN, Marks and Spencer and Valeo are trading too flat according to our slope model.

Trade rationale

- Our DIEM equity momentum framework indicates credits in the HiVol index have, on average, a significantly more credit negative signal than those in Main (Figure 161). We select the credits with strongest credit negative signal among the HiVol names. See below for details on DIEM strategy performance in 2007.

- On both a spot and forward basis, the ratio of the two indices is at a low since 2001.

- Our Loan standards model continues to indicate a further worsening of the credit cycle in 2008. Our recommended trade would potentially benefit in such a scenario as: i) we would expect a divergence between the riskier HiVol names and the non-HiVol names (as we saw in 2002 in Figure 161); and ii) HiVol contains a large proportion of cyclical companies (see *Global Credit Market Strategic Outlook 2008*, European IG section for a further discussion).

- The index skews currently work in favour of this trade. The Main 5yr skew is at 2bp – ie, single names are trading roughly 2 bp tight of the index on average.

- Implementing in forwards space removes default risk and exploits flat curves identified by our slope model.

Figure 161: Quantitative relative value signals indicate that HiVol is rich compared with Main
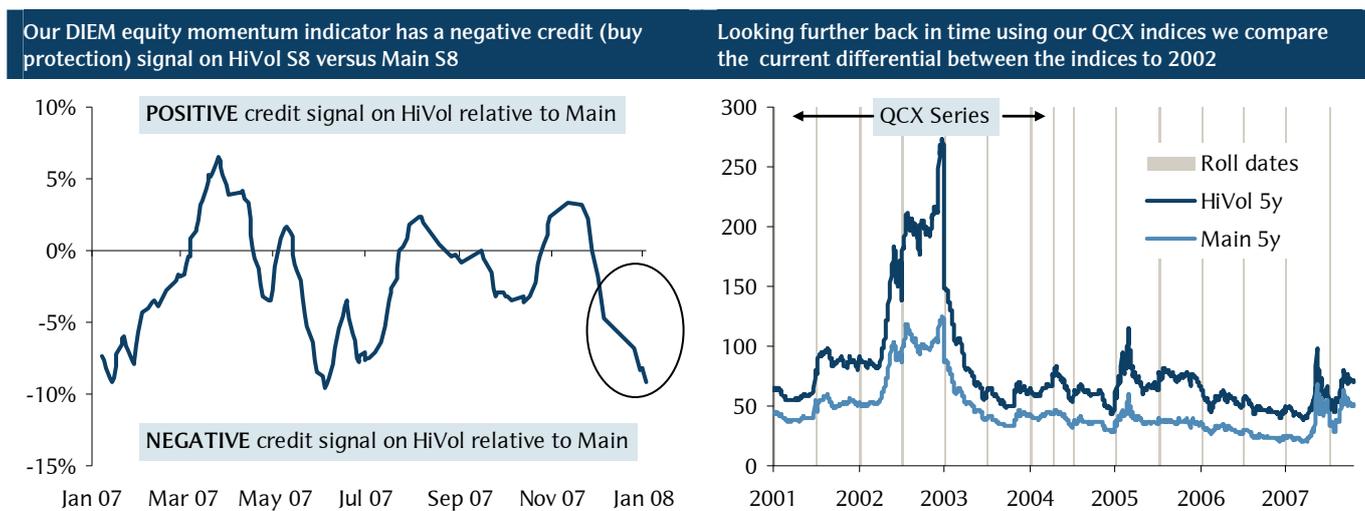
Source: Markit, Barclays Capital

Using DIEM to select credits

Figure 162 highlights those names from iTraxx HiVol series 8 with the lowest DIEM score of -2, ie, a short risk/buy protection signal. Although further negative retail news is a distinct possibility, we select from these names those credits that have not already experienced a significant spread move (DSG and Kingfisher). We also do not select Continental for our final list as our fundamental analyst is more positive on this name over the longer horizon.

Figure 162 also reports trading levels as of close 7 January, and the 5s10s curve signal from our Quantitative Slope model. See *CDS Curve Trading Handbook 2008*, 6 November 2007, page 122 for a full description of our quantitative models.

Figure 162: Selected HiVol S8 credits with DIEM signal of -2 (buy protection)

Company	Rating Moody/S&P	5yr mid/1M change	5s-10s (Mids) / 1M change	ATM6M equity Vol	1M stock return	5s10s slope model signal	DIEM signal
iTraxx HVOL8		**91/17**		**23/5**			
Accor	Baa3/BBB	61/11	20/2	35%	-10%	Steep	-2
Adecco	Baa2/BBB	70/7	19/0	33%	-10%	Neutral	-2
Comp de St-Gobain	Baa1/BBB+	92/4	20/0	35%	-12%	Neutral	-2
Continental	Baa1/BBB	94/12	22/-3	36%	-13%	Flat	-2
DSG International	Baa2/NR	166/55	26/-2	49%	-39%	Flat	-2
GKN	Baa3/BBB	91/10	19/-1	48%	-18%	Flat	-2
Kingfisher	Baa3/BBB-	205/66	31/1	47%	-22%	Flat	-2
Marks & Spencer	Baa2/BBB	93/20	26/0	35%	-17%	Flat	-2
Next	Baa2/BBB	114/33	25/-1	42%	-22%	Neutral	-2
PPR	NR/BBB-	113/15	27/0	34%	-13%	Neutral	-2
Valeo	Baa2/NR	112/26	22/1	49%	-22%	Flat	-2
Vinci	Baa1/BBB+	85/4	18/-1	34%	-23%	Neutral	-2

Source: Markit, Barclays Capital

Trade risks

▪ Default risk: In the spot implementation of the trade there is residual default risk on names in the iTraxx Main index other than the selected credit. This risk equates to approximately €48,000 loss per default at 40% recovery per €10mn notional in iTraxx Main 5yr. Using the forwards format of the trade removes jump-to-default risk.

▪ Carry costs: The trades in the format described are negative carry. If spreads remain where they are, the trade will underperform. Note that the forwards version of the trade has a much lower negative carry. For instance, Using Valeo as an example, the spot trade has negative annual carry of roughly (112bp – 61bp) = 51 bp. The forwards version would have an annual negative carry of (22 bp – 15 bp) = 7 bp.

▪ Spread compression: Naturally, if the selected names tighten relative to HiVol the trade will underperform. This could happen in a return to a strongly positive credit environment.

Index skew

A secondary consideration on execution is that of index skew levels. Figure 163 gives the time series of index skew (defined as market spread minus intrinsic spread), which shows that iTraxx Main skew is currently positive at 2bp. The trade as suggested will benefit from this skew as we wish to sell the index versus buying the single names. For a further discussion of index skew see our *CDS Curve Trading Handbook 2008*, 6 November 2007, page 122.

Figure 163: Index skew series for iTraxx HiVol and Main series 6-8 (market spread minus intrinsic)

iTraxx Main 5yr skew increasing in the past week	iTraxx HiVol 5yr skew
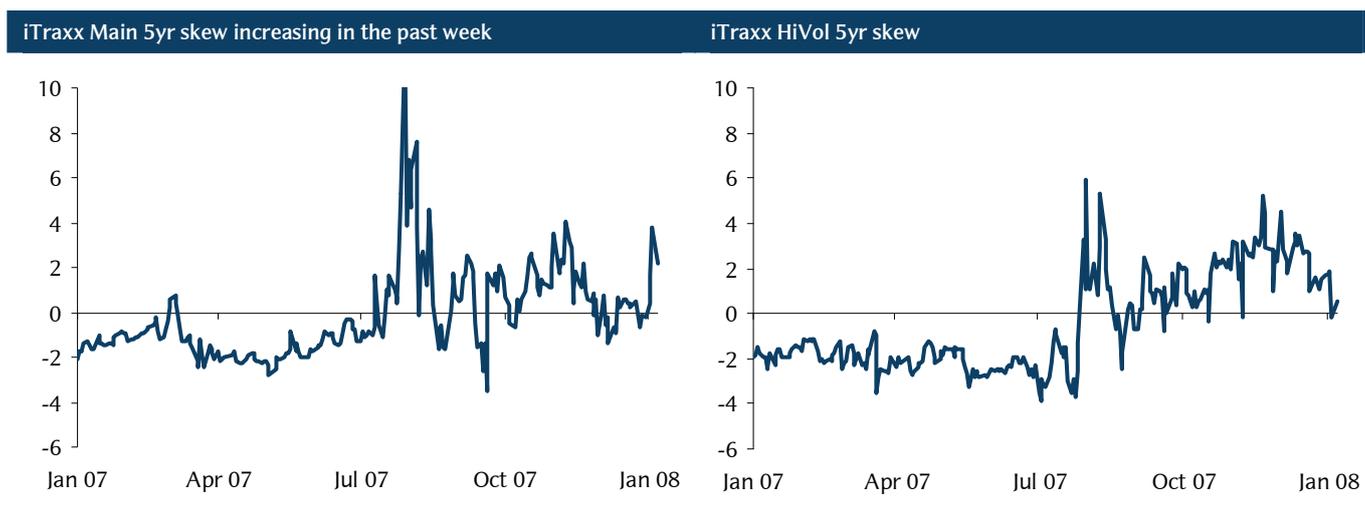
Source: Markit, Barclays Capital

Summary of relative value systematic strategies

Based on the tests above, we summarise the strategies in Figure 164. The highlighted rows represent the strategies we consider to have promising performance.

Figure 164: Summary of indicative strategy performance

	Weighting	Index combination	Indicative Sharpe Ratio	Typical # trades per year	Stability profile
Momentum in Index Relative Performance (MIRP)	1:1	Main vs CDX IG	0.6	7	Medium
	1:1	Main vs HiVol	0.8	7	Medium
	1:1	Main vs Xover	0.6	22	Medium
Mean-reversion	Spread ratio	Main vs CDX IG	Zero	10+	Poor
	Spread ratio	Main vs HiVol	Zero	10+	Poor
	Spread ratio	Main vs Xover	Zero	10+	Poor
Financials Index Ratio Reversion	Spread ratio	Fin Sub vs Senior	1.0	10	Good
Index Dynamic Indicator of Equity Momentum (iDIEM)	1:1	Main vs CDX IG	0.4	5	Medium
	1:1	Main vs HiVol	0.5	4	Medium
	1:1	Main vs Xover	0.8	4	Good

Source: Barclays Capital

The last section of this chapter presents a further example of linkage between equity and credit markets on a macro level.

Long equity volatility, short credit protection

Aaron Brask, Ulf Erlandsson, Graham Rennison

Originally published as *Long equity volatility, short credit protection,* 21 February 2008.

The relentless widening in CDS spreads over the past few weeks has created what appears to be another disconnect between the credit and equity markets along the lines seen last summer. iTraxx Main – where the most significant widening has been concentrated – moved more than 50bp higher on the month, reaching levels of around 130bp yesterday. Much of the widening is attributable to the technical effects associated with structured products rather than deteriorating fundamentals, in our view. Equities, while also down over this period, have had a seemingly muted reaction compared with the spike in spreads. The same applies for equity-implied volatility.

We would expect either equity markets to correct and realign with the worsening environment being priced into credit, or credit spreads to retrace. From another perspective, hedging through equity markets now looks cheap relative to credit protection. To position for a possible correction, we investigate two types of trades.

▪ Index trades: Purchase index variance or puts and sell iTraxx Europe 5yr protection

The primary risk to these trades is that structured credit technical effects continue to push spreads wider with limited reaction in the equity market, leading to mark-to-market losses on a near-term basis. In the medium term we would, however, expect the cost of downside protection to converge in these two markets.

Figure 165: The disconnect between credit and equity, tic-by-tic return indices

Euro STOXX50 versus iTraxx Main tic-by-tic return series, 26 Jul 07 = 100 (Using 10x scaling on credit returns)

Disconnect between equity and credit according to statistical model
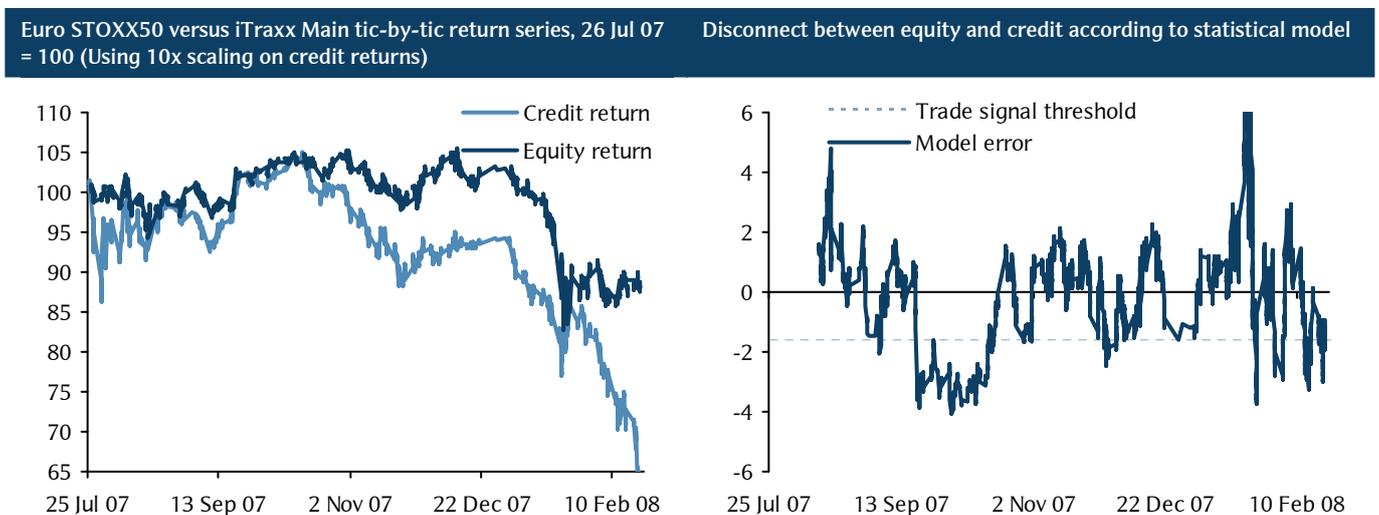
Source: Bloomberg, Barclays Capital

Equity markets slow to react again?

Our analysis in *The Capital Structure Disconnect,* 2 August 2007, highlighted the divergence in the two markets at the beginning of the credit crunch. Figure 166 indicates how the equity and equity-implied volatility markets moved as spreads began to widen. Equities, and implied volatility to some extent, proved robust for two or three weeks, while the iTraxx Europe moved higher, but eventually capitulated and sold off dramatically. However, as Figure 167 indicates, equities and equity volatility appear almost immune to the current spike in the iTraxx levels.

Figure 166: The disconnect at the beginning of the credit crunch – And eventual capitulation

iTraxx Europe Series 7 versus Euro STOXX 50

iTraxx Europe Series 7 versus Euro STOXX 50 1Y ATM vol
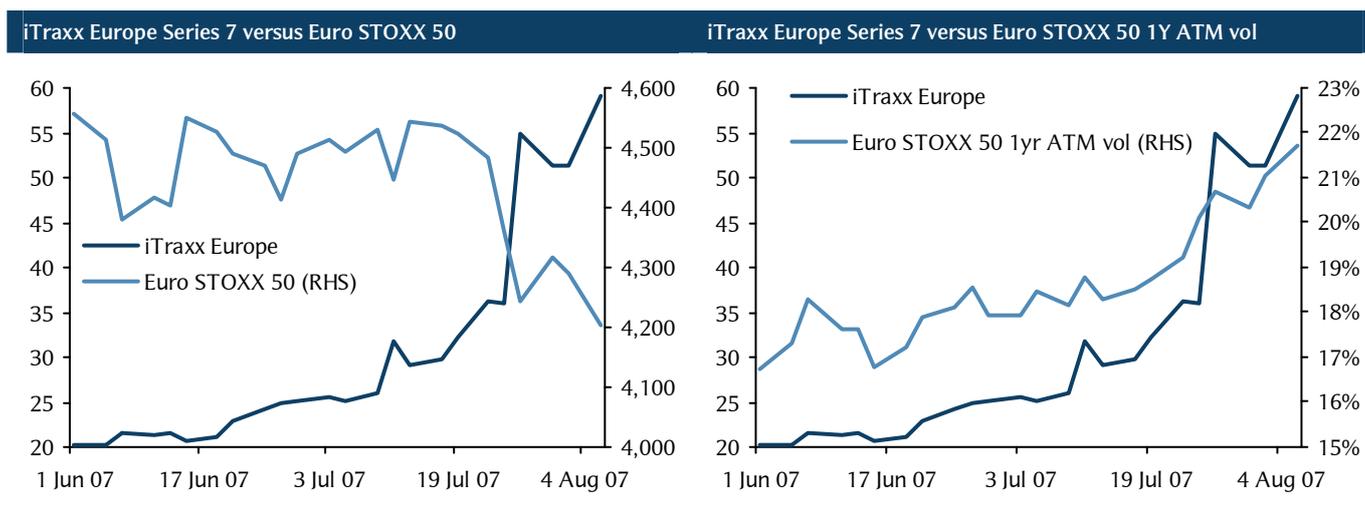
Source: Markit, Reuters, Barclays Capital

Figure 167: The disconnect today – An equity capitulation in the waiting?

iTraxx Europe Series 8 versus Euro STOXX 50

iTraxx Europe Series 8 versus Euro STOXX 50 1Y ATM vol
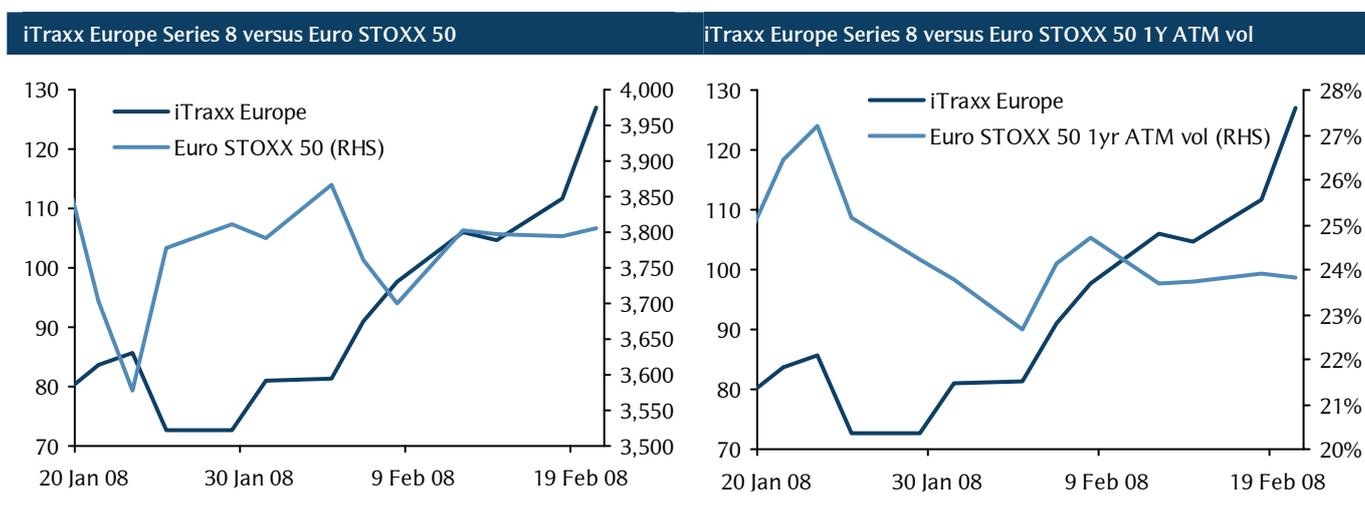
Source: Markit, Reuters, Barclays Capital

Buying equity volatility versus selling credit protection at the index level

We recommend purchasing Euro STOXX variance or ATM puts. The Euro STOXX 50 volatility term structure is elevated at the short end but is also slightly upward sloping beyond the 1yr maturity. Lower participation rates and the 5-2yr spread indicate value in longer-dated maturities (*Equity Index Volatility Report*, 18 February 2008) for variance and puts. Accordingly, we recommend using maturities beyond December 2009. We also note that skew is still very high and, thus, recommend ATM strikes for puts, which integrates a higher equity delta into the trade as well.

Variance trades can be set up by equating the total variance notional (variance level x variance units) with the present value of the spread payments on the iTraxx leg as described in our previous note (*Credit vs variance swaps: a tale of two indices*, 27 October 2005). Put strategies should be set up by equating the put premium with the present value of the spread payments. We believe that this construction produces the best hedge ratio in that it reduces the net market exposure of the long-short trade.

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Index curve trading

Credit curves have been a rich topic of analysis over the past three to four years as the credit market has developed. Barclays Capital Quantitative Credit Strategy has published extensively on both single-names and index curves throughout this period.

The CDS Curve Trading Handbook 2008 offers a thorough introduction to all manner of topics on curves, mostly associated with single-name curve trades. Here, we shift attention to strategies on index curves. Although curve liquidity has suffered during the credit crunch volatility, index curve trading has continued, in large part due to the extensive curve positions built up pre credit-crunch, and to correlation desk hedging.

In this section we give an overview of index curve dynamics and frameworks for assessing curve shapes. We then look at a couple of systematic strategies that attempt to profit based on fundamental and technical trading rules. We conclude the section with an analysis of more complex curve trades involving more than two legs.

The topics here link closely with the analysis of curve steepeners as alternative methods of being long credit risk presented in Systematic directional strategies *as well as the extensive section on* Trading CDS index forwards, *which are essentially curve trades in disguise.*

Trading index curves

Most of the iTraxx and CDX indices now have contracts trading at term structures other than just the 5yr point – typically the 3yr, 7yr and 10yr also trade. This facilitates straightforward curve trading, although liquidity and transaction costs vary substantially. Details of the available contracts are given in *Indices: The basics*.

In this section we focus on standard curve positions that are typically entered into on a DV01-neutral basis. This involves setting the notionals on the legs such that the total DV01 of the trade is equal to zero. As a result, small parallel shifts in the curve have no effect on the P&L on the trade, and the P&L is directly proportional to changes in the slope. We refer the reader again to *Indices: The basics* for discussions of the technical aspects and definition and calculation of DV01s.

Curve trades can also employ other weighting schemes. Equal-weighted trades are discussed in the next section *Trading CDS index forwards*. A thorough discussion of curve weightings is given in the *CDS Curve Trading Handbook 2008*.

Index curve dynamics

Curve dynamics can be surprisingly complex. However, index curves are somewhat simpler than single-name curves, as they are affected by market-wide forces and expectations rather than the specifics of companies. Curves have generally proved to be highly directional, with steepeners generally performing in benign credit conditions and flatteners performing in distressed credit conditions.

Figure 168 shows the time series of 5s10s slope on the iTraxx and CDX on-the-run investment grade indices. Here, we use our QCX data to back-fill the curves through to 2001. The general pattern is straightforward, with steeper curves during the benign market environment and rapid flattening – and very recently, inversion – during the more distressed market conditions.

Figure 168: Investment grade curves at unprecedented levels – 2001-08
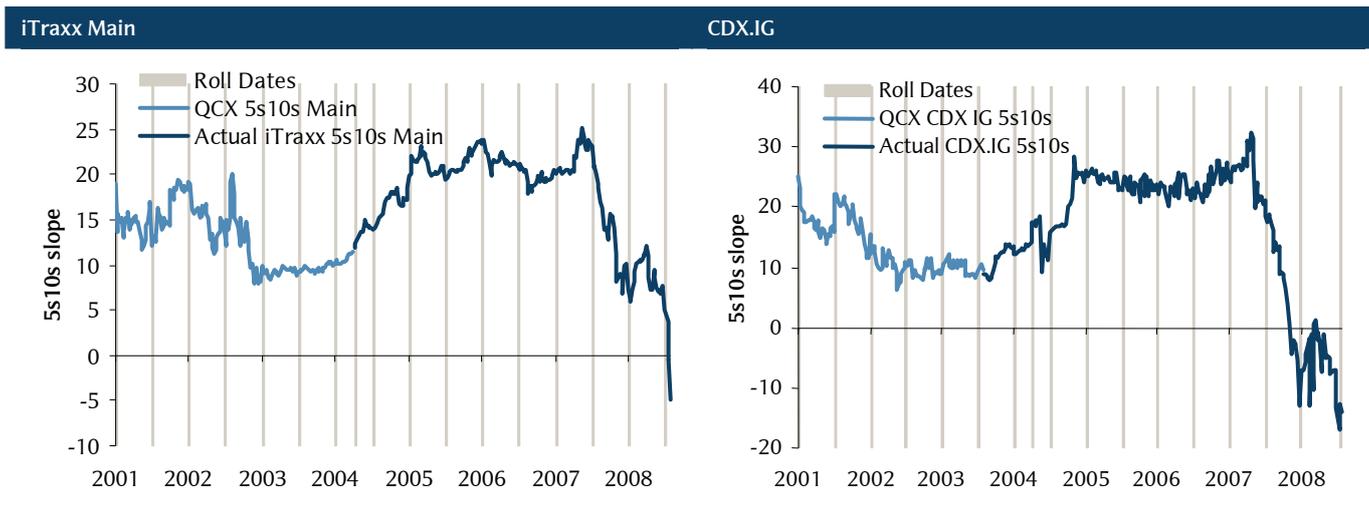
Source: Markit, Barclays Capital

Figure 169 shows the corresponding iTraxx Xover 5s10s charts. We show two versions of our QCX indices – in the left-hand panel the actual QCX series generated from single-name data available at the time, and in the right-hand chart a modified series that adjusts for the differing rating profiles between today's European high-yield CDS universe and the very thin universe in existence in 2001-02. We believe this second series is much more informative for today's market. See the *Appendices* for more details of the QCX and rating-adjustment methodology.

In both charts we find that the recent flattening is consistent with curve behaviour during the 2002 credit bear market. Again, we find a markedly more dramatic picture in the rescaled chart, indicating that current flat curves in Xover could progress to significantly inverted curves as spreads widen further and, critically, as default potential is priced in.

Figure 169: iTraxx Xover 5s10s slope – Extended using QCX
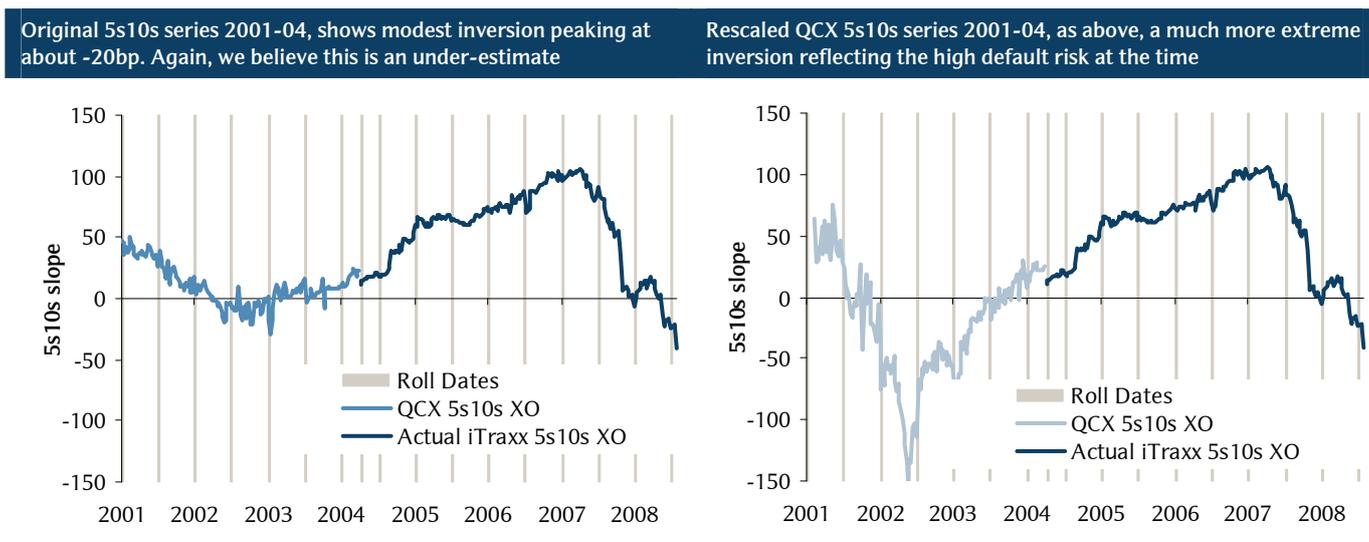
Source: Markit, Barclays Capital

The collapse in curves during the credit crunch

The rapid flattening and inversion of index curves during the credit crunch deserves some closer analysis. We consider some possible technical or supply/demand reasons for the collapse and also the theoretical reasons that justify this repricing in Figure 170.

Figure 170: Flattening curves in the credit crunch – What happened?

Theoretical factors	Technical factors
Repricing of default timing: Curves reflect the market's view of the likely timing of default. When a credit crunch hits, it makes sense that any rise in default rates will be priced closer in time, consistent with a flatter curve.	August-October 2007: Initial underperformance of steepeners (exacerbated by convexity in the widening) began the unwind of massive crowded steepener carry strategies.
Forwards: Credit forward spread levels can be calculated from the curve. When spreads widen and curves remain steep, forwards are priced much higher. This may not make sense when events affect only the short to medium-term horizon.	November 2007: Structured credit technical effects in IG led to dealers selling large amounts of IG curves, with sympathetic flattening in Xover.
	January 2008: Surge in buying of short-dated protection for loan book hedging – and hedge fund/prop desk anticipation of such buying – causes curves to collapse.
Convexity effects: steepener trades become unattractive to hold in periods of volatility owing to their negative convexity properties.	September 2008: Further jump-to-default hedging during the market panic, with more companies drawing on their bank lines and short dated protection hedges bought to cover those loans.

Source: Barclays Capital

Figure 171 shows a series of charts that graphically illustrate the collapse. Each chart shows a cross-section diagram of 5yr spreads versus 5s10s slope, with single-name CDS in the iTraxx Main and Xover indices shown as small squares, and the three indices marked as large diamonds.

The first chart shows the state of the market during the pre-credit crunch era in May 2007, when curves were at their steepest. The shape of the cross-section is sharply upward sloping, with wider spread names having steeper curves. The next two charts move through the credit crunch, first to November 2007 and then May 2008, showing a progressively flatter cross-section, with wider names becoming flatter and inverting. The final chart shows the extreme cross-section witnessed in early-October 2008, where a substantial number of inverted names drag the whole cross-section under.

Note that in all the charts the indices can lie well away from the cross-section fitted line based on the single-name data. This implies significant levels of curve skew at times, representing market forces on the indices versus the single-names. Skew is discussed in *Advanced topics.*

Figure 171: The progression through the credit crunch of euro CDS curves

29 June 2007 – Steep upward sloping cross-section, little dispersion

30 November 2007 – Cross-section flattening and widening

30 May 2008 – Flat cross-section. Increasing number of inverted names.

15 October 2008 – Substantially inverted cross-section
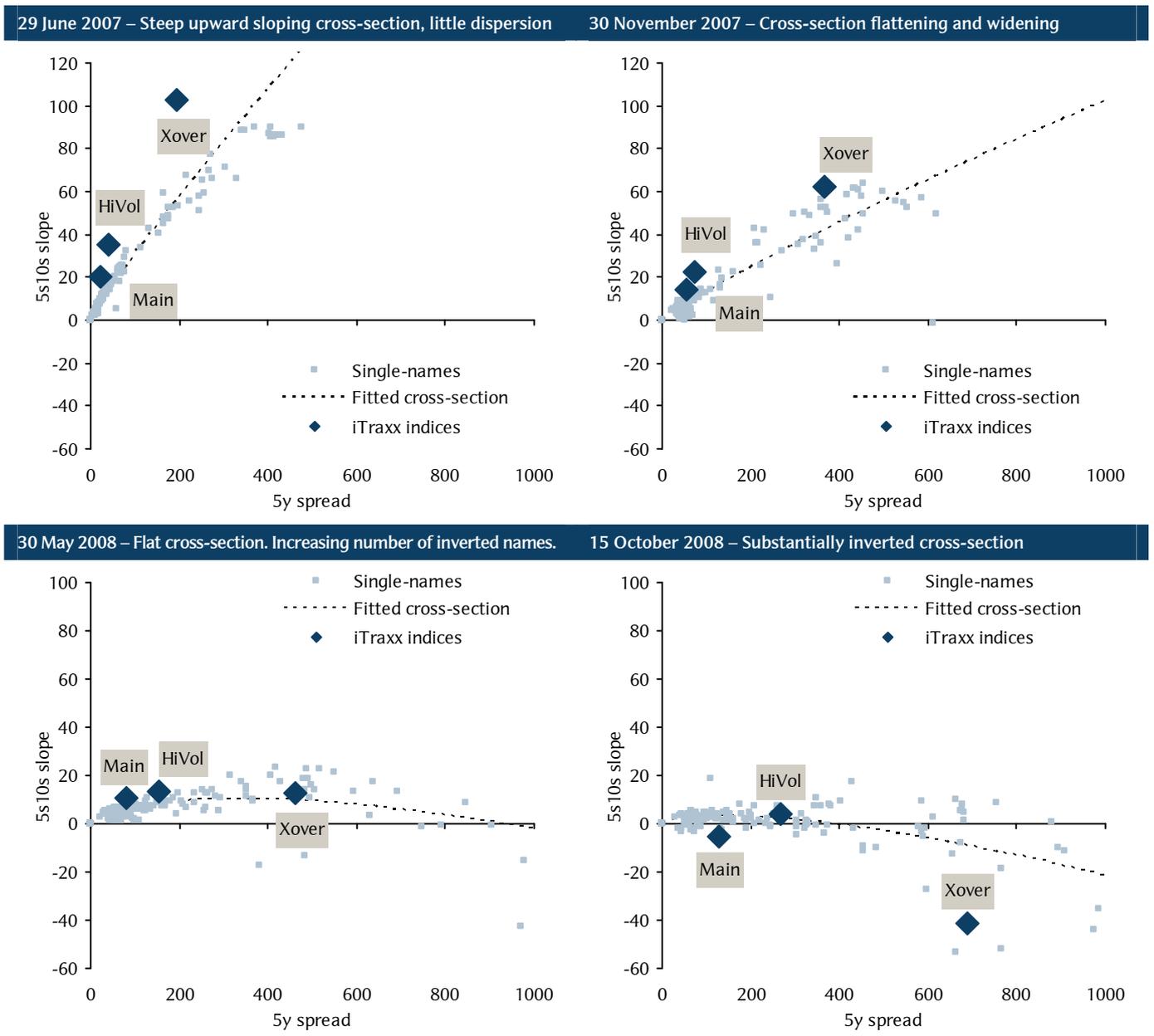
Source: Markit, Barclays Capital

Horizon of peak credit risk

Another interesting interpretation of the flattening in curves is in terms of the market's perception of the horizon from today at which default risk peaks. CDS spread curves contain information on the relative pricing of default risk through the whole term structure. It's interesting to calculate how many years out from today the marginal default risk is implied to be highest.

We can do this analytically by converting to forwards space. We leave a full discussion of forwards until the next chapter, but in basic terms, we can derive from the spot credit curve term structure the implied spread and different points in time. Here we will focus on the implied 1yr index spread at each forward starting date. The 1yr index does exist for iTraxx and is not liquid in CDX, so this may seem a somewhat hypothetical exercise. However, looking at 1yr forwards provides a more easily understood interpretation of curve shape and can motivate standard curve trades.

In order to calculate the forward term structure we first fit a spline to the liquid points on the spot curve. This allows a more sophisticated interpolation than standard linear methods. The 1yr forward spreads are then calculated using the methods described in the next chapter. Figure 172 shows both the fitted spot and forward term structures on 14 October. In order to calculate, for example, the 1yr iTraxx spread five years from now, we need spot spread data on the 1yr to 6yr points. Therefore, the maximum forward start date is nine years from now.

Figure 172: Forward and spot term structures, CDX IG and iTraxx Main, 14 October 2008

Spot term structure										
	1yr	2yr	3yr	4yr	5yr	6yr	7yr	8yr	9yr	10yr
CDX IG	181	184	184	183	182	180	178	176	173	169
iTraxx Main	97	119	120	121	122	123	124	124	123	122
1yr forward term structure										
	0 (Spot)	1yr from now	2yrs from now	3yrs from now	4yrs from now	5yrs from now	6yrs from now	7yrs from now	8yrs from now	9yrs from now
CDX IG	184	183	181	178	173	165	157	140	123	100
iTraxx Main	119	122	123	126	127	127	125	120	112	99

Note: Shaded spreads are market quotes. Source: Barclays Capital

Why look at the 1yr forward term structure?

In fact the 1yr forwards tell us much more about the relative risk priced at different horizons than the spot curve. This is in part due to the fact that the 1yr CDS spread is easier to interpret as a 1yr breakeven default rate. We are all used to thinking of the spot 1yr spread in this way – a spot 1yr of 1,000bp with 40% recovery means an implied default probability of 1,000bp/(100-40%) = 16.66%. Forward 1yr spreads can be mapped similarly. In this way, 1yr forwards can be thought of as marginal default probabilities, given no default until that time. This is equivalent to the hazard rate or default intensity process.

The forward term structure also frequently reveals a different shape than the spot term structure. In the example in Figure 172, CDX IG 3s5s is trading at -2bp whereas the difference between the 1yr CDS in three years and five years time is 13bp. It makes more sense, theoretically, to think of the risk in five years time being 13bp less than the risk in three years time – than it does to think of it as only 2bp less.

Taking this one step further we can extract the peak 1yr spread. In the case of CDX IG on 14 October 2008, this is the spot 1yr, ie, risk is currently maximum right now and expected to gradually decrease. For iTraxx Main, the peak risk is still priced out at four years from now.

Forward term structure time series

Figure 173 shows a 3D representation of the forward term structures over the past year on CDX IG. The chart clearly shows the rapid reassessment of default timing through the bear flattening.

Figure 173: CDX IG – implied 1yr spread forward curve across time
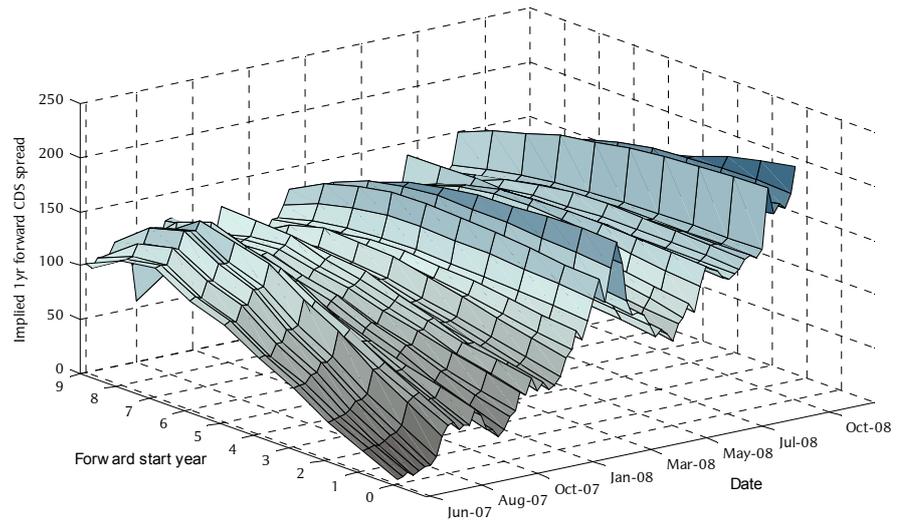
Source: Markit, Barclays Capital

Figure 174 shows the actual year of peak 1yr forward implied spread on CDX IG. After falling rapidly up to mid-March it then recovered during the summer before collapsing after the Lehman default. The right-hand panel shows the 5yr on-the-run spread for reference.

Figure 174: Monitoring the horizon at which peak spreads are implied on CDX IG
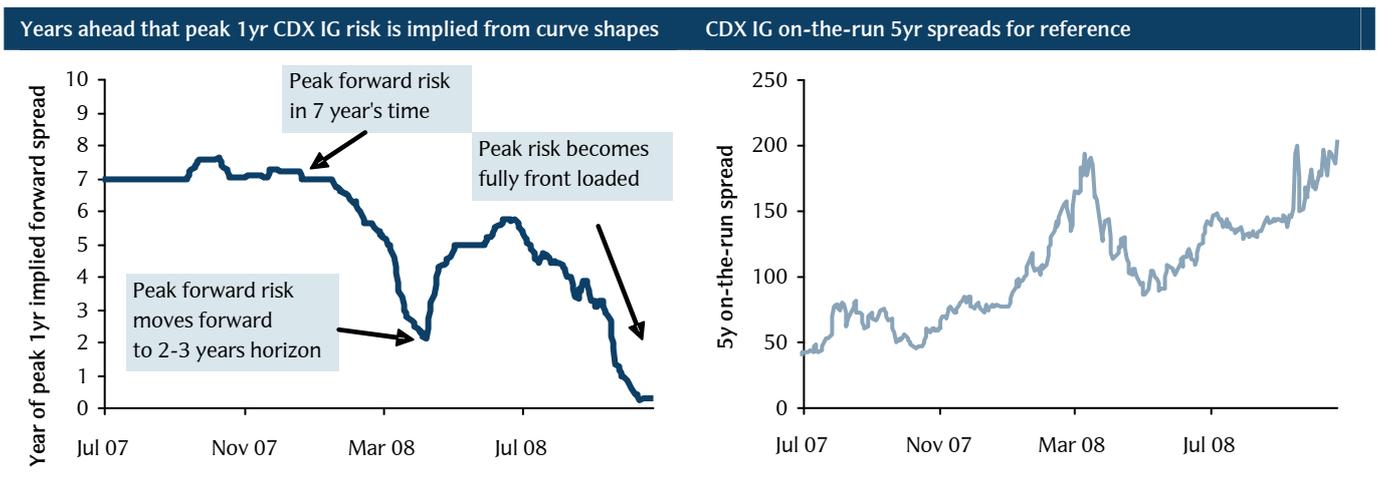
Source: Markit, Barclays Capital

Figure 175 and Figure 176 show the corresponding charts for iTraxx Main. One noticeable difference between the time series charts is how the peak risk horizon has only recently fallen similar to that of CDX IG. It was relatively stable during the first part of this year. This reflects the view that defaults would remain low in European investment grade, which changed rapidly in October 2008. We revisit these patterns in the discussion of front-end dynamics in the next section.

Figure 175: iTraxx Main – implied 1yr spread forward curve across time
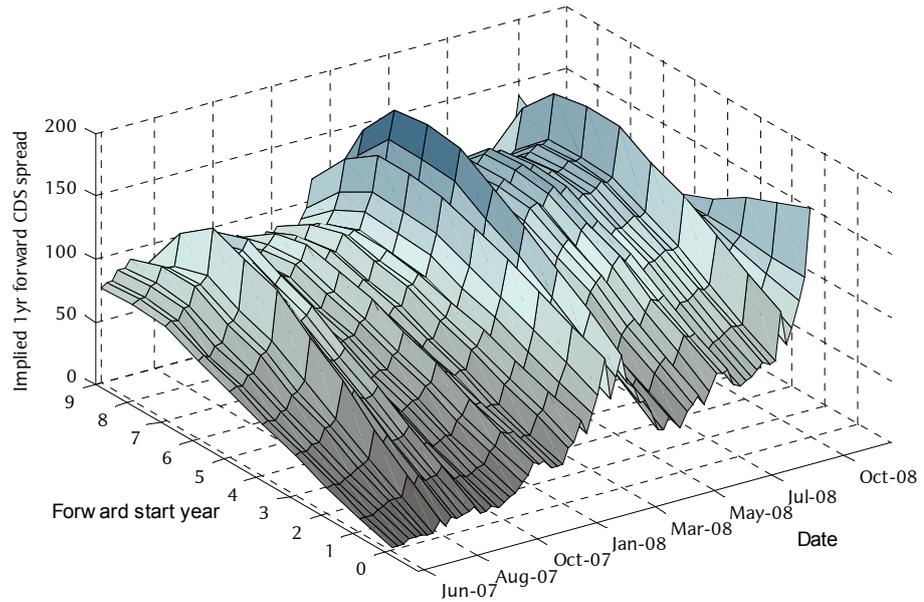
Source: Markit, Barclays Capital

Figure 176: Monitoring the horizon at which peak spreads are implied on iTraxx Main
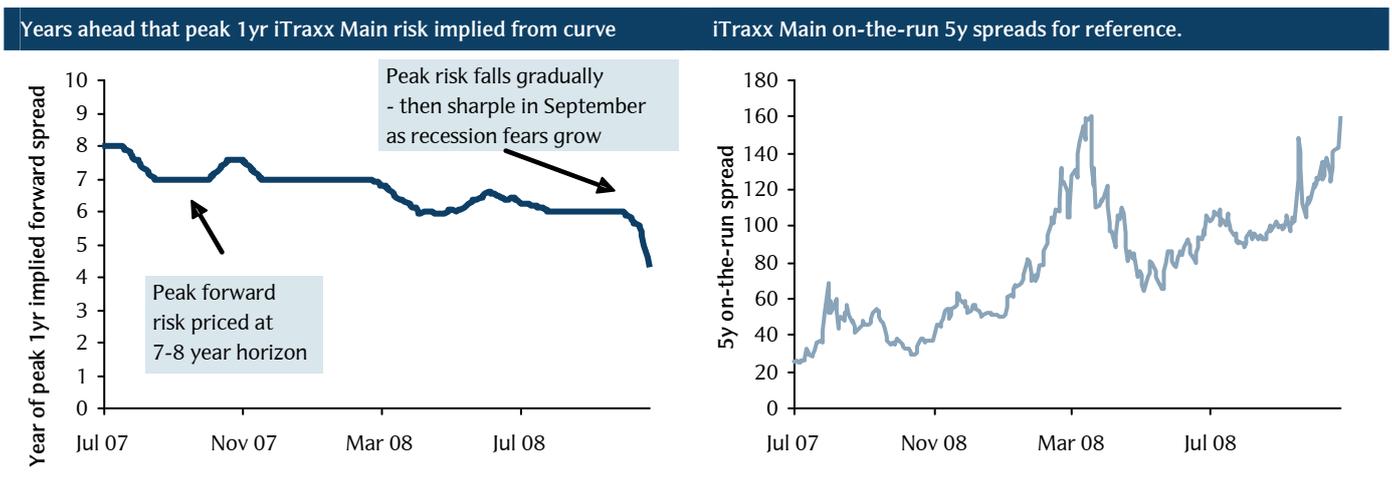
Source: Markit, Barclays Capital

Index curve directionality

Figure 177 shows two scatter charts, one for CDX IG and one for iTraxx Crossover. The charts look at concurrent monthly changes in 5yr spread on the horizontal axis, and monthly changes in 5s10s slope on the vertical axis. Each data point represents a month in the period 2001-08, and we separate out the data points from the benign market environment of 2003 to mid-2007.

In both cases there is a clear relationship for the distressed credit regime. As spreads widen, curves tend to flatten and vice versa. In the benign credit environments the effect is similar in the case of the Crossover curve. For the investment grade CDX, the directional dynamics are not as clear in this period.

Figure 177: Directionality of curves: 5s10s curve tends to steepen/flatten as spreads tighten/widen

CDX IG – Directionality in distressed regimes

iTraxx Xover – Directionality present across regimes
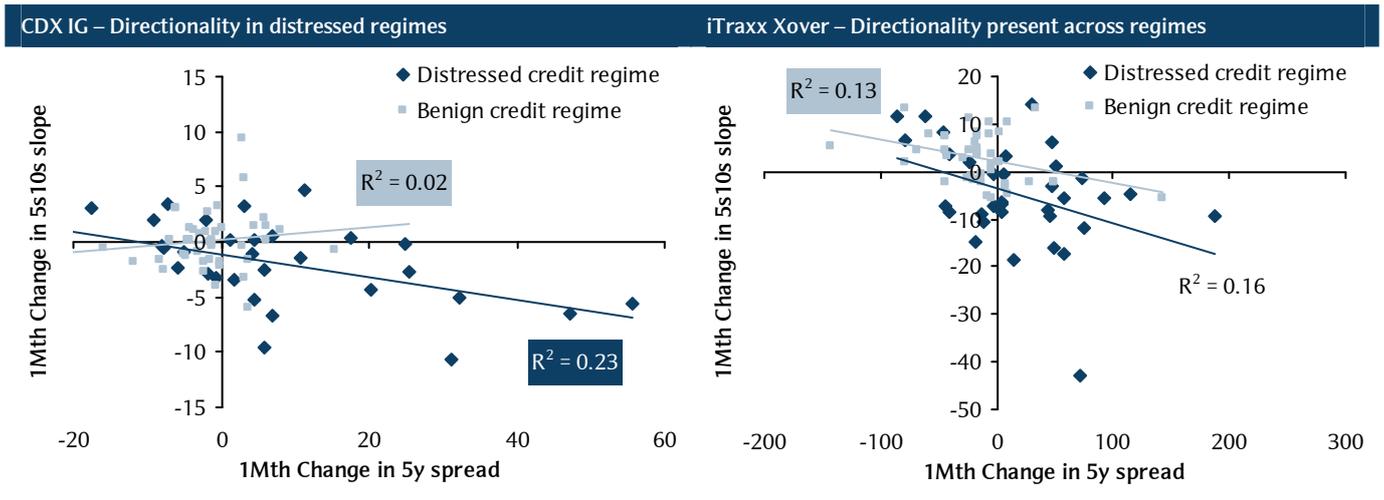
Source: Markit, Barclays Capital

Front-end versus back-end curve dynamics

Originally published as *Perceived jump risk increasing in European IG, 14 October 2008*.

The deluge of financial variables reaching unprecedented levels has extended to index curves. iTraxx Main 5s10s on Series 8, 9 and 10 have inverted for the first time. Unlike earlier episodes of high volatility, however, the front end of the curve is driving the overall shape, consistent with a more distressed market. This brings iTraxx Main trading patterns in line with those of CDX IG, as we see in Figure 178.

We believe this may signal a general shift in European curve dynamics, given heightened idiosyncratic risk and increasing jump-to-default hedging activity. However, Figure 179 highlights that the curve and the spread distribution of the constituents of the iTraxx remain considerably less distressed than in the CDX.

Figure 178: iTraxx Main curve dynamics are falling in line with CDX IG dynamics

CDX IG 9 – 1yr spread and 5s10s curve during 2008

iTraxx Main S8 – 1yr spread and 5s10s curve during 2008
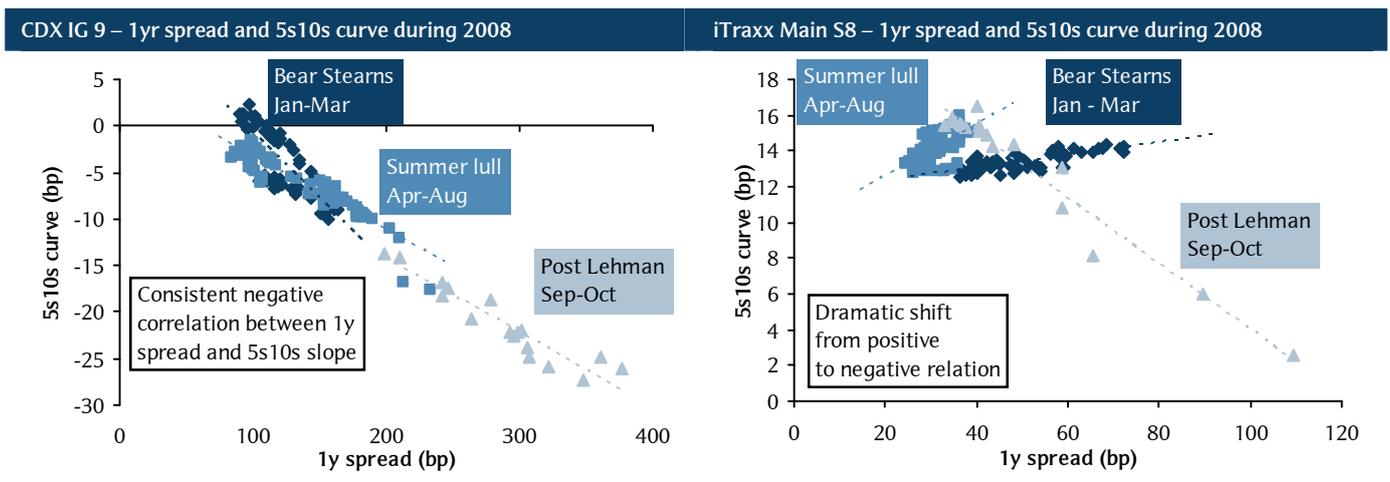
Note: We use iTraxx Main S8 and CDX IG9 to give us a longer time series.
Source: Markit, Barclays Capital

Figure 179: However, the CDX IG constituents remain more dispersed and the curve more distressed

| Current curve shapes – CDX vs iTraxx Europe | Spread distribution of constituents |
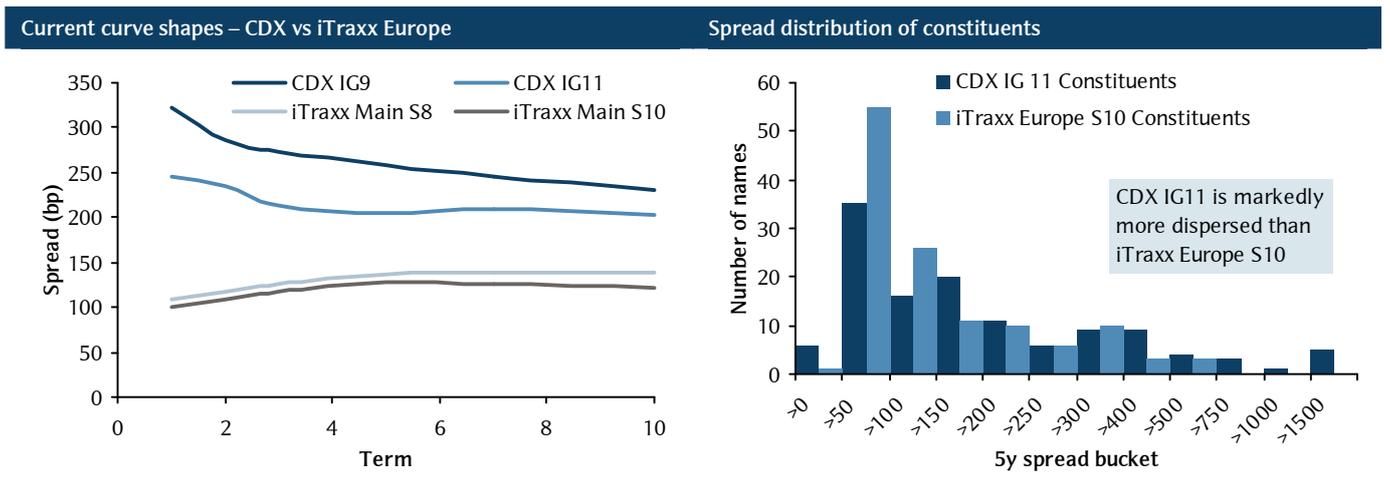
Source: Markit, Barclays Capital

Comparing CDX and iTraxx curve time series

We further illustrate the recent behaviour in the time series context in Figure 180 and Figure 181, comparing the patterns seen in front-end (1s5s) and back-end (5s10s) curves. These charts also highlight the dramatic inversion in the CDX curves, driven by the distressed constituents, and the relative stability of the iTraxx Main 5s10s.

Figure 180: Changing behaviour – iTraxx Europe S8 and S9 (intrinsic levels from single-names)
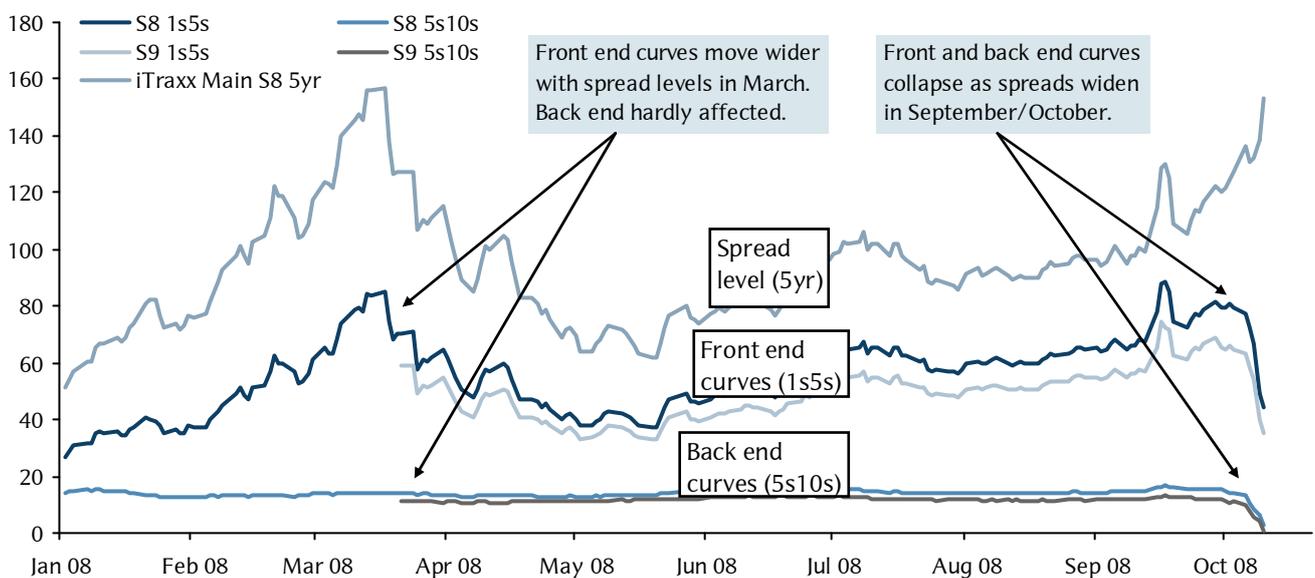
Source: Markit, Barclays Capital

Figure 181: CDX IG 9 and 10 curves (intrinsic levels from single names)
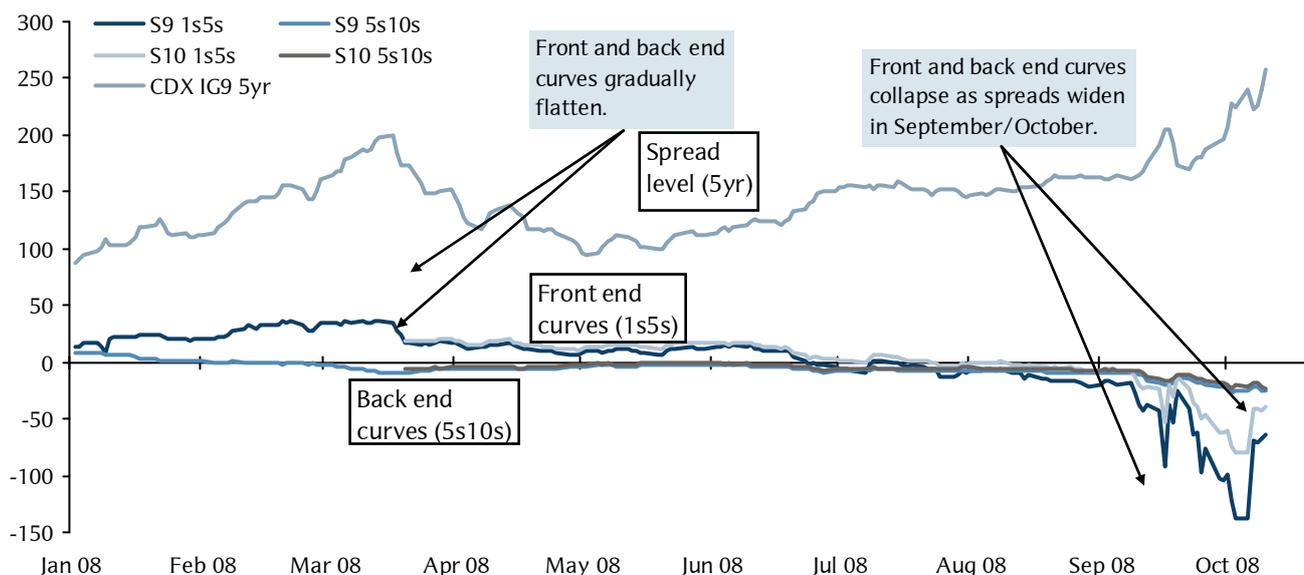
Source: Markit, Barclays Capital

Macro curve strategies

We look at two systematic curve strategies based on the iTraxx Xover on-the-run 5s10s curve. Both strategies switch between steepeners and flatteners using a set of rules. The first model, RPARS, is a pure time series approach that attempts to capture the persistence of returns generated by curves. The second model, BLSC, was developed in conjunction with the Barclays Capital Index Products team, and uses more fundamentally motivated variables to identify turning points in curve trends.

RPARS: A time-series/risk premium curve strategy

Our first example model, denoted the RPARS (Risk-premium Adjusted Regime Switching), uses the following observations to generate trading signals:

- The persistency of positive or negative P&L periods in holding an XO steepener is high, as hinted by visual inspection of Figure 182. This suggests that potentially, the strategy could be based on two states of the world: one where curves are steepening, and one where curves are flattening.

- The compensation for being in the steepener, and hence long credit risk, is highly time-varying. Specifically, around turning points of the cycle, this compensation tends to be very high (when curves are flat and may start to steepen) or very low (when curves are steep and may be about to flatten). This suggests that the risk compensation could be added as component in the model: if investors get little compensation for being in the steepener, then their propensity to switch into a flattener should be greater.

Figure 182: iTraxx XO steepener cumulative return and risk premium
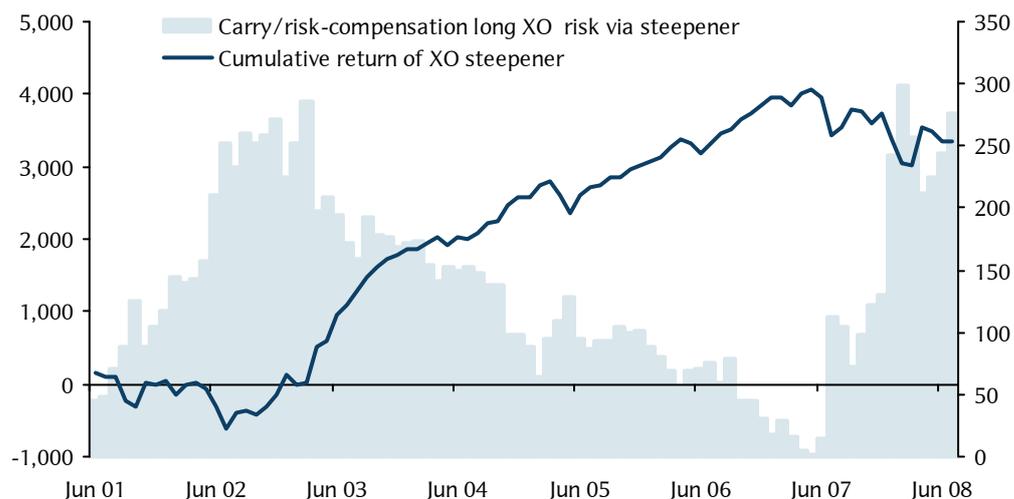
Source: Barclays Capital

Modelling the persistency in the XO steepener return

First, to specify the state-dependency, and the fact that states appear to be persistent, we use a Markov regime switching model. In this model, we assume that all data observations are drawn for either of two distributions: in our case, one distribution where returns on the steepener are flat or negative and, second, another distribution where returns are positive. In equation form:

$$y_t = \mu_1 \cdot \text{Prob}(S_t = 1) + \mu_2 \cdot \text{Prob}(S_t = 2) + \varepsilon_{t,Q_t} \qquad (1)$$

where the coefficients μ_1, μ_2 are the average returns on the XO steepener in each of the respective regimes. The regime (or state) variable S_t is governed by a Markov process: we note that the transition between one state to another is governed by a transition matrix $\mathbf{P}$, such that

$$\mathbf{P} = \begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix}$$

where each of the individual elements p_{ij} denotes the probability to transition from state *i* to *j*.

We also allow for two different volatility regimes via the state variable U_t (with associated transition matrix Q, showing up through residual ε_{t,U_t}. Simply put, we can describe the distribution of returns as

$$y_t \sim N\left(\mu_{S_t}, \sigma_{U_t}^2\right)$$

In the academic literature, we would refer to this type of model as an extended Markov switching model. Please refer to Hamilton (1994) for more information on estimation and inference in the model.

Given these two sets of probabilities, one for being in a flattening regime, and one for being in a high-volatility regime, for the purposes of credit trading, the flattener position will be most compelling if we are in the flattening, high volatility regime, as

unless the flattening is large enough, the carry will overtake the flattening of the curve as the main driver of the curve P&L. Hence, we will look for the probability of being in either the steepening regime, with high or low volatility, or the flattening regime but with low volatility as the aggregated probability that

$$Steepener_t = \text{Prob}(S_t = 1) + \text{Prob}(S_t = 2) \cdot \text{Prob}(U_t = 1)$$

We estimate the model via quasi-maximum likelihood, with results available in Figure 183. The model fits well to the data and efficiently demarcates the high return, low volatility regimes as highlighted in Figure 184. We use this together with the transition matrices in Figure 183 to infer the probability that we will be in either a steepening or a low volatility state in the next. The resulting probability series is then the ingoing variable into the allocation rule described below.

Figure 183: Parameter estimates of the Markov switching model

Parameter	Estimate	p-value	Parameter	Estimate	p-value
Low steepener return regime			**High steepener return regime**		
μ_{NEG}	-27.6	0.08	μ_{POS}	20.4	0.00
$p_{NEG,NEG}$	0.954	0.06	$p_{POS,POS}$	0.977	0.03
Low volatility regime			**High volatility regime**		
σ_{LOW}	17.8	0.00	σ_{HIGH}	62.9	0.00
$Q_{LOW,LOW}$	0.873	0.01	$Q_{HIGH,HIGH}$	0.92	0.00

Source: Barclays Capital

Figure 184: Low returns regimes in the Crossover steepener
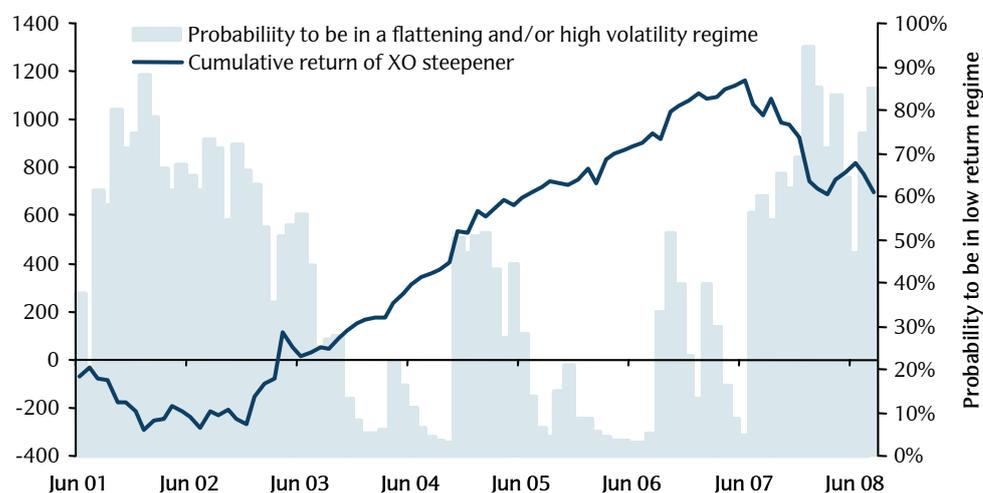
Source: Barclays Capital

The risk compensation angle

The second stage of this system takes into account the risk compensation that we receive from being long the steepener. For each point in the sample data, we calculate the carry from a DV01 neutral steepener in order to quantify this risk compensation. Then we normalise this risk compensation on a [0,1] scaling via a logistic function such that:

$$RiskComp_t = \frac{\exp(\beta \cdot Carry_t)}{1 + \exp(\beta \cdot Carry_t)}$$

We estimate β by linking the above equation to the one-step ahead Crossover steepener return, through a binary framework where the dependent variable takes on the value of one if the next month's steepener return is positive and zero otherwise. By doing so, we generate probabilities that next month's Crossover steepener return will be positive based on the current risk compensation. We estimate the β over the sample running up to 2005 so as not force the model to overfit on the 2007-08 flattening. The resulting probability series is essentially a slightly more accentuated and inverted version of the carry profile shown in Figure 182.

Joining the model together

Finally, with these two sets of 'probabilities' (the regime-switching probability is straightforward, the bounded [0,1] risk-compensation is admittedly more tenuous), we simply take a straight average and make our investment decision on the basis of whether the resulting sum is above or below 0.5. This is illustrated in Figure 185.

Figure 185: Switching between the steepener and flattener according to the time-series/risk compensation RPARS model.
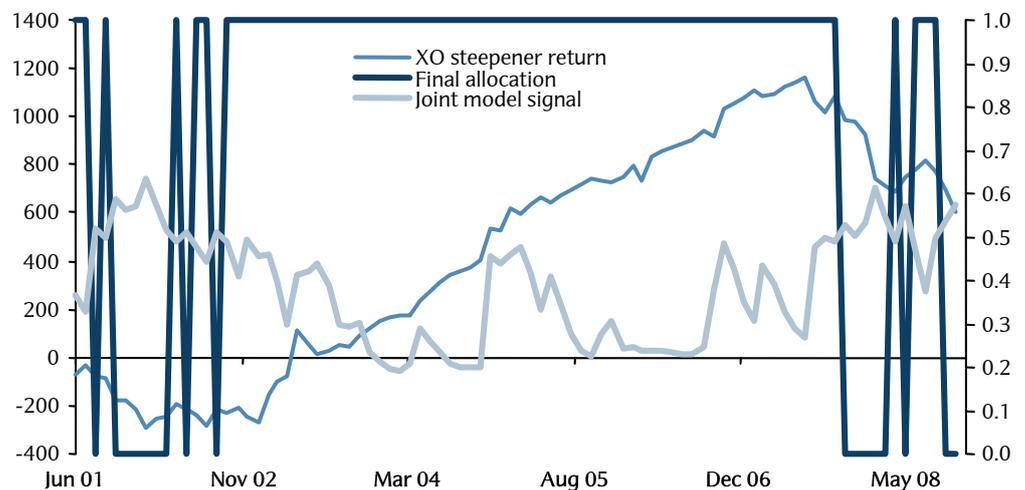
Source: Barclays Capital

We can see how this strategy legs into the steepener fairly early on in 2002, as the risk compensation makes this very attractive, and we are starting to see the first increase in probability that we are in the steepening state, Through the persistence in the time-series model, we are then able to stay consistently in the steepener until 2007, when the risk compensation becomes very low and, again, we start to see increased probabilities that we are in a flattening state. In this turn of the cycle, however, the model goes back to the steepener fairly early, as the compensation again becomes the overwhelming element.

We benchmark the straight steepener strategy versus RPARS in Figure 186. As we have seen, the outright Crossover steepener has been a profitable strategy throughout this cycle, with an average monthly return of 6.9bp per month and a Sharpe ratio of 0.43 (pre-transaction costs). In contrast, RPARS achieves an average monthly return of 17.1bp with a Sharpe ratio of 1.13. Pre-transaction costs, the cumulative P&L of each strategy is 6.0% for the pure steepener and 15.3% for the RPARS.

Figure 186: RPARS versus a straight rolling steepener strategy

Legend:
- Cumulative P&L differential between steepener and RPARS
- XO steepener cumulative P&L (bp)
- RPARS cumulative P&L (bp)

Avg return: 17.1bp per month
Sharpe ratio: 1.13

Avg return: 6.9bp
Sharpe ratio: 0.43
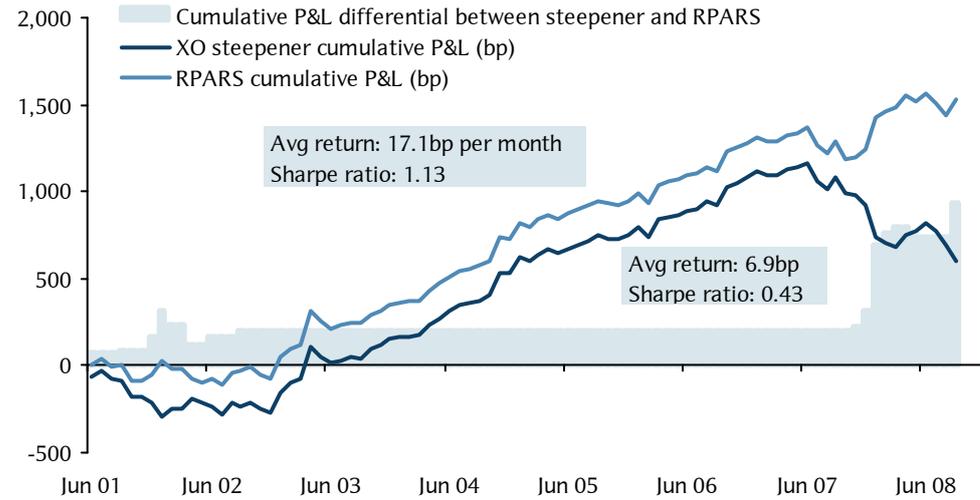
Source: Barclays Capital

Barclays Capital Long-Short Credit Steepener Strategy (BLSC)

Jose Mazoy, Yuan Tian, Graham Rennison, Ulf Erlandsson, Arup Ghosh

The Barclays Capital Long-Short Credit Steepener index (BLSC) reflects the performance of the Long-Short Credit Steepener strategy. Using economic fundamentals, the strategy aims to capture value by dynamically switching from a steepener to a flattener using the on-the-run iTraxx Crossover 5yr and 10yr as underlying. A long-only DV01-weighted 5s10s steepener strategy consists of selling protection on the 5yr and buying protection on the 10yr. The notional of each leg is chosen to achieve DV01 neutrality on the roll day. Empirically, we observe that a negative relationship exists between the 5s10s iTraxx Crossover slope and the slope of the EUR 2s10s swap curve and a negative relationship between the 5s10s iTraxx Crossover slope and stock market volatility. Based on this empirical observation, we construct a framework for switching from a steepener to a flattener using as a signal the EUR swap curve and a measure of volatility on the stock market.

The indices are used in connection with Barclays Capital products.

BLSC index rationale

The BLSC index reflects the performance of the Long-Short Credit Steepener strategy. Using economic fundamentals, the strategy aims to capture value by dynamically switching from a steepener to a flattener using as underlying the on-the-run iTraxx Crossover 5yr and 10yr. Using theoretical and econometric arguments, we establish a relationship between the iTraxx Crossover 5s10s curve and the following fundamental variables:

- Equity volatility: credit curves flatten as equity volatility rises; and

- Interest rates: credit curves flatten as rates fall, or yield curve steepens.

From a theoretical angle[11], structural credit risk models treat default as an event triggered by economic fundamentals. For instance, in Merton's model, default occurs when firm value falls below a certain threshold commonly modelled as an increasing function of firm leverage. Hitting such a default barrier becomes more likely if the firm exhibits large fluctuations in its assets. Since a positive relationship exists between the volatility of firm value and equity volatility, we expect a positive relationship between the CDS spread and equity volatility. In terms of credit curves, therefore, increasing equity volatility should imply increasing shorter-term default risk, leading to a curve flattening.

Interest rates also have an economic link to spreads and curves. We discuss these in our empirical studies *Yield curve regime behaviour in US Credit*, 27 January 2006, and *Euro credit and yield curve regimes*, *European Alpha Anticipator*, 16 February 2006. Using the structural firm model theory again, an increase in the short interest rate should decrease the default probability, all else being equal. This is because pricing occurs in the risk-neutral world and the short rate influences the risk-neutral drift in the firm's value process. Therefore, we should expect a negative relationship between CDS spreads and short-term rates, or the slope of the yield curve. Empirically, falling short-term rates also

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[11] Please refer to 'Regimes in CDS Spreads: A Markov switching model of iTraxx Europe Indices', Carol Alexander and Andreas Kaeck, ICMA Centre Discussion Papers in Finance.

tend to coincide with a turn in the business cycle towards a more recessionary environment, which naturally leads to higher default rates.

When the swap curve steepens, perceived default risk should rise. There are two reasons for this. First, the curve can steepen due to short rates falling; this returns us to the argument in the above paragraph. Second, a steeper curve reflects high rate expectations and/or a higher risk premium. An increase in market uncertainty will feed into the curve through a higher risk premium and a steeper slope. Thus, higher volatility will lead to a steeper yield curve and a flatter credit curve.

Below, we analyse graphically the relationships of these variables with iTraxx Crossover 5yr level and 5s10s curve. The next section explores these relationships more formally, using econometric methods.

Figure 187 shows a plot of the VSTOXX level against the Crossover 5s10s curve. In this and the following charts, as well as in the econometric analysis of the next section, we use our QCX extended time series versions of the iTraxx Crossover index to include the 2001-03 period during which single-name CDS traded but the indices did not yet exist[12]. Visually, we find a reasonably consistent relationship: when volatility is high, the curve tends to be flatter and vice versa. The period around 9/11 appears to be an exception, with high volatility and a less pronounced move in the curve. In fact, the chart obscures slightly the scale of the flattening: about 25bp over the remainder of September 2001.

Figure 187: Slope of the Crossover curve shows a negative relation with equity volatility, as measured by VSTOXX
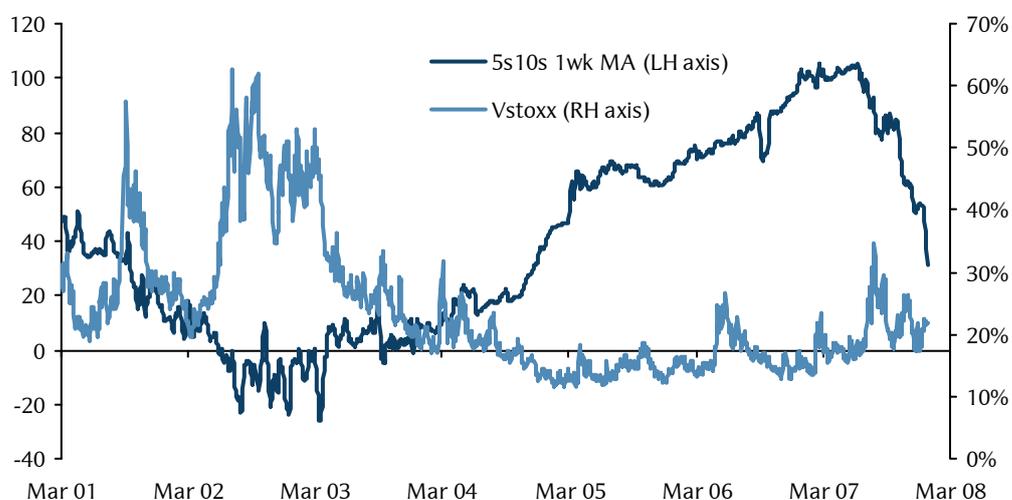
Source: Markit, Barclays Capital

Figure 188 shows the Crossover 5s10s curve versus the 2s10s slope of the European swap curve. We find an overall convincing negative relationship through this sample period. Several short periods of positive correlation do exist, though – notably in the final few months of 2001 and during the first few months of 2003. One reason we use both the euro swap curve and the VSTOXX as indicators in our strategy is that it helps to deal with temporary breakdowns in relationships such as this. We discuss the statistical properties of the observed co-movement in the Econometric Analysis section below.

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[12] *See* CDS Curve Trading Handbook 2008, *6 November 2007, page 145 for details of Barclays Capital's QCX indices.*

Figure 188: Slope of the Crossover curve shows a negative relationship with the Euro swaps 2s10s slope
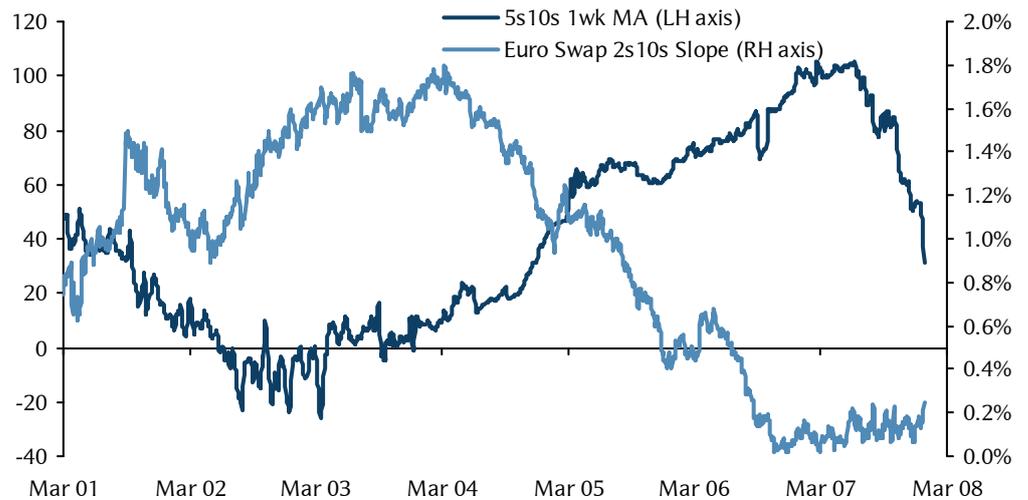
Source: Markit, Barclays Capital

Econometric analysis

As described above, there is a meaningful economic relationship between the slope of the CDS curve and variables such as the slope of the yield curve and the volatility of the stock market. Using a statistical model, we now attempt to quantify these relationships by describing the dynamic relationships that exist among them.

To summarise the econometric results:

- There is a statistically compelling equilibrium relationship among the CDS curve, the 2s10s slope of the EUR swap curve and the level of equity volatility.

- As such, we can expect the dynamics of the swap curve and the VSTOXX to be informative in terms of the future direction of the slope of the CDS curve.

- The CDS curve adjusts to this equilibrium level, at a fairly modest pace.

The VECM formulation that we adopt takes the following form:

$$\Delta y_{i,t} = \alpha_i + \gamma_i \underbrace{\left(y_{1,t-1} - \beta_1 y_{2,t-1} - \beta_2 y_{3,t-1} \right)}_{\text{(i) Long run (dis)-equilibrium}} + \underbrace{\sum_j \zeta_{i,j} \Delta y_{i,t-1}}_{\text{(ii) Short-term adjustment}} + \varepsilon_{i,t} \qquad \text{for i=1 to 3} \qquad (1)$$

With the vector y being,

$$y_t = \begin{bmatrix} SlopeCDS_t & SlopeRates_t & VStoxx_t \end{bmatrix}'$$

The formulation links the change in each of the variables today t to: 1) an adjustment to the equilibrium component; and 2) adjustments to short-term dynamics in previous periods. Our key focus here is what is denoted as the equilibrium relationship. The most intuitively appealing description of this technical term is probably via the actual estimation results (again, for detail on how we arrive at these results, please see the technical appendix).

$$\text{Equilibrium relationship} = SlopeCDS + 0.43 \times SlopeRates + 2.17 \times VStoxx - 134.10 \qquad (2)$$

So what does this set of numbers tell us? An alternative representation shows us that this relationship tends towards zero over time, which, in turn, means that if one variable grows, the others will have to adjust in order to revert to equilibrium:

$$SlopeCDS + 0.43 \times SlopeRates + 2.17 \times VStoxx - 134.10 \quad \text{-> 0} \qquad (3)$$

The strategy

Based on the relationships described above, we construct a framework for dynamically switching between a steepener and a flattener on the 5s10s iTraxx Crossover. A steepener position usually benefits from positive carry. In that sense, we design a strategy that favours a steepener unless there is a strong flattening indication. The trading strategy is a combination of a long-term and a short-term component. The long-term component is based on the slope of the yield curve, and the short-term component is based on the equity market volatility.

The trading decision will be made on the 20th (or the following business day if that is not a business day) of each month. At that time, the long-term and short-term signals will be computed and, according to indications, a steepener or a flattener position will be entered. We chose the 20th as the trading day because 20 March and 20 September are series roll dates; thus transaction costs in executing the strategy can be avoided.

As we demonstrated above, the VSTOXX index also exhibits a negative correlation with the 5s10s iTraxx Crossover. In addition, this variable exhibits a trending behaviour over stable time periods, but mainly, it responds quickly to market conditions and exhibits jumps. As with the EUR slope, we also apply a counting rule on the VSTOXX changes, but this time, our aim is different. Here, we want to identify a drastic jump on the volatility series; the counting rule measures the proportion of positive occurrences over the past 20 business days. If this proportion is larger than 60%, a flattening position will be entered. A higher threshold and a shorter look-back period were chosen for this variable because the aim is to identify drastic jumps in the series.

BLSC – September 2008 update

Originally published as *Surviving the slopes of the credit crunch: Barclays Long Short Credit steepener strategy (BLSC),* 25 September 2008.

The Barclays Capital Long-Short Credit steepener (BLSC) strategy switches between steepeners and flatteners on the iTraxx Crossover 5s10s curve according to economically motivated rules. The strategy is designed to benefit from the long credit exposure of DV01-neutral steepeners during stable credit market conditions, while protecting investors in volatile, high default-risk periods by switching to flattener positions.

Despite unprecedented volatility in CDS index curves, and sometimes overwhelming technical forces, the performance of BLSC has been stable thus far in 2008, generating an annualised excess return of 0.18% versus a rolling steepener strategy excess return of -3.78%. In this short report, we review the strategy and its performance so far.

The BLSC strategy was introduced in *A new direction in credit indices*, dated January 2008 and the investable BLSC index, which reflects the performance of the funded version of the strategy, forms one of the Barclays Capital credit index family.

Dynamic curve positioning

In Figure 189, we contrast the performance of BLSC with that of a steepener, which rolls once a month since the inception of the iTraxx indices in June 2004. High-yielding index steepener positions were popular during the pre-credit crunch era, generating consistent returns. However, the onset of volatility rapidly reversed the steepening trend, as default risk started being re-priced into the front end of the term structure.

Figure 189: Cumulative excess returns of BLSC since June 2004

BLSC captures much of the upside of a pure steepener during benign credit conditions...

… while limiting downside in distressed credit conditions
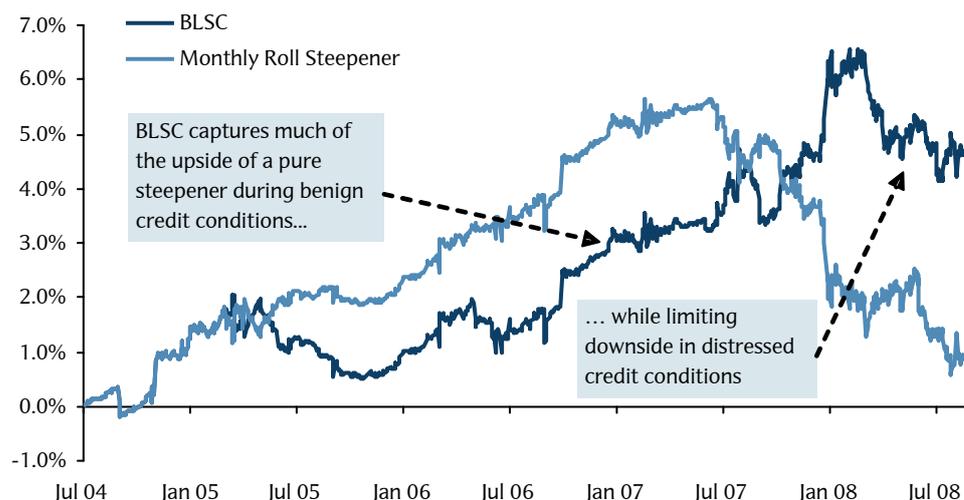
Note: Returns prior to 21 January 2008 are produced from back-testing. Source: Markit, Barclays Capital

The BLSC strategy was designed not only to capture some of the attractive risk-adjusted returns of steepener positions during benign credit markets, but to be able to switch rapidly to a flattener if economic conditions worsen. Index curve behaviour tends to be closely related to the macro credit conditions. Figure 190 summarises the properties of DV01-neutral steepeners on CDS indices.

Figure 190: Properties of DV01-neutral index steepeners

Benign credit market conditions	Distressed credit market conditions
Curves tend to steepen reflecting default risk being priced into the latter part of the term structure	Curves tend to flatten reflecting default risk being priced into the front end of the term structure
Positive carry and roll-down	Jump-to-default exposure to names in index
Volatility of the curve is generally much lower than that of 5yr spreads.	Negative convexity – affects performance when spreads are volatile

Source: Barclays Capital

Overview of the BLSC strategy

Using theoretical and econometric arguments, a relationship can be established between the iTraxx Xover 5s10s curve and the following fundamental variables:

- Equity volatility: credit curves flatten as equity volatility rises.

- Interest rates: credit curves flatten as rates fall or yield curve steepens.

Rules based on these relationships are applied on the 20th of each month and a steepener or flattener signal derived. Figure 191 shows the BLSC signals overlaid on the 5s10s Xover slope. The signal is binary, either a steepener or flattener at each signal. While there are sporadic switches into flattener mode up until July 2007, there is a clear shift to a predominantly flattener bias during the credit crunch. Full details of the BLSC strategy can be found in *A new direction in credit indices*, January 2008.

Figure 191: iTraxx Crossover on-the-run 5s10s curve and BLSC signal
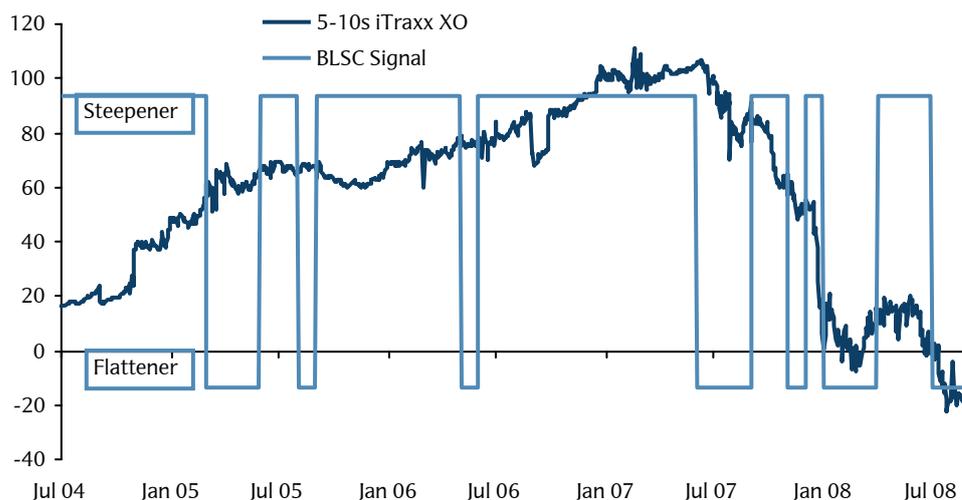
Source: Markit, Barclays Capital

The BLSC total return index

The BLSC index is a total return (funded) index that reflects the performance of the BLSC strategy. The index time series is shown in Figure 192.

Figure 192: The BLSC index which tracks the BLSC strategy (funded format)

Annualised total return: 4.24%
Annualised excess return: 1.11%
Annualised Sharpe ratio: 0.61
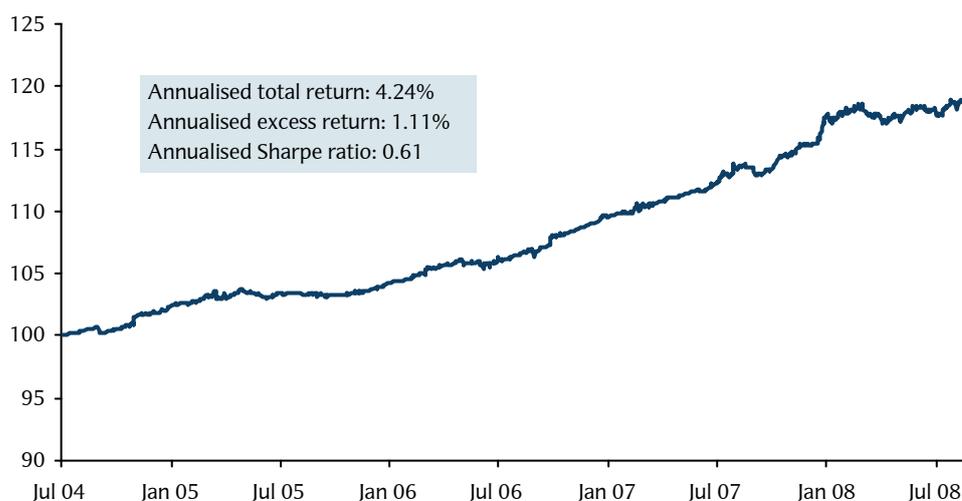
Source: Barclays Capital

Butterfly trades

Our final section on curve trades introduces a simple framework for analysing more complex positions on the indices which combine two different curves trades.

iTraxx Main 3s5s7s butterfly

Originally published as *iTraxx Main 3s5s7s butterfly: Exploiting the 5yr kink*, 4 September 2008.

The 3s5s slope on iTraxx Main on-the-run has gradually increased, and the 5s7s has decreased as spreads have widened over the past year. This has created a kink at the 5yr point, which is more dramatic than we have previously seen (see Figure 193 and Figure

194). Although this may persist in the near term, we expect this to normalise in the scenario of a substantially weaker economy with wider spreads and increasing default risks, as well as in most rally scenarios.

Trade format: Buy €70mn 3yr protection, sell €100mn 5yr protection and buy €44mn 7yr protection.

Current levels: Calculations based on mids with 5yr at 100bp, 3s5s at 20bp and 5s7s at 4bp, giving a 5yr kink of 16bp.

Trade metrics: Net zero DV01, effective annual carry: -€17,600. One default at 40% recovery: +€67,200. Equal weight between 3s5s flattener and 5s7s steepener.

Target P&L: At the 3mth horizon, approximately €100,000 on normalisation of the kink to historical levels of around 5bp, €275,000 in a distressed market or €50,000 in a rally.

Convex payoff: We consider numerous scenarios below, finding that the trade could perform well in market distress or a rally, giving a convex payoff. Analytic positive convexity is approximately €1,000 per basis point.

Time decay: Due to complex roll-down, DV01 decay and convexity dynamics, the potential P&L can change dramatically depending on the trade horizon. We analyse each scenario at monthly horizons out to 12 months and also consider even longer holding periods.

Timing: A gradual normalisation could begin any time and weak economic or company-specific news should start to flatten the front end in particular. Executing on S9 may benefit from roll-down pricing over the upcoming index roll.

Trade risks: Further increase in the kink of the curve. We expect any such increase to be temporary. Transaction costs are approx €25,000 per basis point of total bid-offer spread across the three legs.

Figure 193: A substantial kink has developed at the 5yr point in the iTraxx Europe S9
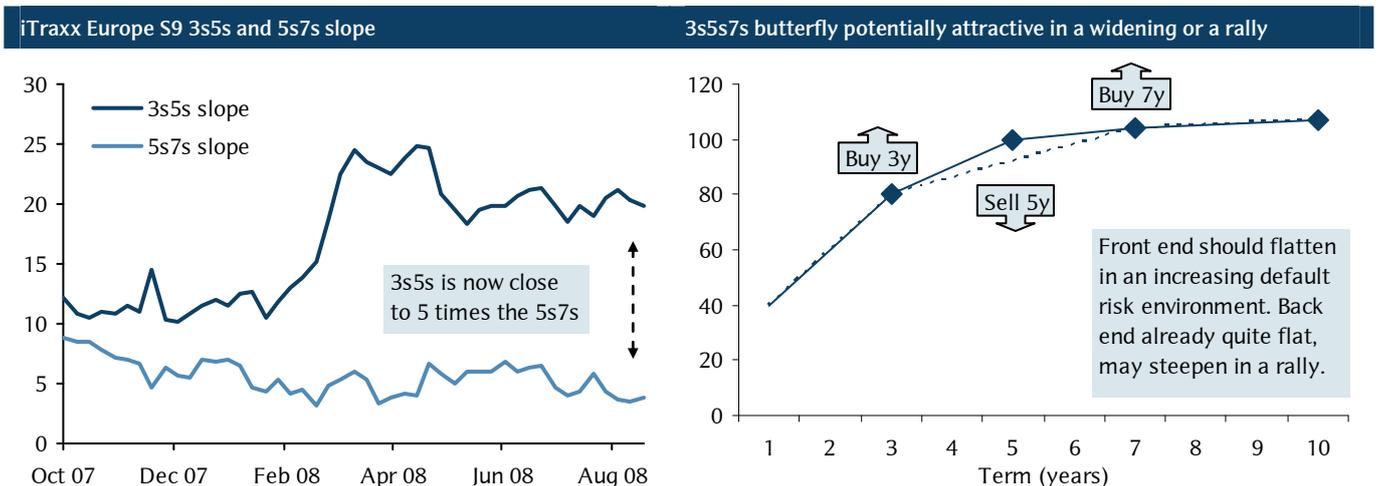
Source: Markit, Barclays Capital

The kink in the curve

Trading of 'kinks' in the interest-rate swap curves has long been a popular strategy, with substantial research backing and even a dedicated Bloomberg butterfly trade calculator. With the liquidity available in the 3yr, 5yr, 7yr and 10yr points on iTraxx Main, similar strategies are now possible in credit markets.

A kink can potentially be explained on fundamental grounds. Where there is a perceived local peak in risk in the term structure, it may be reasonable for forward spread levels to peak accordingly. This may be observed on single-names around significant redemption dates, for instance. On the index level, we believe the kink is more technical, perhaps developing due to the superior liquidity of the 5yr point. In this case we would expect the kink to normalise over time, especially in the event of the front end of the curve becoming more active in a higher perceived default risk regime.

A simple definition of the kink in the curve is simply the difference between the slope on the 3s5s and the slope on the 5s7s. The larger this number, the further the 3s5s7s portion of the curve is from being linear.

$$5\text{yr kink (bp)} \quad = \quad 3\text{s5s slope} - 5\text{s7s slope}$$

$$= \quad 2 \times 5\text{yr spread} - 3\text{yr spread} - 7\text{yr spread}$$

Other definitions can also be useful; for instance expressing the kink as a percentage, or looking at kinks in terms of ratios of forward spreads.

Figure 194: The 'kink' at the 5yr point is close to an all-time high – we expect it to collapse if we move into a higher default rate period such as Source: 2002, or in a rally
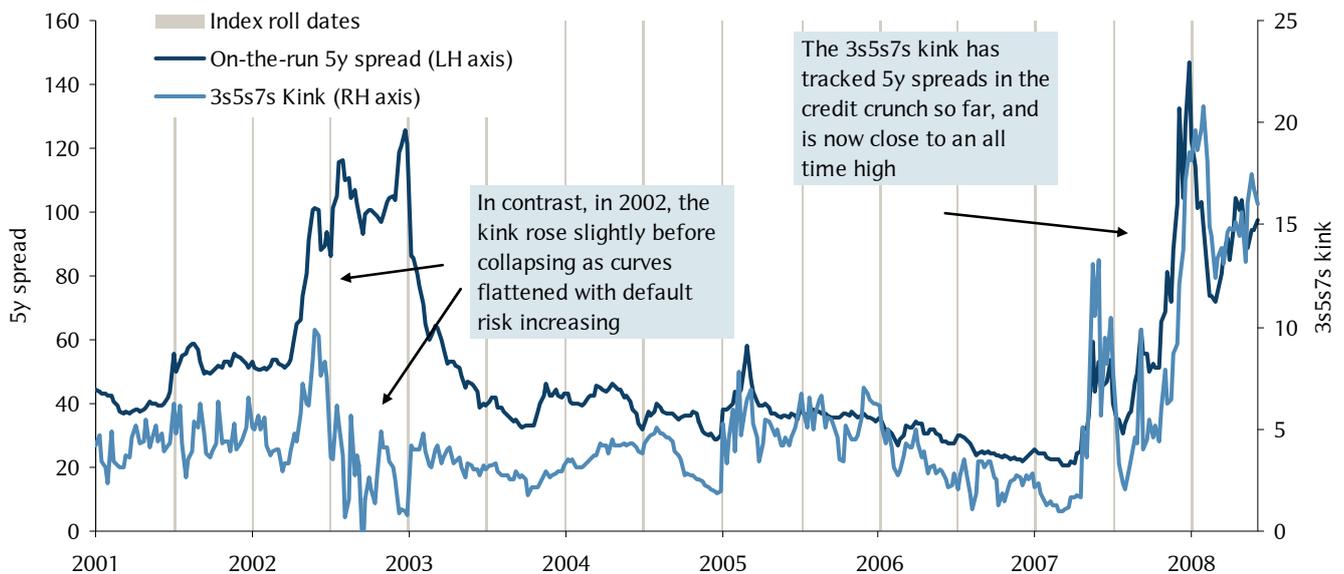
Source: Markit, Barclays Capital

CDX IG shows less of a kink than iTraxx

Figure 195 shows two comparisons of the iTraxx Main and CDX IG curves. In the left-hand panel, we plot the kink measure for the two indices over the credit crunch period. After initially tracking each other quite closely, there is now a marked divergence, with the CDX IG kink greatly in excess of the iTraxx kink.

In the right-hand panel we compare the current kinks in the curve in a different manner by looking at the forward curves. Since the trade is based on the difference between the 3s5s and 5s7s curve, we can instead analyse the implied 2yr CDS spreads at different forward starting dates. Again, we see that the iTraxx curve demonstrates a much more pronounced peak in 2yr spread risk around 2011 to 2012 start dates, corresponding to the 5yr point in the spot term structure.

Figure 195: 5yr kink through the credit crunch – comparison of iTraxx Main and CDX IG

The 5yr kinks of CDX and iTraxx have diverged during the crunch
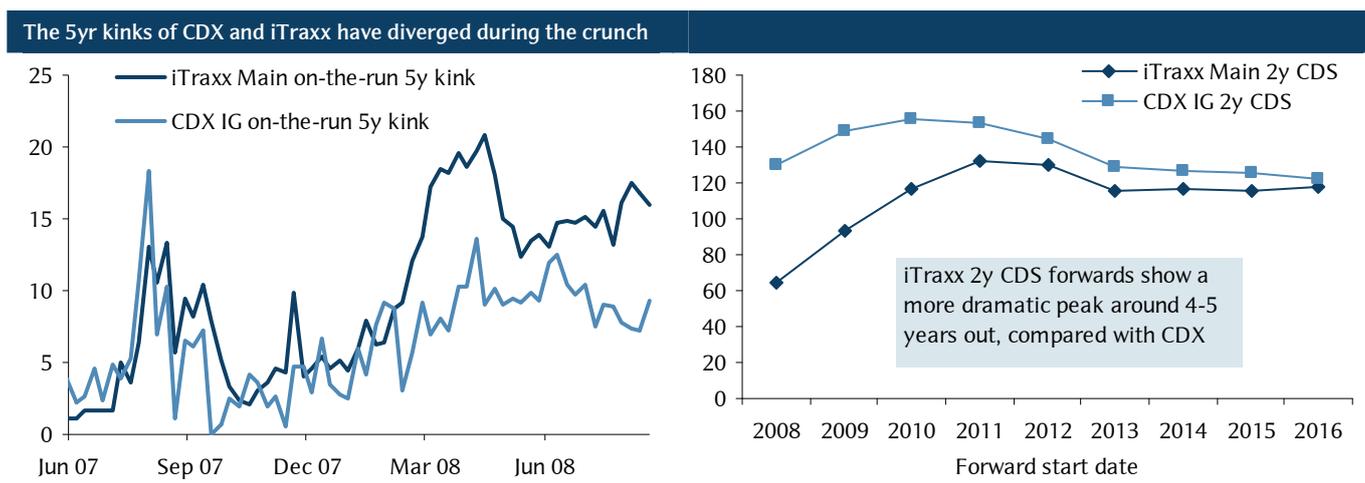
Source: Markit, Barclays Capital

Scenario analysis

Due to the complex nature of butterfly trades, the potential P&L in different scenarios is non-trivial. While the trade is set up to benefit from a drop in the kink, mark-to-market is not perfectly correlated with the kink measure given above. In particular, three factors add subtle dimensions to P&L calculations: Firstly the trade is highly sensitive to the path of roll-down of the three curve points; Second, over time, the DV01 sensitivities of the three curve points change; Finally, as spreads move, the DV01s across different tenors change at different rates.

For these reasons it is essential to test this trade across various final spread curve scenarios and at different investment horizons. We use eight curve scenarios, detailed in Figure 196, and test each scenario for a trade horizon from one to 12 months. The results are shown in Figure 197 and Figure 198.

Figure 196: Scenario descriptions

Scenarios	Description	Notes
Kink normalisation	5yr at 100, flatter curve	Spreads stay at same level, but the curve flattens such that the kink returns to historical levels.
Moderate widening	5yr at 120, flatter front end	Based roughly on 21 February 2008 curve, kink still above historical levels.
Idiosyncratic distress	5yr at 150, inverted curve	(Hypothetical) If IG companies start running into liquidity problems or defaults start to occur, the curve may widen and invert slightly.
Systematic distress	5yr at 200, flat curve	(Hypothetical) In the event of further systematic-driven widening, we expect the curve to flatten but not invert, as idiosyncratic defaults not imminent. A more extreme version of mid-March 2008.
Widening with increasing kink	5yr at 120, kinked curve	(Hypothetical) Artificial curve with steeper 3s5s and flat back end.
Modest rally	5yr at 70, steeper curve	Based roughly on 14 May 2008 curve.
Bull market	5yr at 30	Based roughly on 10 October 2007 curve.
No change scenario	5yr at 100	Today's curve.

Source: Barclays Capital

Roll-down assumptions

We assume linear roll-down from 7yr to 5yr and again from 5yr to 3yr. The P&L computations are also sensitive to roll-down assumptions in the front end of the curve, up to three years. For these, we have used off-the-run index levels, with 1yr and 2yr remaining times to maturity to give indicative levels. For further details of completing the iTraxx term structure please refer to *iTraxx off-the-run trading*, 14 August 2008.

Figure 197: 3s5s7s scenarios and payoffs at different horizons

Kink normalisation, 5yr at 100, flatter curve

Mark-to-market, including carry at different trade horizons

Moderate widening, 5yr at 120, flatter front end

Mark-to-market, including carry at different trade horizons

Idiosyncratic/default-driven distress, 5yr at 150, inverted curve

Mark-to-market, including carry at different trade horizons

Extreme systematic distress, 5yr at 200, flat curve

Mark-to-market, including carry at different trade horizons

Source: Markit, Barclays Capital

Figure 198: 3s5s7s scenarios and payoffs at different horizons
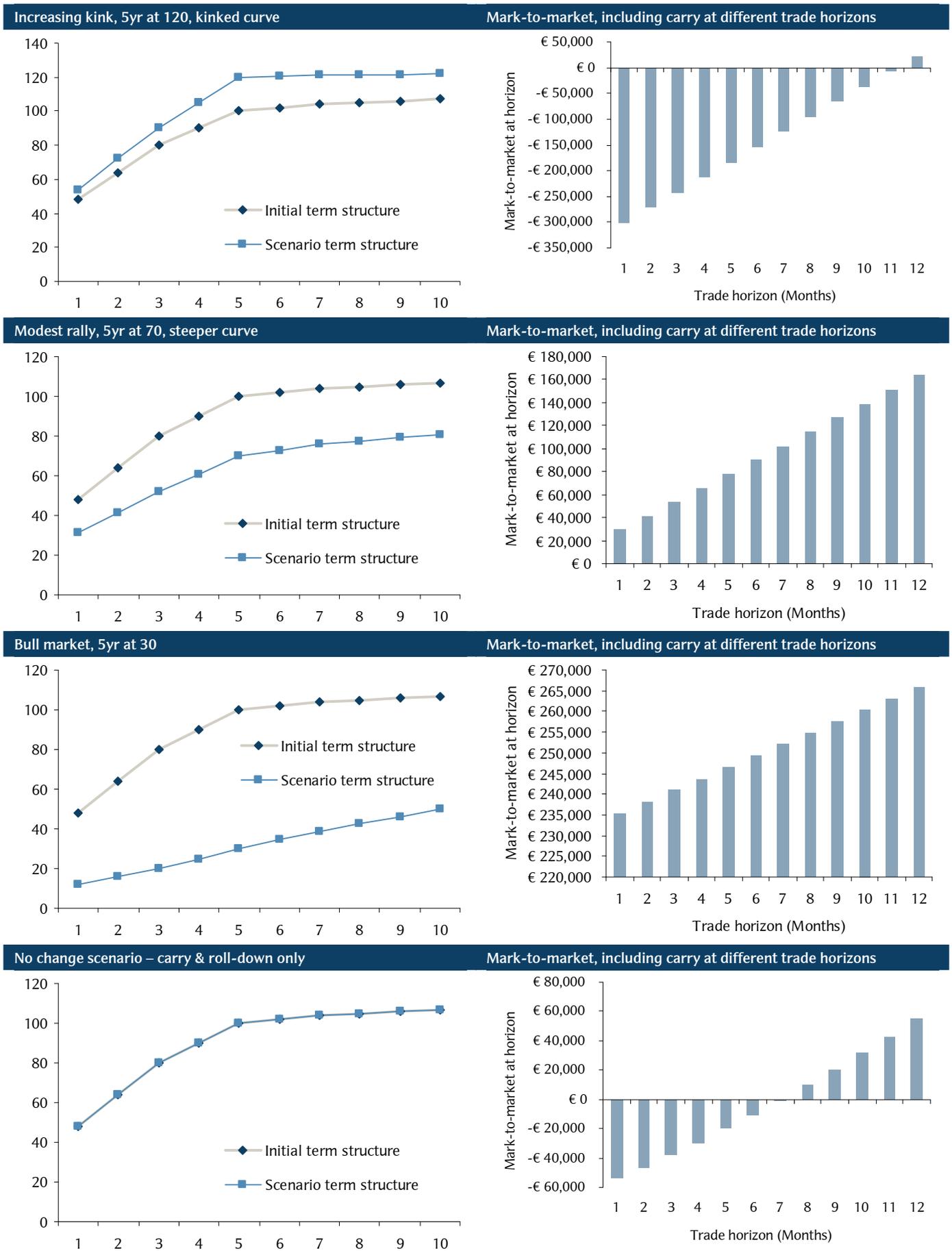
Source: Markit, Barclays Capital

Longer holding periods

As mentioned already, the payoff profile for the butterfly trade varies substantially depending on the investment horizon. It is worth noting that in at least some of the loss-making scenarios given above, it may be worth holding on to the position if risk limits and/or stop losses allow, as the profile can change substantially.

To illustrate this, in Figure 199 we show hold-to-maturity profiles for two of the key scenarios from above. In the first case of a moderate widening, the downside of the trade is never extreme, and gradually diminishes as roll-down helps to boost the trade P&L even if spreads stay at the scenario levels. In contrast, the benefit of the trade in the event of a distressed market diminishes with time such that after around 20 months the trade only breaks even in such a scenario and loses money at even longer horizons.

Figure 199: Hold-to-maturity profiles of selected scenarios – Important to consider
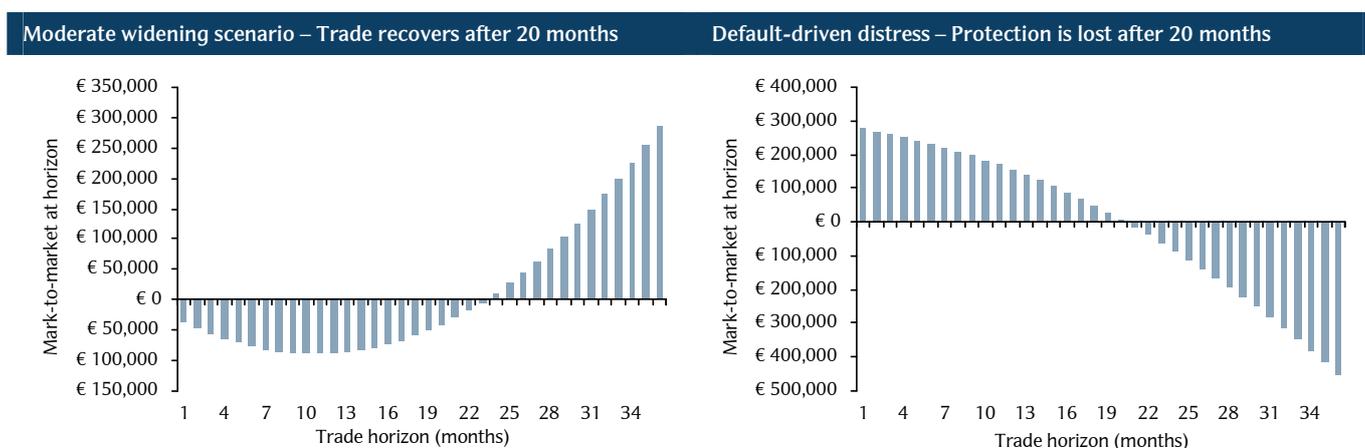
Source: Markit, Barclays Capital

Considerations coming up to the roll

Although the index roll to series 10 is coming up in a few weeks time, we believe it may be worth implementing this trade now as the position may benefit from any roll-down effects that are sometimes exaggerated over the roll date. We do not believe the trade will be significantly handicapped by being on off-the-run indices. Please see *iTraxx off-the-run trading*, 14 August 2008 for an in depth discussion of off-the-run index trading and liquidity.

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Trading CDS index forwards

A CDS index forward provides protection against default of the underlying reference entities for an agreed premium beginning on a future start date for a fixed term. For example, selling protection on iTraxx Main S10 5yr5yr forward involves entering a contract that has no cash flows at all until year five. That is, no premiums are received, and no payments are made even if reference entities default. From year five to year 10, annual premiums are received on the remaining (non-defaulted) notional of the index, and any default payments of remaining constituents are met in full.

In practice, CDS index forwards are traded using standard contracts of different tenors. We describe the implementation – and the extent to which it is an approximation to a real forward – below. First, we look at two broad sets of applications.

Forwards as short- or medium-term trades

CDS forwards have a variety of applications. As short- or medium-term trades (where the position is not held beyond the forward start date), buying or selling forward protection can be viewed as a spread-directional trade with an altered risk-reward profile:

- Selling forward protection benefits from spread tightening and curve flattening but is flat on default.

- Buying forward protection is often thought of as a cheap short, benefiting from spread widening or curve steepening, but with much lower carry cost.

We give several examples of such trades in action on iTraxx Main and Senior Financials.

Forwards held to the forward start date

As a long-term trade, buying or selling forward protection implicitly takes a view on future spread levels. If held until the forward start date, the trade performance is, in theory, a function of whether the spot spread at that time is above or below the implied forward spread locked in at trade inception.

Later in this section we attempt to quantify various factors that affect the levels at which we ought to be happy to buy or sell forward protection where the intention is potentially to hold until the forward start date.

Completing the forward term structure

In the final part of this section we explore some innovative ways of completing the forward term structure using off-the-run indices, which allow many different forward start dates and term combinations.

Implementing CDS index forwards

The true CDS forward contract provides default protection from some forward start date to a maturity date for an annual premium agreed today to be paid during the protection period. This premium level is in fact derived straight from standard spot CDS premiums through arbitrage-free pricing. This is detailed in the next section.

Despite being a common trading tool in the liquid markets there is no active market in true credit forward contracts. Instead, traders mimic forwards by constructing equal-weight curve positions, such that default payments net off prior to the maturity of the shorter default swap. Typically, there will be cash flows before the start date of the contract in most circumstances, including:

- For par CDS contracts (eg, typical single-name trades), there will be residual cash flows before the start date, equal to the difference in premiums on the two constituent legs.

- For off-par CDS contracts (eg, CDS indices), there will be upfront payments at inception of the trade.

- For all CDS contracts (indices or single names) that are quoted on an upfront and running spread format.

The effect of these cash flows on the forward breakeven spread is discussed below.

Pre start-date cash flows

How important are these early cash flows to the pay-off of the forward trade? Early cash flows can be reinvested, and the reinvestment rate then affects the trade economics. In more extreme situations they can be very significant: for instance, in the case of selling 5yr5yr single-name forward protection struck at a 10yr spread of 450bp and a 5yr spread of 400bp, the proxy forward accrues 50bp per year in the first five years, compared with nothing on the true forward. If a default happens at the end of year four, the proxy forward has made 200bp. The early cash flows alter the breakeven spread level for the trade, where we define:

> Breakeven spread =   Spot spread on the forward start date such that
>
> the total P&L of the forward trade equals zero

The effect on the breakeven spread of the early cash flows depends on their sizes and the probability of defaults in the underlying names.

Breakevens on CDS indices

For CDS index trades the calculation of breakevens is more complex as there are typically upfront payments involved, owing to the fixed-premium nature of index swaps. In addition, the number and timing of defaults of constituents plays a part, although the exact effect of defaults is quite subtle:

- On a default before the start date, the protection payments of Par – Recovery net off between the two legs of the trade, resulting in no cash flow. However, the notional of the index is now reduced by the weight of that name.

- Future coupon payments are now based on the reduced notional.

- The final mark-to-market at the forward start date is also calculated off the reduced notional.

Using the example of the iTraxx Xover S9, we consider buying €10mn 5yr5yr forward protection through an equal weight 5s10s steepener on 8 September 2008, with the 5yr trading at 530bp. Current fixed coupons imply an upfront payment of around €250,000 and annual coupons of €10,000. We then assume:

- A reinvestment rate of 4% for all early cash flows.

- A total of six defaults, evenly spaced, before the forward protection start date.

Figure 200 plots all the details of this trade before the forward start date in June 2013. In the left-hand panel we show the timing of the defaults and the consequent falls in portfolio notional through time. In the right-hand panel we see the modified, compounded early cash flows.

The final payment shown in the right-hand panel is the negative of the value, in June 2013, of all the cash flows received early. This payment reduces the total P&L to zero, by construction. The 5yr spot spread in June 2013, which would produce such a final cash flow, is 531bp (which happens to be close to current spot 5yr spread). However, this breakeven is considerably higher than the theoretical implied forward breakeven, which for these spread levels is 505bp, reflecting the beneficial early cash flows.

Figure 200: Cash flows and portfolio notional in the event of default on the Xover forward
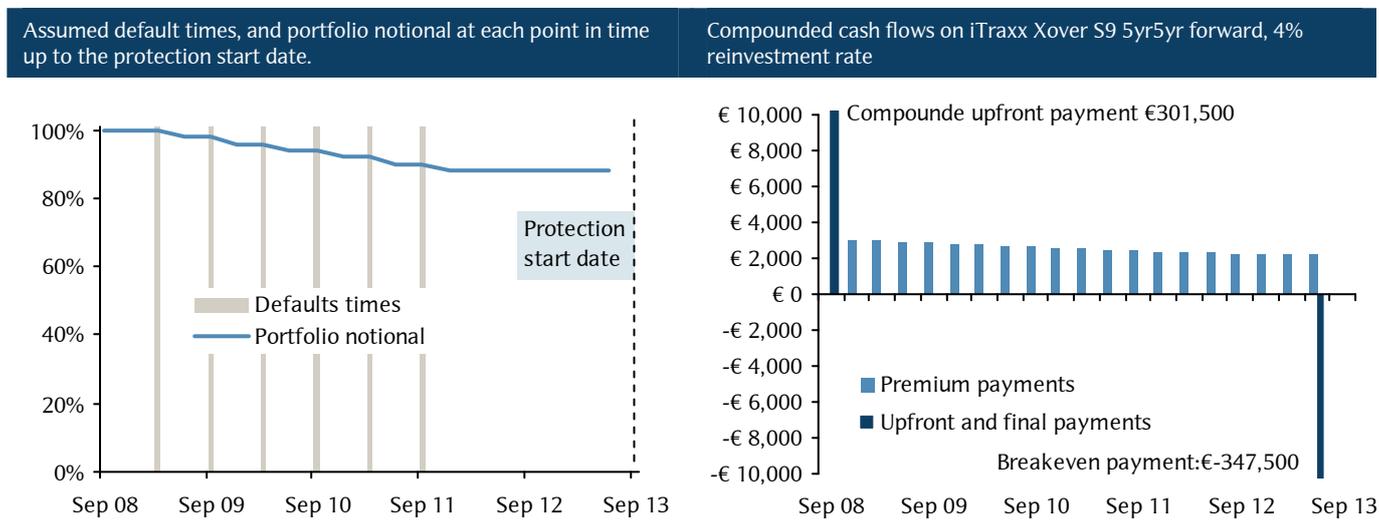
Source: Barclays Capital

Calculation of breakeven spreads

Breakeven spreads for a variety of default and reinvestment rate scenarios are presented in the left-hand panel of Figure 201. We assume evenly distributed defaults in varying numbers and two different reinvestment rates. Clearly the reinvestment rate has more impact for these numbers of defaults.

So why does the breakeven drop with defaults? The answer is because of the scale of the upfront payment on day one, compared to the small net coupons. In an extreme scenario, if all the names default on day two, the forward protection buyer is left with the upfront payment and no liabilities – this equates to a breakeven of zero. In intermediate scenarios, each default reduces the notional left in the index, and therefore leaves that fraction of the upfront payment locked in. The final payment will also be on a smaller notional, allowing the breakeven level to fall. Defaults also reduce subsequent coupon payments, but in this case the coupons are so small that it does not affect the breakeven much.

The timing of defaults makes only a small difference on an index like this – front-loading or back-loading defaults alters breakevens by less than 3bp in most cases. Note that default timing would have a more dramatic impact on single-name forward returns.

The right-hand panel shows the theoretical implied forward term structure, for each of 1, 2, 3, 4 and 5yr forwards. We can then compare the 5yr5yr forward of 508bp to the breakevens in the left-hand panel.

Figure 201: Breakeven spreads for iTraxx Xover S9 5yr5yr forward in the presence of defaults
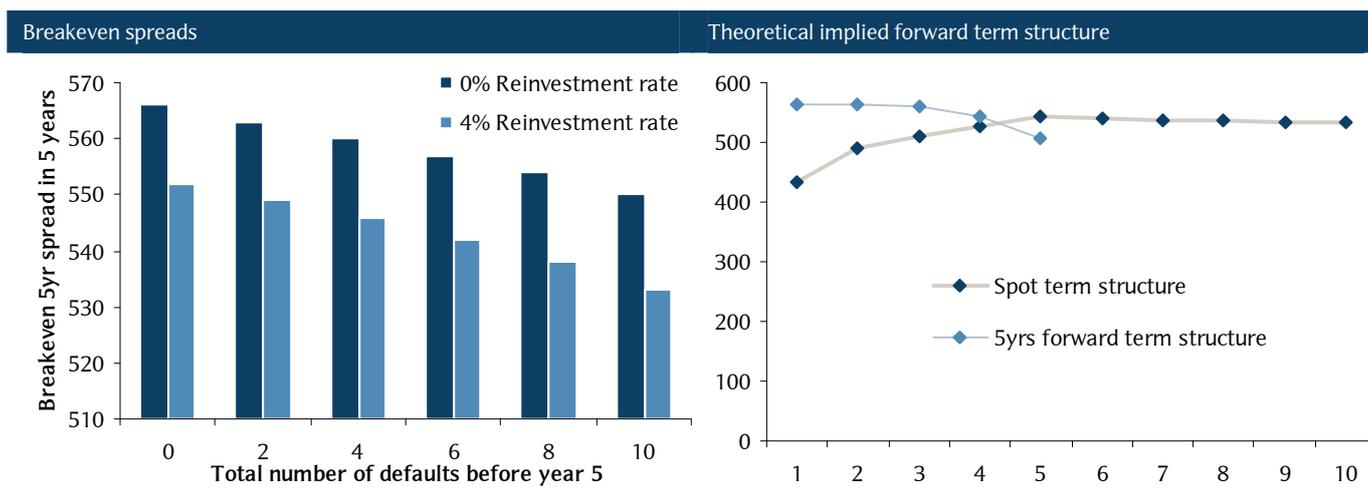
Source: Barclays Capital

Calculation of theoretical forward spreads

It is also useful to review the calculation of theoretical breakeven forward spreads, as these are more frequently quoted and used than the detailed practical calculation given above.

Making assumptions of recovery rates for when an entity actually defaults, it is possible to back out market-implied default probabilities from CDS quotes on a name. An index is actually a basket of several names, and unlikely to default in its entirety. Therefore the concept of default probability for single-name curves can be replaced by a default rate for indices.

The implied default rate generally increases exponentially with time when the credit curve is upward sloping. We indicate this in Figure 202b for iTraxx Main on 21 September 2006, during the benign credit market period. In this example, while the cumulative default rate in the first five years is 2.72%, the default rate in the next five years is 9.03% - 2.72% = 6.31%.

Pricing a forward spread off this credit curve explains why forward curves are much steeper for upward sloping curves. A 5 x 5 forward for the iTraxx would price in a 6.3% default rate from year 5 to year 10 (conditional on no defaults before year five), or an annual default rate of 1.3% (assuming uniform risk of defaults across any given period). This is higher than the average annual default rate for both the 5yr and 10yr spots, which are 0.5% and 0.9%, respectively (making the same assumptions of uniform risk of default across any given period).

Figure 202: iTraxx Main spot and forward curves and implied default probabilities (21 Sept 2006)
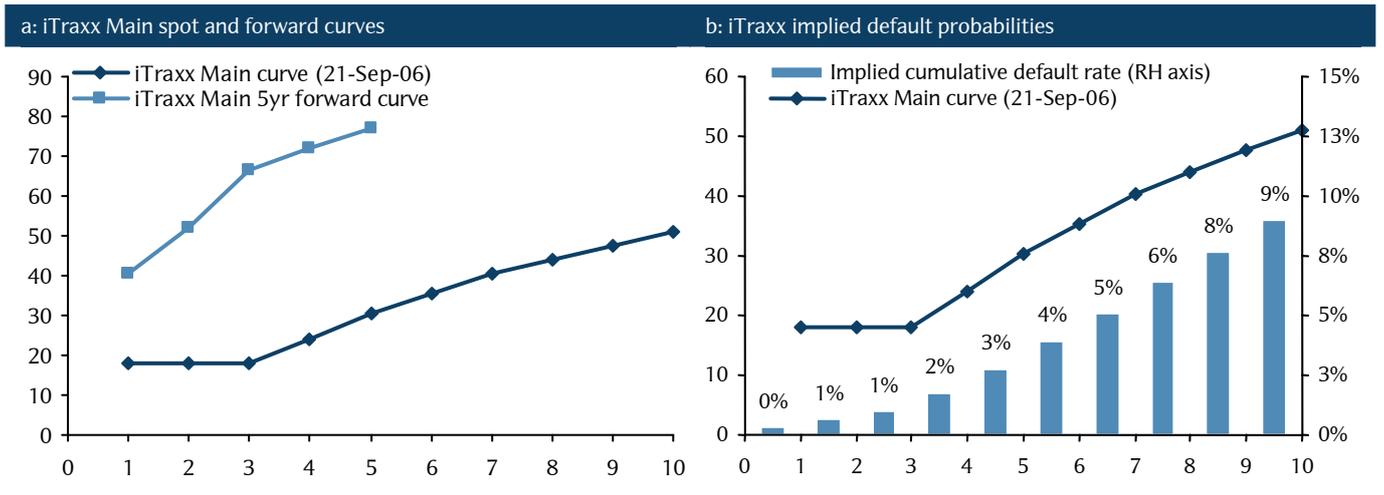
Source: Markit, Barclays Capital

Pricing forwards through expected losses

Forwards are priced by equating expected losses over two differing time horizons. Typically a 5yr forward, five years hence, would be priced as follows:

Exp. loss over 5 yrs, in 5 yrs time	=	Exp. loss over the next 10 yrs	-	Exp. loss over the next 5 yrs
$F_{5,10}\,PV01_{5,10}$	=	$S_{10}\,PV01_{10}$	-	$S_5\,PV01_5$

Here, the expected loss is given by spread x PV01 as indicated. This follows from the pricing of CDS by equating expected loss to the expected premium, given by the product of the premium and the PV of 1bp risky coupon stream, or PV01 as it is normally termed. Please refer to *Indices: The basics*

for full details and definitions.

Rewriting the above expression, we derive the forward spread level to be:

$$F_{5,10} = \frac{S_{10}\times PV01_{10} - S_5 \times PV01_5}{PV01_{10} - PV01_5} = \frac{\text{Expected loss}}{\text{Expected duration}}$$

It is evident from this equation that the forward spread depends on two factors:

- The expected loss over the contract period
- The expected duration of the contract.

The steeper the spot curve, the larger the forward expected losses and the shorter the forward expected durations, both of which drive up the forward spread.

This is schematically illustrated in Figure 203, which plots the spot CDS curve against the PV01 of each tenor. The shaded areas represent the expected losses for contracts of different tenors, and the difference between the two represents the expected loss over the forward period.

The steeper the spot CDS curve is, the greater the difference between the shaded areas, and the shorter the expected duration of the forward, resulting in a higher forward spread.

Figure 203: iTraxx OTR Main spread versus PV01, 21 September 2006
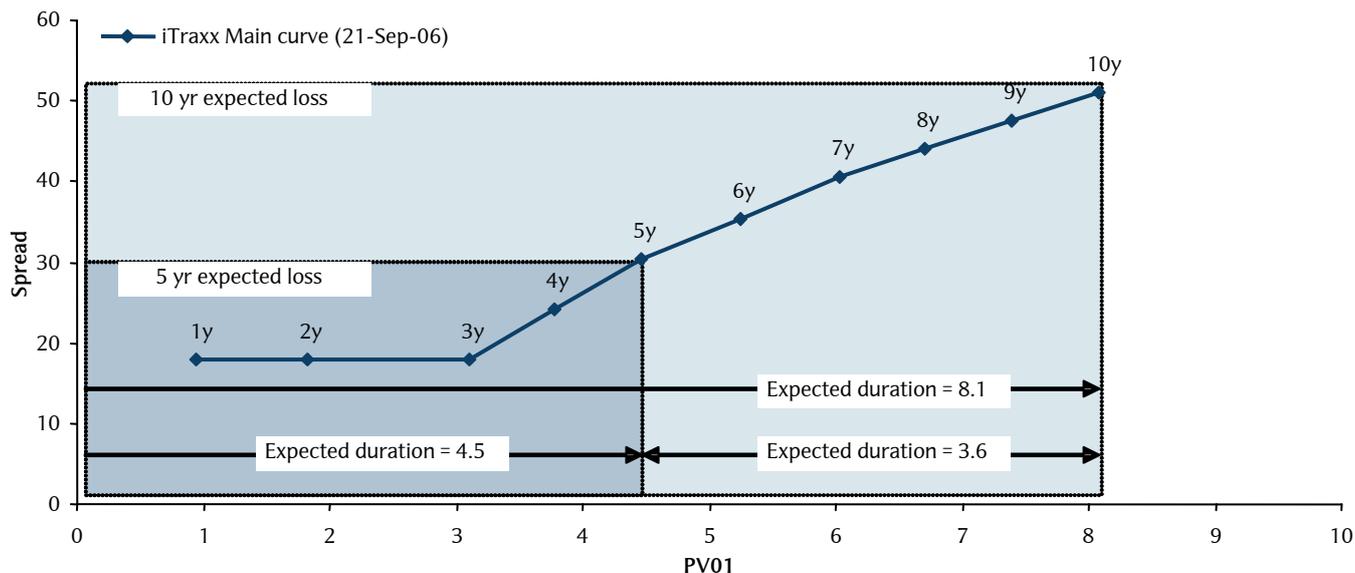
Source: Markit, Barclays Capital

Spot curve inversions

While steep spot curves lead to even steeper forward curves, the scenario changes as spot curves flatten. For flat or inverted spot curves, the forward spread is generally level with or below the spot. This is indicated in Figure 204, in which we compare iTraxx Main on 21 September 2006 and 24 September 2008. As we can see, the 5yr forward curve on 24 September 2008 is much closer to the spot curve.

Figure 204: iTraxx Main spot and forward spreads; comparing 21 Sept 2006 and 24 Sept 2008
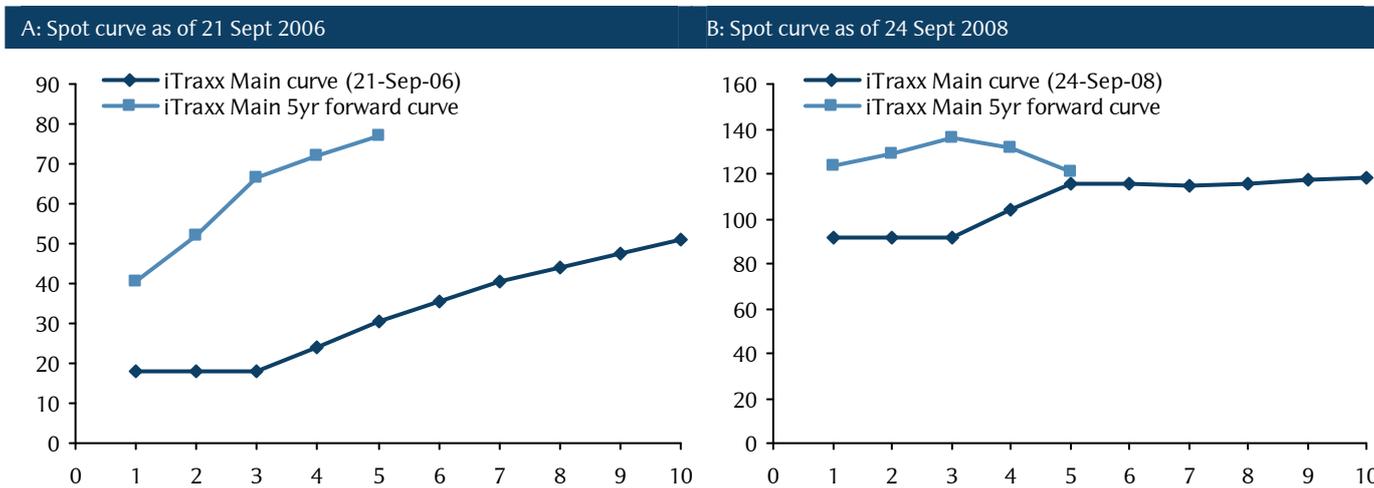
Source: Markit, Barclays Capital

Figure 205a and Figure 205b compare the expected losses in both cases and provide an explanation of this being so. For the curve on 24 September 2008, we can see the expected loss in the first five years is greater than that in the second five years, as priced by the market. Correspondingly, the forward spread is also lower than the spot.

Figure 205: iTraxx Main expected losses; comparing 21 September 2006 and 24 September 2008
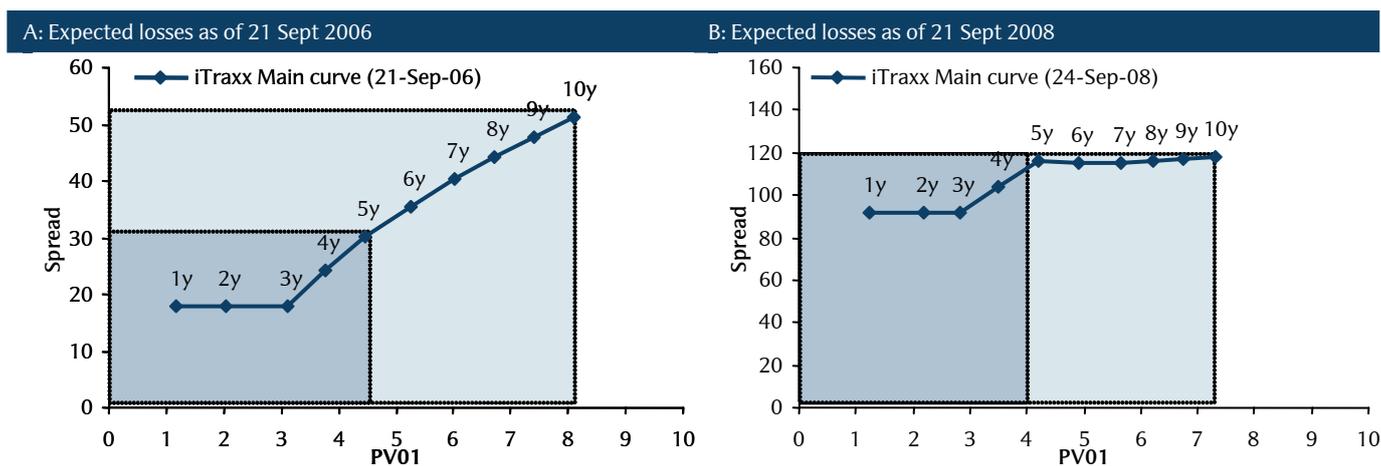
Source: Markit, Barclays Capital

Using forwards to position for spread widening

Originally published as *Cheaper hedging using iTraxx Main forwards*, 26 November 2007.

Forwards can be used to express a bearish view on iTraxx Main. Current flat curves make notional-neutral steepeners (long forward protection trades) an attractive and cheap alternative to buying protection for investors with the view that iTraxx Main spreads will continue to go wider. By trading the curve, the negative carry of a bearish position is dramatically reduced (up to 75% we calculate; Figure 206) but the short duration exposure can be scaled to be the same as the spot trade. The trade-off is that the forward trade receives no payment on default.

To illustrate this, consider the following DV01-equivalent trades on iTraxx Main S8:

- Spot trade: Buy 5yr spot protection by buying €10mn 5yr protection (reference level 64.75bp).

- Forward trade: Buy 5x5 forward protection by selling €13.7mn 5yr (reference 64.75) and buying €13.7mn 10yr protection (reference 80.25).

We can compare the risk/reward of the two trades as follows:

Figure 206: Altering risk/reward – comparing two trade formats on iTraxx Main with equivalent short-duration exposure

Format	Net DV01 (P&L per 1 bp wider*)	Annual cost in carry & roll-down	Default payment with 40% Rec (in years 0-5)	Main to 100bp 5s10s to 12bp (1mth horizon)	Main to 40bp 5s10s to 18 bp (1mth horizon)	Main unchanged 5s10s to 14 bp (1mth horizon)
Spot	€+4,500	€-84,000	€+48,000	€+122,000	€-100,000	€-7,000
Forward	€+4,500	€-22,000	€ 0	€+127,000	€-98,000	€-17,000

*Note: *DV01 assumes a parallel widening. We discuss curve exposure below. Source: Barclays Capital*

The forward trade is of course exposed to the 5s10s curve. See the following for some of our views on current curves.

- If iTraxx Main goes wider, the 5s10s curve could continue to flatten marginally (as we assume in Figure 206). However, the gain on spread widening more than compensates for any loss on the flattening.

- In terms of breakeven, if the 5yr widens to 100bp in one year then the forward trade is still in the money provided the 10yr is greater than 95bp (5s10s of -5bp),

according to our analysis. Historically (from 2001-07), Main 5s10s has never traded below about 9 bp.

- Conversely, if spreads rally, both trades will lose money through short duration. However, judging by historical trading patterns, Main could steepen as it rallies (as we assume in Figure 206).

- If curves continue to flatten but the 5yr remains unchanged, the forward trade will marginally underperform.

Note that notional-neutral steepeners are not currently an attractive way of expressing bearish spread views on iTraxx XO or Senior Financials. This is because we expect considerable bear-flattening and inversion behaviour on both these indices. Typically, IG non-financials only experience meaningful bear-flattening at much-wider spread levels. The senior financials component of Main is too small (20%) to significantly affect the overall curve shape. Please refer to the *CDS Curve Trading Handbook 2008*, 6 November 2007, for a detailed discussion of forwards and curve behaviour.

Current curve shape in iTraxx Main – some thoughts

iTraxx Main 5s10s is looking flat at around 16bp compared with recent history – the average 5s10s since 2004 has been 21bp. However, using our QCX indices, which extend the series back to 2001 (see *CDS Curve Trading Handbook 2008,* 6 November 2007 p.145), the current curve actually is about average. The low point in 2002 was 9bp at the peak of the default cycle (Figure 207). We would expect a continued slight flattening tendency on further widening (consistent with historical patterns).

Some considerations for a 5s10s DV01-steepener on iTraxx Main:

- Marginally bullish in this environment.

- Carry and roll is approximately €45,000 over one year (5yr reference 64.75)

- Suffers from negative convexity (see *CDS Curve Trading Handbook 2008*, 6 November 2007, page 59).

- Potential for further technical/unwind driven flattening into year-end.

- Long default risk in underlying names.

Figure 207: iTraxx Main 5s10s, using QCX extended time series, one-week moving average

Source: Markit, Barclays Capital

Expressing views through forwards: iTraxx Financials versus Main

Originally published as *Expressing views through forwards: iTraxx Financials vs Main*, 21 November 2007.

The unprecedented pattern of the iTraxx Senior Financials (Sen-Fin) Index trading in line with iTraxx Main at the 5yr point has been the subject of much recent discussion. Although perhaps justified through continuing concerns in financials, and – at present – less concern in non-financials, there are arguments for the crisis to spill over to corporates at the six to 12-month horizon (see *European IG credit: Main at 100?*, 16 November 2007).

Investors wishing to express the view that the ratio of Main:Sen-Fin will normalise over the medium term should consider trading in the forwards rather than the standard 5yr-5yr switch.

Example trade format: Sell iTraxx Sen-Fin 5x5 forward protection and buy iTraxx Main 5x5 forward protection, 1:1. Eg, sell €20mn Sen-Fin 10yr, buy €20mn Sen-Fin 5yr, buy €20mn Main 10yr and sell €20mn Main 5yr protection.

We note that this trade may experience high mark-to-market volatility in the short term. If financial news flow continues to be negative, entry levels could become more attractive in the coming weeks.

Benefits of this trade format

- Using our QCX time series **we find the average ratio of Main:Sen-Fin to be 2:1 from 2001-07** (Figure 208). Following our credit strategists' view for Main to be in the 100bp range next year, a base scenario could be for Sen-Fin to recover to c.50bp. In this scenario the above trade has a P&L in the range of €250,000.

- **This format is attractive for investors constrained in taking short-term financials default risk.** The trade benefits from a neutralisation of short-term default risk in the financials (the 5x5 forward position has default risk from years 5 to 10 only – we anticipate unwinding this trade well before year 5).

- Although the Sen-Fin curve is trading flat already (in the 2-3bp range), we believe that on further negative news, the curve will flatten further or invert, in line with precedent from other distressed financials. This effect dampens losses on the financials short forward protection (see scenario analysis below).

- Trading the forwards outperforms a straight switch in other likely scenarios, according to our analysis below.

Figure 208: The Main:Sen-Fin ratio is at an historical low – using QCX we trace back to 2001

Extending the horizon: QCX iTraxx series	Ratio of 5yr to 5yr spreads, QCX Main and Sen-Fin
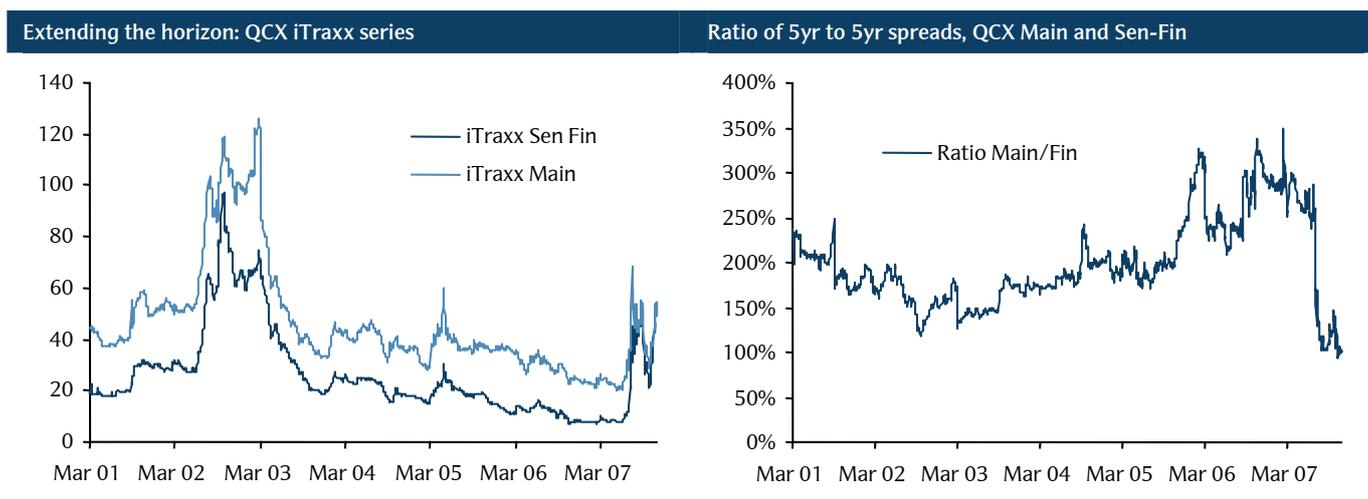
Source: Markit, Barclays Capital

Risks to this format

- The trade is slightly negative carry. If spreads remain unchanged, the 12mth estimated P&L is around -€55,000.

- The Sen-Fin Index may continue to underperform Main in the short term if there is further financials-related concern, leading to significant mark-to-market volatility. However, the format we recommend partially hedges this scenario – avoiding default risk and benefiting from a potential curve inversion – see scenarios below.

- If the Sen-Fin Index 5s10s curve steepens back to historical norms and spreads fail to rally, the trade may suffer losses. However, we believe this is unlikely – for curves to normalise we believe spreads need to rally significantly. We discuss why we believe financials curves should trade flat at heightened spread levels in *CDS Curve Trading Handbook 2008*, 6 November 2007, page 34.

For a treatment of CDS forwards, please see *CDS Curve Trading Handbook 2008*, 6 November 2007, page 115.

Scenario analysis

The scenarios stated here are based on historical spread patterns where stated, or on assumed curve dynamics in line with our Quantitative Curve Models (see *CDS Curve Trading Handbook 2008*, 6 November 2007, page 20). In each case we compare the recommended trade with the standard switch of selling €15mn 5yr iTraxx Sen-Fin protection versus buying €15mn 5yr iTraxx Main protection. We scale the switch trade to have a similar upside payoff in the event of the simple base case scenario playing out (Main to 100bp, Sen-Fin to 50 bp).

Figure 209: Scenario analysis – comparing the forwards trade with the spot switch

Scenario – spreads are 5yr spreads, curves shown in chart	Chart of today's curve versus scenario curve

Scenario: Main to 100 bp, Sen-Fin recovers to 50bp.

Horizon: 12 months

Forwards trade estimated P&L: +€270,000

Spot switch trade estimated P&L: +€270,000

Note: In this scenario we have intentionally scaled the two trades to have similar pay-offs. We can then compare the risk-reward across the other scenarios below.

Scenario: Main to 100bp, Sen-Fin also to 100bp, slightly inverted.

Horizon: 12 months

Forwards trade estimated P&L: +€130,000

Spot switch trade estimated P&L: -€60,000

Comment: Forwards trade benefits from the anticipated inversion of the 5s10s curve at this level.

Source: Markit, Barclays Capital

Figure 210: Scenario analysis – comparing the forwards trade with the spot switch, continued

Scenario – spreads are 5yr spreads, curves shown in chart	Chart of today's curve versus scenario curve
Scenario: Moderately bullish scenario – return to 10 October 2007 levels. Horizon: 12 months Forwards trade estimated P&L: -€55,000 Spot switch trade estimated P&L: +€25,000 Comment: In this scenario the forwards trade suffers slightly from the negative carry and the rally in Main.	
Scenario: Very bullish scenario – return to 30 May 2007 levels. Horizon: 12 months Forwards trade estimated P&L: +€95,000 Spot switch trade estimated P&L: +€50,000 Comment: Forwards trade benefits from the rally in financials in this scenario.	
Scenario: Main and Sen-Fin drift wider to 70bp Horizon: 12 months Forwards trade estimated P&L: +€15,000 Spot switch trade estimated P&L: -€30,000 Comment: Forwards trade benefits from a slight flattening in the 5s10s Sen-Fin.	
Scenario: Trade works partially – Main to 60bp, Sen-Fin to 40bp Horizon: 12 months Forwards trade estimated P&L: +€80,000 Spot switch trade estimated P&L: +€100,000 Comment: Forwards trade benefits from the anticipated inversion of the 5s10s curve at this level.	

Source: Markit, Barclays Capital

Figure 211: Scenario analysis – comparing the forwards trade with the spot switch, continued

Scenario – spreads are 5y spreads, curves shown in chart	Chart of today's curve versus scenario curve
Scenario: Trade fails – Main goes to 60bp, Sen-Fin to 100bp Horizon: 12 months Forwards trade estimated P&L: -€145,000 Spot switch trade estimated P&L: -€280,000 Comment: Forwards trade benefits from the anticipated inversion of the 5s10s curve at this level.	
Scenario: Spreads unchanged (carry & roll-down). Horizon: 12 months Forwards trade estimated P&L: -€55,000 Spot switch trade estimated P&L: -€5,000 Comment: Forwards trade is hurt by negative carry.	

Source: Markit, Barclays Capital

Default risk of spot switch

A final comment is that the straight switch on the 5yr discussed has significant default risk. A single default with 40% recovery of a name in the iTraxx Sen-Fin in the €15mn x €15mn trade above results in a €288,000 loss (€288,000 = (100% – 40%) x €15mn (1/25 - 1/125).

Main and Fin forwards: October 2008 update

It is informative to analyse the realised path of the forwards trades identified in the previous two sections, a year on from the initial analysis – especially given the tumultuous year that it has been.

Figure 212 shows the trajectories of implied 5x5 forward spreads on iTraxx Main S8 and iTraxx Senior Financials S8 over the past year. Following our initial analysis in November 2007, Main 5s10s curve actually flattened quite dramatically, from around 15bp to about 10bp, without 5yr spreads widening. At the time this was attributed to correlation desk rebalancing of curve risk coming up to year-end. This had the effect of pushing 5x5 forward spreads down, at a time when the financials curve remained unchanged.

During the gradual build-up of systemic concern in January to March 2008, we saw the financials spreads widen back in line with Main spreads, and occasionally trade above on a spot basis. Forwards roughly tracked this same behaviour, as curves remained mostly unchanged. There then followed a stable period between April and August, before the Lehman bankruptcy unsurprisingly pushed financials wider again in line with Main.

In fact the last week of September and first weeks of October have proved to be the most dramatic of this whole period. Two effects have occurred here: 1) government intervention has driven financials spreads substantially tighter than Main spreads; and 2) at the same time, the Main 5s10s curve has flattened and inverted, without substantial further widening in spreads, owing to front-end default hedging by loan books experiencing drawdowns by corporates. The extent of the financials-corporates decompression has pushed forwards apart, as we see in Figure 212, but in fact we believe the effect would have been much more dramatic had the Main curve not come under so much flattening pressure.

Figure 212: Tracking the implied forwards on iTraxx Main S8 and Senior Financials S8
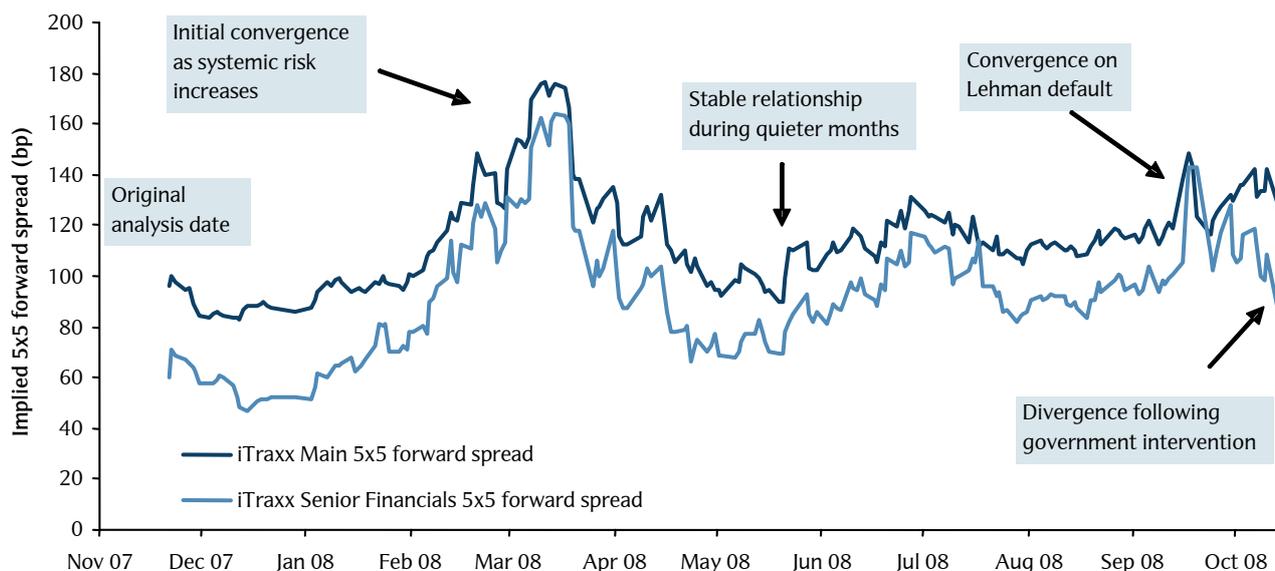
Source: Markit, Barclays Capital

So how might trades implemented on the forwards as discussed above have fared in this period? Figure 213 shows indicative cumulative returns of buying forward Main protection and selling forward Financials protection, on an individual and combined basis. Buying forward Main protection has proved to be a successful trade, despite initially underperforming on the back of the flattening in 5s10s mentioned above. The trade's peak performance was during the March volatility. In the September volatility, performance was reduced by further curve flattening, but is still reasonably strong.

Selling forward financials protection has mostly been a losing trade as financials spreads have widened. The trade has gained back a lot of ground in September, however, following the government intervention.

The combined trade has been disappointing overall. Through most of the period the losses on financials outweighed the gains on Main. Only in the first weeks of October has that pattern reversed and the combined position moved into positive territory. However, given the possibility for further decompression between financials and corporates, we recommend holding on to such a trade.

A final note on this analysis; the original motivation for the forwards implementation over the spot implementation was i) to avoid default risk in individual financials and ii) to offer protection in the case of financials indices trading wider than Main. So far, neither of these scenarios has realised (in Europe at least; in the US they have in spectacular fashion). So while ex-poste it is clear that the spot implementation would have outperformed the forward implementation, we believe none of the realised behaviour would change the ex-ante analysis.

Figure 213: Indicative cumulative returns of buying Main and selling Financials forward protection
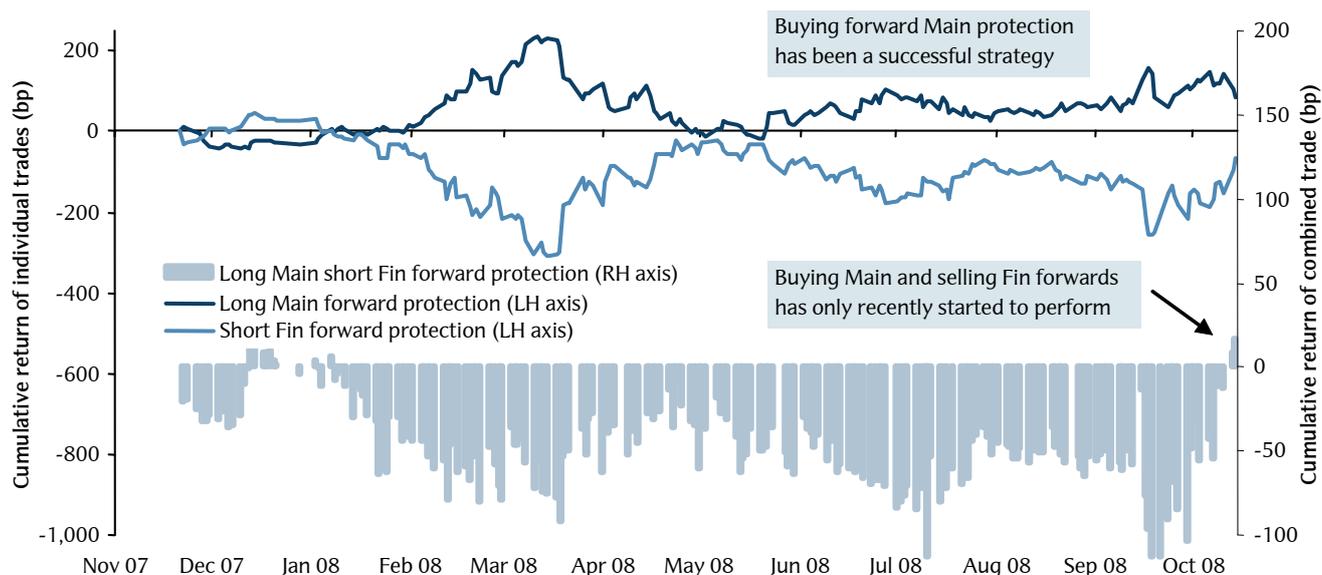
Source: Markit, Barclays Capital

Forwards held to the forward start date

We now return to the second set of applications for forwards, which revolve around taking views on future spread levels. A naïve approach, perhaps, might be to compare the implied theoretical forward spread on, say, iTraxx Xover, to our expectation of where Xover spreads might trade in five years time. However, we find that there are a number of subtleties that need to be accounted for to make a careful comparison. The following section provides a framework for possible analysis of this.

A framework for assessing Xover forwards

Originally published as *Assessing the value in Xover forwards*, 10 September 2008.

The implied 5yr spread in five years' time on iTraxx Xover S9 is around 510bp. Is this cheap? Actually it's hard to say, not just because it is difficult to know what the state of the world will be five years from now, but also because of subtleties in the forward trade. We introduce a framework for assessing forward spreads that we believe should be used even if the intention is not to hold until the forward start date. Based on this, we conclude that buying Xover S9 forwards at or below 500bp currently looks attractive.

- **Breakeven calculation:** Index forwards proxied by equal-weight curve trades have cash flows before the forward start date. This affects the breakeven spread – early cash flows can be reinvested, but will be reduced after defaults: for example, with a 4% reinvestment rate, the breakeven is approximately 552bp with no defaults and 542bp with six defaults. The theoretical breakeven is the implied forward, 510bp.

- **Portfolio migration:** Using S&P transition data we can estimate the effect of rating migration and defaults on the fair spread of the iTraxx Xover S9 portfolio at the forward start date. Counter-intuitively, defaults before the forward start date will tend to reduce the portfolio spread, all else being equal. With rating risk-premium held constant, we estimate a migrated portfolio spread of 600bp in the case of no defaults and 500bp after six defaults, for example.

- **Empirical analysis:** Using reconstructed data back to 2001, we analyse Xover 5yr5yr forward levels through the credit cycle, and find that 400bp is a conservative floor, but with the potential for levels above 700bp in distressed markets.

Figure 214: Considerations on trading the iTraxx Xover S9 5yr5yr forward
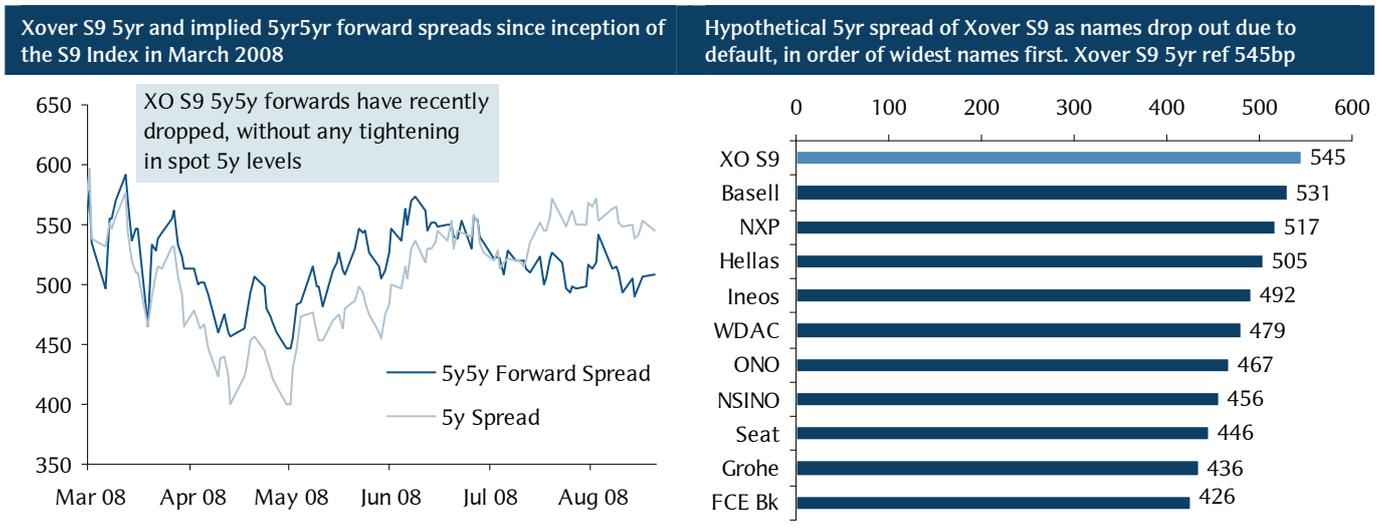
Source: Markit, Barclays Capital

Portfolio migration

An important subtlety of the forward trade is that it references the fixed set of names in the portfolio, not those in the on-the-run series. The fair spread of the final portfolio at the protection start date will therefore depend on both the rating migration and possible default of the constituent names. Therefore, in considering the breakeven spreads, it is not enough to consider whether we believe a generic iTraxx Xover 5yr portfolio should be trading above or below such levels, but specifically the iTraxx Xover S9 portfolio.

This turns out to be a non-trivial exercise. Deteriorating names will tend to push the spread of the portfolio wider. However, in the event of a default prior to the start date, the fair spread of the portfolio minus the defaulted name will therefore typically fall. Note that, by construction, there is no net cash-flow on a default prior to the start date.

Here we present a possible framework for assessing this effect on the fair portfolio spread at maturity, using rating transition data from S&P. We use the global five-year transition matrix formed from actual rating changes and defaults in the 1981-2007 period. Based on this and the current broad rating profile of iTraxx Xover S9, we can calculate an expected rating distribution of a migrated portfolio. This is shown in the left-hand panel of Figure 215. A couple of points stand out from the chart:

- Of the remaining rated names, (ie, excluding defaulted names and those not-rated - NR), the remaining profile has a bias for improvement, with considerably fewer CCC and B-rated names and more investment grade names.

- This analysis forecasts a high number of defaults at 10 out of 50. We believe this is an over-estimate for the specific case of the European iTraxx Xover S9 names – see below.

- The analysis also forecasts a substantial increase in the number of companies with ratings withdrawn. It is difficult to make any conclusions about the final credit quality of these names.

Given that the underlying data set for the transition matrix is global, we believe the cumulative default rates, shown in the right-hand panel of Figure 215, may be an over-estimate. Reliable transition data is not available for a European data-set unfortunately, but

generally default rates are lower in Europe for a variety of reasons. We refer the reader to *European Alpha Anticipator: High yield and leverage loans – Uneasy summer*, 23 May 2008 for further details. To account for this, in the following analysis all calculations are done on the basis of variable numbers of defaults from zero to 10. In the cases where there are fewer than 10 defaults, we place the remaining names in the CCC category.

Figure 215: Expected portfolio migration based on global S&P rating transitions, 1981-2007
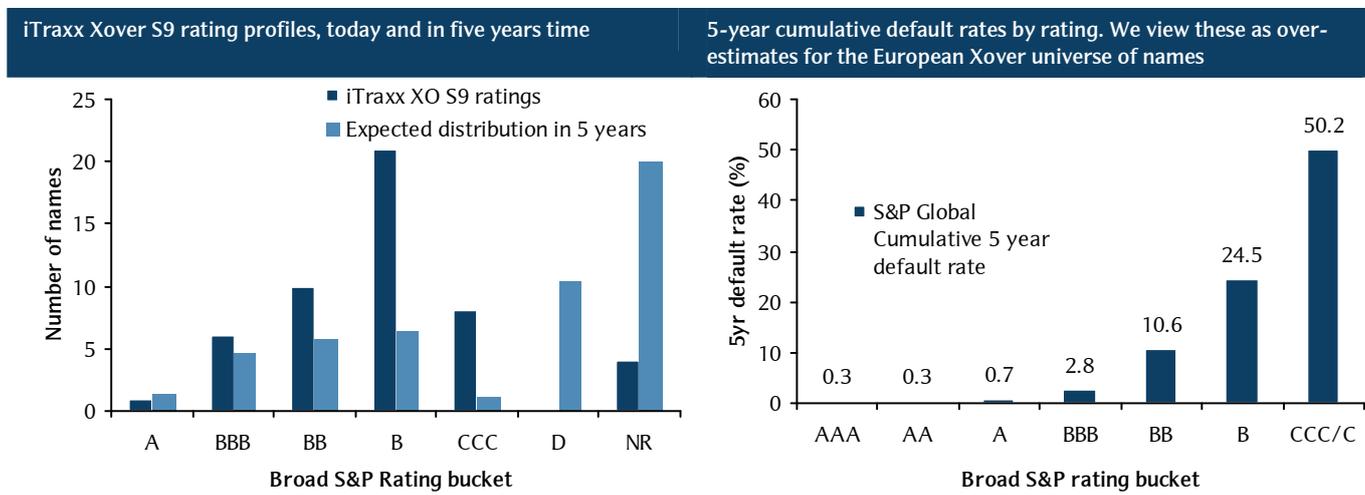
Source: S&P, Bloomberg, Barclays Capital

Converting migrated portfolios to a fair spread

The next question is how to assess the spread impact of rating migration and defaults in the portfolio? Since it is the final spread of the portfolio that is to be compared to the breakeven, this is central in the decision to trade.

We opt for a straightforward approach to this task, as any method will involve a series of assumptions. We first estimate a relationship between current spread levels and ratings from names in the portfolio. Typically, there is an approximately linear relationship between 5yr spread and the historical default rate, as shown in the right-hand panel of Figure 216. We can interpret the intercept and the slope of this relationship as:

- Intercept: Represents a core credit market risk-premium level.

- Slope: Represents the degree of compression or dispersion between high and low-rated companies.

Both of these quantities will be highly time-varying. In particular, we know that currently, market risk-premium is high, but that dispersion remains relatively low, as Xover is relatively compressed with Main. We would expect the intercept level itself to be highly correlated with the spread on iTraxx Main.

It is unfortunately beyond the scope of this report to carry out a thorough empirical analysis of the variation of this relationship. However, it does allow us to transform our forward fair portfolio spread problem into more familiar terms. Specifically, we can assume that risk premium levels and compression levels remain fixed and, using the relationship, reprice the fair spread of the migrated iTraxx Xover S9 portfolio at the forward start date.

In the left-hand panel of Figure 216, we show the weighted average fair spreads for the migrated portfolio with different numbers of defaults, and using the rating profile given in Figure 215. Where we reduce the number of defaults, we place those names in the CCC category. Defaults reduce the final spread, since names that are near default typically have

the widest spreads. The impact is significant, with almost a 200bp difference in fair spread depending on the number of defaults. A name-based illustration of this effect was also given in the right-hand panel of Figure 214.

In a further stage of this analysis, using empirical methods we can adjust the risk premium and compression variables according to our expectations in the future and reprice the index accordingly.

Note: In these calculations we assume that the NR companies have spreads that are evenly distributed across the spectrum, and therefore do not affect the estimated fair spread. The four companies that do not have ratings in the current portfolio are in fact well distributed spread-wise. Naturally, the fair spread would be quite different in the case of the names being mostly poor or high quality. The most common reasons for ratings to be withdrawn would be in the event of an acquisition (typically by a higher-rated entity) or a refinancing or secondary buy-out, where public debt is bought back and replaced with private loans. In the first case we would expect tighter spreads, while it is hard to generalise in the second case.

Figure 216: Estimated fair spreads for the migrated portfolio at the forward start date
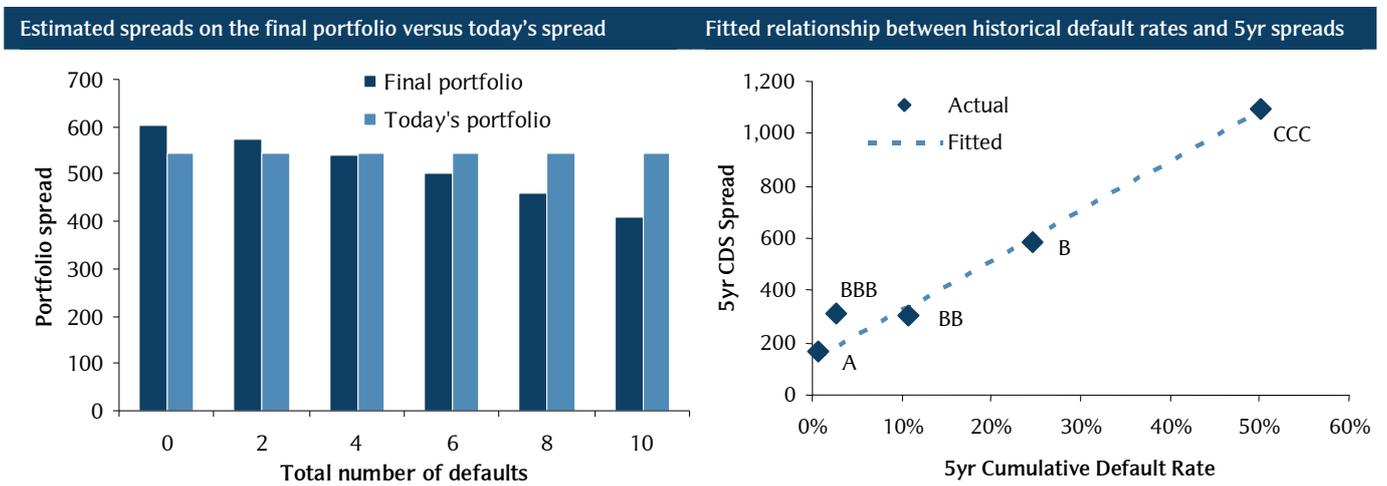
Source: Markit, Barclays Capital

Fundamental analysis can improve estimates

As mentioned earlier, further fundamental analysis can also improve these fair spread estimates. In particular, it may be possible to subdivide the Xover S9 constituents into categories such as true high yield companies, LBO companies and fallen angels. The rating transition and default rates for these groups could be substantially different. In addition, the debt-maturity/liquidity profiles of individual companies could be taken into account, possibly changing default timing expectations.

Historical Xover levels and forwards

In the final section of this chapter we examine the empirical angle, looking at historical iTraxx Xover spreads and forwards using our reconstructed QCX data, which go back to 2001. The data sets used here are described in the *Appendices*.

Figure 217 shows the time series of 5yr spot spreads and implied 5yr5yr forward spreads for the on-the-run iTraxx Xover series from 2001-08. The period 2001-04 uses our reconstructed data under two different assumptions. In the left-hand panel we use the original QCX series based on available single-name CDS in the respective periods. In

the right-hand panel we also show our rating-adjusted QCX levels, where we rescale spreads in such a way as to reflect the generally higher quality of available CDS names in the 2001-04 period. This second data set offers a more extreme idea of where spreads may have reached, particularly at the peak of European defaults in 2002 (the European annual default rate reached high double digits in this period). See *iTraxx family: How wide and how flat can they go?, 19 February 2008*.

Our main conclusion from Figure 217 is that forward spreads have remained relatively high, even in the credit bull market, thanks to extremely steep curves. The historical average level looks to be around 500bp from end-2004 onwards, and perhaps nearer 400bp before this. However, if we use the rating-adjusted levels, we find averages as high as 700bp pre-2004. Either way, in our view, 400bp seems like a reasonable floor level.

Figure 217: On-the-run Xover 5yr spread ands 5yr5yr implied forward spreads, 2001-08
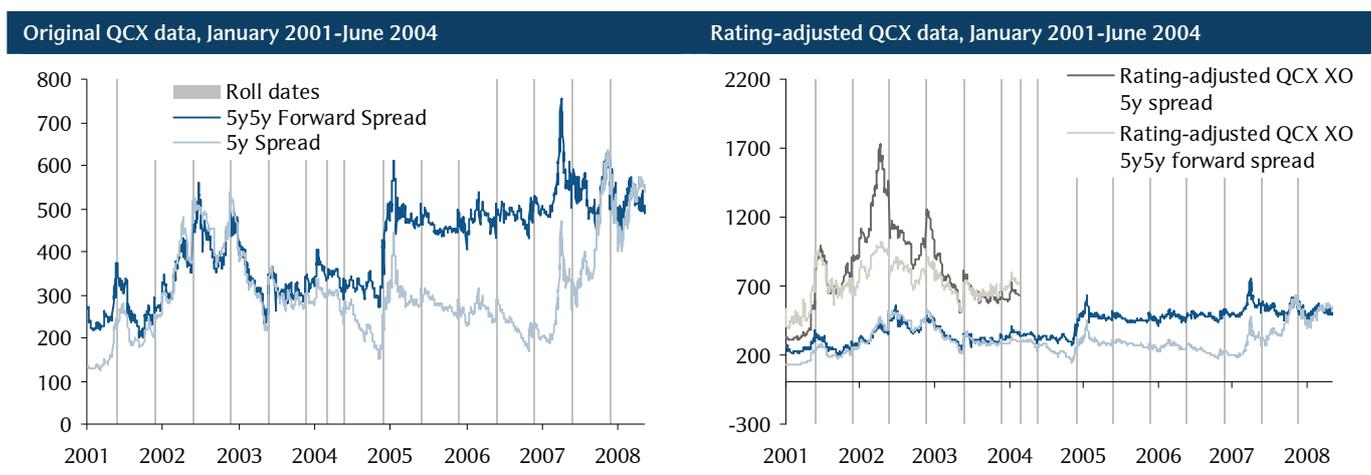
Source: Markit, Barclays Capital

As final examples, we can also examine forward spreads as they play out on particular index series. Since any forward trade held until maturity would be on a fixed series, this is especially relevant. Figure 218 shows the spread on the 5yr contract and the theoretical spread on the 5yr5yr forward for iTraxx Xover Series 1 (start date June 2004, in the left-hand panel) and QCX iTraxx Xover Series 5 (start date March 2003, in the right-hand panel). In the case of buying the forward on Series 1, the trade looks to be in the money as of marking to market today. The spread on the forward contract remained in a fairly tight band throughout, especially compared with the spread on the 5yr contract.

In contrast, the spread on the 5yr5yr contract on the QCX Series 5 started below the spot level (since the curve was slightly inverted) and has fallen slightly since then. This would leave a long forward protection position out of the money at the forward start date in June 2008. However, it is interesting to note that the constituents in our reconstructed QCX Xover series 5 were mostly fallen angels, many of which returned to investment grade during this period. In particular, six of the 30 names are now in iTraxx Main S9. Today's iTraxx Xover series 9 portfolio is much more mixed, with potentially fewer fallen angels that can migrate back up the ratings spectrum.

Figure 218: iTraxx Xover series 1 and QCX iTraxx Xover series 5 spreads

| iTraxx Xover Series 1 spreads, June 2004-September 2008 | QCX iTraxx Xover Series 5 spreads: March 2003-June 2008 |

Spread on the 5y5y S1 forward has remained fairly stable and currently trades above its starting level

XO S1 5y contract
XO S1 5y5y forward contract

XO QCX S5 5y contract
XO QCX S5 5y5y Forward Contract

At maturity, the 5y5y forward converges to the 10y contract (not shown) which is now a 5y CDS. In this case the 5y5y forward ended tighter than at inception.

Source: Markit, Barclays Capital

How do we arrive at 500bp?

The above discussions highlight the complexity of assessing forward levels. Although we believe our framework could be improved with further empirical and fundamental analysis, more layers of assumptions will also add more uncertainty. Thus, taking into account the various steps, we can come up with a level at which we would be happy to buy forward protection as follows:

- Assume there are four defaults over the five years and we have a 4% reinvestment rate. This gives a breakeven today of 546bp, which corresponds to a theoretical forward spread of 508bp.

- Based on the migration analysis, four defaults leaves an estimated portfolio fair spread of 539bp.

- We will assume that risk premium levels remain elevated like today, at least in the high yield market (although we acknowledge the credit crunch may well have blown over for investment grade companies in five years time).

- Empirically, implied forwards on Xover have traded around 500bp or above in the past few years, and our ratings-adjusted analysis shows that in more stressed periods the forwards can be much higher.

On balance we believe the risk-reward of buying 5yr5yr forwards around 500bp or below is attractive (ie, 10bp inside where we are trading today). This would correspond to a 5yr at 535bp and 10yr at 522bp.

Completing the iTraxx term structure

Extract from *iTraxx off-the-run trading, 14 August 2008.*

Here we explore a completely different angle of usage for off-the-run indices; that of completing the term structure of spreads. Currently, the iTraxx indices only trade in the 3yr, 5yr, 7yr and 10yr points. For a variety of applications – some of which are discussed below – it may be useful to be able to trade other points on the curve. Off-the-run indices offer a proxy method of doing this. As the series 7 7yr index has the same maturity date as a series 9 6yr index (if it were to exist), perhaps we can use this to proxy positions in a 6yr iTraxx.

This section focuses only on iTraxx Main. iTraxx XO does not have enough tradeable term structure points yet to facilitate the same ideas.

The left-hand panel in Figure 219 shows the 3yr, 5yr, 7yr and 10yr spreads for iTraxx Main S9 on 8 August, together with a fitted curve filling in the 1yr, 2yr and up to 10yr points. To fit these curves we use the same procedures outlined in Appendix A. The right-hand panel shows the spreads of proxy indices with the same maturity dates. Although not perfect, there is evidently some similarity in curve shape.

Figure 219: Creating an approximate full tradeable iTraxx Main term structure using matched maturity off-the-run series, 8 August 2008
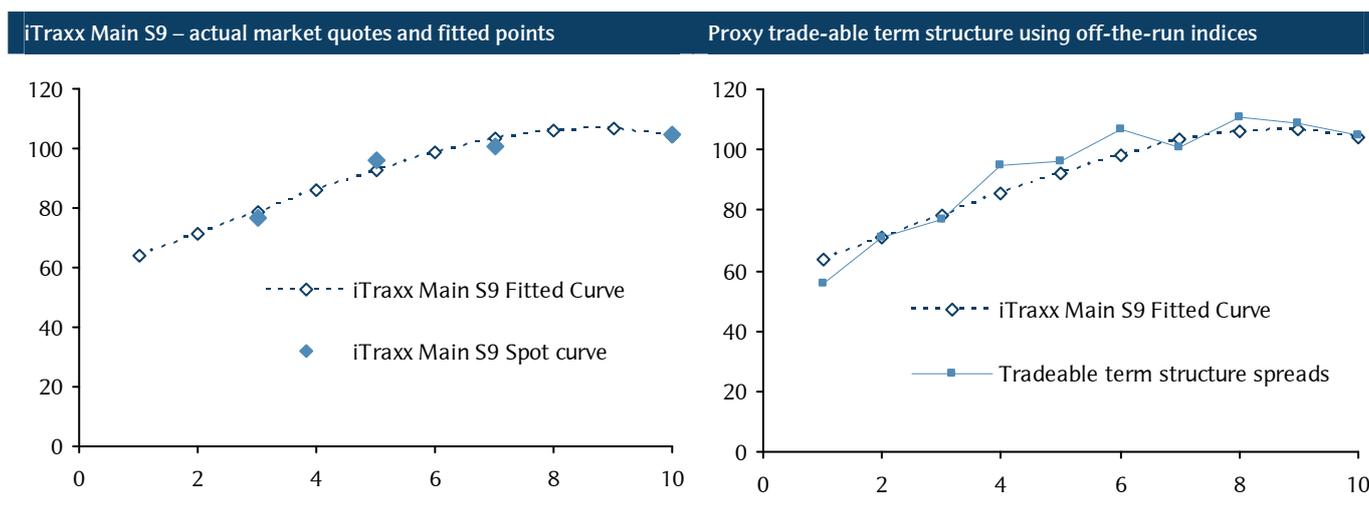
Source: Markit, Barclays Capital

Figure 220 gives further details of these proxies – the index used, market spread and DV01. We note that, due to substantially different coupons in some instances, the DV01 sensitivity of the proxy index can differ substantially from a theoretical DV01 of the fitted curve point.

Unfortunately, we find that the front end of the curve out to two years may be unreliable, owing to a lack of available data. We include it in the charts for illustrative purposes but would not envisage trading at this end of the curve.

Figure 220: Tradeable and fitted term structures, 8 August 2008

Term	Fitted term structure	Fitted DV01	Proxy index	Market spread	Actual DV01
1 year	64	1.3	Series 5 – 3yr	56	0.8
2 year	71	2.0	Series 7 – 3yr	71	1.8
3 year	79	2.8	Series 9 – 3yr	77	2.7
4 year	86	3.5	Series 7 - 5yr	95	3.4
5 year	92	4.2	Series 9 - 5yr	96	4.3
6 year	98	4.9	Series 7 - 7yr	107	4.8
7 year	103	5.7	Series 9 - 7yr	101	5.8
8 year	106	6.4	Series 5 - 10y	111	6.0
9 year	107	7.1	Series 7 – 10yr	109	6.5
10 year	104	7.8	Series 9 – 10yr	105	7.8

Source: Markit, Bloomberg, Barclays Capital

Assessing the proxy term structure

The charts in Figure 219 actually tell us very little about the usefulness of a proxy term structure for trading purposes. To make a proper assessment of this, we need to analyse actual returns performance empirically.

To do this, we use data over the previous year to run the following tests.

- First, we calculate at, each point in time, the full theoretical fitted term-structure of iTraxx Main based on the 3yr, 5yr, 7yr and 10yr on-the-run points.

- Using this fitted term structure, we can calculate weekly total returns of selling protection on each tenor, from 1yr out to 10yr, including premiums received.

- Next, for each point on the term structure, we find the matching off-the-run index, similar to those shown in Figure 220. For historical analysis, the required index changes depending on the on-the-run series.

- Using the correct coupons and spreads for each proxy index, we can then calculate total returns, including premiums of selling protection on each tenor.

Figure 221 presents four charts of cumulative returns, rebased to 100 in July 2007, for the 2yr, 4yr, 6yr and 9yr points as examples. Overall we think the tracking is reasonable, with modest deviation occurring in the period of peak spread volatility in February-April 2008.

Figure 221: Total return performance of proxy versus fitted iTraxx Main term structure points
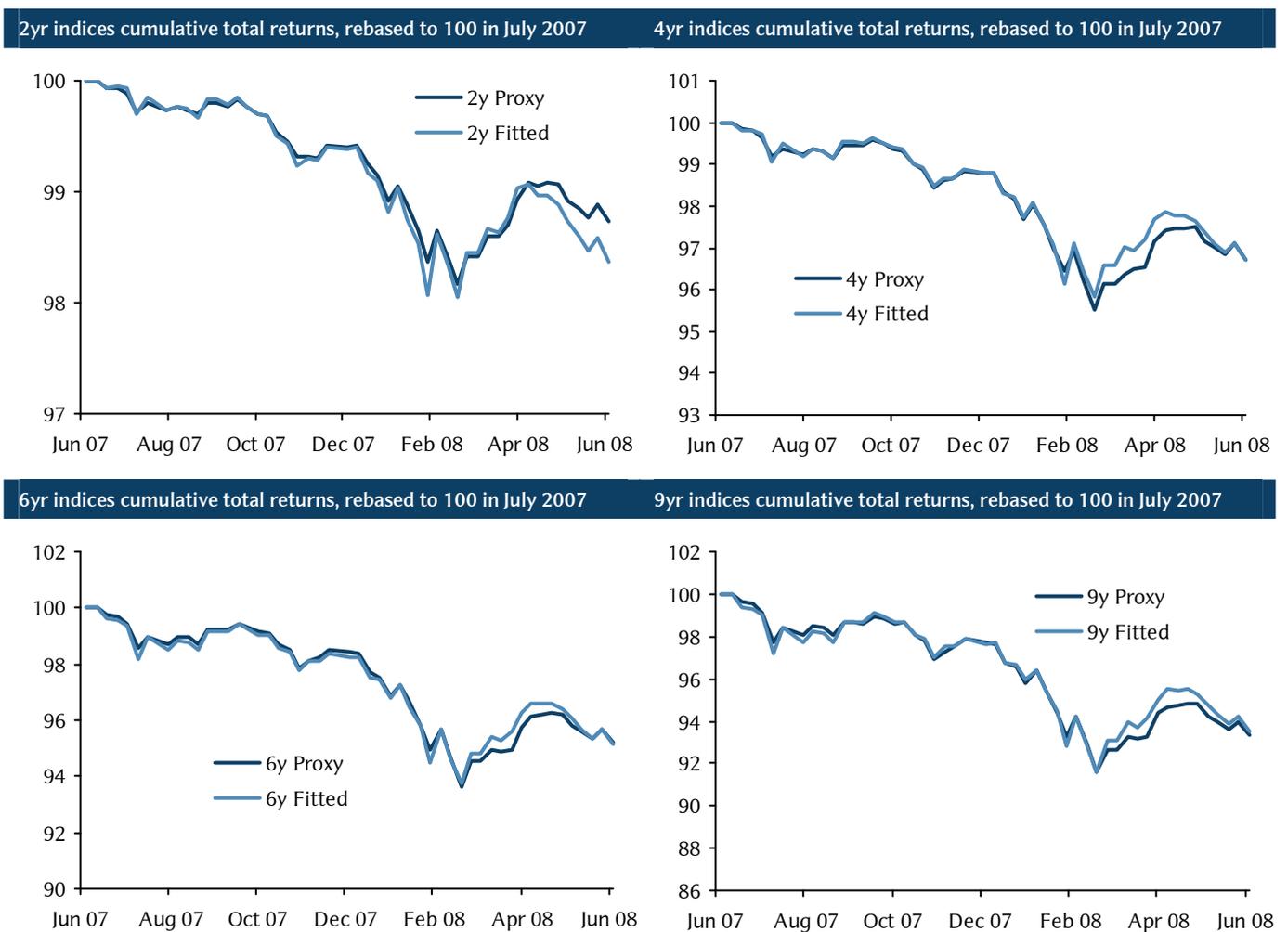
Source: Markit, Barclays Capital

More formally we can look at the correlation of weekly total returns on the proxy indices versus the theoretical indices. The results of this are shown in Figure 222. The 3yr, 5yr, 7yr and 10yr points are included for completeness but are exactly matched by the on-the-run index. The other tenors are matched surprisingly well on this basis, with all correlations bar the 1yr above 90%. It is not too surprising that the quality of the tracking is weaker in the 1yr as the data quality in this part of the curve is very low. We note that this period is one of extreme volatility, and so this good tracking performance is all the more encouraging.

As discussed before, the performance of tracking like this will inevitably be affected by idiosyncratic spread movements in underlying names that differ across series. While this may be problematic we discussed possible solutions, including single-name hedging of problem credits in the first section of this report.

Figure 222: Correlations of returns on proxy indices with theoretical fitted index returns –weekly data, July 2007-July 2008
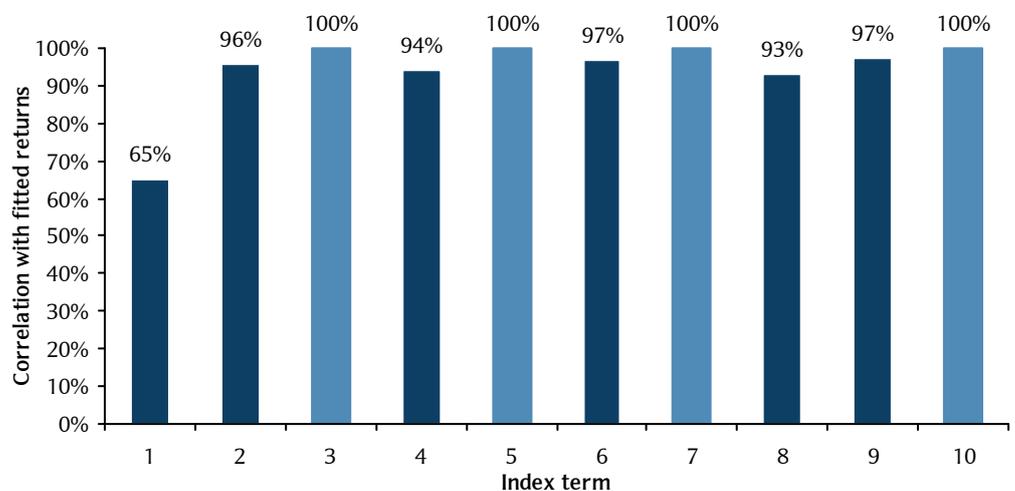
Source: Markit, Barclays Capital

Why complete the term structure?

So why bother to complete the term structure in this way? In fact, there are several applications, including:

- Better maturity-matched hedging strategies

- Optimising efficiency of long and short positions

- Interest-rate swaps style curve strategies, for example with forwards.

Although in-depth analysis of these topics is beyond the scope of this publication, we discuss the basics of the second two points here.

Optimising trades

Figure 223 presents a selection of indicative trade 'efficiency' metrics for considering optimal term structure points for implementing long or short positions. These are not comprehensive considerations however – in particular, constituent differences between the indices and curve risk must be taken into account when deciding on an actual trade.

The efficiency metrics we use are:

- For long credit-risk positions intended to generate income, the carry and roll-down expected to be earned per unit of mark-to-market volatility expected to be

sustained. The greater the income per unit vol, the more attractive that point of the term structure is to sell protection on.

- For short credit-risk positions designed as spread hedges, the cost in terms of carry and roll-down to be incurred per unit of DV01 protection provided against spread widening. The lower the cost of the protection, the more attractive that part of the term structure is to buy protection on.

This table is intended as indicative, but it highlights the possibility of optimising positions based both on maturity desired and the above metrics of efficiency.

Figure 223: Indicative metrics for selecting optimal long or short positions, 8 August 2008

Maturity	Proxy index	Current spread (bp)	Current DV01 (bp)	Approx carry and roll-down over one year (bp)	Annualised mark-to-market volatility (bp)	Effective cost of buying protection per unit DV01	Income from selling protection per unit volatility
1	Series 5 – 3yr	56	0.8	56	59	66.1	0.9
2	Series 7 – 3yr	71	1.8	72	89	40.9	0.8
3	Series 9 – 3yr	77	2.7	79	153	29.5	0.5
4	Series 7 - 5yr	95	3.4	97	211	28.6	0.5
5	Series 9 - 5yr	96	4.3	100	245	23.3	0.4
6	Series 7 - 7yr	107	4.8	111	272	23.1	0.4
7	Series 9 - 7yr	101	5.8	106	307	18.2	0.3
8	Series 5 - 10yr	111	6.0	116	351	19.3	0.3
9	Series 7 – 10yr	109	6.5	114	369	17.5	0.3
10	Series 9 – 10yr	105	7.8	111	389	14.4	0.3

Source: Markit, Barclays Capital

Forward term structures

The second application we discuss is in trading a full forward term structure of CDS spreads. In the interest-rate swap world, forward term structures are frequently used to express trades of various kinds. In the credit world, forwards are much less frequently used, despite offering some similar benefits. A full discussion of the benefits and technicalities of CDS forwards can be found in our publications including the *CDS Curve Trading Handbook 2008*, 6 November 2007, *Expressing views through forwards: iTraxx Financials vs Main*, 21 November 2007, and *Cheaper hedging using iTraxx Main forwards*, 26 November 2007.

Figure 224 gives some simple examples of theoretical forward curves priced from the on-the-run iTraxx Series 9 curve. In the left-hand chart we look at the theoretical 5yr Main spread starting in each of the forward years indicated. The 2008 number matches today's spot price. This chart essentially indicates how the market is pricing the evolution of 5yr spreads over the next few years. Spreads are 'expected'[13] to increase to around 130bp in three to four years before falling back.

The right-hand panel shows theoretical 1yr iTraxx Main spreads at each forward year. The pattern here is more dramatic, with a peaking of risk only in years five to seven, with spreads falling rapidly back to current levels by 2010.

As mentioned above, most credit investors do not trade the iTraxx term structure with these patterns in mind. However, by using tradeable proxies via the off-the-run indices, we can still position against any of the patterns seen here. For instance, it may be attractive to position for a recovery in 1yr spreads at a much shorter range than priced by the market – for instance in two to three years.

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[13] Here the term 'expected' really means expected on a risk-neutral or market-implied basis.

Figure 224: Forward term structures can provide insight into market's perception of default timing

Theoretical price today of iTraxx Main 5yr starting in different years	Theoretical price today of iTraxx Main 1yr starting in different years
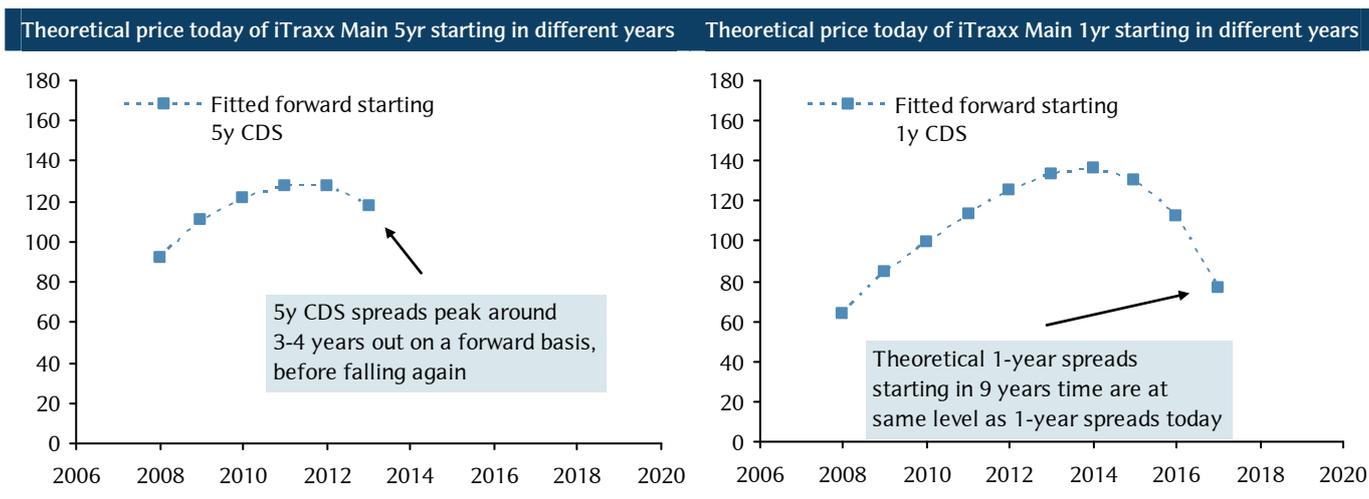
Source: Markit, Barclays Capital

Performance of forward proxies

We can test the performance of proxies on forwards in a similar way to those on the outright term structure points, by calculating theoretical fitted returns on forwards versus the proxies. In fact, for simplicity we mimic all forwards with equal-notional curve positions – eg, a 5yr CDS starting in three years time is modelled as a long protection position in 3yr versus a short protection position in eight years[14].

Figure 225 presents the performance. For forward 5yr CDS, the correlations are reasonable, with the 3yr forward starting the weakest with a correlation of 79%. Note that the 5yr forward can be exactly constructed using the 5yr and 10yr on-the-run indices so the correlation is 100%.

The performance of the 1yr CDS is weaker, unfortunately. Although some of the correlations are over 80%, other terms, the 5yr forward and 7yr forward in particular, show no relation at all to the theoretical returns. Overall, we would recommend further analysis in specific situations before implementing the 1yr forward proxies.

Figure 225: Correlation of returns of proxy forward protection positions versus theoretical

5yr CDS, n years forward – correlation reasonable overall	1yr CDS, n years forward – less convincing proxies
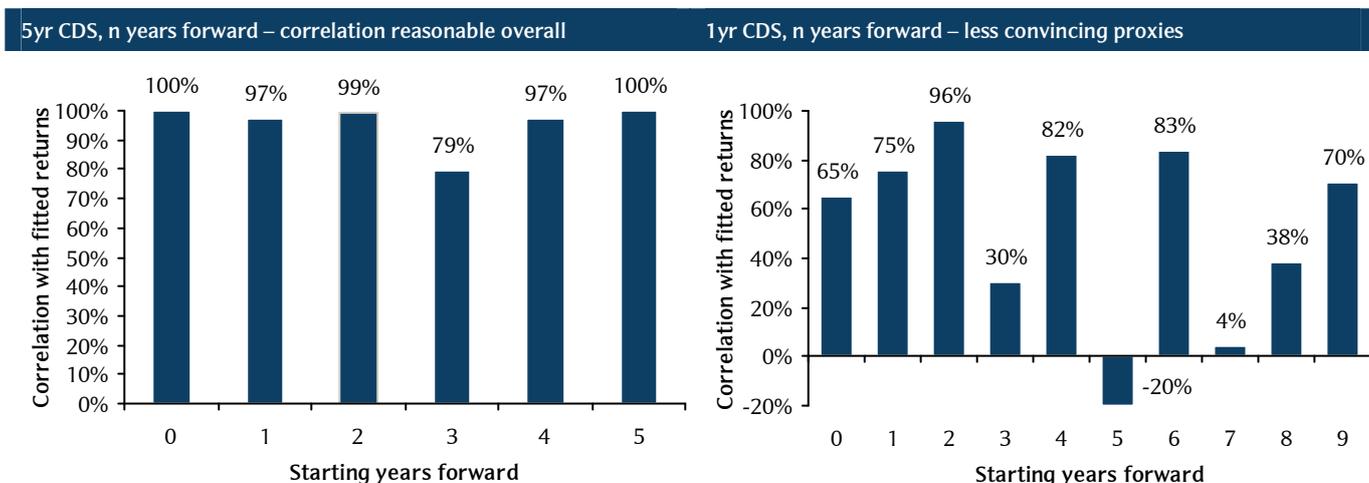
Source: Markit, Barclays Capital

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[14] *These approximations work well when curves are flat but may give different overall returns to a true forward in the case of non-flat curves, where the approximate strategy has non-zero cash-flows prior to the start date.*

Systematic hedging and replication

The use of CDS indices as hedging tools is a core application in the market today. The credit crunch period has, for the first time, drawn explicit attention to the performance of hedges of cash instruments with synthetic ones. The cash CDS basis has varied enormously in the period, adversely affecting hedging performance, and opening a myriad of questions on how hedges should be constructed and how they can be improved. A comprehensive analysis of hedging methods is beyond the scope of this guide. However, we present here the results of two recent studies. The first analyses performance of systematically hedging bond portfolios according to sets of rules. The second article looks at the related question of how best to replicate cash indices using synthetic indices. We note that both studies were published during the summer of 2008, before the period of most extreme volatility in September and October 2008. Look out for future research pieces updating performance for these months.

Hedging bond portfolios with CDS indices

Originally published as Hedging IG bond portfolios with CDS Indices*, 29 May 2008*

The use of CDS indices as a quick and cost effective way to hedge portfolios of corporate bonds has increased markedly in the past few years. The extreme volatility over the past nine months, not least in the CDS bond basis, has led many portfolio managers to question the usefulness of such hedges. In our original publication we take an in-depth look into this topic by empirically testing hedging performance on large samples of historical bond portfolios. In this article we reproduce a brief synopsis of our findings. The key results are summarised below:

- A CDS index overlay is an effective way of reducing the volatility of a corporate bond portfolio, typically by 30-70% when observed on a monthly returns basis.

- Hedging effectiveness varies substantially over time. Perhaps surprisingly, performance was strong during the credit crunch period, provided that hedge ratios were chosen carefully. For typical bond portfolios, volatility reduction is around 30-40% in benign periods and 50-70% in times of market stress.

- We find monthly rebalancing to be more effective than static hedges, although not dramatically so. In fact, static hedges might outperform in periods of high volatility.

- The performance of the hedge falls when the bond portfolio differs substantially in composition from the iTraxx index, though by perhaps less than expected. In benign periods, the reduction in volatility is around 5-10% greater for portfolios that resemble the iTraxx compared to those that do not. In times of market stress it can be 20-30% better.

- Finally, the performance of hedges can be increased by using a better-matched index, although some sub-indices appear more useful than others. Figure 226 provides a summary of our findings from empirical testing.

Figure 226: Which indices are useful for hedging bond portfolios?

Bond portfolio composition description	Alternative hedging strategies tested				
	Main 5yr	Main 10yr	HiVol 5yr	Sen Fin 5yr	Sub Fin 5yr
General bond portfolio	✓				
Long-dated bonds	✗	✓			
Very long-dated bonds (>10yr)	✗	✓			
Low-rated bonds (BBB)	✓		✗		
Financial bonds	✗			✓	
Subordinated financial bonds				✓	✗

Source: Markit, Barclays Capital

Why use CDS indices as hedges?

For most corporate bond portfolio managers, the ability to rapidly and cost-effectively reduce overall credit risk is highly desirable, especially in volatile times like we have seen during the credit crunch. CDS indices provide really the only practical tool for doing this, for those managers able to use them. Although usage in this regard is already widespread, the extreme volatility, especially in the bond-CDS basis, has raised questions around the viability and cost-effectiveness of CDS index hedges. Figure 227 shows some of the advantages and disadvantages of using CDS indices as hedging tools.

Figure 227: CDS indices as hedging tools for bond portfolios

Advantages	Considerations/risks
▪ Liquid credit proxy – CDS indices still provide the only liquid means to rapidly reduce credit risk.	▪ Cost – premium payments for index protection can be substantial and take away from portfolio carry.
▪ Low transaction costs – hedges can be added and removed or rebalanced cheaply, thanks to low transaction costs.	▪ Bond-CDS basis – various factors lead to sometimes substantial basis risk between synthetic and cash instruments, especially in volatile times.
▪ Trading sub-indices – the sub-indices provide a second level of granularity. The core of our analysis below examines how useful these sub-indices can be for general hedging purposes.	▪ Composition differences – bond portfolios can differ substantially in composition, (rating, maturity, and sector) from indices.
▪ Simple trading and administration – compared with single-name CDS hedges, indices simplify the hedging task, especially when mark-to-market is the primary concern and not default risk.	▪ Sensitivities change over time – hedge ratios do not remain constant, especially in changing market regimes.
	▪ Jump-to-default – index hedges will very rarely hedge losses on a default precisely. Single-name CDS must be used to achieve this – see below.

Source: Barclays Capital

iBoxx versus iTraxx: An index view of hedging bonds with CDS

Figure 228 presents a simple analysis to demonstrate the relationship between bond and CDS returns. The graphs plot excess returns on the iBoxx Euro Corporates Index versus returns on iTraxx Main on-the-run. In the left-hand panel returns are calculated on a monthly basis and on a daily basis in the right-hand panel.

Figure 228: Do iTraxx returns actually correlate with bond returns? Depends on the frequency of observation – here we look at iBoxx excess returns versus iTraxx Main 5yr returns, 2005-08

A: Monthly returns – a meaningful relationship with some correlation

$y = -0.1476x - 1.6426$
$R^2 = 0.6177$
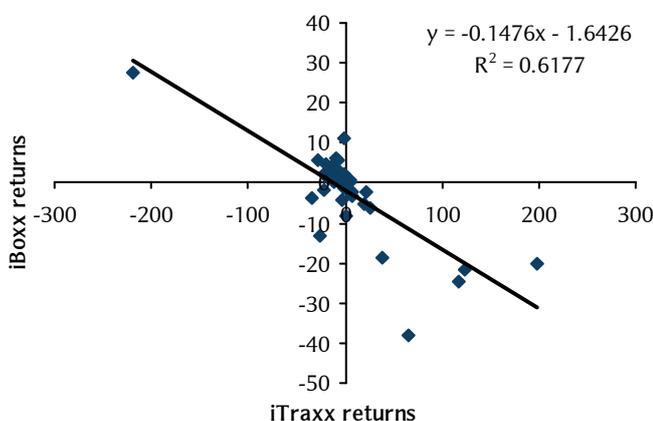
B: Daily returns – a meaningless relationship with no correlation

$y = -0.0416x - 1.2176$
$R^2 = 0.0039$
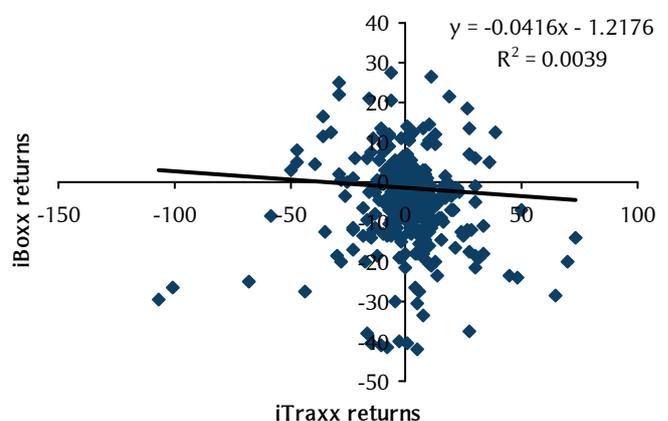
Source: Markit, Barclays Capital

For the monthly returns, the relationship seems fairly stable. The R-squared value suggests that 62% of the monthly P&L volatility of the iBoxx index was explained by the iTraxx over the period under consideration. In contrast, for daily returns, the low R-squared value of 0.4% indicates that hardly any of the daily P&L volatility of the iBoxx index was explained by the iTraxx.

These results show, at a basic level, that hedging using CDS indices has some merit, but only when the observation frequency is sufficiently low. Due to technical forces and different liquidities, day-to-day movements may prove to be uncorrelated. In the remaining analysis, we use monthly observation frequencies throughout.

Testing hedging strategies

This section presents results of the extensive empirical testing we have carried out.

Calculating hedge ratios

The starting point of any hedging strategy is the calculation of hedge ratios. Hedge ratios or betas are estimated empirically for sub-indices of the iBoxx Euro Corporate index, based on rating, sector and maturity. Full details of the methodology of calculating betas are covered in our original publication, *Hedging IG bond portfolios with CDS Indices*, 29 May 2008.

Hedging a portfolio using individual bond hedge ratios

The hedge ratio for a portfolio is calculated as follows:

- Individual bond betas are determined by matching bonds to the iBoxx sub –index on the basis of sector, rating and maturity.

- The portfolio beta is set equal to the sum of betas of individual bonds weighted by the price of the bonds in the portfolio at the start of the month.

- The hedge for the portfolio is implemented by buying protection on 5yr iTraxx with notional equal to beta multiplied by the price of the portfolio.

- The portfolio beta is recalculated at the beginning of every month, and the hedge is reset (later, we also test a strategy with a static hedge set at the beginning of the year).

As an example, let us consider a bond portfolio with similar sector/rating distribution to the iTraxx main index as in January 2006. Figure 229 tracks the P&L volatility of this portfolio through the next year, both before and after hedging.

Figure 229: Hedging a bond portfolio with iTraxx 5yr – example: hedged and unhedged returns
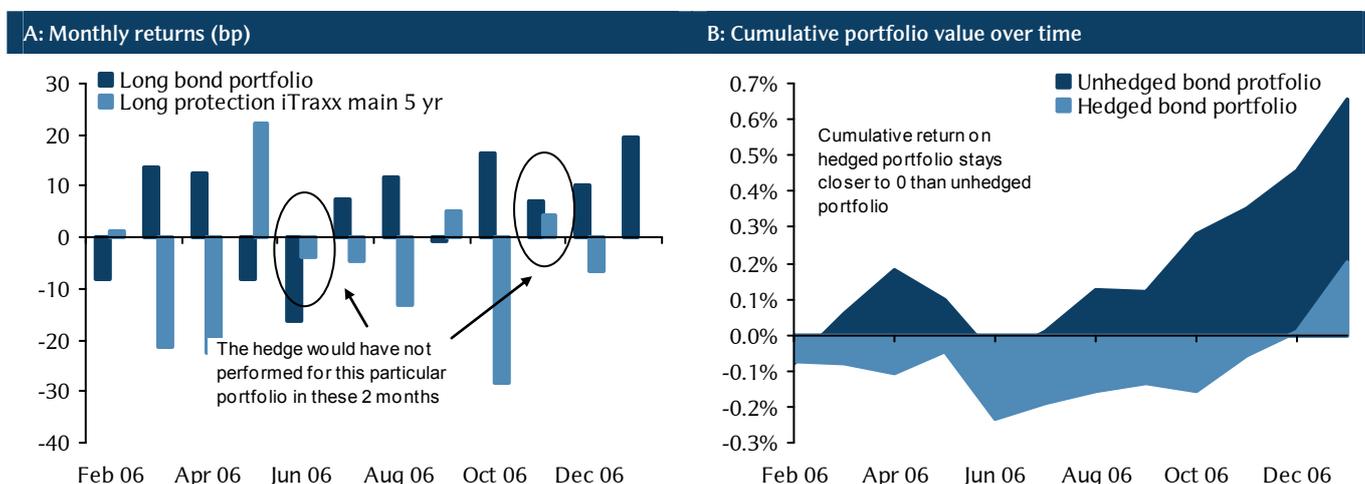
Source: Markit, Barclays Capital

The plot on the left indicates monthly returns for being long credit risk through bonds, and short credit risk through the iTraxx main index. In most months, these returns are of opposite signs and in this case iTraxx seems a good hedge for the portfolio.

The plot on the right indicates the cumulative returns of the portfolio before and after hedging. As the purpose of a hedge is to keep the value of a portfolio constant, the hedge seems to have been successful for this portfolio over this time period.

Generalising across similar portfolios

It is not possible to generalise the performance of any hedging strategy from the results of a single portfolio. Thus, for the purpose of testing we create multiple portfolios all of which have randomly-chosen constituents within certain constraints.

The hedge on each portfolio is determined as described in the previous section. Figure 230 plots the distribution of monthly performance for 1,000 portfolios (of 100 bonds each), all of which have a similar sector/rating profile as the iTraxx index itself. The portfolios were all chosen from bonds in the iBoxx index in January 2005, and the returns distribution plotted is for each month from January 2005 to January 2006 for each portfolio.

The two distributions analyse the portfolios both before and after hedging. Visually we can see that the hedged portfolio has a monthly return that is closer to 0bp than the unhedged portfolio.

Figure 230: Monthly performance distribution for a 1,000 portfolios
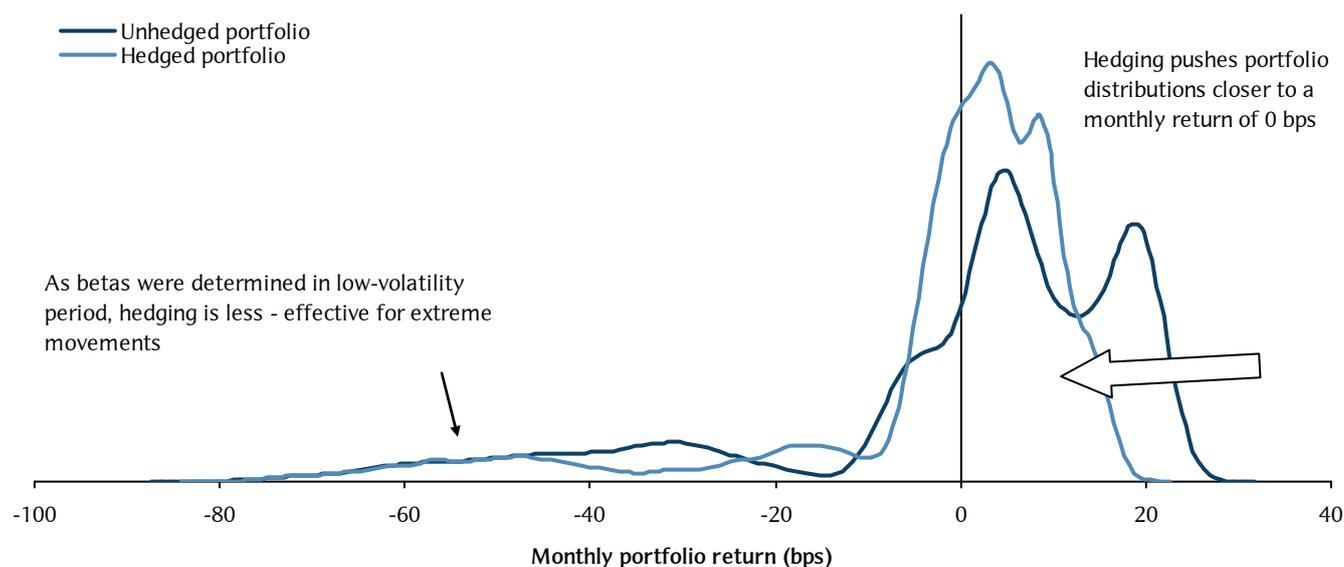
Source: Markit, Barclays Capital

Measures of hedge performance

It is not possible to come up with a universal measure of 'hedging effectiveness' that applies to every investor. Broadly speaking, however, the goal of the hedge will be to reduce overall volatility on the portfolio due to market moves.

For a robust estimator of hedge performance as well as an easy way to compare between two different strategies, we define two numerical measures for hedge performance. The measures attempt to answer the following questions:

Is a hedge effective?

An effective hedge will tend to reduce the P&L volatility of a bond portfolio. In fact, it will tend to reduce both positive and negative P&L towards an average of zero returns. Thus, we define the P&L volatility of a portfolio as the mean absolute deviation from zero. For a given bond portfolio:

$$P\&L \ volatility = \frac{1}{N} \times \Sigma \left| r_i \right|$$

where:

N = number of monthly observations

r_i = portfolio return on the "i"th month

We define the effectiveness of a hedge as follows:

Hedge effectiveness = percentage reduction in P&L volatility of portfolio

How much does a hedge cost?

Though a hedge might be effective, it may also be expensive to implement. As our strategies look at using the iTraxx indices to hedge bond portfolios, the carry paid on the hedging leg would be the cost of the hedge.

We define the cost-effectiveness of a hedge as follows:

Hedge cost effectiveness = hedge effectiveness/average monthly carry paid

For the 1,000 bond portfolios in Figure 230, hedge performance measures are as indicated below:

Figure 231: Hedge performance distribution for 1,000 portfolios resembling the iTraxx Index composition (January 2005 to January 2006)
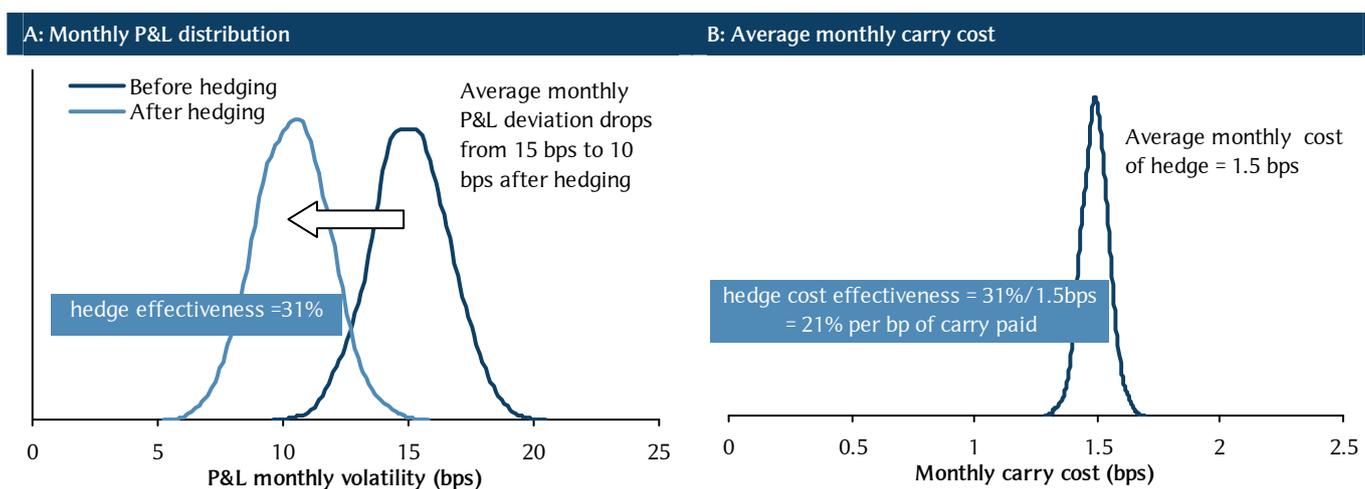
Source: Markit, Barclays Capital

Hedging tests

We now apply these techniques in a series of tests, which we summarise in Figure 232, and which all work under the same assumptions as above.

While we give a brief overview of the different tests and the conclusions that we arrived at in our original publication, *Hedging IG bond portfolios with CDS Indices*, 29 May 2008, we analyse each test individually.

The tests highlighted in Figure 232 are based on different compositions of bond portfolios based on sectors, maturity, rating and seniority. In each case, we have a base test (usually using the iTraxx 5yr index) and an alternative strategy designed to better match the portfolio constituents.

Figure 232: Summary of hedging strategies and tests

	Test description	Test portfolio composition				Alternative hedging strategies	
		Sector	Rating	Maturity	Seniority	Strategy 1	Strategy 2
	Tests measuring efficacy of using different iTraxx sub – indices to hedge bond portfolios of different compositions						
1	Test hedging of bond portfolio similar to iTraxx main	Non-fin: 80% Fin: 20%	AA: 10% A: 45% BBB: 45%	3-7yr	Senior	iTraxx 5yr	–
2	Test hedging of randomly-chosen bond portfolio	–	–	≤10yr	Senior	iTraxx 5yr	–
3	Test hedging of bond portfolios with long-dated bonds	–	–	≤7yr: 25% 7-10yr: 75%	Senior	iTraxx 5yr	iTraxx 10yr
4	Test hedging of bond portfolios with very long-dated bonds (>10yr)	–	–	≤7yr: 25% 7-10yr: 50% ≥10yr: 25%	Senior	iTraxx 5yr	iTraxx 10yr
5	Test hedging of bond portfolios with low-rated bonds (BBB)	–	AA/A: 25% BBB: 75%	≤7yr	Senior	iTraxx 5yr	iTraxx HiVol 5yr
6	Test hedging of bond portfolios with financial bonds	Non-fin: 25% Fin: 75%	–	≤7yr	Senior	iTraxx 5yr	iTraxx Sen Fin 5yr
7	Test hedging of bond portfolios with subordinated financial bonds	Non-fin: 25% Fin: 75%	–	≤7yr	Non-fin: Sen Fin: Sub	iTraxx Sen Fin 5yr	iTraxx Sub Fin 5yr
	Tests measuring efficacy of different hedging characteristics – re-hedge frequency and extreme versus average volatility						
8	Test hedging of bond portfolio similar to iTraxx Main for different frequencies of rebalancing of hedges	Same as test 1				iTraxx 5yr Dynamic hedging	iTraxx 5yr Static hedging
9	Test hedging of bond portfolio similar to iTraxx Main for reduction of extreme volatility as opposed to average volatility	Same as test 1				iTraxx 5yr MAD measure	iTraxx 5yr RMS measure

Source: Barclays Capital

For each test defined above, we generate a set of 1,000 portfolios (each of 100 bonds) all chosen randomly from the iBoxx index. The portfolios replicate as closely as possible the composition given above for the particular test. Portfolios are generated at the start of every year since 2005, ie, one set each in January 2005, January 2006, January 2007 and January 2008.

We calculate the 'hedge effectiveness' and 'hedge cost effectiveness' measures, described in the previous section for all the generated test portfolios. Each portfolio is tracked just for one year. This is because expected deterioration of credit quality of individual bonds, reduction of bond maturities and other such factors will typically cause deviations from initial portfolio characteristics over time.

The following table provides a summary of the results of each of the tests.

Figure 233: Summary of results of hedging tests

| Test description | Alternative hedging strategies | | Test result |
	Strategy 1	Strategy 2	
Tests measuring efficacy of using different iTraxx sub – indices to hedge bond portfolios of different compositions			
1 Test hedging of bond portfolio similar to iTraxx Main	iTraxx 5yr	-	Hedges work better in highly volatile periods, but also cost more.
2 Test hedging of randomly chosen bond portfolio	iTraxx 5yr	-	In general, the iTraxx index is better at hedging portfolios that have a similar composition.
3 Test hedging of bond portfolios with long-dated bonds	iTraxx 5yr	iTraxx 10yr	Longer-dated (>7yr) bond portfolios are better hedged with iTraxx 10yr than iTraxx 5yr.
4 Test hedging of bond portfolios with very long-dated bonds (>10yr)	iTraxx 5yr	iTraxx 10yr	Very long-dated (>10yr) bond portfolios are better hedged with iTraxx 10yr than iTraxx 5yr.
5 Test hedging of bond portfolios with low-rated bonds (BBB)	iTraxx 5yr	iTraxx HiVol 5yr	Hedging lower-rated bond portfolios with Hivol seems to confer minimal advantages, both in high- and low-volatility environments but not enough to justify the higher costs.
6 Test hedging of bond portfolios with financial bonds	iTraxx 5yr	iTraxx Sen Fin 5yr	When financials drive market volatility, hedging financial bonds with iTraxx Sen Fin is preferable than hedging with iTraxx Main. Also, whatever index is being hedged with, it is preferable to treat financial bonds separately from non-financial bonds in any given portfolio.
7 Test hedging of bond portfolios with subordinated financial bonds	iTraxx Sen Fin 5yr	iTraxx Sub Fin 5yr	For hedging subordinated financial bonds, there is no strong reason to choose iTraxx subordinated financials over iTraxx Senior financials.
Tests measuring efficacy of different hedging characteristics: re hedge frequency and extreme versus average volatility			
8 Test hedging of bond portfolio similar to iTraxx Main for different frequencies of rebalancing of hedges	iTraxx 5yr Dynamic hedging	iTraxx 5yr Static hedging	Monthly rebalancing is generally more effective than static hedges, though not dramatically so. In fact in periods of high volatility static hedges might outperform dynamic hedges.
9 Test hedging of bond portfolio similar to iTraxx Main for reduction of extreme volatility as opposed to average volatility	iTraxx 5yr MAD measure[1]	iTraxx 5yr RMS measure[2]	In periods of high volatility an iTraxx hedge improves in its ability to reduce extreme fluctuations in returns of a bond portfolio.

Note: 1) Captures change in average portfolio returns volatility; 2) Captures change in extreme portfolio returns volatility.
Source: Barclays Capital

Replicating cash bond portfolios with derivatives

Originally published as Tracking the iBoxx through the credit crunch, *20 August 2008*

Arup Ghosh, Yuan Tian, Jose Mazoy

The past 12 months have seen the relationship between cash and derivative instruments diverge significantly, most prominently for credit. A cursory comparison of cash and derivative credit instruments, such as the iBoxx and iTraxx, suggests that the relationship between the two asset classes has broken down completely.

However, our analysis suggests that the relationship has changed rather than broken down. Before the credit crunch, the iBoxx and the iTraxx exhibited a contemporaneous relationship; during the credit crunch the iBoxx has lagged the iTraxx.

In our original publication we presented and analysed a strategy that tests this change in relationship through the synthetic reproduction of cash bond portfolios/indices using derivatives.

Here we reproduce the key elements of the strategy and our findings from that report.

Replicating the iBoxx

This publication focuses on reproducing exposure to the iBoxx indices. We concentrate on synthetic replication, ie, replication through derivative instruments only. In this section we provide an overview of the replication strategy, the iBoxx index itself and the different Barclays investable indices that we use for the replication.

Replication strategy: Returns disaggregation

The main exposures in any cash bond portfolio are interest rate and credit risk, and to replicate these we use interest rate and credit default swaps. The strategy works by explicitly modelling the IR and credit risks inherent in a bond index/portfolio, and replicating them separately. The final replication combines these two components.

Test portfolio: iBoxx Euro Corporates index

The iBoxx Euro Corporates index is widely accepted for benchmarking the eurozone investment grade bond universe, and we adopt it as a suitable test portfolio for our strategies. Figure 234 presents a time series of the iBoxx from Mar 05-Jul 08.

Figure 234: iBoxx Euro Corporates Bond index (as of July 2008)

No. of Bonds	1046
Market Value	891bn
Average Mod Duration	4.285yrs
Average yield	6.732%
Z Spread	156bp
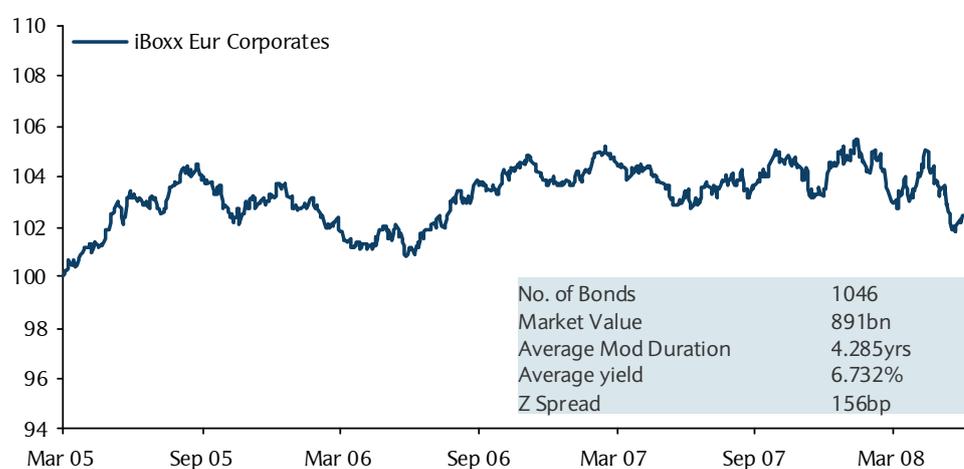
Source: Markit, Barclays Capital

Barclays investable indices

Barclays Capital produces investable indices based on liquid derivatives, such as the Barclays Capital Nominal Swap indices and Credit indices, which we use in our replication strategies.

The Barclays Capital Nominal Swap indices replicate the performance of investing in nominal interest rate swaps, while the Barclays Capital Credit index family replicates the performance of going long/short the iTraxx on the run series.

Measure of performance

Our analysis uses tracking error as the measure of replication performance. This measures how closely a portfolio follows the index to which it is benchmarked and is calculated as the standard deviation of the difference between the portfolio and index return.

Replication strategy

As explained previously, our replication strategy works by separately modelling the IR and credit risks. For this purpose, first, the cash bond index is itself split up into IR and credit components using z-spreads over swaps. Each component is then individually replicated by using either interest rate or credit default swaps. The final replication combines these two components. Figure 235 provides a schematic representation of the replication strategy.

Figure 235: Explicit modelling of IR and credit risk
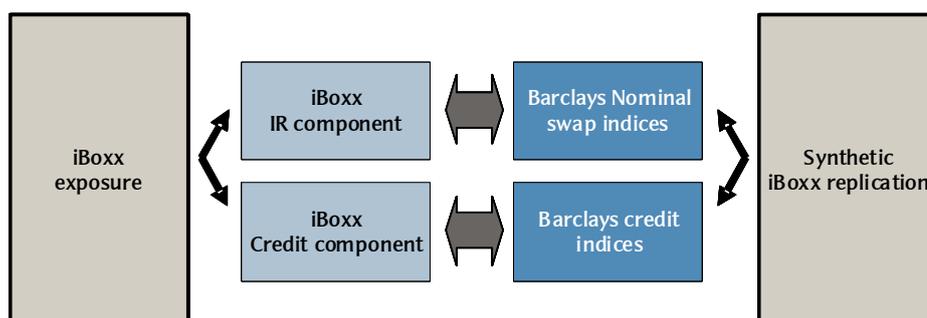
Source: Barclays Capital

This strategy's main advantage is that in times of stress, when the replication deviates from the iBoxx, it provides clear indications as to which component, credit or interest rates, is responsible.

Splitting up the iBoxx

Credit and IR components

In order to separate the components of the iBoxx, we use the z-spread of bonds as a proxy for credit spreads (premia). Using this, we can separate the interest rate and credit component as shown in Figure 236.

Figure 236: iBoxx split-up: IR and Credit components
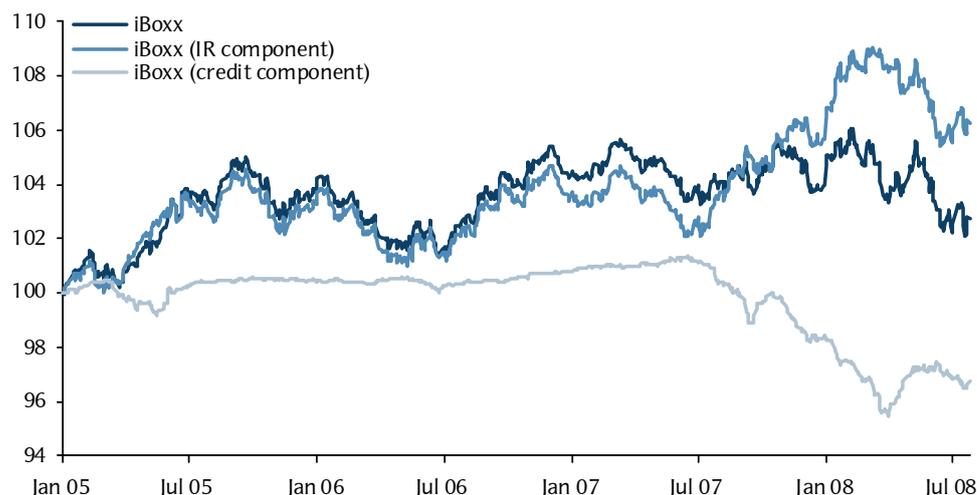
Figure 236 indicates that during the credit crunch the IR component outperformed the iBoxx. Also, as one would expect, the credit component exhibits very low volatility before the credit crunch, but underperforms dramatically during the credit crunch.

Obviously, this disaggregation of risk is approximate, but it is adequate for our purposes in this publication.

Replicating IR risk

Interest rate swaps provide the best means of replicating or hedging IR exposure, and our original publication *Tracking the iBoxx through the credit crunch*, 20 August 2008, analyses different methods of replicating IR exposure using the same.

Here we reproduce the results obtained through using a technique involving empirical estimation.

We use Barclays indices for the 5yr swap rate and the 2s10s steepener to replicate the performance of investment in swaps. The funding leg is replicated through Eonia.

Figure 237 plots the resultant IR replication together with the iBoxx IR component.

Figure 237: iBoxx IR component replication
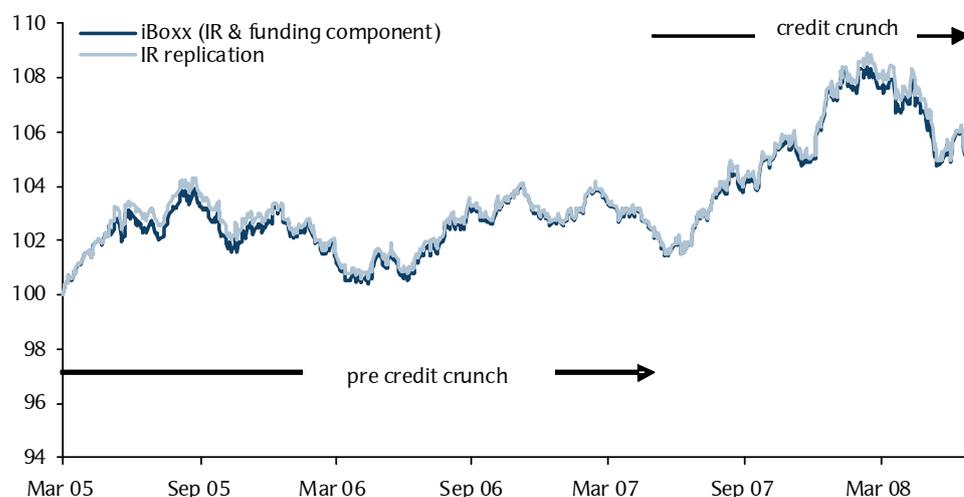
It is evident, even from visual analysis, that the replication closely mirrors the iBoxx IR component, both before and during the credit crunch.

Figure 238 plots the annualised tracking error of the replication *vis-à-vis* the iBoxx IR component.

Figure 238: Tracking error (bp) of monthly returns for iBoxx IR replication
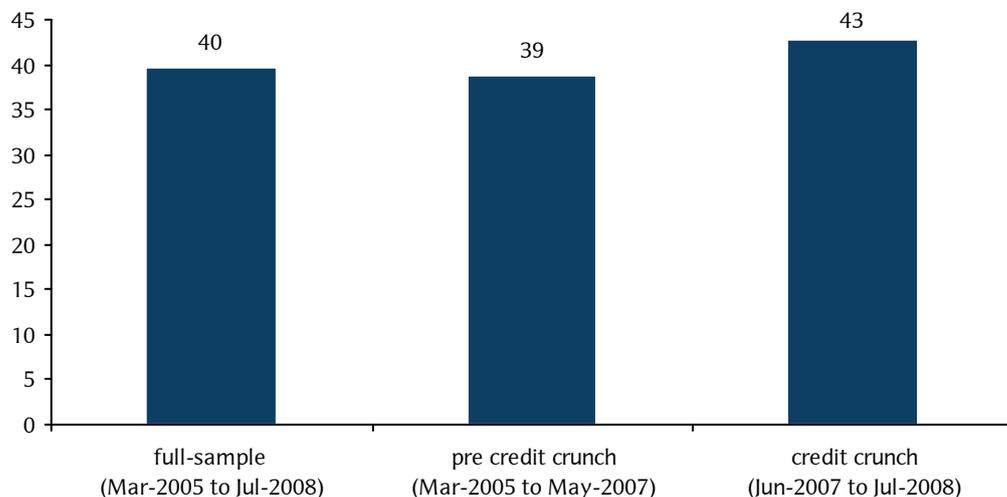
Source: Bloomberg, Markit, Barclays Capital

While we believe the tracking error of 40bp is acceptable, more than actual numbers, in this case, it is interesting to note the stability of replication, before and through the credit crunch. Thus, we can be confident that our strategy is successful in replicating IR risk.

Our original publication analyses other methods of replication, which bring down the tracking error for the IR replication to as low as 20 bps.

Replicating credit risk

CDS indices are generally accepted by the wider market as a liquid and cost-effective way to replicate credit risk. Thus, to replicate iBoxx credit risk, we use exposure to the Barclays credit indices (with the iTraxx as the underlying), weighted using the appropriate hedge ratio.

As PCA analysis of the iTraxx credit curve indicates that the 5yr point explains up to 98% of the volatility in the credit curve by itself, we only use that point for our replication. To derive the weight of the index to be used, we define the following long-term relationship to hold between the iBoxx credit component and the credit index in terms of returns.

$$\left[\text{iBoxx}_{\text{credit}}\right]^{\% \text{ returns}} = \alpha + \beta_0 \times \left[\text{Credit Index}_{5\text{yr}}\right]^{\% \text{ returns}} + \varepsilon$$

β_0 in the above expression is the required weight of the credit index to replicate credit risk. Solving for the regression (on weekly returns) over a rolling window of 52 weeks derives the time series for weights. The resultant replication is plotted in Figure 239.

Figure 239: iBoxx credit component replication
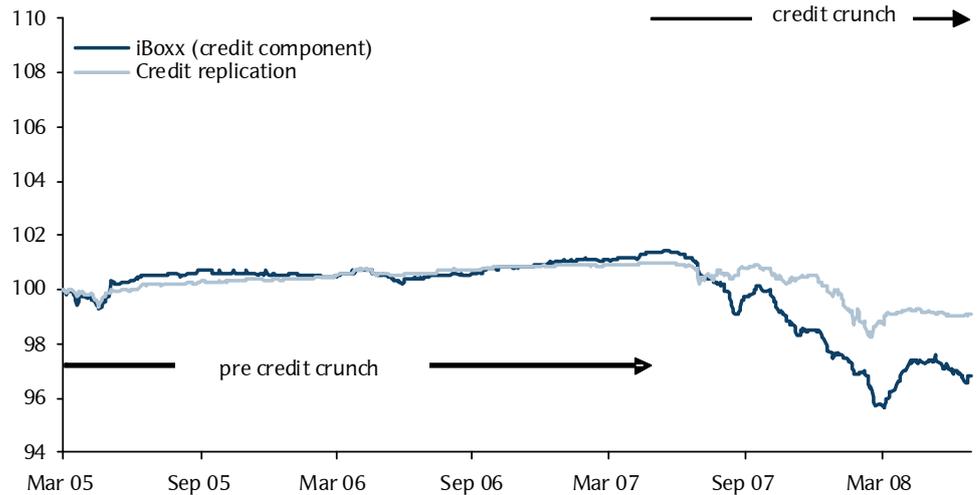
As we can see, the replication is far from ideal, especially during the credit crunch. In particular, it seems that the credit replication strategy is almost passive in the credit crunch period. This is borne out by the graphs in Figure 240.

Figure 240: Estimated weights of Barclays Credit indices for replication
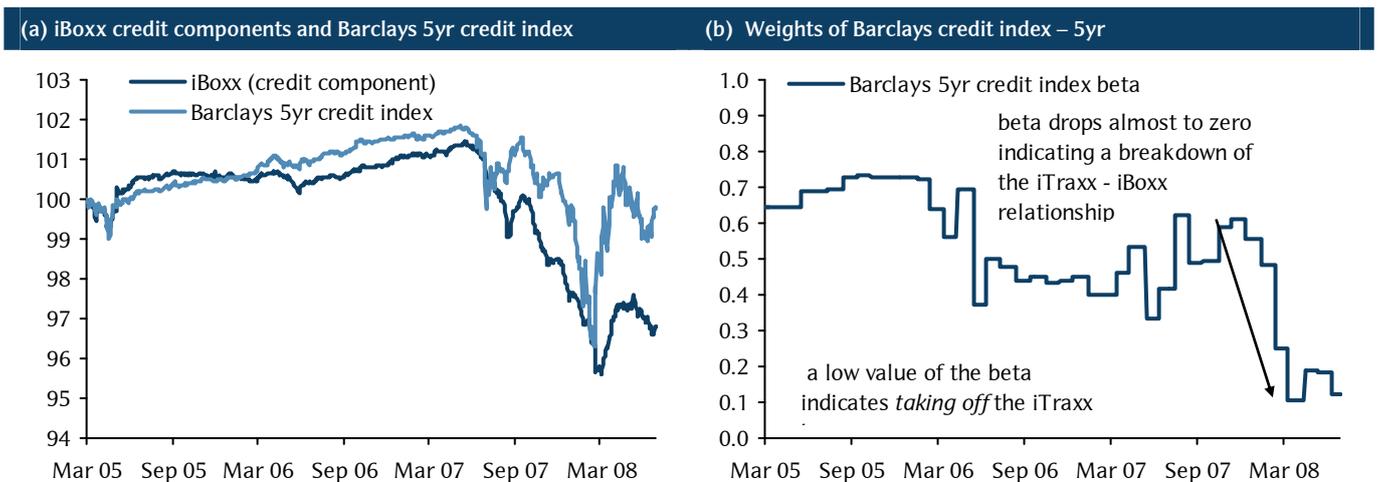
The plot on the right indicates the 'beta', or the weight of the iTraxx index used in the replication. This drops sharply during the credit crunch, indicating that the relationship described above does not hold in this period. With the beta dropping to almost zero, it is equivalent to *taking off* the credit leg of the replication.

Figure 241 plots the tracking error for each of the credit and IR components. The credit replication is comparable in performance to the IR replication before the credit crunch and unsurprisingly, it performs quite poorly during the credit crunch. Thus, this strategy allows us to conclude definitively that it is the credit replication that breaks down and to quantify to what extent.

Figure 241: Tracking error (bp) of monthly returns for iBoxx credit and IR replications
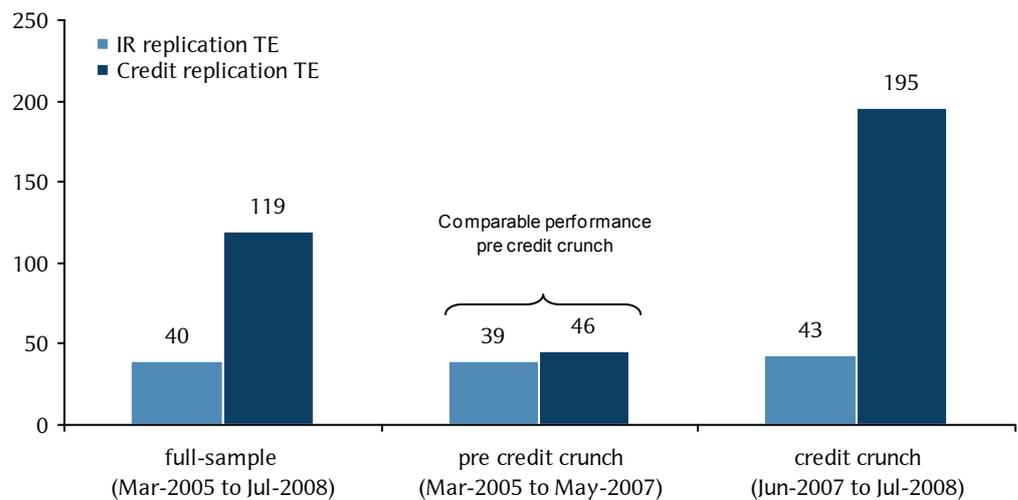
Source: Markit, Barclays Capital

Overlaying the IR and credit replications

Overlaying the credit and the IR replications allows us to create the full iBoxx replication as indicated in Figure 242. The latter shows that the replication performs well until the credit crunch, when it deviates quite a bit from the iBoxx. However, post-March 2008, the replication seems to track the iBoxx closely again.

Figure 242: iBoxx replication (aggregate)
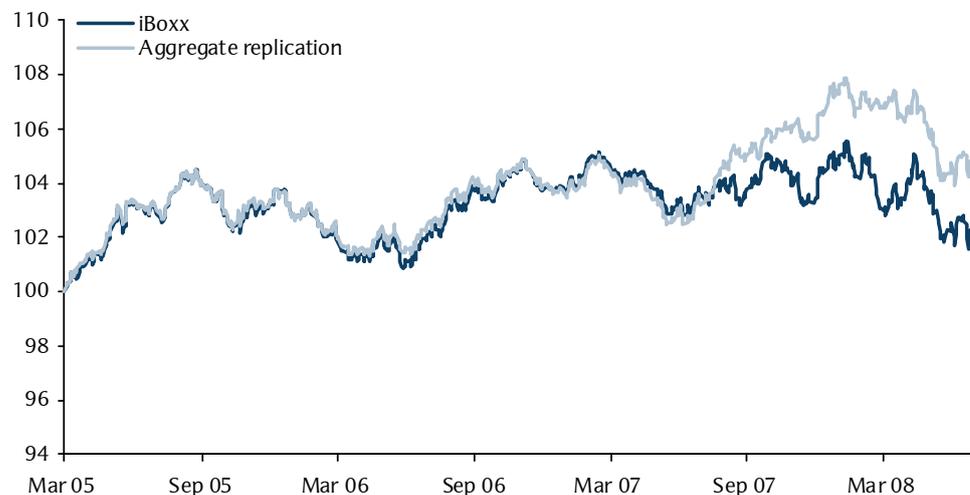
Source: Markit, Barclays Capital

Figure 243 compares the tracking errors of the IR and credit components versus those of the full replication. We can see that before the credit crunch the performance of the full replication and its components are very similar and quite good. During the credit crunch, the performance worsens because of the deterioration of the performance of the credit component.

Figure 243: Tracking error (bp) of monthly returns for the aggregate replication and components (Mar-05 to Jun-08)
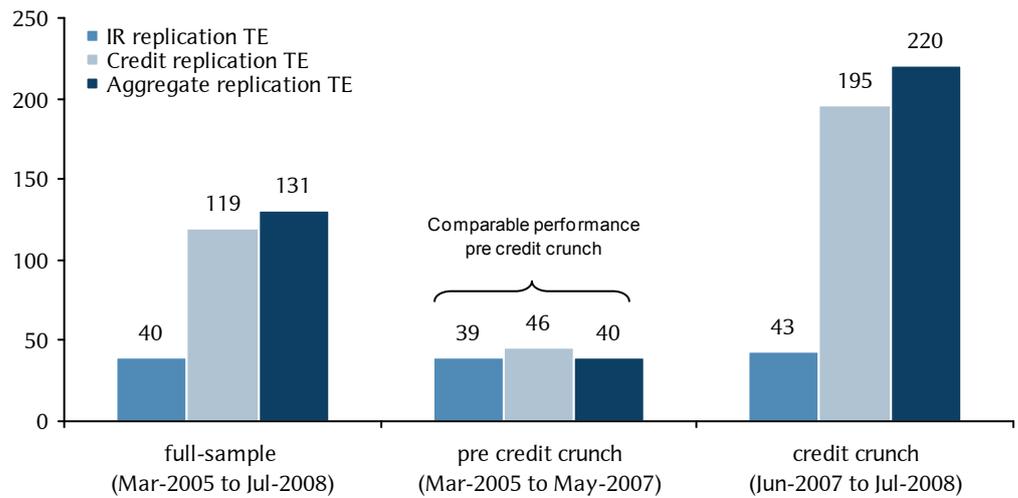
Source: Markit, Barclays Capital

Analysing the Credit leg further

In the previous section, our analysis suggested that the iTraxx is a poor proxy for the iBoxx credit component. In this section we investigate if this finding is accurate.

There are two main reasons for the previous replication to deviate from the iBoxx credit component:

- higher volatility of the iTraxx compared with the iBoxx credit component; and

- a lagging relationship of the iBoxx credit component compared with the iTraxx

These are highlighted in Figure 244a and Figure 244b.

Figure 244: The iBoxx (credit component) versus the iTraxx
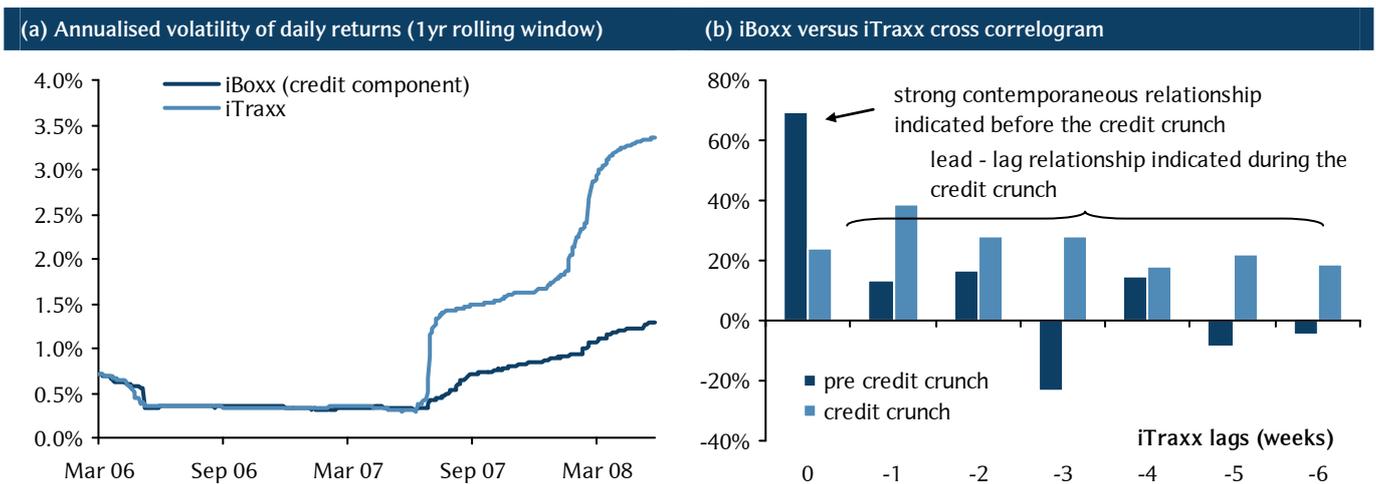
Source: Markit, Barclays Capital

The higher volatility of the iTraxx is immediately evident from the graph on the left above. The graph on the right plots the correlation of iBoxx returns to contemporaneous iTraxx returns, as well as iTraxx returns series that lagged by one-to-six weeks as indicated on the x-axis. The plot indicates a strong contemporaneous relationship between the indices before the credit crunch. After the latter a lead-lag relationship between the iTraxx and iBoxx seems to be in evidence.

Thus, we expect the iTraxx to be a bad proxy for the iBoxx credit component on a contemporaneous basis. However, over extended periods of time, we would expect the two series to move similarly.

A credit beta of 1

Following the previous analysis, we can reason that the iTraxx leg is going to improve replication performance over long time horizons. To test this, we analyse the performance of the replication with a beta of 1 imposed throughout and look at the tracking errors over a quarterly time horizon. Figure 245 summarises the results of these tests.

Figure 245: Comparison of credit replications; contemporaneous beta versus a credit beta of 1
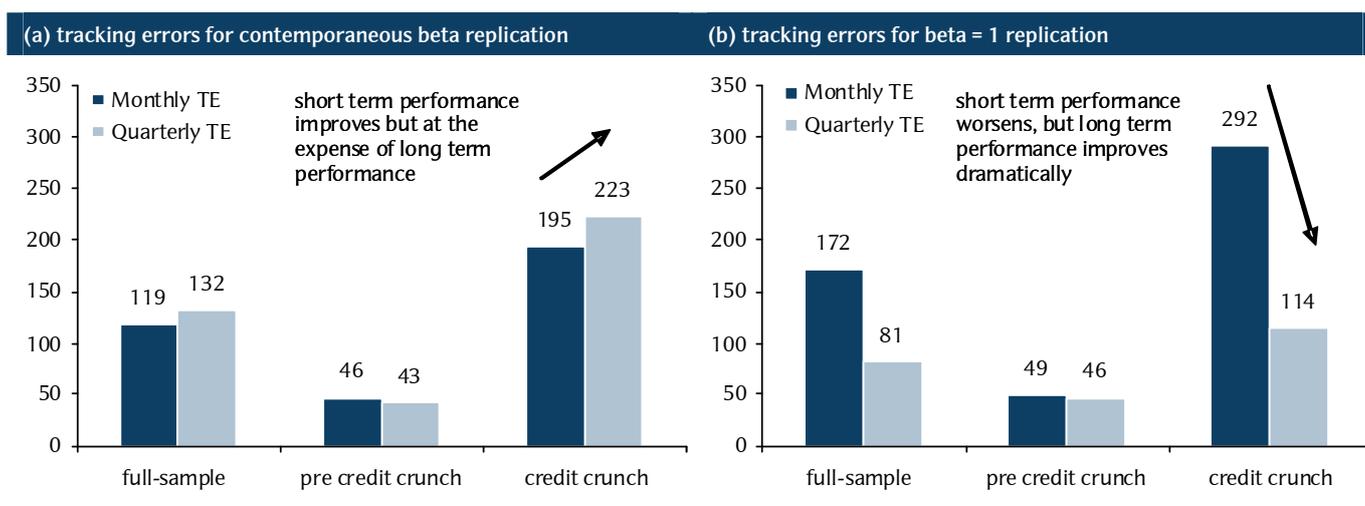
Source: Markit, Barclays Capital

The behaviour of the tracking errors in the plots in Figure 245 is very interesting. Using contemporaneous betas (which drop close to zero during the credit crunch) improves short-term replication at the expense of long-term replication.

In contrast, using a forced beta of 1 dramatically worsens short-term performance, but improves quarterly performance equally dramatically.

It should be mentioned here that the rationale for choosing a beta of 1 is driven by fundamental reasoning: as iTraxx is an index of European IG risk, in the long term it must display the same characteristics as the iBoxx credit component.

These results reinforce our previous contention that while the iTraxx might hinder the replication strategy when measured on short time horizons, it improves it over longer periods of time.

We see identical effects on the short- and long-term performances for the aggregate replication as well.

What beta to use for the credit leg?

As explained in the previous section, a beta of 1 for the iTraxx versus the iBoxx is justifiable on fundamental grounds – indices representing IG credit risk must behave similarly over long time horizons. However, this reasoning for a beta of 1, only works for broad indices, such as the iBoxx and the iTraxx, and would not be directly applicable to bespoke portfolios. Even for the iBoxx, we expect the actual (long-term) hedge ratio to be near 1, but certainly not exactly so.

Thus for a more generic strategy, we need to redefine our calculation of the credit beta. We propose here one such strategy, although we leave the actual implementation to a later publication.

In the light of the lead-lag effects highlighted previously, we can redefine the relationship between the iBoxx and the iTraxx to take this into account. The following multi-variate expression can then be used to calculate the weights for the indices.

$$[\text{iBoxx}_{\text{credit}}]^{\%\,\text{returns}} = \alpha + \sum_{i=0}^{-N} \beta_i \times [\text{iTraxx}_{\text{lag}=i}]^{\%\,\text{returns}} + \varepsilon$$

This expression helps to capture both the contemporaneous as well as the lagged effects of the iTraxx on the iBoxx. We consider lags from 1 to N weeks. The value of 'N' would of course depend on further analysis identifying the most significant lagged time series that need to be taken into consideration.

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Indices: The basics

In this section we review some of the basics of the iTraxx and CDX indices. We assume throughout an understanding of basic credit default swap concepts and conventions. We focus in the initial sections on some of the technical aspects of index contracts that promote standardisation, which in turn leads to greater liquidity. We also cover many practical issues on how to calculate key sensitivities and values associated with standard trading activities.

The global index families

The complete family of tradable credit indices is now fairly large. Figure 246 shows a map of most of the major indices.

Figure 246: Tradable CDS indices – global map by quality and region

Credit Quality		Region		
		Europe	US	Asia
High Grade	iTraxx Europe (Main) 125 IG credits	**iTraxx HiVol** 30 lower rated	**CDX IG** 125 IG credits / **CDX HiVol** 30 lower rated	**iTraxx Asia Ex-Japan** 50 IG credits
		Senior financials 25 senior financials		**iTraxx Japan** 80 IG credits
		Sub financials 25 sub financials		**iTraxx Australia** 25 IG credits
High Yield	**LevX** 75 1st lien + 45 2nd & 3rd lien credit agreements		**LCDX**	**iTraxx Asia Ex-Japan High Yield** 20 HY credits
			CDX Crossover 35 ex IG names	
	iTraxx Crossover 50 HY names		**CDX High Yield** 100 HY names	

Source: Barclays Capital

Widespread literature is available from Barclays Capital as well as from the index provider, Markit (see www.markit.com) on the precise composition rules and procedures used to determine the indices.

Trading conventions

The popularity of the iTraxx and CDX indices as hedging and trading instruments is largely due to the high level of liquidity and related low trading costs. This liquidity is a result of both the large number of market makers (more than 35 licensed on iTraxx, according to Markit) and the standardisation of the contracts themselves. In this section we discuss the different trading conventions that contribute to the standardisation of these products.

CDS index contracts – key facts

iTraxx and CDX index contracts are default swaps referencing a portfolio of names. Here is a summary of some key facts that hold across all the standard indices that we consider. We will return to many of the topics below later in this section.

- **Swap format:** Standard index trades are done as swaps and are therefore unfunded.

- **Reference portfolios:** These are set every six months, on or around 20 March and 20 September (the 'roll dates'), with the names selected according to Markit rules. Names referenced remain unchanged through the life of the trade, except in the event of a default, in which case the name is removed from the index, or a succession event such as a merger, where reference entities may change.

- **Weightings:** Reference names in indices all have equal weights.

- **Index series:** Contracts that reference different portfolios are referred to as series, with new series being created every roll date.

- **On-the-run series:** The on-the-run series is the current index series that has most recently been set. On-the-run series roll to off-the-run after six months, when the new contracts start.

- **Maturity dates:** Contracts have fixed maturity dates. For example the 5yr contract actually has a maturity date 5.25 years after the series starts, so the 20 March 2008 iTraxx series 9 5yr contract matures on 20 June 2013.

- **Term structure:** On most indices there are several terms that can be traded. All indices have a 5yr index. Some also have 3yr, 7yr and 10yr versions.

- **Premiums:** Contracts require the protection buyer to pay an annual basis point premium on the notional of the index to the protection seller. This premium is fixed at inception of the index. The notional may fall during the life of the trade as defaults occur.

- **Default payments:** On the default of a reference credit the protection seller pays the protection buyer an amount equal to (100% - Recovery value) x Notional of protection on single-name. The notional of the contract then reduces by 100% of the weight of that name.

- **Upfront payment:** At the inception of an index trade, the market spread of the index may be different from the fixed premium level. If the market spread is higher than the fixed premium, the protection buyer has to make an upfront payment to the protection seller to compensate them for the below-market level of premiums that they will pay. Similarly, if the market spread is below the fixed premium, the buyer receives a payment from the seller.

- **Early termination:** Index contracts can be unwound at any time. Usually a further payment (positive or negative) is made between counterparties to settle the difference between the fixed premium and market spreads at the time of unwind.

- **Flat curve convention:** For simplicity, all payment calculations associated with CDS indices are, by convention, done on the basis of a flat spread curve.

- **Recovery rate convention:** Likewise, a standard 40% recovery is assumed on all senior indices and 20% on subordinated indices.

- **Restructuring clause convention:** CDX indices use the no-restructuring clause (XR). iTraxx indices use the modified-modified restructuring (MMR) clause.

Maturity profiles and term structures

Because of contract standardisation iTraxx indices trade on constant maturity *dates* rather than constant maturities. Thus, for example, the actual maturity of an index contract with quoted maturities of five years changes from 5.25 years just after inception to 4.75 years just before the next roll-date in six months. It should be mentioned here that, while coupon payments are on the same dates for single-name CDS and iTraxx indices, single-names 'roll' quarterly on 20 March, June, September and December. This causes the actual maturity of single name and index contracts to diverge over different periods of time, as Figure 247 illustrates.

Figure 247: Maturity profiles – indices versus single-name CDS
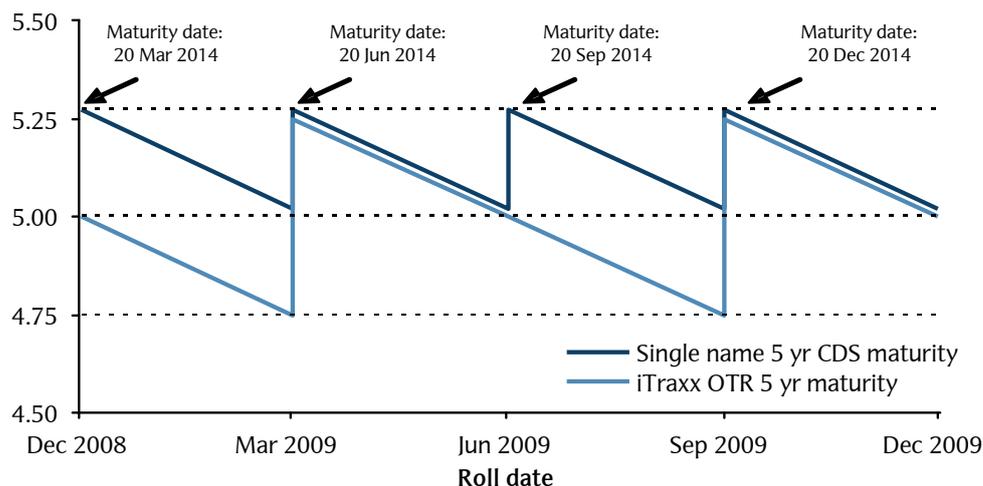
Note: the two series are slightly staggered for representational purposes.
Source: Barclays Capital

Available term structure points vary by index. Figure 248 outlines the different points trading currently along with a gauge of liquidity given.

Figure 248: Available term structure points by index

	3yr	5yr	7yr	10yr
iTraxx Main	✓	✓	✓	✓
iTraxx HiVol	✓	✓	✓	✓
iTraxx Crossover	✓	✓	✓	✓
iTraxx Senior Fin	✗	✓	✗	✓
iTraxx Sub Fin	✗	✓	✗	✓
CDX IG	✓	✓	✓	✓
CDX HiVol	✓	✓	✓	✓
CDX Xover	✓	✓	✓	✓

Source: Barclays Capital

Credit events and settlement

The credit default swap market uses physical settlement as the standard in cases of default for both single names as well as index trades. In practice, an auction process allows investors the choice of either physical or cash settlement – this is described below.

It is extremely unlikely that the whole index will default, but individual constituents might of course do so. To illustrate how recovery payments would be made in such a scenario, we look at the case of the hypothetical default of one of the constituents of iTraxx Europe Crossover. With 50 names, the weighting of each constituent in the index is 1/50 = 2%. The table below highlights the payments that would be made by the counterparties to the trade.

Figure 249: Credit event cash flows

Buyer of protection	The seller of protection
Pays coupon accrued till the date of default on 2% of notional	Pays 2% of notional
Hands in deliverable bonds of the defaulting entity with a face value of 2% of notional	
Subsequently on each coupon date, pays coupon only on a notional of 98% x 1 million	

Source: Barclays Capital

ISDA auction process

The liquidity and attractiveness of indices to express credit views, as well as their use in synthetic CDO transactions, has resulted in a situation where notionals of contracts often far outstrip the amount of outstanding cash bonds. In case of an actual default, this might lead to a shortage of deliverable obligations for buyers of protection. In fact there is even the possibility of a short squeeze distorting bond prices as protection buyers bid up recovery rates of physical deliverables.

Such concerns have led to the development of the ISDA auction process which allows an efficient clearing place for the market and gives buyers and sellers of protection the right to either physically or cash settle their exposures. Further details of the auction process are available from the Markit website, but we present here a very short summary of the operational details.

The ISDA auction following a credit event is a two-stage process allowing buyers and sellers of protection the option of either physical or cash settlement.

- In the first stage of the process dealers submit their bids and offers respectively for bonds/loans they are willing to settle physically. Matching trades are then netted off. The trades left over determine the open interest in the particular bonds (either to buy or sell bonds).

- The second stage, matches the open interest, and establishes the final price at which all other market participants can then cash – settle.

Credit event definitions

Also of significance is the contractual specification of what exactly constitutes a credit event for an entity. ISDA specifies a number of different possible credit events, illustrated in Figure 250:

Figure 250: ISDA credit event definitions

Credit event	Definition
Bankruptcy	Reference entity is either dissolved or becomes insolvent or is otherwise unable to pay its debts
Obligation acceleration	An obligation becomes due before it would otherwise have been because of a default
Obligation default	An obligation becomes capable of being declared due before it would otherwise have been because of a default
Failure to pay	Reference entity fails to make payments as and when they become due even after expiration of any applicable grace period
Restructuring	A change in terms of debt which are unfavourable to the creditor
Repudiation/moratorium	Reference entity or governmental authority challenges the validity of certain obligations (of an amount above the Default requirement)

Source: ISDA, Barclays Capital

Restructuring clauses

The restructuring credit event has been the subject of some debate in terms of the definition of what constitutes a restructuring. The 2003 ISDA definitions classify four types of restructuring clauses as summarised in Figure 251.

Figure 251: Summary of restructuring clauses

Clause	Description
No restructuring (XR)	Debt restructuring is not considered a credit event
Modified restructuring (MR)	Caps the maturity of deliverable obligations at the earlier of 30 months from restructuring date or the longest maturity of a restructured bond (but not earlier than the CDS contract termination date)
Modified restructuring (MMR)	Differs from MR in allowing delivery of obligations which mature up to 60 months from the restructuring date (for restructured debt, and 30 months for other deliverables)
Restructuring (R)	Any change in the amount of principal or interest payments, the postponement of the date of such payments, change in debt ranking or currency of payment is regarded as a credit event.

Note: These definitions are a brief summary – please refer to ISDA documentation for detailed legal definitions.
Source: ISDA, Barclays Capital

The CDX indices all use the XR clause. iTraxx indices use the MMR clause.

Trading off-the-run indices

This is an extract from *iTraxx off-the-run trading*, 14 August 2008.

From the perspective of relative value, as well as optimising directional or hedging positions, off-the-run indices offer a relatively unexplored extra dimension. Indeed, we believe that the choice of any single leg of any index trade should be considered along all three of the following dimensions:

1) Index: Main, HiVol, Senior/Sub financials, Crossover

2) Term: 3yr, 5yr, 7yr, 10yr

3) Series: 1-9

Every choice along these three dimensions presents a trade-off in terms of closeness of fit for application versus cost and liquidity. In this report we will be considering only Main, HiVol and Crossover – however, many parts of the analysis should also apply to the financials indices.

Idiosyncratic risk

One critical, and easily overlooked, element of trading off-the-run indices is that of changing constituents. The whole point of the index rolls is to approximately preserve credit quality of the underlying names. The period from mid-2004 to today has been one of relatively little idiosyncratic activity, at least in European single names, and certainly when compared with the 2001-02 period. However, as we move into the next stages of the credit crunch, and the expected economic slowdown, idiosyncratic risk in terms of downgrades and defaults is likely to increase substantially.

Every trade in an off-the-run index takes implicit bets on particular names, resulting in exposure to idiosyncratic risk. This is especially true when trading relative value between two different index series. Since rating migration tends to lead to dispersion in credit quality of time, the older the index series, the more critical this may become.

Handling constituent differences

The key to handling idiosyncratic risk will always come down to understanding the mismatches between names across indices. We believe the best approach is to link in fundamental analysis or other quantitative methods to understand the names in question. Indeed, some off-the-run index trades can be motivated on the grounds of the implicit basket trade of single names.

A second option is to hedge idiosyncratic risk on potential problem names (or even simply the widest trading names) using single-name CDS. Although this adds to the cost of any off-the-run strategy, the notionals involved are usually small because of the large numbers of names in the indices. In the interests of minimising costs, the 5yr point can be used as a proxy, even if the off-the-run index has a different maturity. For very short horizon trades, such as those discussed in the following micro trading section, idiosyncratic risks may be worth bearing un-hedged.

Off-the-run liquidity and trading conventions

Typically, index users will avoid off-the-run index positions because of reduced liquidity. While it is certainly true that outside the on-the-run and immediate off-the-run series liquidity is weaker, we are finding more frequent quotes in older series, especially around roll-dates. Figure 252 to Figure 255 show recent Bloomberg quotes from Barclays Capital's index trader, with various off-the-run index pricing available. There is a noticeable variability in both the availability of quotes and bid-offer costs, indicating different levels of liquidity.

In particular, as mentioned above, each of the three dimensions affects liquidity:

Main is always the most liquid index, followed by Crossover then HiVol.
The 5yr point is always the most liquid, typically followed by 10yr, 7yr and then 3yr.
The on-the-run index is most liquid and liquidity falls with each series.

Figure 252: The past two series remain liquid typically with daily quotes even in volatile market conditions

```
8/05 11:14:06
From: ●LIONEL JOURDAIN, BARCLAYS CAPITAL
     No Attachments
{BXCD5 <GO>}  RECAPS: mohsen.alizadeh@barcap.com STENT:38

Main 93¾ /94¼    HiVol 188/190  Xover 540/542

              Main          HiVol         Xover
S8/S9         5/5¼          20/22         -4/-1
S7/S8         -3½ /-3       4/6           38/43

3/5y          17/19         28/38         26/32
5/7y          4/4½          5/9           -9/-1
5/10y         8/8½          9/12          -15/-5
5/10y S8      10/10½        11/16         -12/-2
```

Source: Bloomberg, Barclays Capital

Figure 253: Full runs of off-the-run series are available but are quoted less regularly – here we have rolls and curves for iTraxx Main

```
6/19 13:21:30
From: ●LIONEL JOURDAIN, BARCLAYS CAPITAL
       No Attachments
{BXCD5 <GO>}  RECAPS: mohsen.alizadeh@barcap.com STENT:38405  M:07:

  USER     iTraxx Main curves and rolls - S3/S9
 PROFILE       5Y          5/7Y          5/10Y          Roll
          S9 84.75/85.25   6.75/7.25    12.00/12.50
  18      S8 79.75/80.25   8.25/9.25    13.25/14.25    4.75/5.25
          S7 81.75/82.75  12.25/13.25   17.50/19.50   -2.50/-2.00
          S6 78.25/79.25  14.75/16.75   19.00/22.00    3.00/4.00
          S5 75.75/77.75  17.00/20.00   22.50/25.50    1.50/2.50
          S4 72.25/74.25  19.50/22.50   28.50/31.50    3.00/4.00
          S3 63.50/66.50  20.50/23.50   34.50/37.50    7.75/8.75
```

Source: Bloomberg, Barclays Capital

Figure 254: Full runs on iTraxx Crossover are also available but bid-offer costs on older series rise noticeably

```
6/19 13:54:35
From: ●LIONEL JOURDAIN, BARCLAYS CAPITAL
       No Attachments
{BXCD5 <GO>}  RECAPS: mohsen.alizadeh@barcap.com STE

  USER     iTraxx Xover rolls and curves - S3 to S9
 PROFILE        5Y         Roll 5Y        5/10Y
          S9    484/486                    14/18
  18      S8  470.5/472.5    13/14       21.5/26.5
          S7    425/428    43.5/46.5     23.5/28.5
          S6  370.5/374.5  51.5/56.5       41/51
          S5    317/322    50.5/55.5       50/60
          S4    266/273    47.5/52.5       65/75
          S3  254.5/264.5     5/15         96/106
```

Source: Bloomberg, Barclays Capital

Figure 255: iTraxx HiVol off-the-runs are less liquid with infrequent quotes and relatively large bid-offer costs

```
7/28 11:53:14
From: ●LIONEL JOURDAIN, BARCLAYS CAPITAL
       No Attachments
{BXCD5 <GO>}  RECAPS: mohsen.alizadeh@barcap.com STENT:38405

  USER     iTraxx HiVol Rolls and curves
 PROFILE     Ref S9 177/179

  18                  5Y roll                        5/10Y
          S8/S9      18½ /20           S9           10/13
          S7/S8       4/6              S8          12½ /16½
          S6/S7       7/11             S7           15/19
          S5/S6       8/13             S6           21/25
                                       S%           27/31
```

Source: Bloomberg, Barclays Capital

Notes on trading conventions

The quoting conventions shown in Figure 252 to Figure 255 vary in form. Since much of the flow involving off-the-run series involves switching into the on-the-run, many of the quotes are on the basis of rolls. For example, in Figure 252, S8/S9 roll is quoted at 5/5¼. That is, the trader will pay 5bp running to protection sellers on series 8 to roll to series 9, while protection buyers will have to pay an extra 5¼bp running to switch into series 9. Equivalently, S8 can be viewed as trading 5.125bp tighter than S9 on a mids

basis. However, bid-offer may be wider when trading the off-the-run outright rather than as a switch. A similar story is true on the curve, where off-the-run 7yr and 10yr (and occasionally 3yr) points are more often quoted as curve packages (5/7yr, 5/10yr, etc). Liquidity in off-the-run 3yr indices appears to be much lower than other tenors.

Naturally, actual availability of quotes and transactable levels need to be confirmed with traders and will vary depending on market volatility as well as proximity to an index roll date, when activity in off-the-runs typically peaks.

Off-the-run info

Figure 256 provides a detailed summary of iTraxx Main on-the-run and off-the-run spreads, intrinsic spreads (the theoretical price of protection implied by the underlying single-name CDS), typical bid-offer levels and details of the top three widest names contained in the index. As mentioned above, taking note of different constituents is an important part of understanding the risks of any off-the-run trade.

Similar tables for iTraxx HiVol and Crossover can be found in Appendix B.

Figure 256: Current details of iTraxx Main series 1-9

Index	Term	Years to maturity	Market spread 23 July 2008	Intrinsic spread 23 July 2008	Typical bid-offer, where available	Top three names by 5yr spread
iTraxx Series 1	5	1.1	66	62	n/a	Boots
	10	6.1	n/a	112	n/a	Thomson Mul
						Nielsen
iTraxx Series 2	5	1.4	71	66	n/a	Boots
	10	6.4	108	111	n/a	Thomson Mul
						Nielsen
iTraxx Series 3	3	Matured	-	-	n/a	Boots
	5	1.9	77	77	3bp	Thomson Mul
	7	3.9	100	101	3bp	Nielsen
	10	6.9	111	115	3bp	
iTraxx Series 4	3	0.4	56	42	n/a	Boots
	5	2.4	84	85	2bp	Thomson Mul
	7	4.4	105	104	3bp	Nielsen
	10	7.4	114	115	3bp	
iTraxx Series 5	3	0.9	56	54	n/a	Boots
	5	2.9	85	87	2bp	Thomson Mul
	7	4.9	104	103	3bp	DSG Int.
	10	7.9	109	111	3bp	
iTraxx Series 6	3	1.4	60	64	n/a	Boots
	5	3.4	89	92	1bp	Thomson Mul
	7	5.4	103	105	2bp	DSG Int.
	10	8.4	106	112	3bp	
iTraxx Series 7	3	1.9	65	72	n/a	Boots
	5	3.9	90	95	1bp	Thomson Mul
	7	5.9	99	105	1bp	DSG Int.
	10	8.9	104	110	2bp	
iTraxx Series 8	3	2.4	67	70	1bp	DSG Int.
	5	4.4	89	89	½bp	UPM Kymmene
	7	6.4	94	98	1bp	Kingfisher
	10	9.4	98	103	1bp	
iTraxx Series 9	3	2.9	72	77	½bp	DSG Int.
	5	4.9	91	93	½bp	Rentokil
	7	6.9	97	100	½bp	Next
	10	9.9	101	104	½bp	

Source: Barclays Capital

Response to on-the-run

Naturally the main driver of spread changes in off-the-run series will be spread changes in the on-the-run series, reflecting overall credit risk premium. Secondary drivers will be the result of name-specific differences between the indices and curve effects because of the differing maturities.

Figure 257 shows charts of the spread-change betas for iTraxx Main and Crossover 5yr off-the-run indices to changes in the on-the-run spreads. Both charts show a similar pattern, whereby the beta is close to one for the immediate off-the-run series and gradually falls for the older series. These results present no surprises, but indicate that there is likely to be more relative value in the older series.

A corollary of this analysis is that older series will typically not react as violently as the on-the-run index in periods of high volatility. This lower vol may be an attractive property for certain investors, particularly those measuring income to volatility as a Sharpe ratio. We return to this idea in later sections.

Figure 257: Betas of changes in off-the-run spreads to on-the-run spreads over the past year
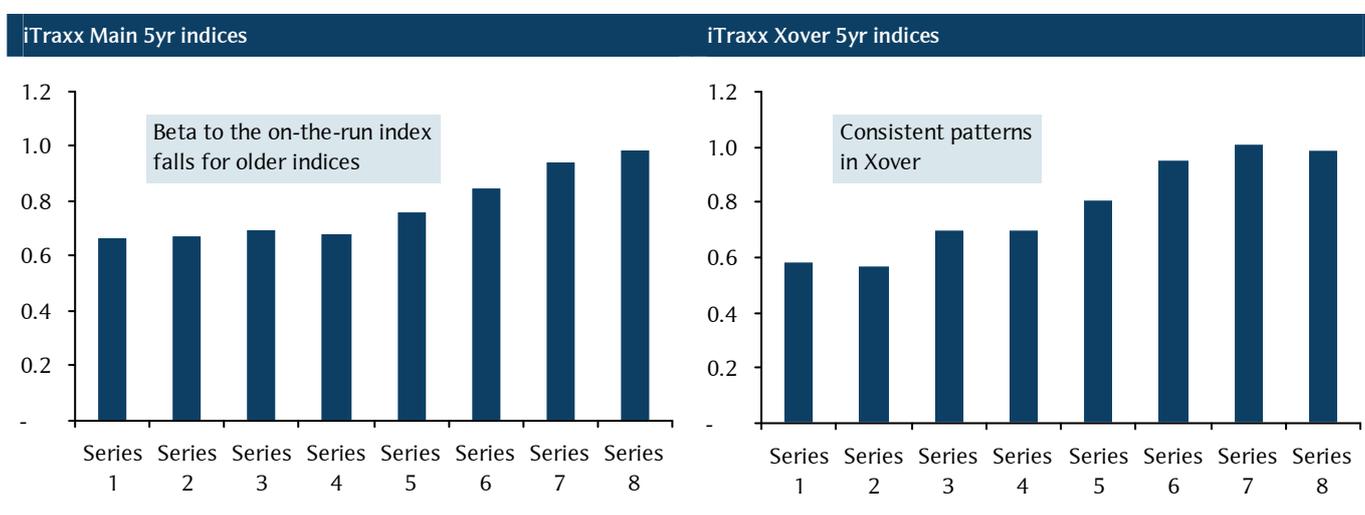
Source: Markit, Barclays Capital

Trading calculations

Upfront payments

Indices have fixed premiums that do not change with market movements. This makes them different in nature to standard credit default swaps as they will typically have a non-zero present value at inception. We refer to a swap with a non-zero present value as an 'off-par' swap, versus a par swap.

Since actual market spreads vary, initial payments must be made or received to compensate for the initial benefit to one of the counterparties. This initial payment is calculated simply as:

> **Initial payment = (Market spread – Fixed coupon)** *x present value of 1bp (PV01)*

where *S* is the current market spread and *C* is the fixed coupon. Obviously when current spread is higher than the coupon a buyer of protection *pays* upfront to compensate for the lower coupon that will be paid subsequently. When current spread is lower than the coupon a buyer of protection *receives* an upfront payment. This is further explained in Figure 258 and Figure 259. We consider hypothetical scenarios of an investor buying

protection on an index with a fixed coupon of 45bp, and different values of the current spread. The figures represent all relevant cash flows for each case, both the fixed coupon payment stream, as well as the differential between the fair value spread and the coupon. This set of differential cash flows are accounted for upfront at trade inception by taking the present value.

In Figure 258 we consider the scenario, where an investor buys protection on 5yr iTraxx series 8 at a spread of 65bp (fixed coupon = 45bp). Effectively, there is then an annuity of 20bp for the duration of the contract that the protection buyer needs to pay the protection seller over and above the fixed coupon payment. Thus the protection buyer makes a positive upfront payment as indicated.

Figure 258: Payment cash-flows for buying protection on iTraxx series 8 at 65bp (20 March 2008)
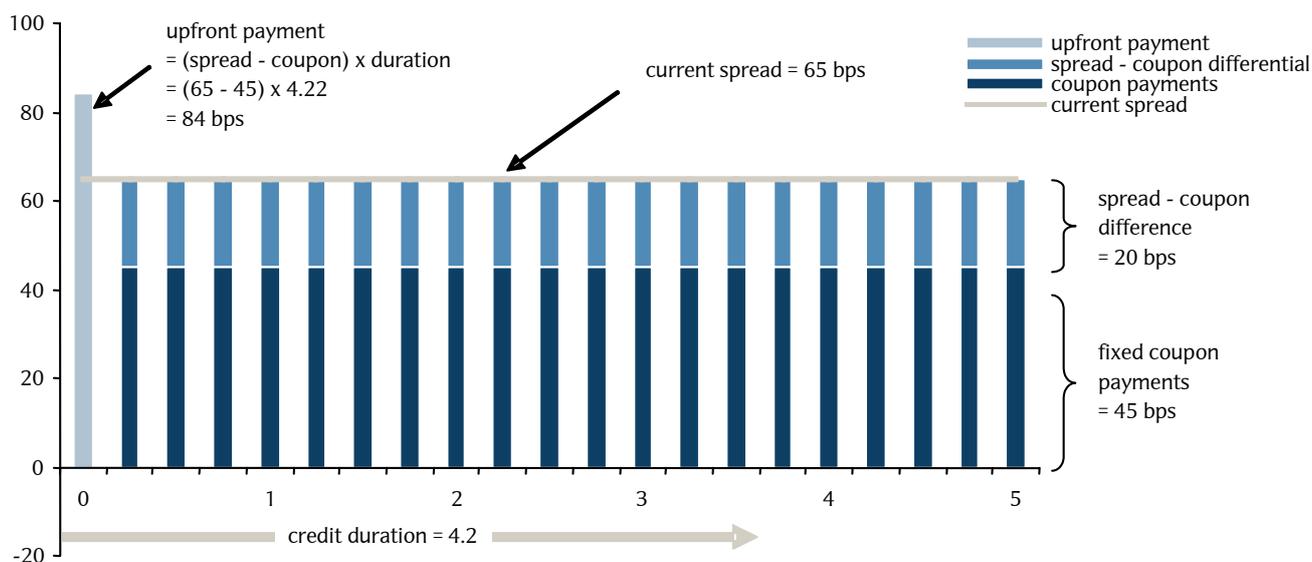
Source: Bloomberg, Barclays Capital

In Figure 259 we consider the scenario where an investor buys protection on an index at a spread of 25bp (fixed coupon = 45bp). This results in an annuity of -20bp for the duration of the contract. Thus the protection buyer *receives* a positive upfront payment as indicated.

Figure 259: Payment cash flows for buying protection on iTraxx series 8 at 25bp (20 March 2008)
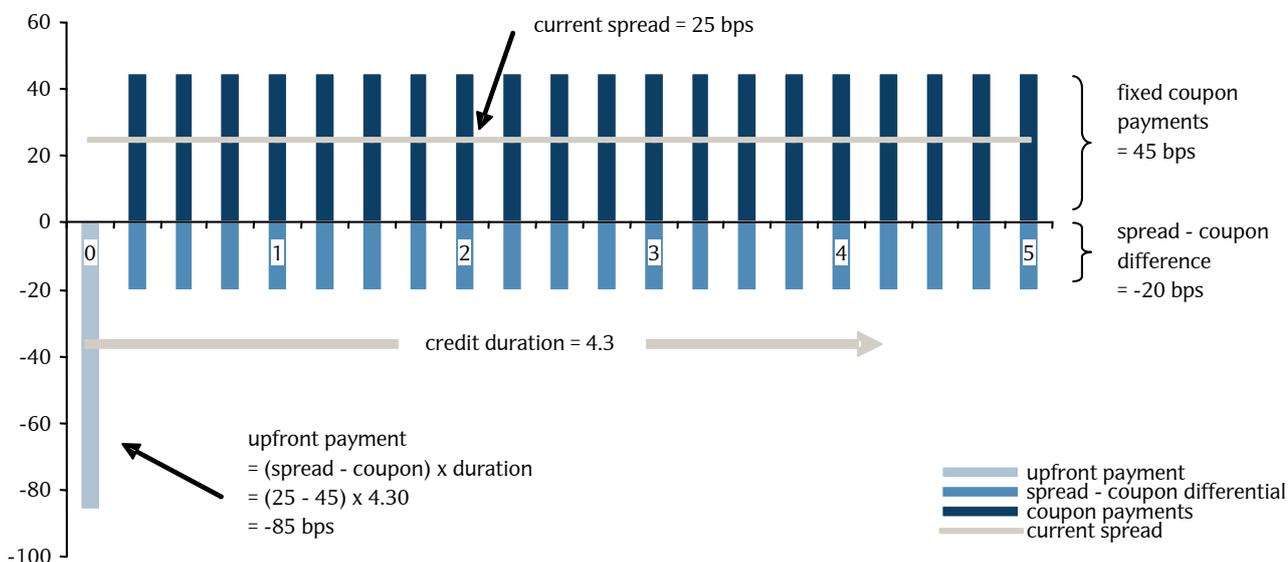
Source: Bloomberg, Barclays Capital

Note that the credit duration is slightly more in the second case, as the lower spread of basis points leads to a lower probability of default and thus a longer expected time to default.

Flat curve pricing conventions

One confusing convention in indices is the use of flat curves for pricing purposes. This is a convention that makes it easy to enter and exit trades, as there is no need for counterparties to agree on the full curve in order to determine the PV01, and hence using the formula above, the PV01, of the trade. By no means does it imply that index curves trade flat. Indeed, each term structure point can trade at any spread, but the PV01 of that particular contract is calculated assuming that the whole curve is trading at that spread. A technical consequence of this is that the implied hazard rate curves generated from flat curves at each term structure point are inconsistent. This has no economic impact.

Closing trades

The effect of the standardised contract terms described above is that investors need only two numbers to completely describe a trade: the maturity date, and the spread for contracts of that maturity. All other numbers are pre-determined for an iTraxx contract and are identical for all market participants. One important consequence of this is that index trades are usually closed out for cash and the contract essentially torn up rather than hedged using offsetting par swaps, as is typically done in single-name transactions. This has several benefits including:

- Transparent pricing: The closing spread wholly determines the final payment.

- No residual positions: In contrast to the use of offsetting swaps, there is no contingent residual position. The P&L on the trade is all cash.

- Cleaner book-keeping: Once terminated, contracts are essentially torn up and need not appear in any live trading book.

Calculating P&L

As in contract initiation, an upfront payment must also be made when an index trade is closed to account for the current market spreads. The P&L on a CDS index trade is therefore equal to the sum of all cash flows involved. Specifically this will include the initial and final payments, the accrued coupons, and any default payments made.

The example given in Figure 260 helps further explain this.

Figure 260: Illustrative index trade on iTraxx Europe S8
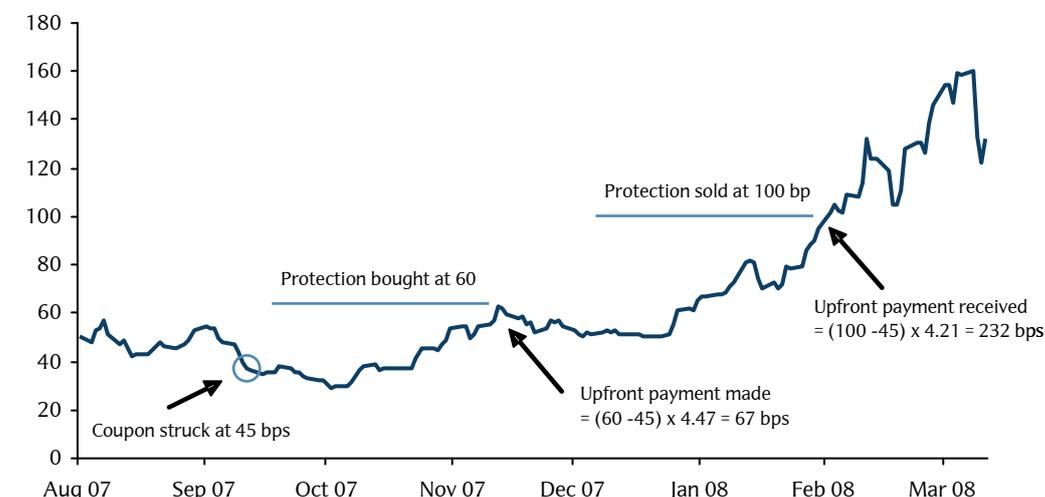
Source: Barclays Capital

This figure illustrates the case of a hypothetical investor entering an index trade at an initial spread of 60bp on 22 November 2007 and exiting it at 100bp on 8 February 2008.

P&L = Accrued Coupon + (Final payment – initial payment) + default payments

= 78/360 x 45bp + (232bp - 67bp) + 0 = 174.75bp

Note the Actual/360 day count convention. There were no defaults in this period.

Trading metrics

Here we review the main trading metrics used and discussed for risk management and trade evaluation. Many of these will be revisited in *Index calculations using Bloomberg* later in this section.

Carry

The term 'carry' is often a vague one and in the case of CDS indices this is certainly the case. Carry is often defined in some sense as the deterministic portion of the return on an asset, or the return if the market spread remains unchanged. In the case of a single-name CDS, annual carry is equal to the annual premium earned by selling protection, provided there is no default. Since single-name CDS are typically entered into as par swaps, this carry is also equal to the market spread. We distinguish between two meanings of carry in the context of CDS indices:

- Cash flow carry: This is the annual fixed coupon earned by selling protection on the index on the notional remaining in the reference portfolio. This is an actual cash flow amount. As already described, this fixed coupon amount may be different from the market spread.

- Effective carry: We define the effective carry as the market spread and ignore the fixed coupon. Most market participants referring to the carry on an index trade are using this definition of carry. However, it is *not* a cash flow.

It turns out that we can justify the use of the term effective carry in the context of the loose definition of carry as the return if market spreads remain unchanged. Suppose an investor sells protection at market spread S on an index with a fixed coupon C and unwinds after t years, during which time there are no defaults and the market spread remains unchanged. Then the return is (using the formula from the previous section):

Return $= t \times C - (S - C) \times \text{PV01}(0) + (S - C) \times \text{PV01}(t)$

$= t \times C + (S - C) \times (\text{PV01}(t) - \text{PV01}(0))$

$\sim t \times C + (S - C) \times t$

$= t \times S$

Here we use the approximation that the PV01 falls approximately linearly with time so that $(\text{PV01}(t) - \text{PV01}(0)) \sim t$. This shows that the return is approximately the effective carry as defined.

Roll-down

Roll-down measures the P&L that would be realised purely due to the decaying time-to-maturity of the different CDS legs assuming that the spread curve remains constant. Roll-down is just one potential P&L path. The roll-down is not linear with the horizon of the trade (unlike the carry) – the magnitude and sign of the P&L from roll-down can change with different trade horizons.

Calculating roll-down – an example

Roll-down has to be calculated for each leg of the trade separately. In Figure 261 we present an example calculation for the 5yr roll-down over six months on iTraxx 8 for a short €10mn protection position. The 5yr spread rolls down 5bp over six months. In order to calculate the return due to this roll-down, we need to know the PV01 after six months. Calculating this in Excel or from Bloomberg we get a 4.5yr PV01 of 4.17. Final roll-down for the 5yr position is €10mm x 4.17 x 5bp = €20,850.

Figure 261: 6mth roll-down computation on 5yr iTraxx S9 (1 Aug 08)
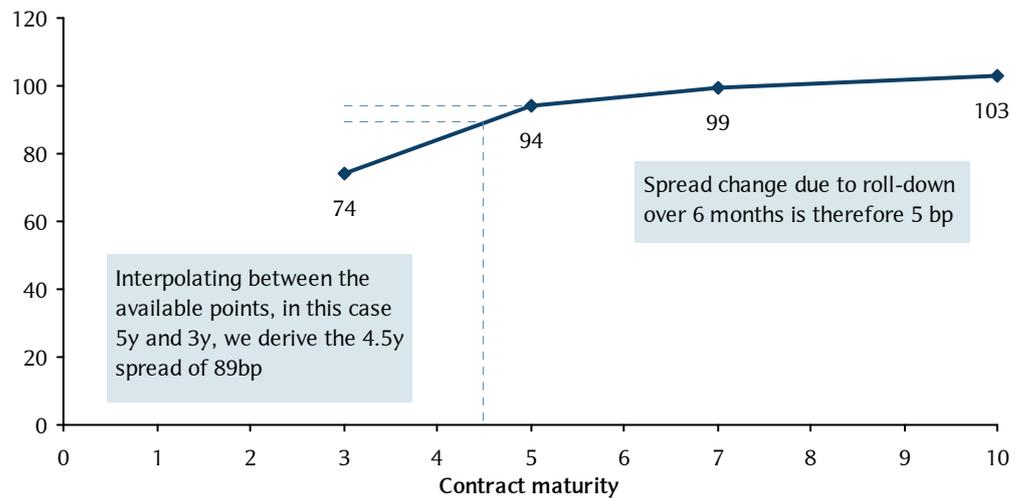
Source: Markit, Barclays Capital

Note that roll-down is a pre-trade metric of performance assuming the curve remains unchanged. Actual P&L will be based on the final spread curve at the trade horizon date.

Duration and delta (PV01/DV01)

It is important to distinguish between the credit duration (or PV01) and the delta (or DV01) of index contracts. For contracts at par (which would include most new single-name contracts) these two are the same. However, they can be significantly different for off-par contracts including almost all index contracts. We briefly define and describe these two parameters of a CDS contract.

Duration or PV01

Duration of a CDS contract, also termed as risky-PV01, commonly refers to the duration of the fixed (premium) leg.

Thus:

> **PV01 is the effective duration of a CDS contract adjusting for default risk**

Analytically PV01 is calculated as:

$$PV01 = \frac{1}{N} \sum DF_k \times P_k$$

where
　　　　　　　　　　　　　　N = coupon frequency;

　　　　　　　　　　　　　　DF_k = discount factor till the kth time period

　　　　　　　　　　　　　　P_k = survival probability on the kth period

This expression is the same as that for a risk-free duration but with an extra discounting factor given by the survival probability P_k.

Thus the P&L of a CDS position is given by the present value of an expected stream of cash flows given by the differential between current spread, and the contract spread.

$$PV = (S - C) \times PV01$$

For a contract at par, S is equal to C, and the above expression equates to zero.

Delta or DV01

The delta of a CDS contract, also termed risky-DV01, gives the expected change in P&L for a 1bp parallel shift in the underlying credit curve.

Thus:

> **DV01 is the P&L sensitivity of a CDS contract to parallel curve shifts**

This can be derived from the above expression for P&L of a CDS position as follows:

$$DV01 = \frac{\partial PV}{\partial S} = PV01 + (S - C)\frac{\partial PV01}{\partial S}$$

For a contract at par, S is equal to C, and thus DV01 and PV01 are identical. However, the further away from par a contract is, the more its sensitivity to spread change diverges from its credit duration as shown in Figure 262.

Figure 262: Delta and duration versus spread for 5yr iTraxx Crossover 9
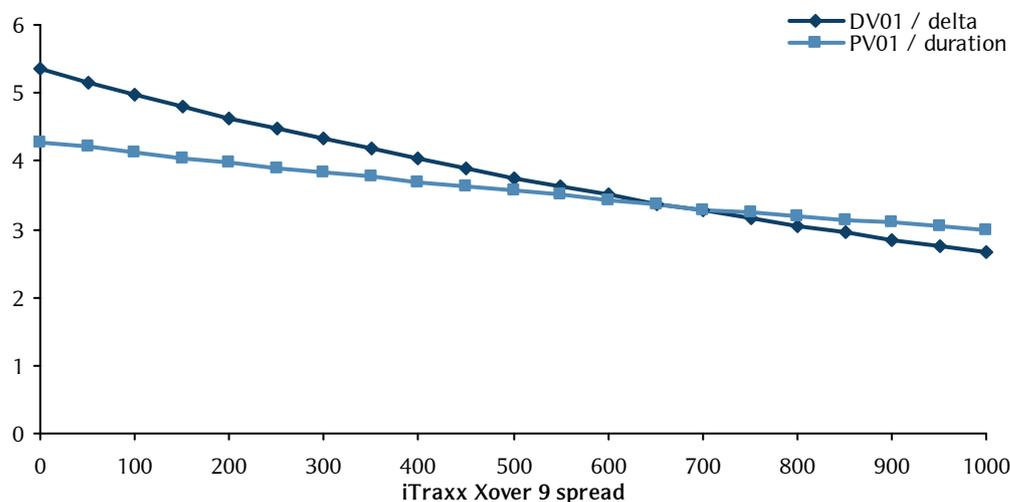
Source: Bloomberg, Barclays Capital

We highlight this difference between PV01 and DV01 for off-par contracts in the next section where we discuss the Bloomberg pricing function CDSW.

It should be mentioned here that the nomenclature used above is not unique, and different market participants sometimes use different terms for the same concepts. For example, CS01 or Credit Spread 01 is another often-used term for DV01.

Convexity

Convexity turns out to be an important effect in curve trades. The term 'convexity' in the context of CDS trades refers simply to the fact that the DV01 of a contract changes

as spreads change. This becomes important for curve trades as the DV01-ratio also changes, leaving positions potentially over- or under-hedged.

Convexity is sometimes thought of as a secondary effect in terms of P&L. In curve trades, however, convexity effects become much more pronounced compared with only selling or buying protection. The magnitudes for the iTraxx Crossover index are given as an example in Figure 263. Convexity is also more significant for higher spread names/high volatility scenarios. As a rule of thumb, any P&L scenario that involves a 5yr spread change of more than 100bp, convexity should be taken into account.

Figure 263: P&L effect of convexity of a 5s10s steepener on the Crossover Series 7
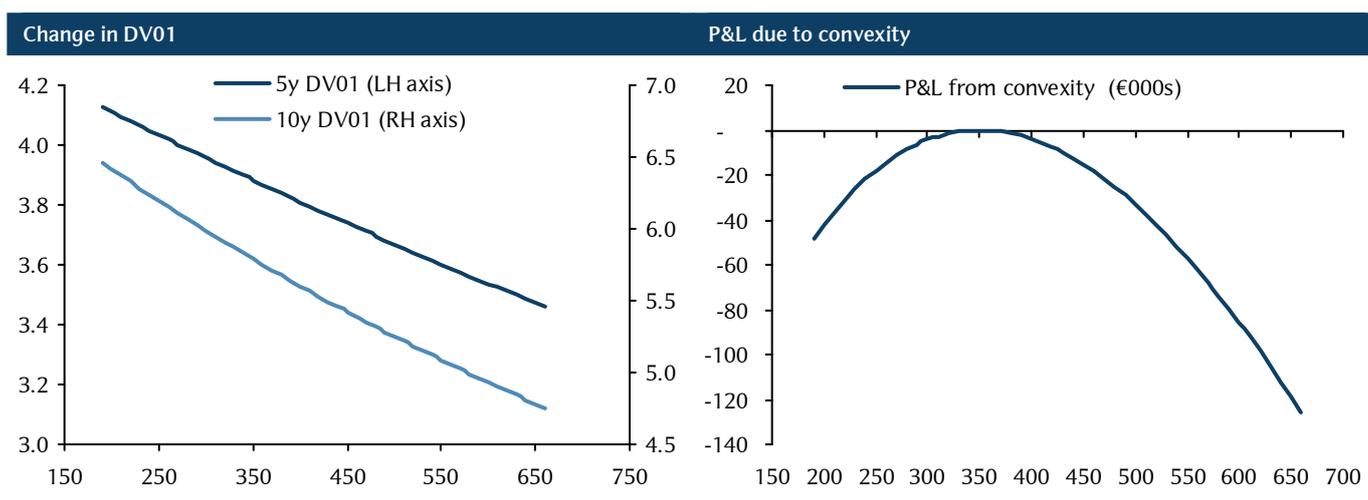
Notes: Struck at 86bp (index 5yr ref: 350bp). Notional on the 10yr is €10mn. The x-axis is the 5yr spread and we assume that the 5s10s stays constant.
Source: Markit, Barclays Capital

What is convexity and how does it affect P&L?

When spreads are volatile, convexity becomes a significant contributor to P&L. For curve trades in particular, the effect of convexity is sometimes not intuitive. Convexity refers to the change in the DV01 that results from changes in spread. The mark-to-market on a default swap is calculated by multiplying the change in spread by the DV01 *at the time of closing the trade*. This final DV01 is based on the final spread curve. The DV01 at trade inception (used, for instance, in calculating weights) is irrelevant in calculating the mark-to-market.

An illustration of the effect of change in spread on the DV01 is given in Figure 264. Increasing the spread reduces the survival probability and therefore increases the discounting of cash flows. This results in a lower DV01.

Figure 264: Understanding convexity – with a higher spread, the coupon stream is discounted at a higher rate, resulting in a lower DV01
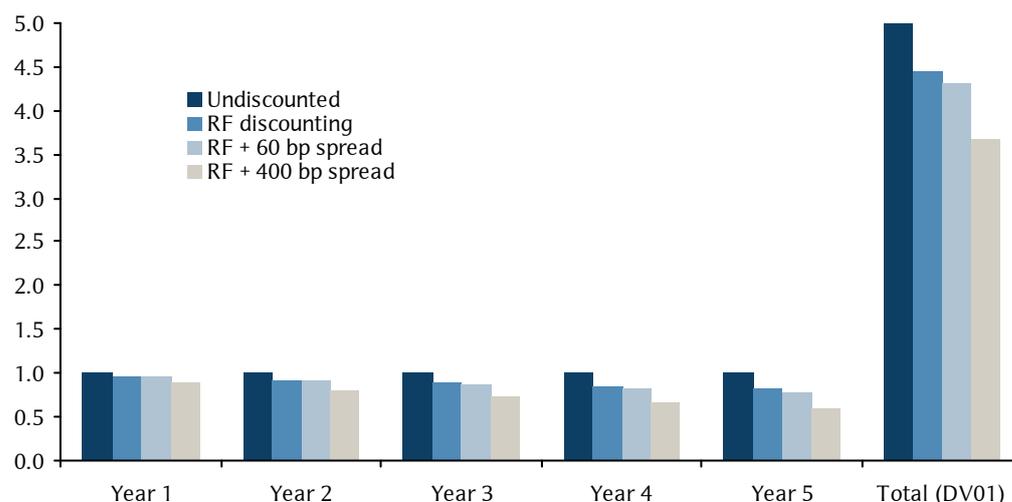
Source: Barclays Capital

How does this affect P&L? This is best understood in the following worked example:

Convexity – worked example

Suppose we sell €10mn 5yr protection on a name at 50bp. The DV01 at inception is approximately -€4,660 (the loss per bp of widening).

Suppose the spread widens immediately to 500bp, and we consider closing the transaction by buying back €10mn 5yr protection at 500bp.

This will lock in a loss of 500bp minus 50bp = 450bp per year for the five years.

However, with spreads at 500bp, the market-implied probability of default has risen dramatically.

Therefore, there is a greater chance that the company defaults before year five, and that we may not need to make all five of the 450bp payments.

In fact, the new DV01 has fallen to -€3,900 per bp. The change is due to the extra discounting caused by the lower probability of the company surviving until year five.

The P&L on the trade is then 450bp x -€3,900 = -€1,755,000.

Note that this is less than if we had used the original DV01:

450bp x -€4,660 = -€2,097,000.

Selling protection, therefore, is described as a positive convexity position.

Convexity in index curve trades

Convexity effects in curve trades can be complicated to understand. The sign and magnitude of the effect depends on the tenors involved in the trade, the direction (steepener or flattener) and the notionals used. We recommend using a scenario analysis to determine the effect of convexity.

In DV01-neutral curve trades the effect of convexity is best understood in the context of a change in the hedge ratio, ie, the initial DV01-ratio used to weight the trade.

Some general rules apply. For DV01-neutral trades:

A **flattener** typically has **positive convexity** – that is, losses from a steepening are dampened by convexity, while gains from a flattening are exaggerated.

A **steepener** typically has **negative convexity** – that is, gains from a steepening are depleted by convexity, while losses from a flattening are exacerbated.

> **Convexity as a sensitivity**
>
> Terminology involving convexity can be confusing, even just in the context of CDS. The concept of convexity we discuss here relates to the impact of change in DV01 on the mark-to-market of positions.
>
> Convexity can also refer to the sensitivity of a CDS position to changes in DV01. This is then an ex-ante risk-measure and is calculated as the second derivative of the present value of the CDS with respect to the spread.
>
> For example, selling €10mn 5yr protection at 100bp with a DV01 of -€4,338 has a convexity – as a sensitivity – of about €3. That is, for every bp the spread widens, the DV01 drops by €3.

Index calculations using Bloomberg

The Bloomberg models of pricing credit default swaps are widely regarded as the market standard for single names and index trades. The relevant function is CDSW, and indices can be accessed through the Bloomberg ticker for that index. For example, Figure 265 presents the CDSW pricing screen for an iTraxx Crossover series 10 contract of 5yr maturity, and this was brought up by the command: *ITXEX510 <CRNCY> CDSW*.

Figure 265: Bloomberg CDSW pricing screen (iTraxx Crossover series 10)

Deal Information section:
Standardised contract information for iTraxx.

Calculator:
Trade P&L calculation.

Spreads:
Calculation inputs; viz.
1. CDS curve
2. Swap spreads
3. Recovery assumption

Source: Bloomberg, Barclays Capital

The screen is divided into three sections as indicated – deal information, calculator, and spreads. We highlight the important variables in the following sections.

Deal information

The fields in the 'Deal Information' section are standardised for iTraxx contracts, and thus are mostly unchangeable. These include the Effective and Maturity dates specifying the duration of the contract as well as the parameters settled by dealer poll before the roll like the assumed recovery rate and the coupon (given by the 'Deal Spread'). The most important input in this section is the size of the contract traded. It is

interesting to note how the 'Effective Date' field is always the date on which the index series being priced became on-the-run.

Figure 266: 'Deal Information' from the Bloomberg CDSW pricing screen (iTraxx Crossover series 10)

Source: Bloomberg, Barclays Capital

Spreads

This section has the most significant input, viz. the level of the CDS at which the contract is being priced. As per market convention, a flat credit curve is used for credit index trades, as illustrated in the figure. Further, this section gives the default probability term structure of the index as priced by the market. This is backed out from the credit curve using the pricing model chosen in the 'Calculator' section.

Figure 267: 'Spreads' from the Bloomberg CDSW pricing screen (iTraxx Crossover series 10)

Source: Bloomberg, Barclays Capital

Calculator

The 'Calculator' section provides the choice of three different models for pricing index contracts: Bloomberg, JP Morgan and the Hull and White models. The other fields provide various pricing information including mark-to-market, carry and P&L sensitivity to spread changes.

Figure 268: 'Calculator' from the Bloomberg CDSW pricing screen (iTraxx Crossover series 10)
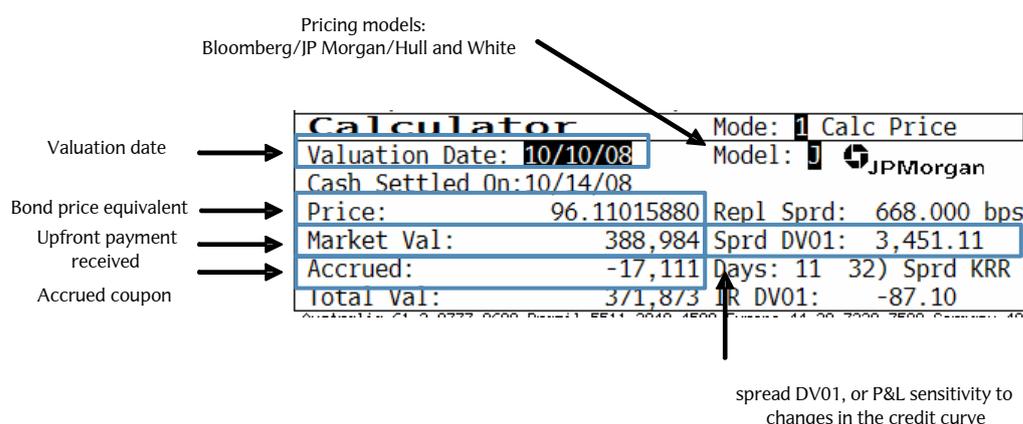
Source: Bloomberg, Barclays Capital

We highlight each factor briefly by presenting actual calculations of the scenario presented in Figure 265; viz. 5yr iTraxx Crossover at 668bp on 9 October 2008.

Figure 269: Pricing fields from the 'Calculator' section of CDSW

Fields	Description
Settlement date	This is the valuation date that is used for all carry calculations
Market val	This field gives the mark-to-market position of an investor who had bought protection on the index on the roll-date (20 Mar 08) and is also the upfront payment that needs to be made by a buyer of protection on the valuation date. The calculation of the actual value is as follows: $$(Spread_{final} - Coupon) \times PV01_{final} \times Notional$$ = (668 − 560) bp x 3.601 x €10mn = €388,984 *Note that the value of the PV01 or credit duration of the contract is not available directly from the CDSW screen, but can be calculated from the above expression for 'Market Val'*
Price	This field gives the bond-price equivalent of the CDS contract. At par, ie, if an index trade is struck at the coupon itself, the bond price is 100. Subsequent mark-to-market changes are reflected in the market val on a notional adjusted basis. This price is analogous to the 'clean price' of a bond, and ignores accrued coupon. Thus a rise in spreads, or a credit deterioration causes a drop in price. The calculation of the value is as follows: $$100 - \frac{Market\ Val}{Notional}$$ = 100 - €388,984/€10mn = 96.11
Accrued	This field gives the carry earned by seller of protection from the last coupon date till the settlement date. The market convention is ACT/360. The calculation is as follows: $$Coupon \times \frac{ACT}{360} \times Notional$$ = - 560bp x 11/360 x 10mn = - €17,111
Sprd DV01	This field gives the sensitivity of the mark-to-market position of the contract to a 1bp change in the par CDS spread. Thus a buyer of protection can expect to gain/lose €3,451 for every basis point increase/decrease in spreads. *Note that the value of the PV01 implied by the field 'Market Val' is different from that given by 'Sprd DV01', this is because the contract being analysed is off-par as explained in the previous section 'Duration and delta'*
IR DV01	This field gives the sensitivity of the mark-to-market position of the contract to a 1bp change in the swap curve. Thus a buyer of protection can expect to lose/gain €87 for every basis point increase/decrease in swap spreads. *Note that the fields 'IR DV01' and 'Sprd DV01' are separate because all CDS pricing models assume that credit risk is independent of interest-rate risk.*

Source: Bloomberg, Barclays Capital

Advanced topics

This section is dedicated to an assortment of more advanced topics on CDS indices that delve into subtleties of the contracts and trading conventions.

The skew

Credit indices are essentially basket trades on single-name entities. Thus given the individual CDS spreads it is possible to arrive at a fair value estimate for the level of the index spread. When the market-quoted spread of the index trades away from this theoretical value, we can talk about an observable basis or skew. This basis is of concern to investors both as a relative value trade and as an indicator of market fundamentals.

We define the index skew as follows:

> **CDS index skew = Market index spread - Intrinsic index spread**

The intrinsic spread is not exactly equal to a simple average of the constituent spreads. The different credit durations of the individual names, and technical factors such as different pricing conventions for single names as opposed to indices, also need to be considered. In fact some of these factors are themselves responsible for driving the basis.

Other technical/market factors also influence the basis, for example:

- higher trading volumes drive volatility higher on credit indices as compared to the constituent CDS of the same index; this will tend to drive the basis wider.

- demand mismatch for buying/selling protection in the market also drives the basis. A higher demand for selling protection will drive the basis tighter and vice versa.

Generally, the higher the spread level of the index, the higher the maximum the basis reaches. Thus the basis is of more significance for the Xover as compared to the investment grade iTraxx Main. The histograms in Figure 270 show the frequency distribution of the basis for both Main and Xover over the past four years. As expected, the distribution for the main index is narrowly clustered around zero, with a bias towards positive. The Xover distribution also shows a bias towards positive, but the distribution is more dispersed with a significant negative basis as well.

Figure 270: iTraxx indices basis frequency plot (June 2004 to October 2008)
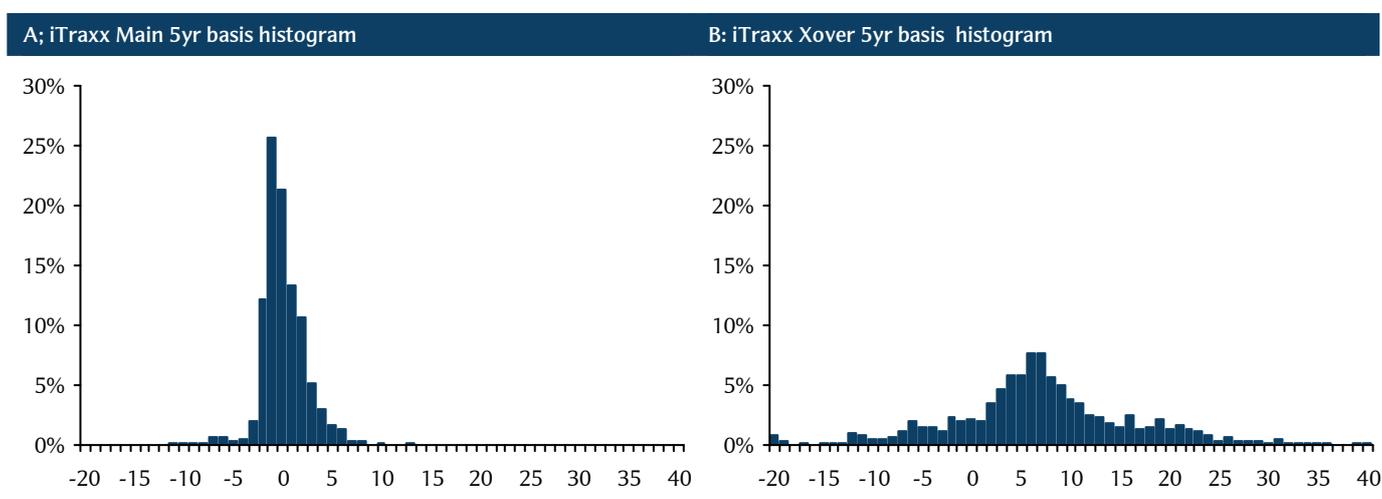
Source: Markit, Barclays Capital

It is interesting to observe the development of the basis over time, as it provides indications of trading patterns in the market. Figure 271 shows the skew behaviour on iTraxx Main, Hivol and Xover over the past four years (the same data for the aforementioned histograms).

Figure 271: iTraxx basis – inception to 10 October 2008 (Main, Xover and Hivol)
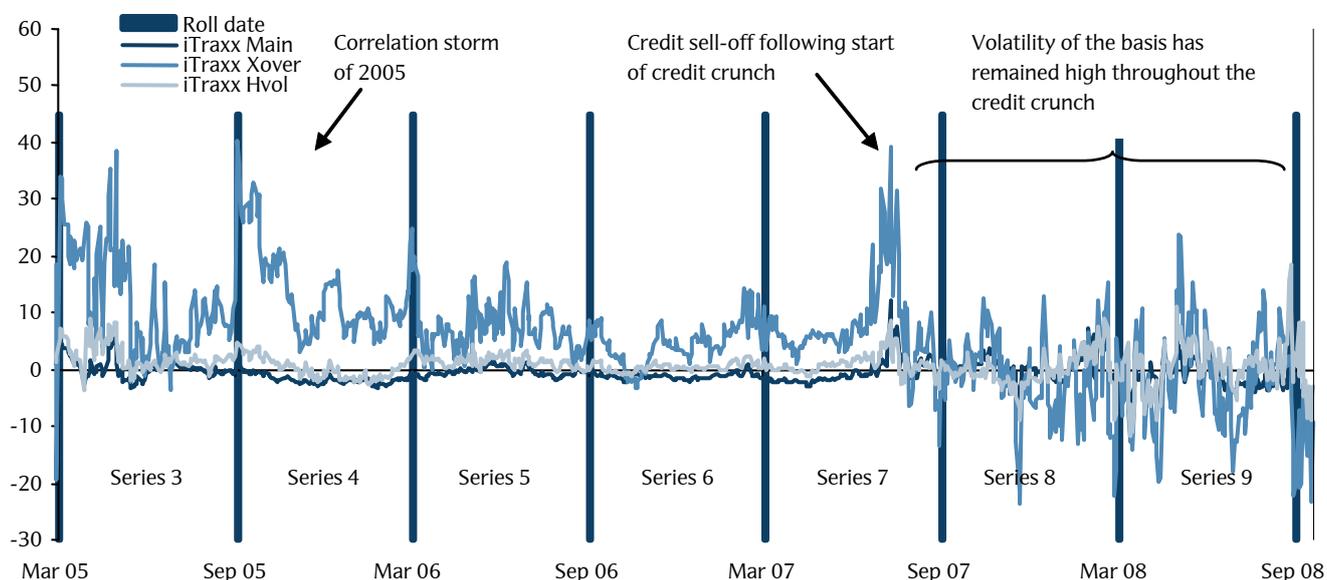
Source: Markit, Barclays Capital

Focusing on the period that marked the beginning of the credit crunch last year, we see that consistent with other market sell-offs, the skew grew significantly over the first few months of series 7 (March-May 2007). This led to index arbitrageurs becoming more active capping the potential skew, and as evident in the graph, the skew in series 8 never reached the levels of series 7 (especially for the Xover). Despite this, skews in the recent volatility have been among the highest we have seen since the May 2005 correlation storm. Indeed, the drop in single-name liquidity, especially in crossover names, has led to large bid-offer levels, meaning that only large skews can be effectively monetised.

As mentioned before, the index skew is also sharply affected by market demand for buying/selling protection, and this becomes relevant around roll dates. Thus indices generally undergo sharp changes in their basis approaching a roll.

Directionality of basis

In volatile market conditions like the recent period, the index basis can also be expected to be volatile, as indicated in Figure 271. This volatility is partly driven by the difference in liquidity of the index compared to the single-name CDS of its constituents;changes in the index spread can be expected to lead changes in single name spreads. Figure 272 provides a graphic view of this directionality. Here we plot a scatter chart of iTraxx basis (for Main and Xover indices) versus spread changes on the relevant index for the preceding one month.

Figure 272: Basis directionality in bull/bear markets

A: iTraxx Main basis versus spread change over preceding month	B: iTraxx Xover basis versus spread change over preceding month
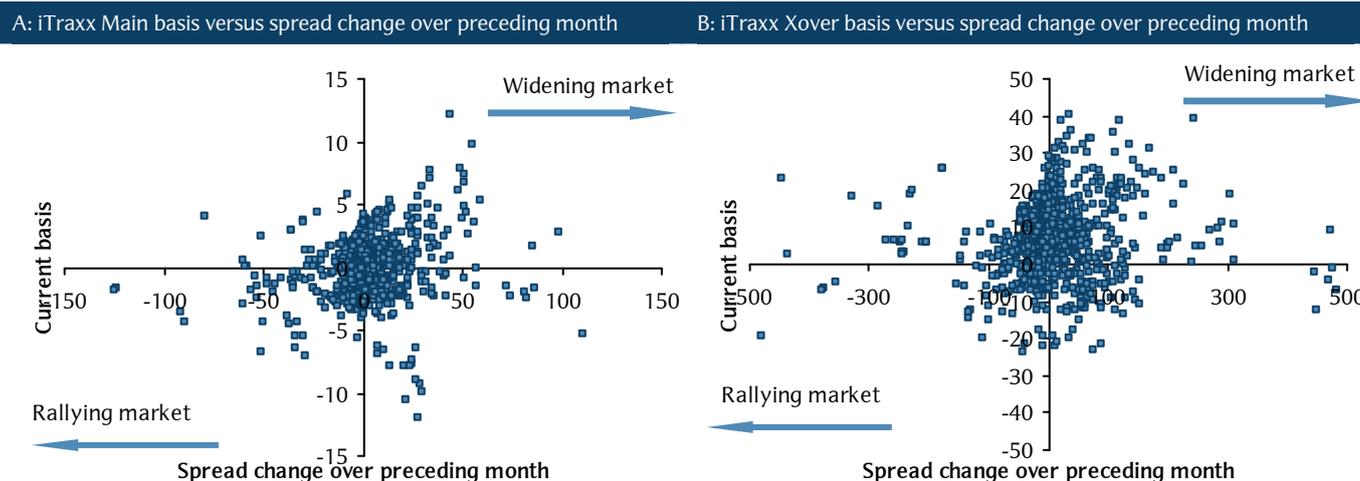
Source: Markit, Barclays Capital

While there isn't a sharply defined relationship between a bull/bear market and the direction of the basis, a general pattern does seem to exist. Widening credit markets in general seem to have led to positive index basis, and vice versa for rallying markets.

Trading the skew: Replicating a CDS index using the underlying single-names

For investors to exploit the index skew, CDS indices need to be replicated exactly using the underlying single names. In order for a replication to be exact, all cash-flows must match in all states of the world between the replicating portfolio and the CDS index. As a by-product of the derivation we can deduce the theoretical market spread of the index (the 'intrinsic spread'). The replication strategy is relatively simple in theory. In practice, a full index-arb is a complex trade to execute, both technically and administratively.

Replication recipe:

To replicate a short protection position on an index with *N* constituent CDS, with weight $\frac{1}{N}$ on each name, maturity date *T*, fixed coupon *C*, market spread at time *t*, S_t^{Index}, we can use the following portfolio of single-names:

Sell protection on each underlying single name, with notional $\frac{1}{N}$ and current market spread S^i.

Two technical factors need to be considered here:

- Single-name CDS maturity should exactly match the index maturity (note that this will involve using off-the-run maturities in the periods 20 March-20 June and 20 September-20 December).

- The CDS should be 'struck' at a coupon of *C* instead of the current market spread S^i. Thus the single-name legs of the trade will be struck off-par and require that upfront payments are made/received This upfront payment, calculated identically as for an index trade is equal to $(S^i - C) \times PV01^i$ for a given name.

Thus the total payment made to enter the replicating portfolio is $\sum_{i=1}^{N}(S^i - C) \times PV01^i$

A true replicating portfolio is obtained only if all these conditions are met. Later we discuss relaxations of these conditions and the implications on the trade.

Note that a replicating strategy on the CDX indices has an additional complication in that the index trades with no restructuring documentation, in contrast to single names, which trade with modified restructuring.

Matching cash flows

In order to demonstrate that this strategy truly replicates the pay-off of the index, we need to consider the premium leg and default legs separately. Figure 273 illustrates this equivalence. Cash flows match exactly on either leg, with or without defaults.

Figure 273: Hypothetical index and replicating strategy with three names and two defaults
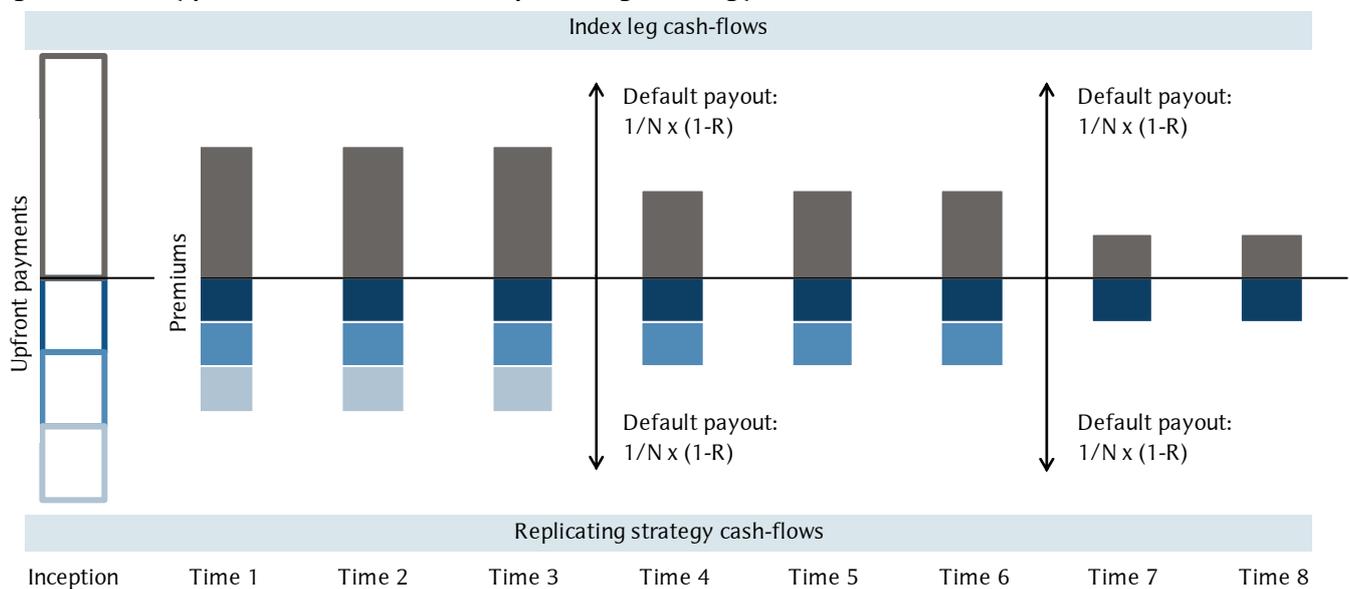
Source: Barclays Capital

Calculating the intrinsic index spread

Since the cash flows of the replicating strategy match those of the index, then so should the upfront payments, or else there is an arbitrage. The upfront payment on the index is simply $(S^{Index} - C) \times PV01^{Index}$ (note that by market convention we use a flat spread curve to calculate the index PV01). Therefore the intrinsic spread, $S^{Intrinsic}$, must satisfy:

Upfront payment on Index = Upfront payment on replicating portfolio

$$(S^{Intrinsic} - C) \times PV01^{Index} = \sum_{i=1}^{N}(S^i - C) \times PV01^i$$

Value of the arbitrage

If the market spread is not equal to the intrinsic spread then there is a non-zero index skew, $S^{Market} - S^{Intrinsic}$. The value today of this arbitrage opportunity is simply derived from above as:

$$\text{Arbitrage value today} = (S^{Market} - C) \times PV01^{Index} = \sum_{i=1}^{N} (S^i - C) \times PV01^i$$

Practical difficulties of the index arb

The replication recipe given above is difficult to implement in practice. Some of the issues include:

- The large number of single names involved makes for administrative difficulties and timing risk (not all names will be executed simultaneously). For this reason, HiVol and Xover are the preferred indices for the trade.

- Bid offers tend to be at their widest when index volatility (and hence the skew) is high. This significantly limits the proportion of any skew that can be captured.

- In practice, some market participants choose to sacrifice the accuracy of the replicating portfolio by trading the on-the-run par CDS swaps, sometimes leading to better execution. However, this results in convexity mismatches as well as possibly maturity mismatches, which then need to be managed. In particular, large moves in a single name may result in unmatched mark-to-market between the index and replicating portfolio.

Rolling between index contracts

The CDS indices 'roll' as mentioned before, is the bi-annual process of resetting the basket of names that form the index. Along with this, the roll also resets the different contract specifications for the latest series of the index, the most significant being the fixed coupon and the maturity dates for the contracts. Thus the difference in spread between two series of an index can be explained through the following three factors:

- difference in maturity

- difference in constituents

- technical effects, like demand for buying/selling protection

We highlight the effect of each of these factors in the section titled 'Pricing the Roll'. In the next section, however, we look at how the roll is traded in the market. In our analysis here we look at the detailed generic aspects of rolls from an empirical and theoretical perspective.

Barclays Capital Global Credit Strategy teams cover individual index rolls in depth nearer the time of actual rolls, including specific details of new entrants and pricing of actual contracts: for example, most recently *Rolling to series 10: Markit changes the play*, 26 August 2008.

Trading the roll

When investors switch their positions on a roll date to the on-the-run index, they can do so through two explicit trades: one closing out their position on the old series, and another which opens an equivalent position in the new series. Thus the roll can be traded just as the difference in spreads between two series of an index. However, two explicit trades mean two sets of transaction costs, making the trade more expensive and less liquid. Market makers thus provide liquidity for the roll by offering a single trade for the same, in effect lowering transaction costs. The following spread quotes on the iTraxx from the trading hours of 1 April 2008, help illustrate this:

Figure 274: Trader quotes for iTraxx main S7/S8/S9, 1 April 2008

```
iTraxx Main curves and rolls - S7/S8/S9
            5Y            5/7Y          5/10Y        3/5Y
S9     114.5/115.5       3.25/4.25      4.5/5.5      23/27
S8     108.25/109.25     5.5/6.5        8.75/9.75    28/32
S7     109.5/111         8.75/10.75     12/14        29/35

            Roll 5Y      Roll 7Y       Roll 10Y     Roll 3Y
S8/S9       6/6.5        3.75/4.25      1.75/2.25    10/13
S7/S8     -1.75/-1.25   -6.25/-4.25    -5.75/-4.75
```

Source: Bloomberg, Barclays Capital

As shown below, from the quotes for 5yr series 8 and series 9, we can determine that an investor wishing to buy or sell the roll would have to:

buy the roll	sell the roll
sell protection on series 8 at 108.25bp	sell protection on series 8 at 109.25bp
buy protection on series 9 at 115.50bp	buy protection on series 9 at 114.50bp
Pay net of 7.25bp	Receive net of 5.25bp

Thus by explicitly trading series 8 and 9, an investor realises roll costs of 5.25/7.25bp. This implies a mid of 6.25bp, and a 2bp bid-ask spread. However, the actual market for the roll is 6.00/6.50bp, as indicated in the above screenshot. This implies the same mid level for the roll but at a much lower bid-ask of 0.50bp.

Pricing the roll

As explained earlier, the difference in spread between two series of an index can be explained by the following three factors:

- difference in maturity

- difference in constituents

- technical effects like demand for buying/selling protection

The following figure illustrates how these effects can be analytically separated, providing a clearer picture of the dynamics behind the roll:

$$_8 S_{Market}^{Dec-12} \Rightarrow {}_8 S_{Intrinsic}^{Dec-12} \Rightarrow {}_8 S_{Intrinsic}^{Jun-13} \Rightarrow {}_9 S_{Intrinsic}^{Jun-13} \Rightarrow {}_9 S_{Market}^{Jun-13}$$

$$\downarrow \qquad \downarrow \qquad \downarrow \qquad \downarrow$$

S8 basis   Maturity effect   Constituents effect   S9 basis
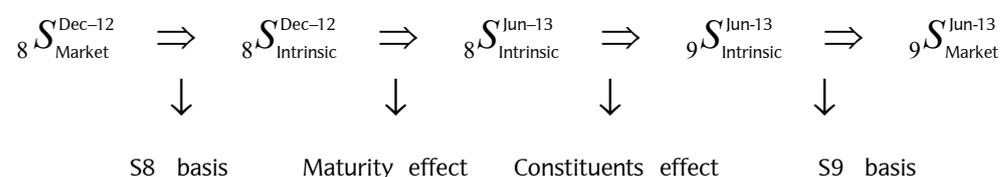
We use as an example the difference in spreads between iTraxx main series 8 and series 9. To arrive from the spread of series 8 to that of series 9 we change three parameters one at a time. Each change of a factor helps us capture the effects of that factor, as illustrated below:

Parameter change	Effect captured	Effect captured
Change from market quotes to index-intrinsic spreads	Technical effects	S8 basis + S9 basis
Change maturity from Dec-12 to Jun-13	Maturity effect	Maturity basis
Change constituents from those of series 8 to those of series 9	Constituents effect	Constituents basis

We analyse each of these effects while looking at the historical patterns.

Maturity component of the roll

The effect of the difference in maturity between indices is generally straightforward to predict. Given an upward sloping credit curve, a roll-up will cause spreads on the new index to be wider than the old one. This roll-up is just the increased maturity (of six months) of the new series compared to the old one. Thus we conjecture that the maturity effect can be largely explained by the slope of the iTraxx curve itself. In fact, the roll-up can be explained as just a function of the on-the-run index spread and the maturity mismatch between the off-the-run and on-the-run indices.

We formulate the maturity basis as a linear function of the independent variables as follows:

$$\text{Maturity basis} = \beta_0 + \beta_1 \times \text{Maturity diff.} + \beta_2 \times \text{Index spread}$$

Figure 275 plots the maturity effect in basis points for data from iTraxx main series 4 to series 8, and allows a visual analysis of the data. Each data series plots the maturity basis between off-the-run and on-the-run indices with a specified maturity difference.

As is evident, the maturity effect changes almost linearly for changes in on-the-run spreads or maturity differences.

Figure 275: Maturity basis – what proportion of the roll spread is explained by the maturity gap between the off-the-run and on-the-run series? (iTraxx Series 4-8)
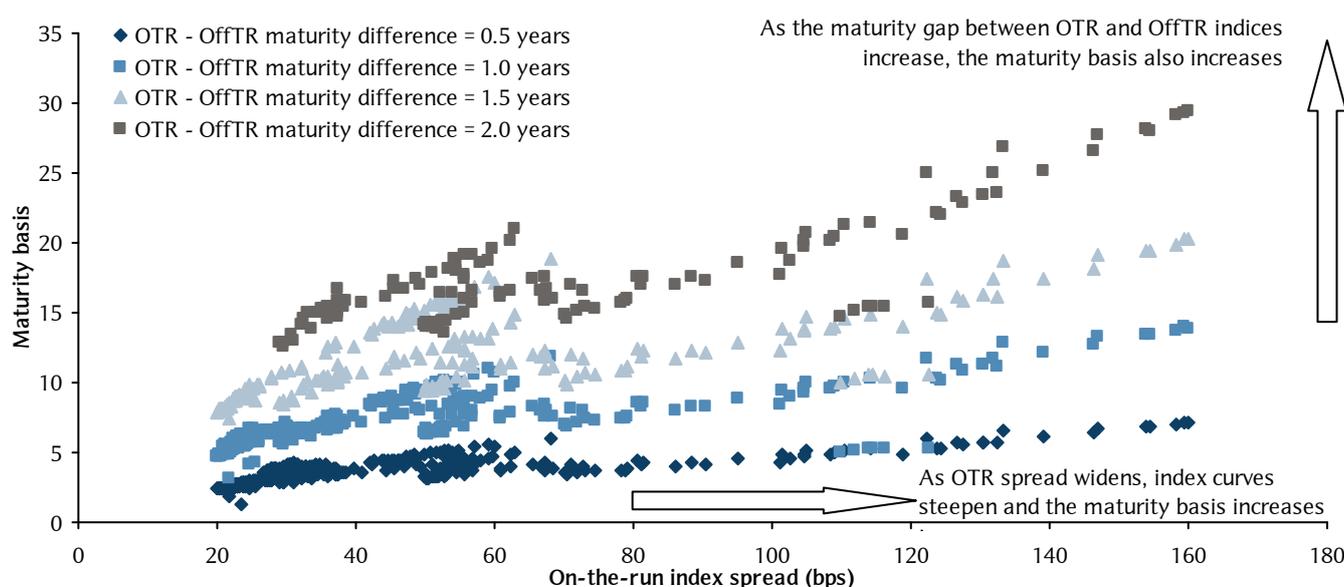
Source: Markit, Barclays Capital

Analysing the data using standard regression techniques, we get an adjusted R squared value of 0.91. This indicates that our assumed linear relationship is a good fit.

Constituents effect on the roll

The effect of the difference in constituents varies across indices. As the indices have pre-specified ratings requirements for constituents, viz investment grade for iTraxx main and sub-investment grade for iTraxx Xover, the names being replaced in each index will tend to be names that have diverged from this ratings requirement. This will tend to have opposite effects on the iTraxx main and iTraxx Xover. Names in the iTraxx main that are being replaced will have lower ratings/higher spreads than the other constituents. Thus the effect of a difference in constituents will tend to drive the on-the-run index tighter. Those being replaced in the iTraxx Xover will have higher

ratings/lower spreads than the other constituents, and thus the effect will be to drive the on-the-run index wider.

This becomes evident in a graphical analysis of the constituent basis using the same data set as above on iTraxx main series 4 to series 8 from January 2006.

Figure 276: Constituent basis – what proportion of the roll spread is explained by the difference in constituents between the off-the-run and on-the-run series? (iTraxx Series 4-8)
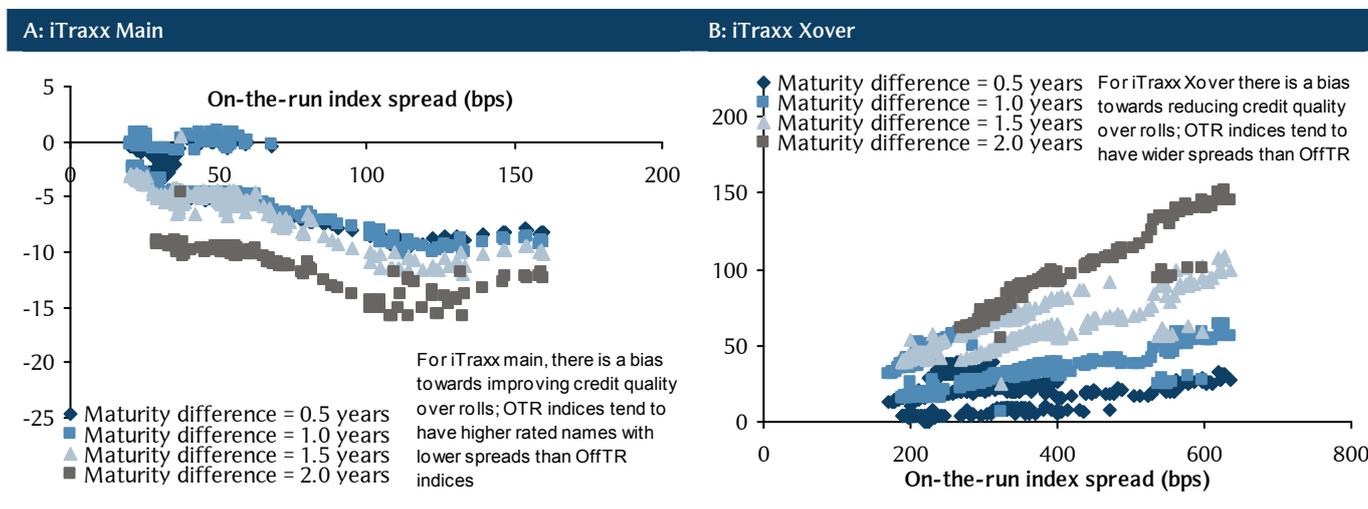
Source: Markit, Barclays Capital

The constituent basis is more often negative for the iTraxx Main, and this tends to increase as spreads widen. Contrarily for the Xover, this basis is positive and also increases as spreads widen.

It is worth pointing out that this basis also increases with an increase in maturity difference between the on-the-run and the off-the-run index. This is because the divergence in ratings/spreads between constituents that have been replaced and the index increases on average with the passage of time.

Demand and supply effects

Along with the effects of the change of names and maturity increase, market demand for buying/selling protection on the new and old series also significantly affects spread levels. These technical effects, however, vary from case-to-case, and it is not easy to generalise them.

Recovery rate assumptions and CDS pricing

Originally published as *Assumed recovery rates and CDS pricing*, 8 October 2008

The current stressed credit market climate has brought not only the reality of defaults to the attention of investors, but also the fear of unknown recovery rates. In fact all CDS users, in assessing the price of protection, implicitly take a simultaneous view on the probability of a default and on the recovery rate in the event of a default. However, the linkage between these three quantities – default probability, CDS spread and expected recovery rate – is not entirely straightforward.

Spread, recovery and default probabilities

The basic credit default swap-pricing relationship ties together a credit's default probabilities and recovery rates with a market-observable attribute, the CDS spread. While default probabilities and expected recovery rates might be regarded as fundamental attributes of any credit entity, they are both unobservable. In fact they are implied *simultaneously* by the market-observable CDS spread.

The relationship between these attributes can be approximated as follows:

$$P_{def} \times (1 - RR) \approx S \times \text{PV01}$$

As is apparent, spreads can be used to express fundamental views on either a credit's default probability, or its recovery rate upon default, *only by assuming the market holds the other attribute constant*.

Historically, however, credit default swap spreads have been used by investors to take a fundamental view on default probabilities.

To illustrate with an example, a spread of 100bp on iTraxx Series 10 with a 40% recovery assumption implies a cumulative default probability of 8.39% in five years' time. A rise in spread to 120bp would traditionally be viewed as implying that the market perception of default probability has increased to 10%, *while keeping expected recovery rates constant*.

The reason spreads are traditionally linked to default probabilities is because recovery rates are hard to ascertain far ahead of the actual default event, and in benign credit conditions are a secondary consideration. Thus the synthetic credit market has traditionally operated with standardised assumptions of recovery rates – 40% for senior bonds and 20% for subordinated bonds – based on long-term historical averages of the same. In actual fact, these averages are seldom realised in practice.

In the current conditions of high credit stress, we believe it is quite conceivable that markets will start explicitly pricing in the recovery risk on default through CDS spreads.

To revisit the above example, viewed from the perspective of recovery rates, a rise in spread to 120bp could imply a fall in recovery rates to 28%, while 5yr default probability stays constant at 8.39%.

In the next section we discuss, from a theoretical perspective, how a change in market perception of different credit risks would affect CDS levels and curve slopes, as well as investors' P&Ls.

Fundamental views on recovery rates

In this section we highlight how spreads can be used to express fundamental views on recovery rates. In all the illustrative examples, we assume that default probabilities are held constant and changes in CDS spreads only reflect changes in the market perception of recovery rates.

Effect on spread levels

The risky duration (PV01) of a credit only depends on the default probabilities and the swap curve. Changes in recovery rate assumptions have no effect on it. Thus the expression $P_{def} \times (1 - RR) \approx S \times \text{PV01}$ implies that a reduction of recovery rate estimates with default probabilities unchanged would cause a rise in spreads and vice versa.

Figure 277 illustrates this change in spreads for iTraxx Series 10 across the whole term structure.

Figure 277: iTraxx Main S10 credit curves at different recovery rate assumptions (levels as of 2 October 2008)
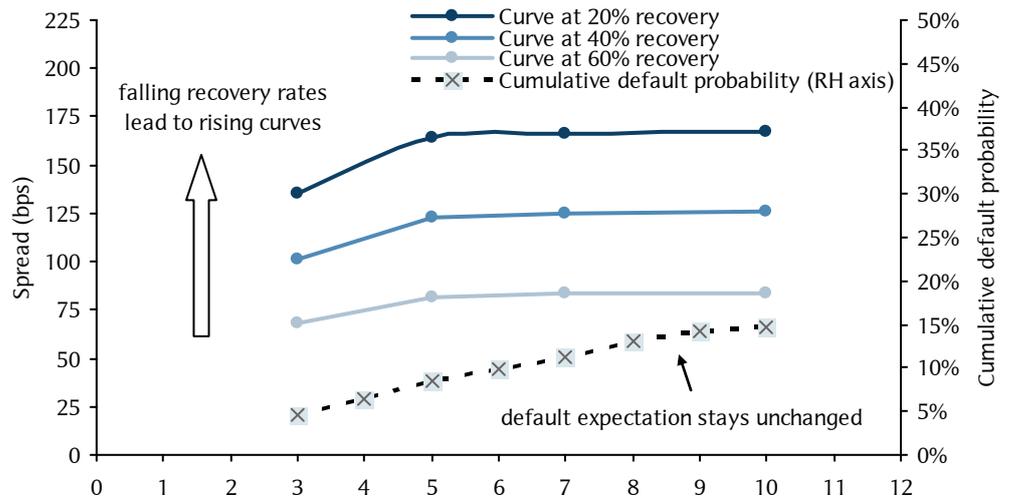
Source: Markit, Bloomberg, Barclays Capital

P&L impact

As explained before, changing recovery rates while holding default probabilities constant only affects CDS spreads and not the credit duration. Thus the P&L impact is straightforward to predict and can be approximated by the following expression:

$$P\&L\ impact = \Delta S \times PV01 \approx -P_{def} \times \Delta RR$$

Obviously, a fall in recovery rates will cause positive P&L for buyers of protection and vice versa. This is illustrated in Figure 278, which shows the Bloomberg CDSW pricing screen for iTraxx Series 10 with different recovery assumptions. We use illustrative values of spreads and recovery rates here.

Figure 278: P&L impact of recovery rate assumptions with default probability held constant

Source: Bloomberg, Barclays Capital

In the left-hand graph, CDSW indicates that for a spread of 100bp, and recovery rate of 40% the 5yr cumulative default probability is 8.39%. The right-hand graph indicates that by reducing recovery rates to 20% spreads must be increased to 133.25bp to keep the default probability constant. This implies a change in fundamental credit view of only the credit entity's recovery value (on default), and not its likelihood of actually defaulting.

The above example suggests that a widening of 33.25bp is required, in this case to compensate for the extra risk due to reduced recovery rates.

Comparing the exact P&L impact from the CDSW screens with the approximate calculation given in the previous page, we get the following:

Approximate P&L impact	Exact P&L impact from CDSW screen
$-P_{def} \times \Delta RR$ = - 8.39% x (20% - 40%) x 10mn = 167,800	Market value @ 20% recovery – market value @ 40% recovery = 59,493 – (-89,759) = 149,252

Source: Bloomberg, Barclays Capital

Thus the spread widening does seem to compensate approximately for the increased risk. In fact, the first calculation is not exact for two reasons: first, it does not consider the full default probability curve; and second, it doesn't discount expected (default) cash flows by the swap rate. Nonetheless the approximate calculation provides a rough measure of the P&L impact that can be expected due to a change in recovery rates.

Effect on curves

From Figure 277 it is easy to see that changes in recovery rate assumptions affect not only spread levels but also credit curve slopes. This slope effect, however, is less straightforward to predict, and we can see even from the figure that it varies across the term structure. In fact the effect on slopes is dependent on the initial curve itself.

This is illustrated in Figure 279, which highlights the effect of changes in recovery rates on the different iTraxx indices (current slopes/recoveries are marked by the circles). As we can see, falling recovery rates imply steepening/flattening of curves depending on whether they were initially upward or downward sloping, respectively (again assuming unchanged default expectations).

Figure 279: Expected slope in the iTraxx indices for changes in recovery rate assumptions (levels and slopes as of 2 October 2008)
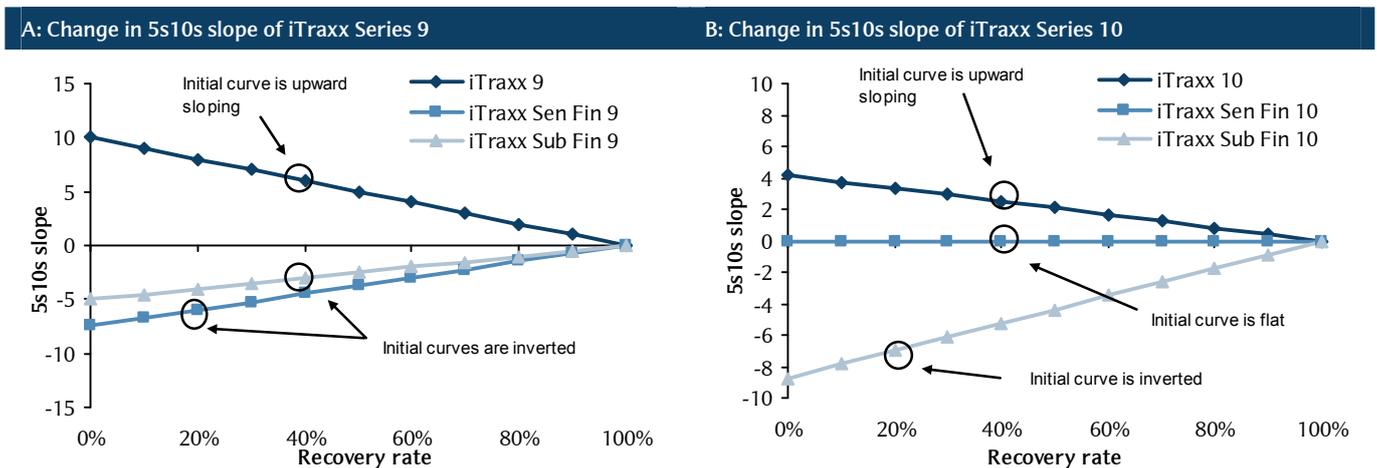
Source: Markit, Bloomberg, Barclays Capital

Figure 280 summarises the effects of recovery rate assumptions on different curves and the rationale for the same.

Figure 280: Effects of recovery rate assumptions on upward/downward sloping curves

Initial curve	Recovery rate assumptions		Rationale
	Increase	Decrease	
Upward sloping	Curve flattens	Curve steepens	In an upward sloping curve, most of the risk is priced either in the back end or uniformly throughout the curve. A reduction in recovery rate assumptions causes expected losses to increase across maturities, but more in the longer term than the short term. This causes curves to steepen further. An increase in recovery rate assumptions has the opposite effect.
Downward sloping	Curve steepens	Curve flattens	In a downward sloping curve, most of the risk is priced into the front end and thus reduced recovery rate assumptions lead to increased losses in shorter maturities compared to longer maturities. An increase in recovery rate assumptions has the opposite effect.

Source: Barclays Capital

Analogous to the previous case, here the P&L effect of changes in recovery rates is transmitted to the curve investor through change in slopes.

A more mathematical explanation for the behaviour of curves with changing recovery rates is presented below. From the basic spread, recovery, default probability relationship it is possible to derive the following expression for the slope of a curve:

$$S_2 - S_1 = (1 - RR) \times \left[\frac{P_{def2}}{PV01_2} - \frac{P_{def1}}{PV01_2} \right]$$

P_{def2} must always be greater than P_{def1} as they are cumulative probabilities of default. However, the concentration of risk as given by $P_{def}/PV01$ will depend on the shape of the curve.

For normal curves, the concentration of risk will be higher for longer maturities, and thus these curves will steepen when recovery rates decrease. For inverted curves, the concentration of risk will be higher for shorter maturities, and these curves will flatten further when recovery rates decrease.

Index breakeven spreads – a default perspective

With 5yr spreads on the OTR iTraxx series 10 indices at all-time highs, and curves at all-time flat levels, we show simple breakeven and spread-implied default statistics to aid trading and hedging decision-making. These statistics may be useful in considering longer-term trade horizons but they are not intended as trade recommendations.

An approximate expression to calculate the breakeven spread over time 't' is as follows:

$$\text{Carry paid} \quad = \quad S \times t \quad = \quad \underbrace{\frac{N-n}{N} \times (S_{be} - S) \times PV01_{be}}_{\text{Rolldown}} + \underbrace{\frac{n}{N}(1-R)}_{\text{Default payout}}$$

Here 'S_{be}' is the breakeven spread at the trade time horizon, 'N' is the number of constituent names in the relevant index, and 'n' is the number of defaulting names.

Figure 281 summarises the levels for Main, Hivol and Xover for 5yr and 10yr spreads. The shaded cells give the spread widening required for a buyer of protection to break even after one year. Five different scenarios are highlighted, which include, for each index, a varying number of defaults from none to four. As the number of defaults increases, the spread widening required for breakeven drops to the extent where even a spread tightening gives positive returns (highlighted in grey). For Main, and Hivol, if spreads remain unchanged, the breakeven is about three and two defaults, respectively.

For Xover, the current spread levels seem to be pricing in over six defaults. Defaults are calculated at a 40% recovery level. With reduced recovery levels, the spread widening required for breakeven will generally be less.

Figure 281: Breakeven spread widening over a one-year horizon for a buyer of index protection with varying numbers of realised defaults, based on 13 October 2008

Index	Assumed recovery rate	No. of names	Spread (bp)	DV01	Spread implied defaults over 1 year		Breakeven spread widening (bp)							
					Probability of default	No. of defaults	0 defaults	1 default	2 defaults	3 defaults	4 defaults	5 defaults	6 defaults	7 defaults
Main 5 yr	40%	125	128	4.42	2.51 %	3	35	22	9	-5	-18	-31	-45	-58
Main 10 yr	40%	125	125	7.51	2.46 %	3	18	11	4	-3	-10	-17	-25	-32
Hivol 5 yr	40%	30	274	4.01	5.30 %	2	80	22	-38	-100	-163	- 229	-	-
Hivol 10 yr	40%	30	274	6.48	5.31 %	2	45	13	-22	-56	-92	- 128	-	-
Xover 5 yr	40%	50	686	3.38	12.76 %	6	240	199	158	117	74	31	-13	-57
Xover 10 yr	40%	50	653	4.79	12.18 %	6	145	119	93	66	39	12	-16	-43

Source: Markit, Moody's, Barclays Capital

Figure 282 summarises the breakeven steepening/flattening of 5s10s slopes for the different indices. Here, we keep the 5yr spread unchanged over a one-year horizon, changing the 10yr spread to arrive at a breakeven slope.

Figure 282: Breakeven slope for a seller of index 5s10s curve (one-year horizon)

Index	Assumed recovery rate	5yr slope (bp)	5s10s slope (bp)	Final breakeven slope (bp)						
				0 defaults	1 default	2 defaults	3 defaults	4 defaults	5 defaults	6 defaults
Main	40%	128	-3	-16	-12	-7	-2	3	9	14
Hivol	40%	274	0	-27	-8	14	37	63	92	124
Xover	40%	686	-33	-96	-87	-78	-69	-59	-49	-38

Source: Markit, Moody's, Barclays Capital

P&L implications of trading off-par CDS index

Originally published as *Playing off-par without a handicap*, 17 March 2008

The unprecedented index volatility over the last year has brought to light subtleties of P&L computations specific to CDS index contracts, which, until now, have had negligible effect. The S8/S9 roll was unprecedented in the extent to which both the new and the old indices were trading off-par. More interestingly, credit rallied almost immediately after the roll, leading to a situation where while iTraxx S8 was trading significantly below par, S9 was trading significantly above it. This differential led to the possibility of extracting relative value between the two indices.

We analyse the impact of trading off-par CDS indices on DV01 and convexity characteristics, as well as funding costs for investors. Our analysis focuses on iTraxx Xover S8/S9, as the spread levels make the off-par effects more pronounced. However, the general principles discussed would be applicable to any investor looking to roll their positions from one index to another.

Coupon convexity

Typically, investors focus on two factors that differentiate the trading characteristics of the new on-the-run versus the immediate off-the-run index contract: the change in

index constituents and the six-month increase in maturity. Spread volatility can add a third factor, as was evident with the iTraxx S8 and CDX S9 indices all trading significantly off-par. Crossover S8 was struck at 375bp, and, series S9 at 650bp. This difference of 275bp is the highest ever and has a direct impact on the P&L.

Understanding the differential

The P&L of an index trade (ignoring carry) can be expressed as follows:

$$P\&L = \text{Upfront payment received @ S2} - \text{Upfront payment made @ S1}$$

$$= (S2-C)\times PV01_{S2} - (S1-C)\times PV01_{S1}$$

Decomposing the above expression we get two explanatory terms as follows:

$$P\&L = \Delta S \times PV01_{S2} + (S1-C)\times \Delta PV01$$

$$\text{where } \Delta S = \text{change in spread} = (S2-S1)$$

$$\text{and } \Delta PV01 = \text{change in } PV01 = (PV01_{S2} - PV01_{S1})$$

The first term $\Delta S \times PV01_{S2}$ is equivalent to the P&L of a single-name CDS, but the extra second term is unique for an index calculation. This term $(S1-C)\times \Delta PV01$ becomes significant only if two conditions are satisfied:

- The contract is initiated away from par.

- The change in spread between the opening and closing of a contract is large enough to cause a significant change in PV01.

This expression identifies that trade P&L on identical positions on Xover series 8 and series 9 (just after the roll) will be different because of the following effects:

- Higher PV01 of Series 9 due to increased maturity;

- Convexity effect due to off-par contract (given by the second term)

These two effects work in the same direction, so the net effect of the coupon-convexity is to further increase the sensitivity of positions in series 9 to a change in spreads.

Figure 283 illustrates the effect of these two terms in the calculation of P&L of identical positions in Crossover Series 8 and 9 calculated immediately after the roll (25 March 2008).

Figure 283: Off-par convexity effects in identical positions in Xover S8 and S9 (P&L as % of notional)
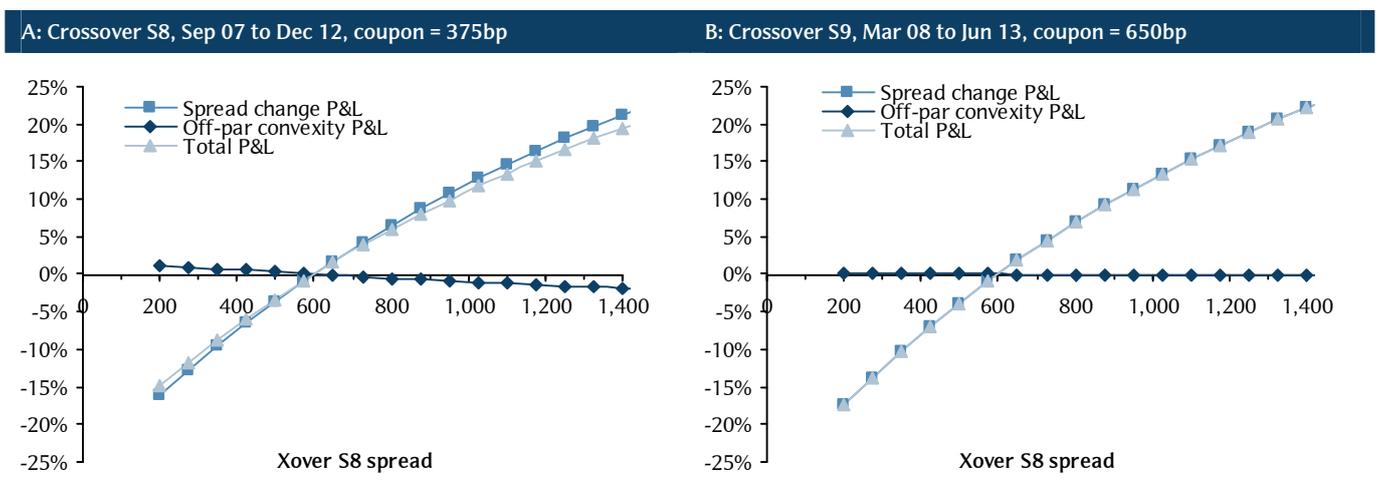
Source: Barclays Capital

Even from visual inspection it is evident that while this convexity has an effect on the P&L for Series 8, it is less for Series 9 since it is so close to par: for example, a 200bp

widening in spreads from current levels leads to €92,000 greater profit in S9 than S8, for identical €10mn long protection positions. Of this, € 61,000 is due to the off-par convexity effect, while €31,000 is due to the higher PV01 of S9.

The proportion of P&L differential due to off-par convexity increases with spread change, as shown in Figure 284.

Figure 284: Split-up of P&L differential (% of notional)
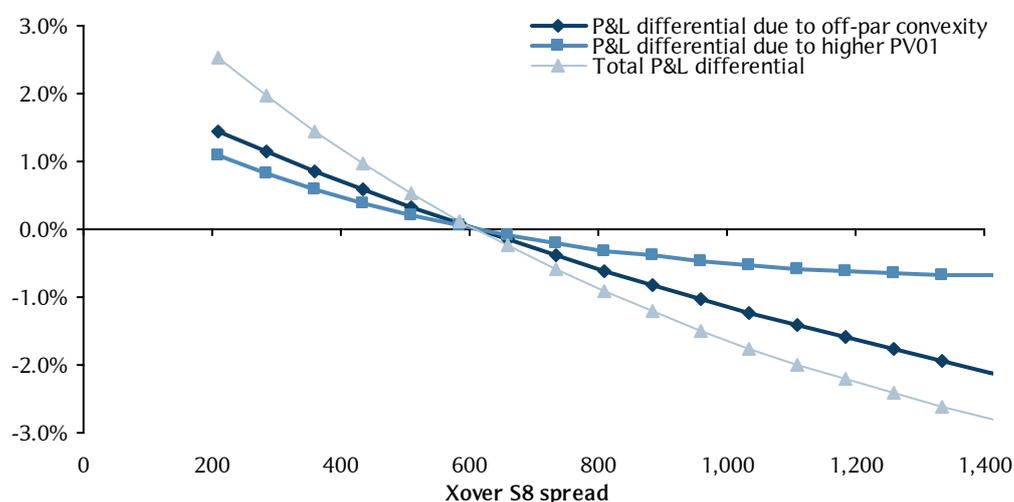
Source: Barclays Capital

Funding impact of trading the roll

The convention of trading the indices with fixed coupon and upfront payments can have a significant impact on investors independent of the implicit credit view. This becomes most apparent when the indices trade significantly away from par, and require large upfront payments or receipts. This section highlights such a funding impact, using as an example the scenario faced by an investor rolling from iTraxx series 8 to series 9.

This roll was unprecedented in the extent to which both the new and the old indices were trading off-par. For the Xover series 8 and series 9 indices, this translated into significant upfront payments for index traders. Figure 285 summarises the statistics for both series of the Xover on the closing of 26 March, two business days after the roll (the figures include the respective upfront payments).

Figure 285: Summary statistics for iTraxx Xover series 8 and 9, 26 March 2008

	Xover series 9	Xover series 8
Coupon	650	375
Current spread	539	518
Duration	3.82	3.59
Upfront payment	4.24%	-5.13%

Source: Markit, Barclays Capital

Despite the fact that the indices have very similar constituents (just six names out of 50 are different), the differing coupons mean that while series 9 was trading above par, series 8 was trading below par. Thus a buyer of protection would receive upfront in the former and pay upfront in the latter. An investor selling series 8 protection and buying

series 9 protection (equi-notionals) could thus expect to receive a net upfront payment of about 9.5% of the notional on either leg while paying out 2.75% (650-375bp) as coupon over the life of the trade. If the above trade is closed out in Dec-2012 (maturity of series 8), the present value of the (risky) annuity of the coupon payments is exactly equal to the upfront payment. This is shown graphically below, where Figure 286b indicates how the net PV of the above trade drops to zero as it is held to maturity.

Figure 286: Equi-notional switch – sell series 8 protection and buy series 9 protection on Xover

Source: Barclays Capital

The trade involves some credit default risk because of the six constituent names that are different in either index, but we ignore that for now. Given the above cash flows, theoretically investors should be indifferent between the two indices. However, as the upfront payments are calculated at EURIBOR, this is only true for investors whose funding cost is also EURIBOR. Hedge funds and other investors who fund at significantly above EURIBOR can thus lock in an advantageous rate for themselves. It is important to point out that this does not indicate a funding arbitrage, as any investor executing the above trade will receive the upfront payment in the form of collateral from its counterparty and would not be at liberty to repo against this collateral. This trade does indicate though the opportunity cost to an investor of not switching index shorts from series 8 to series 9 purely from their own funding perspective. This can be expressed in the form of a funding premium that an investor would be willing to pay for the roll.

To put a number to this funding premium we look at the cost of executing the trade detailed in Figure 287. By executing the trades on the 12 single names that are present in only one of the two series, we can effectively hedge out all credit risk. The trade is held till Dec-2012, as indicated earlier. For the purpose of this calculation we fix the spread of series 9 to the market spread, but calculate the spread of series 8 from the former and the theoretical roll cost (approximately 20bp).

Figure 287: Actual execution of switch trade, accounting for 12 single name discrepancies

Trade leg		Notional
Shorts	Longs	
Xover series 8 protection		1 on the whole index
	Xover series 9 protection	1 on the whole index
Xover series 9 'ins' (new names in series 9)		1/50 on each single name (6 in total)
	Xover series 9 'outs' (names that dropped out)	1/50 on each single name (6 in total)

Source: Barclays Capital

By increasing the funding cost of investors the PV of the coupon annuity decreases, thus making the net PV of the trade rise above zero. We call this net PV the 'Funding P&L'. This P&L when normalised by the expected duration of the trade provides the cost in basis points of not executing the roll for the investor. As indicated in Figure 288, for every 25bp increment in funding cost (spread over Libor), the fair-value of the roll-cost increases by approximately 1bp.

Figure 288: Spread impact of funding
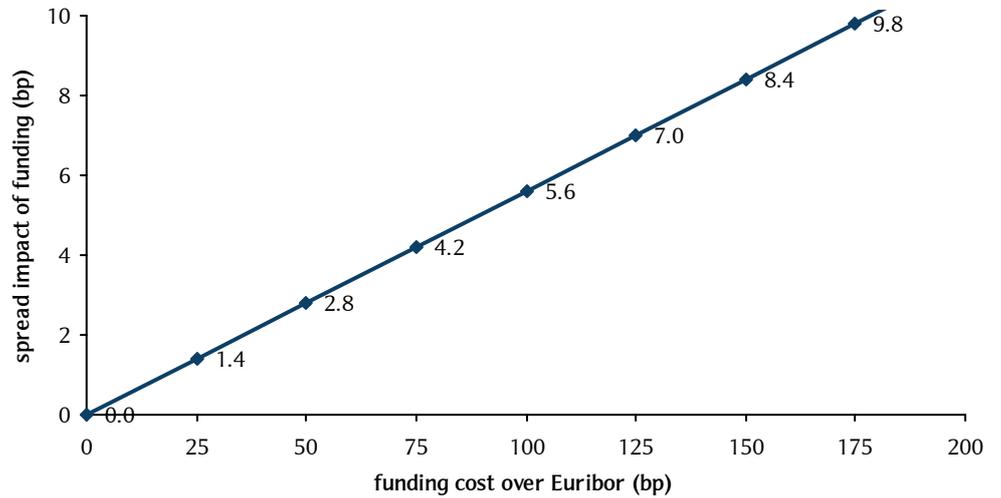
Source: Markit, Barclays Capital

Appendices

Appendix A: Barclays Capital QCX

QCX – A new perspective on the CDS indices

The various different iTraxx and CDX indices provide useful gauges for measuring the performance of credit as an asset class. However, as these indices were constituted fairly recently in 2003-04, they are of limited use in analysing historical trends. Barclays Capital's new proxy CDS indices (QCX) extend the time series of iTraxx and CDX spreads and returns back to 2001. This advance enables macro-level studies of benchmark CDS index behaviour over a full credit cycle.

The QCX indices are constructed using a detailed rules-based approach to avoid survivor-bias. Names were selected based on their likelihood of having formed the constituents of the CDX and iTraxx family between 2001 and 2004. The rules used to choose names, when applied to today's universe, match well with the constituents of the real indices.

How do we construct the indices?

A full description of the rules and assumptions used to construct the indices is given in our publication *CDX and iTraxx: Extending the horizon*, 14 March 2008. The basic ideas can be summarised as follows:

The selection methodology

- Roll dates specified at six monthly intervals from March 2001 (on the 20th of every March and September)
- Index composition kept as close as possible to 20% financials, 10% utilities, 70% industrials
- Individual names are included one-by-one in the index based on liquidity and spread levels (used as ratings proxy)
- The final set for each series of QCX includes:
- (i) 125 names for CDX and ITRAXX IG; (ii) 35 names for CDX XO; (iii) 30 names for ITRAXX XO.
- Index level calculated for each date in the series by calculating the intrinsic spread
- viz. the DV01-weighted average spread, modified for flat curve assumptions
- Coupon for the virtual series calculated on each roll-date by rounding average spreads of constituents to nearest multiple of five
- Companies that have spreads quoting above 1500bp are assumed to have defaulted and removed from that series from that day onwards

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Note that we do not use historical ratings as part of the selection criteria, owing to the difficulties of obtaining accurate data on the complete universe. Moreover, our definition of the Crossover indices is not based on rating transition from investment grade to high yield. As shown in original publication, we achieve a close fit when applying the rules today in terms of matching today's constituents (typically around a 70% overlap).

Creating constant-rating QCX series

Under the original methodology described above, the QCX indices were created by selecting single-name credits historically using similar rules to those applied to define the iTraxx indices today. Due to a very different European credit market in 2001-03 – in particular an absence of any true high-yield companies – the indices are quite distinct from those today in terms of rating distribution.

Unfortunately, there is no easy fix to this problem as a complete data-set simply does not exist. However, we can use the (time-varying) relationship between rating-based expected default rates and spreads to recalibrate each theoretical QCX index series to mimic the ratings distributions in Series 8. Using a combination of global single-name CDS data, together with corporate bond data, we find reasonably stable relationships of this kind, allowing the series to be suitably rescaled between roll dates. Underlying dynamics are still driven by the original QCX series.

Appendix B: Off-the-run index data

The data used throughout this report is based on MarkIt single-name and index spreads. Our QCX data, and all skew calculations, are based on single-name curve data, with restrictions placed on the number of price contributors always exceeding five to help improve data reliability. Index level data is available for most curve points for periods both on and off-the-run. A significant amount of the off-the-run index data pre-2006 is actually missing or unreliable, however, so we use a rules-based system to fill in missing data. The system works as follows, looping through all missing data in order:

- We compute the intrinsic spread for both the off-the-run with missing market quote and respective on-the-run index.

- Proxy market spread is defined as the intrinsic spread + previous value of the off-the-run skew + the change in the on-the-run skew between the two days.

This approach allows for a substantially non-zero skew on the off-the-run series, but forces dynamics to be related to the on-the-run skew, which is empirically seen to be accurate in periods with complete data.

Note that all the analysis contained in this report on micro trading patterns and strategies uses only actual market quotes and no reconstructed off-the-run quotes from this procedure.

Intrinsic model

We use a standard intrinsic model, the details of which can be found in the *CDS Curve Trading Handbook 2008*, p149. All curves are rolled down to the required index maturity using the curve fitting approach outlined below. Full adjustments are made for the off-par CDS contracts struck at the index coupons.

Curve fitting using Nelson-Siegel

We use a customised version of the Nelson-Siegel family of curves and a standardised fitting routine to build fitted single-name and index curves. This is a statistical approach, often used in interest-rate swap yield curve modelling. Curves are parameterised as:

$$S(T) = \beta_0 + \beta_1 \exp\left(-T/\tau\right) + \beta_2 \cdot T/\tau \cdot \exp\left(-T/\tau\right)$$

$S(T)$ is the spread for maturity T between 0 and 10 years, and $\beta_0, \beta_1, \beta_2, \tau$ are estimated parameters.

See *Parsimonious Modelling of Yield Curves*, Charles R. Nelson, Andrew F. Siegel, Journal of Business Vol. 60, No. 4, October 1987.

Appendix C: Index membership

Figure 289: iTraxx constituents; Series 1 to 10 (spread range over the last year)

Credit name	Country	5yr CDS spread		Index membership	
		Min	Max	Main	Xover
Autos & Components					
BAYERISCHE MOTOREN WERKE AG	Germany	26	396	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Continental AG	Germany	59	634	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Daimlerchrysler Ag	Germany	26	408	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Fiat SpA	Italy	58	1050	-,-,-,-,-,-,-,-,-,-	-,-,-,7,6,5,4,3,2,1
Peugeot SA	France	37	509	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Renault Credit Intl Sa	France	37	525	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Valeo	France	63	506	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Volkswagen Ag	Germany	26	388	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Banks					
Abbey National Plc	United Kingdom	34	153	-,-,-,-,-,-,-,-,2,1	-,-,-,-,-,-,-,-,-,-
ABN Amro Bank Nv	Netherlands	34	191	-,-,8,7,6,5,4,3,2,-	-,-,-,-,-,-,-,-,-,-
Banca Monte Dei Paschi Di Siena Spa	Italy	34	150	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Banca Popolare Italiana	Italy	55	202	-,-,-,7,6,5,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Banco Bilbao Vizcaya Arg	Spain	33	152	10,9,8,7,6,5,-,-,-,1	-,-,-,-,-,-,-,-,-,-
Banco Comercial Portugal	Portugal	39	159	-,-,-,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Banco Espirito Santo SA	Portugal	43	191	10,9,8,7,6,5,4,3,-,-	-,-,-,-,-,-,-,-,-,-
Banco Santander Central Hispano SA	Spain	33	160	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Barclays Bank Plc	United Kingdom	39	262	10,9,8,7,6,5,4,3,2,-	-,-,-,-,-,-,-,-,-,-
Bayerische Hypo-Vereinsbank	Germany	39	147	-,-,-,-,-,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
BNP Paribas Sa	France	25	120	10,9,8,7,-,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Capitalia SpA	Italy	25	25	-,-,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Commerzbank Ag	Germany	39	163	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Credit Agricole SA	France	26	163	10,9,8,-,-,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
HSBC Bank Plc	United Kingdom	27	148	-,-,-,-,-,-,-,3,2,1	-,-,-,-,-,-,-,-,-,-
ING Bank NV	Netherlands	22	185	-,-,-,-,-,-,-,-,-,1	-,-,-,-,-,-,-,-,-,-
Intesa Sanpaolo SpA	Italy	26	125	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Lloyds Tsb Bank Plc	United Kingdom	27	210	-,-,-,-,-,-,-,-,-,1	-,-,-,-,-,-,-,-,-,-
Royal Bank Of Scotland	United Kingdom	37	316	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
San Paolo-IMI SpA	Italy	6	6	-,-,-,-,6,5,4,3,-,-	-,-,-,-,-,-,-,-,-,-
Societe Generale	France	26	151	10,9,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Standard Chartered Bank	United Kingdom	39	183	-,-,-,-,-,-,-,3,-,-	-,-,-,-,-,-,-,-,-,-
Unicredito Italiano Spa	Italy	43	151	10,9,8,7,6,5,4,-,-,1	-,-,-,-,-,-,-,-,-,-
Basic Materials					
Akzo Nobel Nv	Netherlands	25	129	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Anglo American Plc	United Kingdom	26	554	-,-,-,-,-,-,4,3,2,1	-,-,-,-,-,-,-,-,-,-
BASF Ag	Germany	17	134	10,9,8,-,-,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Bayer Ag	Germany	25	136	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Ciba Speciality Chemicals Holding I	Switzerland	49	316	-,9,8,7,6,5,-,-,-,-	10,-,-,-,-,-,-,-,-,-
Clariant Ag	Switzerland	50	454	10,9,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-,-,2,1
Corus Group Plc	United Kingdom	171	708	-,-,-,-,-,-,-,-,-,-	-,-,-,7,6,5,4,3,2,1
Degussa AG	Germany	57	359	-,-,-,-,-,5,-,-,-,-	-,9,-,7,6,-,-,-,-,-
Imperial Chemicals Industries Plc	United Kingdom	13	64	-,-,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Koninklijke Dsm NV	Netherlands	28	117	10,9,8,7,6,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
M-Real Oyj	Finland	559	2452	-,-,-,-,-,-,-,-,-,-	-,-,8,7,6,5,4,3,2,1
Norske SkogIndustrier ASA	Norway	284	1420	-,-,-,-,-,-,-,-,-,-	10,9,8,7,-,-,-,-,-,-
Rhodia SA	France	194	988	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,2,1
Solvay Sa	Belgium	20	125	-,-,8,7,6,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Stora Enso Oyj	Finland	114	558	-,-,-,7,6,5,4,3,2,1	10,9,8,-,-,-,-,-,-,-
Svenska Cellulos AB	Sweden	42	396	10,9,8,7,6,5,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Thyssen Krupp AG	Germany	39	425	10,9,8,7,6,-,4,3,-,-	-,-,-,-,-,-,-,-,-,1
UPM-Kymmene Corporation	Finland	89	484	-,-,8,7,6,5,4,3,2,1	10,9,-,-,-,-,-,-,-,-
Communications					
Alcatel Lucent	France	256	1205	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,-,4,3,2,1
Bertelsmann Ag	Germany	31	141	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
British Telecommunications PLC	United Kingdom	38	190	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Cable And Wireless Plc	United Kingdom	196	497	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,2,1
Carlton Communications	United Kingdom	22	312	-,-,-,-,-,-,4,3,-,1	-,-,-,-,-,-,-,-,-,-
CIR-Compagnie Industriali Riunite S	Italy	105	804	-,-,-,-,-,-,-,-,-,-	10,9,8,-,-,-,-,-,-,-
Colt Telecom Group Plc	United Kingdom	209	455	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,2,1
Deutsche Telekom Ag	Germany	38	190	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Eircom Group PLC	Ireland	113	254	-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,5,4,3,2,1
Ericsson Lm Telefon Ab	Sweden	48	357	-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-,-,2,1
France Telecom	France	29	144	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Havas Advertising SA	France	226	454	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,2,1
Hellenic Telecommunications Organization SA	Greece	46	155	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
ITV Plc	United Kingdom	61	396	-,-,-,-,6,5,-,-,-,-	10,9,-,7,-,-,-,-,-,-
Koninklijke KPN Nederland	Netherlands	38	174	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
MMO2 PLC	United Kingdom	21	87	-,-,-,-,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-

| Credit name | Country | 5yr CDS spread | | Index membership | |
		Min	Max	Main	Xover
Nielsen Co	Netherlands	415	975	-,-,-,-,-,-,4,3,2,1	10,9,8,7,6,5,-,-,-,-
Nokia Oyj	Finland	20	109	-,-,-,-,6,5,4,3,2,-	-,-,-,-,-,-,-,-,-,-
Pearson Plc	United Kingdom	34	123	10,9,8,7,6,5,-,-,2,1	-,-,-,-,-,-,-,-,-,-
ProsiebenSat.1 Media Ag	Germany	191	1897	-,-,-,-,-,-,-,-,-,-	-,-,-,7,6,5,-,3,2,1
Publicis Group SA	France	34	171	-,-,-,7,-,-,-,-,-,-	-,-,-,-,-,-,-,-,2,1
Reed Elsevier Plc	United Kingdom	29	149	10,9,8,7,6,5,4,3,2,-	-,-,-,-,-,-,-,-,-,-
Reuters Group Plc	United Kingdom	20	68	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Seat Pagine Gialle SpA	Italy	292	1512	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,2,1
TDC As	Denmark	151	395	-,-,-,-,-,4,3,2,1	-,-,-,-,5,-,-,-,-
Telecom Italia Capital SA	Italy	48	407	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Telefonica De Espana	Spain	38	239	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Telekom Austria (TA)	Austria	29	143	10,9,8,7,6,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Telenor Asa	Norway	33	139	10,9,8,7,6,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Teliasonera AB	Sweden	29	138	10,9,8,7,6,5,-,-,2,-	-,-,-,-,-,-,-,-,-,-
United Business Media Plc	United Kingdom	38	224	-,-,-,-,-,-,-,-,-,1	-,-,-,-,-,-,-,-,-,-
Vivendi Universal	France	38	190	10,9,8,7,6,5,4,3,-,-	-,-,-,-,-,-,-,-,-,-
Vodafone Group PLC	United Kingdom	38	206	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Wolters Kluwer NV	Netherlands	29	114	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
WPP Group PLC	United Kingdom	37	334	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Consumer, Cyclical					
Accor SA	France	36	155	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Air France-KLM	France	52	427	-,-,-,-,-,-,-,-,-,-	10,-,-,-,-,-,-,-,-,-
Boots Group plc	United Kingdom	442	815	-,-,-,7,6,5,4,3,2,1	10,9,8,-,-,-,-,-,-,-
British Airways	United Kingdom	115	553	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,2,1
Compass Group PLC	United Kingdom	28	126	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Deutsche Lufthansa	Germany	43	201	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Dixons Group Plc	United Kingdom	79	740	-,9,8,7,6,5,4,3,2,1	10,-,-,-,-,-,-,-,-,-
Electrolux Ab	Sweden	33	164	10,9,8,7,6,5,4,3,-,1	-,-,-,-,-,-,-,-,-,-
EMI Group Plc	United Kingdom	320	974	-,-,-,-,-,-,-,-,-,-	-,-,-,7,6,5,4,3,2,1
Experian Finance PLC	United Kingdom	36	155	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Glencore International AG	Switzerland	60	1222	10,9,8,7,6,5,4,3,-,-	-,-,-,-,-,-,-,-,-,-
Kingfisher Plc	United Kingdom	101	493	-,-,8,7,6,5,4,3,2,1	10,9,-,-,-,-,-,-,-,-
Ladbrokes PLC	United Kingdom	186	572	-,-,-,-,-,-,4,3,2,1	10,9,8,7,6,5,-,-,-,-
Marks & Spencer Plc	United Kingdom	37	414	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
PPR SA	France	67	657	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Rallye Sa	France	341	1179	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,-,4,3,-,-
Sodexho Alliance Sa	France	29	117	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Sol Melia S.A.	Spain	104	632	-,-,-,-,-,-,-,-,-,-	10,-,8,7,6,5,4,3,2,1
Thomson Multimedia SA	France	118	1850	-,-,-,7,6,5,4,3,2,1	10,9,8,-,-,-,-,-,-,-
TUI AG	Germany	335	927	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,2,1
Consumer, Non-cyclical					
Adecco Sa	Switzerland	39	205	-,-,8,7,6,5,4,3,2,-	-,-,-,-,-,-,-,-,-,1
Allied Domecq Plc	United Kingdom	48	351	-,-,-,-,-,-,-,3,2,1	-,-,-,-,-,-,4,-,-,-
Altadis SA	Spain	40	167	-,-,8,7,6,5,4,3,-,-	-,-,-,-,-,-,-,-,-,-
Aventis SA	France	19	19	-,-,-,-,-,-,-,-,2,1	-,-,-,-,-,-,-,-,-,-
British American Tobacco	United Kingdom	32	144	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Cadbury Schweppes Plc	United Kingdom	37	168	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Carrefour Sa	France	22	105	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Casino Guichard Perrach	France	65	247	10,9,8,7,6,-,4,3,2,1	-,-,-,-,5,-,-,-
Diageo Plc	United Kingdom	29	107	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Fresenius AG	Germany	112	410	-,-,-,-,-,-,-,-,-,-	10,-,8,7,6,5,4,-,-,-
Gallaher Group PLC (UK)	United Kingdom	23	66	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Groupe Danone	France	26	108	10,9,8,-,-,-,4,3,-,1	-,-,-,-,-,-,-,-,-,-
Henkel Kgaa	Germany	24	130	10,9,8,7,6,5,-,-,2,1	-,-,-,-,-,-,-,-,-,-
Imperial Tobacco Group PLC	United Kingdom	70	447	-,-,-,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Koninklijke Ahold NV	Netherlands	53	270	-,-,-,-,-,-,-,-,-,-	-,-,-,7,6,5,4,3,2,1
Metro AG	Germany	30	243	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Nestle Enterprise	Switzerland	11	82	10,9,-,-,-,5,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Next Plc	United Kingdom	63	416	10,9,8,-,-,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Pernod Ricard SA	France	84	662	-,-,-,-,-,-,-,-,-,-	10,-,-,-,-,-,-,-,-,-
Rank Group Plc	United Kingdom	346	909	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,-,-
Rentokil 1927	United Kingdom	12	288	-,-,-,-,-,5,4,3,-,-	-,-,-,-,-,-,-,-,-,-
Rentokil Initial Plc	United Kingdom	39	389	10,9,-,-,6,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Safeway Plc	United Kingdom	43	124	10,9,8,7,6,5,4,3,2,-	-,-,-,-,-,-,-,-,-,-
Sainsbury (J.) Plc	United Kingdom	58	252	10,9,-,-,-,-,-,-,2,1	-,-,-,-,-,-,4,3,-,-
Suedzucker AG	Germany	49	241	10,9,8,-,-,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Swedish Match AB	Sweden	35	155	10,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Tate & Lyle Plc	United Kingdom	57	237	10,9,8,7,6,5,4,3,2,-	-,-,-,-,-,-,-,-,-,-
Tesco Plc	United Kingdom	22	118	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Unilever Nv	Netherlands	17	80	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Diversified					
LVMH Moet Hennessy Louis Vuitton SA	France	28	133	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Six Continents Plc	United Kingdom	30	65	-,-,-,-,-,-,-,-,2,-	-,-,-,-,-,-,-,-,-,-
Wendel Investissement	France	48	1207	-,-,-,-,-,-,-,-,-,-	10,9,-,-,-,-,-,-,-,-

Credit name	Country	5yr CDS spread		Index membership	
		Min	Max	Main	Xover
Diversified financials					
Bank Of Scotland	United Kingdom	49	477	10,9,-,-,-,-,4,3,2,-	-,-,-,-,-,-,-,-,-,-
Credit Suisse Group	Switzerland	39	187	10,9,8,-,-,-,-,-,2,1	-,-,-,-,-,-,-,-,-,-
Deutsche Bank AG	Germany	38	175	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Deutsche Post AG	Germany	24	101	10,9,8,-,-,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Dresdner Bank Ag	Germany	39	161	-,-,-,-,-,-,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Gecina	France	175	854	-,-,-,-,-,-,-,-,-,-	10,9,8,7,-,-,-,-,-,-
Investor AB	Sweden	25	377	-,-,-,-,-,-,-,-,2,1	-,-,-,-,-,-,-,-,-,-
Royal & Sun Alliance Insurance plc	United Kingdom	39	151	-,-,-,7,6,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
UBS AG	Switzerland	39	322	10,9,8,-,-,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Energy					
BP Plc	United Kingdom	13	84	10,-,-,-,-,-,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Repsol YPF SA	Spain	47	313	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Technip-Coflexip	France	30	256	-,-,-,-,-,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Total Capital SA	France	17	109	10,-,-,-,-,-,-,-,-,1	-,-,-,-,-,-,-,-,-,-
Industrial					
Alstom	France	39	439	-,-,-,-,-,-,-,-,-,-	-,-,-,-,6,5,4,3,2,1
BAA Plc	United Kingdom	126	541	-,-,-,-,-,5,4,3,2,1	-,9,-,-,-,-,-,-,-,-
BAE Systems	United Kingdom	31	131	-,-,-,-,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Compagnie De St Gobain	France	43	386	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
European Aeronautic Defence and Space Company	Netherlands	28	217	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Finmeccanica SpA	Italy	28	168	10,9,-,-,-,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
FKI Plc	United Kingdom	112	750	-,-,-,-,-,-,-,-,-,-	-,9,8,7,6,5,4,3,-,1
Hanson Plc	United Kingdom	52	831	-,-,-,7,-,-,-,-,2,1	-,-,-,-,-,-,-,-,-,-
Heidelberger Zement Fin	Germany	101	1185	-,-,-,-,-,-,-,-,-,-	10,-,8,-,-,5,4,-,2,1
Holcim Ltd	Switzerland	39	477	10,-,-,-,-,-,-,-,-,1	-,-,-,-,-,-,-,-,-,-
Invensys Plc	United Kingdom	83	375	-,-,-,-,-,-,-,-,-,-	-,-,8,7,6,5,4,3,2,1
Lafarge SA	France	49	663	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
LINDE AG	Germany	28	127	10,9,8,7,6,5,4,-,2,1	-,-,-,-,-,-,-,-,-,-
Metso Corporation	Finland	45	417	-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,5,4,-,2,1
Philips Electronics Nv	Netherlands	26	106	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Rolls-Royce Plc	United Kingdom	23	132	-,-,-,-,-,-,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Siemens AG	Germany	20	188	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Stagecoach Holdings Plc	United Kingdom	40	118	-,-,-,-,-,-,-,-,-,1	-,-,-,-,-,-,-,-,-,-
TPG NV	Netherlands	24	142	10,9,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Vinci SA	France	51	396	10,9,8,7,-,-,-,-,-,-	-,-,-,-,-,-,-,-,-,-
Volvo AB	Sweden	37	454	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Insurance					
Aegon Nv	Netherlands	35	588	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Allianz SE	Germany	30	135	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Assicurazioni Generali	Italy	29	134	10,9,8,7,6,5,4,-,2,1	-,-,-,-,-,-,-,-,-,-
Aviva Plc	United Kingdom	30	205	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Axa	France	32	229	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Hannover Rueckversicherung AG	Germany	29	143	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Muenchener Rueckversicherungs AG	Germany	27	126	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Scottish Power UK Plc	United Kingdom	20	77	-,-,-,-,-,-,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Swiss Reinsurance Company	Switzerland	31	500	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Zurich Insurance Company	Switzerland	31	166	10,9,8,7,6,5,4,3,2,-	-,-,-,-,-,-,-,-,-,-
Other/non-defined					
Arcelor Finance SCA	Luxembourg	52	724	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Auchan SA	France	22	83	10,9,8,7,6,5,4,-,-,-	-,-,-,-,-,-,-,-,-,-
Basell AF SCA	Luxembourg	545	2588	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,-,-,-
BCM Ireland Finance Ltd	Ireland	348	1180	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,-,-,-,-,-
Cablecom Luxembourg SCA	Switzerland	394	813	-,-,-,-,-,-,-,-,-,-	-,-,-,-,6,5,4,3,2,-
Cognis GmbH	Germany	447	968	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,-,-
Compagnie Financiere Michelin Basel	Switzerland	40	398	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
FS Funding AS	Denmark	316	968	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,-,-,-,-,-
GKN Plc	United Kingdom	56	489	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-,-
Grohe Holding Gmbh	Germany	599	1262	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,-,-
Ineos Group Holdings PLC	United Kingdom	461	2268	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,-,-,-,-
Infineon Tech Holdings	Netherlands	214	964	-,-,-,-,-,-,-,-,-,-	10,9,8,7,-,5,4,3,-,-
ISS Global A/S	Denmark	188	775	-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,5,4,-,-,-
Kabel Deutscheland GMBH	Germany	428	821	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,2,-
ONO Finance II Plc	United Kingdom	485	3081	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,-,-,-,-
Portugal Telecom Int Fin (NL)	Netherlands	48	224	10,9,8,-,-,5,-,-,-,1	-,-,-,7,6,-,-,-,-,-
Ray Acquisition SCA	France	103	410	-,-,-,-,-,-,-,-,-,-	-,-,-,7,6,5,4,-,-,-
Scandinavian Airlines Systems	Sweden	256	884	-,-,-,-,-,-,-,-,-,-	-,9,8,7,6,5,4,3,2,1
Smurfit Kappa Funding PLC	Ireland	208	792	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,-,-
Unity Media GMBH	Germany	429	796	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,-,-,-,-
UPC Holding BV	Netherlands	400	806	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,-,-,-,-
Virgin Media Finance	United Kingdom	437	1333	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,2,1
WDAC Subsidiary Corporation	United States	415	2362	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,-,-
Wind Acquisition Fin SA	Italy	377	782	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,-,-,-,-
Pharma & Biotech					
Sanofi-Synthelabo	France	20	130	10,9,8,7,6,5,-,3,-,-	-,-,-,-,-,-,-,-,-,-

Credit name	Country	5yr CDS spread		Index membership	
		Min	Max	Main	Xover
Technology					
Cap Gemini SA	France	89	299	-,-,-,-,-,-,-,-,-	-,-,8,7,6,5,4,3,-,-
Nordic Telephone Company Holdings Aps	Denmark	320	814	-,-,-,-,-,-,-,-,-	10,9,8,7,6,-,-,-,-,-
STMicroelectronics NV	Switzerland	26	122	10,9,8,7,-,-,4,3,2,1	-,-,-,-,-,-,-,-,-
Utilities					
British Energy Group PLC	United Kingdom	130	478	-,-,-,-,-,-,-,-,-	-,9,8,-,-,-,-,-,-
Centrica PLC	United Kingdom	21	147	10,9,8,7,6,5,-,-,-,-	-,-,-,-,-,-,-,-,-
E.ON AG	Germany	22	146	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-
Edison Spa	Italy	32	97	10,-,8,7,6,5,4,3,2,-	-,-,-,-,-,-,-,-,-
Electricite De France	France	21	146	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-
Endesa SA	Spain	44	245	-,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-
Enel SpA	Italy	38	259	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-
Energias de Portugal SA	Portugal	30	133	10,9,8,7,6,5,4,3,-,-	-,-,-,-,-,-,-,-,-
Energie Baden Wurttemberg	Germany	21	82	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-
Fortum OYJ	Finland	27	116	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-
Gas Natural SDG SA	Spain	20	202	10,9,8,7,6,5,-,-,-,-	-,-,-,-,-,-,-,-,-
Gaz De France	France	21	116	10,9,8,7,6,-,-,-,-,-	-,-,-,-,-,-,-,-,-
Iberdrola SA	Spain	34	223	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-
International Power Plc	United Kingdom	264	765	-,-,-,-,-,-,-,-,-,-	10,9,8,7,6,5,4,3,2,1
Kelda Group Plc	United Kingdom	22	392	-,9,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-,-,-
National Grid Co Plc	United Kingdom	21	118	-,-,-,-,-,-,-,3,2,1	-,-,-,-,-,-,-,-,-
National Grid Transco	United Kingdom	33	226	10,9,8,7,6,5,4,-,-,-	-,-,-,-,-,-,-,-,-
Rwe AG	Germany	21	98	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-
Suez SA	France	24	93	-,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-
Union Electrica Fenosa	Spain	35	126	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-
United Utilities Electricity plc	United Kingdom	31	157	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-
Vattenfall AB	Sweden	22	80	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-
Veolia Environnement SA	France	38	191	10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-,-,-

Source: Markit, Barclays Capital

Figure 290: CDX constituents; Series 1 to 11 (spread range over the last year)

Credit Name	Country	5yr CDS spread		Index membership	
		Min	Max	IG	Xover
Autos & Components					
American Axle & Mfg Inc	United States	257	3394	-,-,-,-,-,-,5,4,-,-,-	-,10,9,8,7,6,-
Arvinmeritor	United States	383	1657	-,-,-,-,-,-,-,-,-,-,-	-,-,-,-,7,6,5
Cooper Tire and Rubber	United States	280	1573	-,-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,6,-
Dana Corp	United States	601	636	-,-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-,5
Delphi Auto System	United States	656	3902	-,-,-,-,-,-,-,-,-,3,2,1	-,-,-,-,-,-,-
Lear Corp	United States	385	3330	-,-,-,-,-,-,-,4,-,-,-	-,-,-,-,-,6,5
Visteon Corp	United States	705	7988	-,-,-,-,-,-,-,-,-,-,1	-,-,-,-,-,-,-
Banks					
Capital One Bank	United States	68	474	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Radian Group Inc	United States	558	3807	-,10,9,8,-,-,-,-,-,-,-	-,-,-,-,-,-,-
Washington Mutual Fin	United States	144	9346	-,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Wells Fargo Company	United States	32	212	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Basic Materials					
Abitibi-Consolidated Inc	Canada	954	7087	-,-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-,5
Alcan Inc.	Canada	22	151	-,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Alcoa Inc	United States	41	462	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Bowater Inc	United States	808	5894	-,-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-,5
Chemtura Corporation	United States	201	910	-,-,-,-,-,-,-,-,-,-,-	11,10,9,8,-,-,-
Domtar Inc	Canada	217	549	-,-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-,5
Dow Chemical Co (Usa)	United States	30	146	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
E. I. Du Pont de Nemours	United States	21	90	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Eastman Chemical	United States	36	123	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Georgia-pacific Corp	United States	307	783	-,-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-,5
International Paper Co	United States	41	376	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Meadwestvaco Corp	United States	69	297	-,10,9,8,7,6,5,4,3,2,1	11,-,-,-,-,-,-
Mosaic Co/The	United States	69	197	-,-,-,-,-,-,-,-,-,-,-	-,10,-,-,-,-,-
Nova Chemicals Ltd	Canada	289	830	-,-,-,-,-,-,-,-,-,-,-	-,-,-,-,7,6,5
Olin Corporation	United States	101	302	-,-,-,8,7,-,-,-,-,-	11,10,9,-,-,-,-
Rohm & Haas Co	United States	27	123	-,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Sherwin-williams Co	United States	29	123	11,10,9,8,7,6,-,-,-,-	-,-,-,-,-,-,-
Temple Inland Inc	United States	92	557	-,-,-,8,7,6,-,-,-,-	11,10,9,-,-,-,-
Weyerhaeuser Co.	United States	75	311	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Communications					
Alltel Corporation	United States	82	989	-,-,-,8,7,6,5,4,3,2,-	-,-,-,-,-,-,-
At&t Corp	United States	18	92	-,-,-,-,-,-,-,-,-,2,1	-,-,-,-,-,-,-
AT&T Inc	United States	27	191	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
AT&T Mobility	United States	20	71	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
AT&T Wireless Services Inc	United States	20	70	-,-,-,-,-,-,-,-,-,-,1	-,-,-,-,-,-,-

Credit Name	Country	5yr CDS spread		Index membership	
		Min	Max	IG	Xover
Bellsouth Corp	United States	18	108	-,-,-,-,-,5,4,3,2,1	-,-,-,-,-,-
Belo Corp	United States	155	951	-,-,9,-,-,-,-,-,-,-	11,10,-,-,-,-
Centurytel Inc	United States	45	217	11,10,9,8,7,6,5,4,3,2,-	-,-,-,-,-,-
Clear Channel Comunicat	United States	472	2626	-,-,-,-,7,6,5,4,3,2,1	-,-,-,8,-,-,-
Corning Inc	United States	23	158	-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,5
Embarq Corporation	United States	70	444	11,10,9,8,7,-,-,-,-,-,-	-,-,-,-,-,-
Expedia Inc	United States	147	500	-,-,-,8,7,-,-,-,-,-,-	11,10,9,-,-,-,-
Frontier Communications Corp	United States	134	569	-,-,-,-,-,-,-,-,-,2,1	11,10,9,8,7,6,5
Gannett Co	United States	69	592	11,10,9,-,-,-,-,-,-,-	-,-,-,-,-,-
InterActiveCorp	United States	89	573	-,-,9,8,7,6,5,-,-,-,-	-,-,-,-,-,-
Liberty Media Corporation	United States	174	590	-,-,-,-,-,-,-,4,3,2,1	11,10,9,8,7,6,5
Motorola Inc	United States	36	395	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
New York Times	United States	60	601	11,10,-,-,-,-,-,-,-,-	-,-,-,-,-,-
Omnicom Group Inc	United States	27	221	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Sprint Nextel Corp	United States	81	753	-,10,9,8,7,6,5,4,3,2,1	11,-,-,-,-,-
Time Warner Inc	United States	43	264	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Tribune Co	United States	877	5280	-,-,-,-,6,-,-,-,-	-,-,8,7,-,-
Viacom Inc	United States	45	276	11,10,-,-,-,-,-,-,-,-	-,-,-,-,-,-
Walt Disney Co	United States	21	80	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Windstream Corp	United States	143	496	-,-,-,-,-,-,-,-,-,-	11,10,9,8,7,-,-
Consumer, Cyclical					
Autozone Inc	United States	35	165	11,10,9,8,7,6,5,4,3,-,-	-,-,-,-,-,-
Beazer Homes Usa	United States	768	2075	-,-,-,-,-,-,-,-,-,-	-,-,-,8,7,6,-
Brunswick Corp	United States	81	1277	-,10,-,-,-,-,-,-,-,-	-,-,-,-,-,-
Carnival Corp	United States	36	228	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Centex Corp	United States	311	618	-,-,9,8,7,6,5,4,3,2,1	11,10,-,-,-,-
CVS Corp	United States	30	115	11,10,9,8,7,6,5,4,3,2,-	-,-,-,-,-,-
D.R. Horton Inc	United States	279	822	-,-,-,-,-,-,-,-,-,-	-,-,-,-,6,5
Darden Restaurants Inc	United States	46	318	11,10,9,-,-,-,-,-,-,-	-,-,-,-,-,-
Hilton Hotels Corp	United States	288	1656	-,-,-,-,-,5,4,-,-,-	-,-,9,8,7,6,-
Home Depot Inc	United States	55	350	11,10,9,-,-,-,-,-,-,-	-,-,-,-,-,-
Hovnanian Enterprises	United States	935	3485	-,-,-,-,-,-,-,-,-,-	-,-,9,8,7,6,-
Jones Apparel Group Inc	United States	181	808	-,-,9,8,7,6,5,4,3,2,1	11,10,-,-,-,-
KB Home	United States	305	658	-,-,-,-,-,-,-,-,-,-	11,10,9,8,7,6,5
Kohls Corporation	United States	56	247	11,10,-,-,-,-,-,-,-,-	-,-,-,-,-,-
Lennar Corp	United States	348	924	-,-,9,8,7,6,5,4,3,-,-	11,10,-,-,-,-
Limited Brands Inc	United States	119	535	11,10,9,8,7,6,5,-,-,-,-	-,-,-,-,-,-
Liz Claiborn INC	United States	115	906	-,10,9,-,-,-,-,-,-,-	11,-,-,-,-,-
Macys Inc	United States	104	544	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Marriott International Inc	United States	40	450	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
May Department Stores Co	United States	93	535	-,-,-,-,-,-,-,-,3,2,1	-,-,-,-,-,-
Maytag Corporation	United States	32	80	-,-,-,-,-,-,-,4,3,2,1	-,-,-,-,-,-
Mcdonalds Corp	United States	22	57	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Mdc Holdings Inc	United States	129	243	11,10,-,-,-,-,-,-,-,-	-,-,-,-,-,-
Mgm Mirage Inc	United States	211	2000	-,-,-,-,-,-,-,-,-,-	11,10,9,8,7,6,5
Mohawk Industries	United States	70	362	11,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-
Newell Rubbermaid Inc	United States	27	164	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Nordstrom Inc	United States	34	378	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Penney J.C. & Co	United States	87	451	11,10,9,8,-,-,-,-,-,-	-,-,-,-,-,5
Pulte Homes Inc	United States	228	516	-,-,9,8,7,6,5,4,3,2,1	11,10,-,-,-,-
Radioshack corp	United States	140	318	-,-,-,-,7,6,5,-,-,-,-	11,10,9,8,-,-,-
Royal Caribbean Cruises Limited (Inc)	United States	157	966	-,-,-,-,-,-,-,-,-,-	11,10,9,8,7,6,5
Sabre Holdings Corp	United States	392	3101	-,-,-,-,7,6,5,-,-,-,-	-,-,-,-,-,-
Southwest Airlines Company Inc	United States	43	223	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Staples Inc	United States	46	342	11,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-
Starwood Hotels & Resorts Worldwide Inc	United States	111	527	11,10,9,8,7,-,-,-,-,-,-	-,-,-,-,6,5
Target Corporation	United States	26	210	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
The Gap Inc	United States	75	141	-,-,-,-,7,6,5,-,-,-,-	11,10,9,-,-,-
Toll Brothers Inc	United States	223	355	11,10,9,8,7,6,5,-,-,-,-	-,-,-,-,-,-
Toys R Us	United States	611	1407	-,-,-,-,-,-,-,-,-,1	-,-,-,-,-,-
Wal-mart Stores	United States	22	98	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Wendys International Inc	United States	183	459	-,-,-,-,-,6,-,-,-,-	11,10,9,8,7,-,-
Whirlpool Corp	United States	48	241	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Yum Brands	United States	47	184	11,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-
Consumer, Non-cyclical					
Aetna Inc	United States	37	163	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Albertsons Inc	United States	93	273	-,-,-,-,-,-,5,4,3,2,1	-,-,-,-,-,-
Altria Finance (C I) Ltd	United States	32	116	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Baxter FinCo BV	United States	17	47	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Boston Scientific	United States	149	331	-,-,-,8,-,-,-,-,-,-,-	11,10,9,-,-,-
Campbell Soup Co	United States	19	58	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Cardinal Health Inc	United States	28	129	11,10,9,8,7,6,5,4,3,-,-	-,-,-,-,-,-
CBS Corporation	United States	56	382	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Cendant Corp	United States	209	2584	-,-,-,-,-,6,5,4,3,2,1	-,-,-,-,-,-
Conagra Foods Inc	United States	24	101	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-
Donnelley (R.R) & Sons	United States	47	311	11,10,9,8,7,-,-,-,-,-,-	-,-,-,-,-,-

Credit Name	Country	5yr CDS spread Min	5yr CDS spread Max	Index membership IG	Index membership Xover
Fortune Brands Inc	United States	74	267	11,10,9,-,-,-,-,-,-,-	-,-,-,-,-,-,-
General Mills Inc (Usa)	United States	28	89	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
HCA Inc.	United States	379	879	-,-,-,-,-,-,-,-,-,-,-	-,-,-,-,7,6,5
Kraft Foods Inc	United States	25	166	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Kroger Company	United States	32	95	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
McKesson Corp	United States	23	115	11,10,9,8,7,6,5,4,3,-,-	-,-,-,-,-,-,-
Quebecor World Inc	Canada	447	2988	-,-,-,-,-,-,-,-,-,-,-	-,-,-,-,7,6,-
Quest Diagnostic Inc	United States	44	171	11,10,9,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-
Reynolds American Inc	United States	59	209	-,-,-,-,-,-,-,-,-,-,-	-,-,-,8,-,-,-
Safeway Inc	United States	32	104	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Sara Lee Corp	United States	28	109	11,10,9,8,7,6,5,-,-,-,-	-,-,-,-,-,-,-
Smithfield Foods INC	United States	229	989	-,-,-,-,-,-,-,-,-,-,-	11,10,9,8,7,-,-
Supervalu Inc	United States	126	393	-,-,-,-,-,6,5,4,3,2,-	-,-,-,-,-,-,-
Tyson foods Inc	United States	81	359	-,-,-,8,-,6,5,4,3,2,1	11,10,9,-,7,-,-
Universal Health SVCS	United States	67	219	11,10,9,8,-,-,-,-,-,-,-	-,-,-,-,-,-,-
Diversified financials					
American Express Co	United States	38	671	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Cigna Corp	United States	36	165	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Cit Group Inc	United States	191	2798	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Fannie Mae	United States	26	94	-,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Freddie Mac	United States	25	97	-,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
General Motors Acceptance Corporation	United States	497	6877	-,-,-,-,-,-,-,4,3,2,1	-,-,9,8,7,6,5
Host Marriott Corp	United States	205	763	-,-,-,-,-,-,-,-,-,-,-	11,10,-,-,-,-,-
Istar Financial Inc	United States	343	5067	11,10,9,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-
MBNA Corp	United States	13	13	-,-,-,-,-,-,-,4,3,2,1	-,-,-,-,-,-,-
National Rural Utilities Cooperative Finance Corporation	United States	27	220	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Residential Capital Corp	United States	1373	11042	-,-,-,8,7,-,-,-,-,-,-	-,-,9,-,-,-,-
Energy					
Amerada Hess Corp	United States	37	353	-,-,-,-,-,-,-,-,-,-,1	-,-,-,-,-,6,5
Anadarko Finance Co	United States	40	212	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Chesapeake Energy Corp	United States	124	924	-,-,-,-,-,-,-,-,-,-,-	11,10,9,8,-,-,-
Conocophillips	United States	26	104	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Devon Energy Corp	United States	23	109	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
El Paso Corporation	United States	170	709	-,-,-,-,-,-,-,-,-,-,-	11,10,9,-,-,-,-
Halliburton Company Inc	United States	22	78	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Hess Corp	United States	39	362	-,-,-,-,-,-,-,-,-,-,-	-,-,-,-,7,-,-
Kerr-Mcgee Corporation	United States	19	99	-,-,-,-,-,-,-,4,3,2,-	-,-,-,-,-,6,5
Pioneer Natural Resource	United States	153	479	-,-,-,-,-,-,-,-,-,-,-	11,10,9,8,7,6,-
Transocean Inc	United States	30	295	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Valero Energy Corp	United States	39	268	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Williams Companies	United States	75	368	-,-,-,-,-,-,-,-,-,-,-	-,-,9,8,7,-,-
XTO Energy Inc	United States	34	349	11,-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-
Industrial					
Arrow Electronics Inc	United States	37	137	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Avnet Inc	United States	41	197	-,-,-,-,-,-,-,-,-,-,-	-,-,-,8,7,6,5
Black & Decker	United States	48	205	11,10,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-
Bombardier Inc	Canada	136	502	-,-,-,-,-,-,-,-,3,-,-	11,10,9,8,7,6,5
Burlington Northern Santa Fe Corporation	United States	25	87	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Caterpillar Inc	United States	27	149	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Csx Corp	United States	49	180	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Deere&co	United States	27	145	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Eastman Kodak Co	United States	179	461	-,-,-,-,-,-,-,4,3,2,1	-,-,-,-,-,-,5
Flextronics Intl Ltd	United States	183	537	-,-,-,-,-,-,-,-,-,-,-	11,10,9,8,7,6,5
Goodrich (Bf) Co.	United States	21	89	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Honeywell International	United States	21	94	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Ingersoll-Rand Co	United States	27	108	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Lockheed Martin Corp	United States	19	56	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Masco Corp	United States	78	451	11,10,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-
Norfolk Southern Corp	United States	26	88	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Northrop Grumman Corp	United States	20	67	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Raytheon Co	United States	20	62	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Ryder System Inc	United States	42	309	11,-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-
Union Pacific Corporation	United States	27	92	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
United Parcel Service Inc	United States	14	87	11,-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-
Insurance					
Ace Limited	Bermuda	28	142	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Allstate Corporation	United States	26	348	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
American Intl Group	United States	52	2529	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Chubb Corp	United States	26	130	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Hartford Financial Services Group Inc	United States	31	905	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Loews Corp	United States	22	106	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Marsh & Mclennan Cos Inc	United States	43	137	11,10,9,8,7,6,5,-,-,-,-	-,-,-,-,-,-,-
MBIA Insurance Corporation	United States	172	2993	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Metlife Inc	United States	33	950	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-

| Credit Name | Country | 5yr CDS spread | | Index membership | |
		Min	Max	IG	Xover
Unum Group	United States	63	387	-,-,-,-,-,-,-,-,-,-	-,10,9,8,7,6,5
XL Capital Ltd.	Bermuda	53	1268	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Other/non-defined					
Boeing Capital Corp	United States	12	234	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Bombardier Capital Inc	United States	29	91	-,-,-,-,-,-,-,-,-,2,1	-,-,-,-,-,-,-
Comcast Cable Comm	United States	35	200	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Countrywide Home Loan Inc	United States	95	1588	-,-,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Cox Communications Inc	United States	46	201	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Delhaize America Inc	United States	46	124	-,-,-,-,-,-,-,-,-,-,-	-,-,-,8,7,6,5
Echostar Dbs Corp	United States	113	659	-,-,-,-,-,-,-,-,-,-,-	11,10,9,8,7,6,5
EOP Operating LP	United States	41	195	-,-,-,-,7,6,5,4,3,2,1	-,-,-,-,-,-,-
ERP Operating LP	United States	61	477	11,-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-
Ford Motor Credit Co	United States	497	4781	-,-,-,-,-,-,-,4,3,2,1	-,-,-,-,-,6,5
General Elec Cap Corp	United States	34	630	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Harrahs Operating Co Inc	United States	433	3432	-,-,-,-,7,6,5,4,3,2,1	-,-,9,8,-,-,-
International Lease Finance Corp	United States	43	1003	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Intl Telecom Satellite	United States	641	1471	-,-,-,-,-,-,-,-,-,2,-	-,-,-,-,-,-,-
L-3 Communications Corporation	United States	123	243	-,-,-,-,-,-,-,-,-,-,-	11,10,9,8,-,-,-
News America Holdings	United States	27	130	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Qwest Corp	United States	115	540	-,-,-,-,-,-,-,-,-,-,-	-,-,-,8,7,6,5
Sears Roebuck Acceptance	United States	158	986	-,-,-,-,-,-,-,4,3,2,1	11,10,9,8,7,6,5
Simon Property Group LP	United States	48	502	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Textron Financial Corp	United States	27	742	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Time Warner Entertainment Company LP	United States	47	274	11,-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,-,-
Verizon Global Funding Corporation	United States	20	173	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Pharma & Biotech					
Amgen Inc	United States	25	128	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Bristol Myers Squibb	United States	21	58	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Wyeth	United States	20	61	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Technology					
Computer Associates International Inc	United States	95	325	-,-,-,-,-,-,-,-,-,-,1	11,10,9,8,7,6,5
Computer Sciences Corp	United States	35	142	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Electronic Data Systems Corp	United States	37	188	-,-,-,-,-,-,-,-,-,2,1	-,-,-,-,7,6,5
First Data Corp	United States	516	1283	-,-,-,8,-,-,-,-,-,-,-	-,-,-,-,-,-,-
Hewlett-Packard Co	United States	21	85	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
IBM Corp	United States	20	88	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Sun Microsystems Inc	United States	71	170	-,-,-,-,-,-,-,-,-,-,1	11,10,9,8,7,6,5
Unisys Corp	United States	517	1432	-,-,-,-,-,-,-,-,-,-,-	-,-,-,-,-,6,-
Xerox Corp	United States	53	601	11,-,-,-,-,-,-,-,-,-,-	-,-,-,-,7,-,-
Utilities					
American Electric Power Co	United States	35	95	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Constellation Energy Grp	United States	46	624	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Dominion Resources Inc	United States	34	144	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Duke Energy Corporation	United States	34	96	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Firstenergy Corp	United States	47	180	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Progress Energy INC	United States	31	77	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
Sempra Energy	United States	31	168	11,10,9,8,7,6,5,4,3,2,1	-,-,-,-,-,-,-
TXU Corp	United States	466	1175	-,-,-,-,-,-,-,-,-,-,-	-,-,9,8,7,6,5

Source: Markit, Barclays Capital

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