

UBS Investment Research

Avoiding a design flaw of early CPDOs



Why early CPDOs are not safe and how to improve on them

■ **Early CPDOs overweight BBB exposure**

Sometimes the first mover in a new technology fails, even when the technology itself succeeds. Early CPDOs may be an example. Early CPDOs use credit indexes of which over 50% is BBB rated. We argue that this heavy BBB weighting is a design flaw, making early CPDOs more risky than commonly thought. But we believe new versions emphasizing higher-quality exposure are a good choice.

■ **What has been missed: BBB returns are not mean reverting**

CPDO analysis to date has focused on mean reversion in credit index spreads. This is a mistake in our view. It is not spreads but returns that drive CPDO risk and return. For BBB indexes, returns are NOT mean reverting, even if credit spreads seem to be. Sometimes index spread changes can be illusions, e.g. removing fallen angels can cause index spreads to tighten, even when excess returns are negative.

■ **Hence, early CPDOs are not safe**

The assumption of mean reversion in a model acts to lower the assumed likelihood of extreme outcomes in the future. Removing the assumption of mean reversion from the BBB index alone is enough to increase early CPDO default risk considerably, e.g. changing a rating from AA to B+, well inside “junk” territory.

■ **Long higher-quality/short lower-quality is a better choice**

While mean reversion is absent from BBB rated indexes, it is a fact for higher quality indexes (e.g. AAA, AA, and A rated). Hence, going long higher-quality indexes and short/flat lower-quality ones makes sense. Like commercial jets, market-value structures have transformational potential. Now investors can move beyond simply wearing default risk and benefit from other sources of value.

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# CPDOs: scam, breakthrough, work-in-progress?

Perhaps no financial product introduced during 2006 sparked such heated debate as the CPDO, a.k.a. “constant proportion default obligation,” a combination of CPPI and CDO technology. CPDOs seemed to offer an unbeatable combination:

- High coupon: typically in the region of LIBOR + 200 bppa
- High rating: typically AAA or AA rated

It seemed like the best of both worlds—spreads associated with high yield risk that would be rated BB/B, but ratings associated with the highest of high grade names (AAA/AA).

Supporters were effusive. Many gushed that CPDOs were amazingly durable, surviving all kinds of simulated stress scenarios. But detractors reacted with scepticism, if not mockery. One spoof likened a CPDO product pitch to a solicitation letter for the notorious “advance fee” or “419” scam.

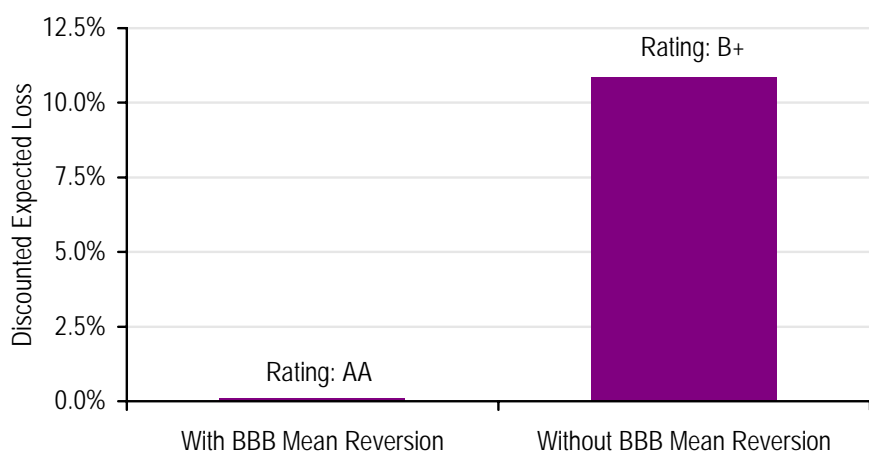
Are the early CPDOs a scam? Or are they a breakthrough, perhaps threatening the old order? This report argues that early CPDOs are neither scams nor messianic. They are more like work-in-progress. Perhaps they are a necessary but imperfect step in the right direction. Or a first-draft of what will become a good tale, but which itself deserves a quick fling into the rubbish bin.

Early CPDOs are like a first draft of what will become a good tale, but which itself deserves a quick fling into the rubbish bin

## Mean reversion can turn weeds into flowers

This report shows that removing the assumption of mean reversion for the BBB rating category alone dramatically increases risk in early CPDOs. As shown in Chart 1, a typical early CPDO rated AA becomes a lowly B+ (i.e. a 10 notch downgrade) when the assumption of mean reversion is dropped for that part of its reference portfolio rated BBB.

Chart 1: Expected losses with and without assuming BBB mean reversion



If BBB indexes are not mean reverting, a CPDO that has an AA rating may actually only deserve a B+, i.e. a 10 notch downgrade, from upper high grade to mid-level junk

Source: UBS

Of course, the next question is whether mean reversion has in fact been overestimated for the BBB category. We argue that it has, because analysis to date has focused on historical index credit spreads.

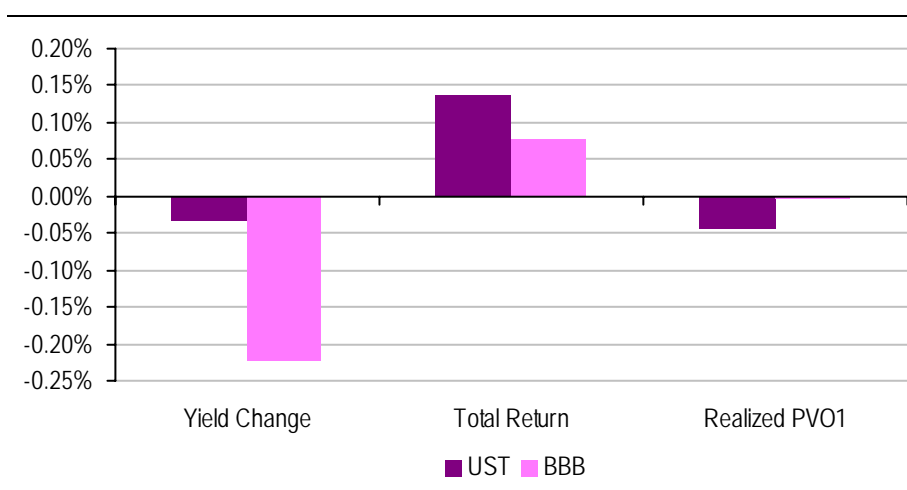
## Historical index spreads are misleading

At first glance, it might seem perfectly reasonable to estimate mean reversion in a given rating category by using its history of index spreads. It is easy to think that the linkage between yield changes and returns that generally applies in fixed income instruments should also apply here.

But credit indexes are an exception. This is because credit indexes rebalance to exclude issuers that no longer meet index criteria, particularly with respect to ratings. For example, Ford and GM bonds left high grade indexes when they lost their investment grade rating.

The removal of fallen angels causes index spreads to tighten, but it does not cause index returns to increase in a proportionate amount. In other words, index spread tightening attributable to the removal of fallen angels is economically insignificant. There is no direct link between index spread changes and realized index returns in this case. (See page 10ff and page 17ff for more details.)

Chart 2: Example of a disconnect between BBB index yield changes and index returns



Source: UBS, Bloomberg, YieldBook. Data covers yield changes and total returns from 31 August 2005 to 1 September 2005, i.e. the month-end roll. Indexes are the Citigroup US Treasury and USD BIG BBB, both 3-7 year.

Chart 2 provides a concrete example. At the end of August 2005, GM and Ford bonds left the Citigroup BIG BBB 3-7 year index. As fallen angels, their credit spreads were wider than the average BBB credit spread. The first date in which Ford and GM bonds were not included in the index was 1 September 2005.

As such, the BBB index yield fell over 20 basis points from 31 August to 1 September. Over the same period, the US Treasury index yield fell approximately 3 basis points. While the UST index yield fell *less* than the BBB index yield, the UST index total return was *higher* (0.14% vs. 0.08%). Realized PV01 was -0.04% for the UST index, but realized PV01 was near zero for the BBB index. This is because removing fallen angels creates no value by itself. Hence, falling spreads do not translate into higher returns in such cases.

Index spread tightening attributable to the removal of fallen angels is economically insignificant—it does not translate into positive returns proportionate to spread changes

Month-end August 2005:

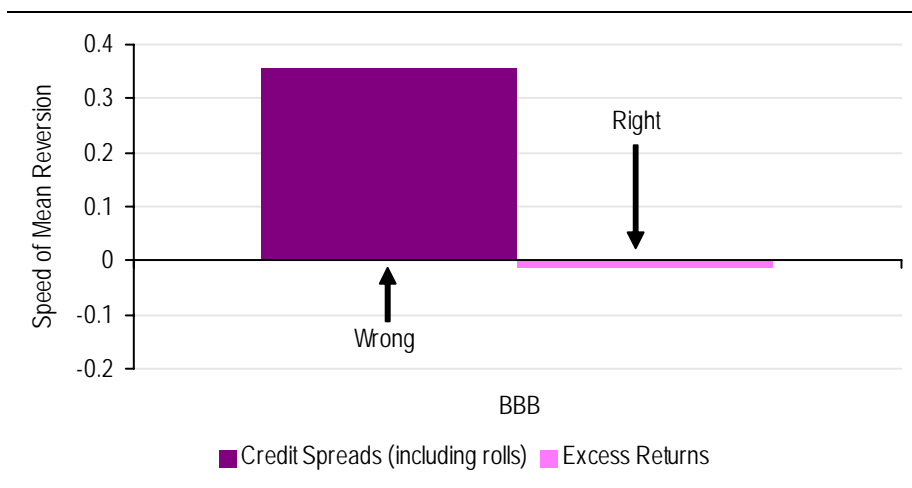
BBB index yield falls 0.20%, UST index yield falls 0.03% (i.e. BBB index credit spread *tightens* 0.17%), ...

...but BBB index return is only 0.08%, underperforming the UST index return of 0.14% (i.e. BBB index excess return was *negative* at -0.06%)

Falling index spreads do not necessarily translate into positive excess returns

To estimate mean reversion more properly, one should focus on index excess returns rather than spreads, as excess returns reflect results net of all costs to index investors. Returns are what investors really care about, not spreads. Chart 3 shows that a large difference exists between using returns and using spreads to estimate mean reversion.

Chart 3: BBB mean reversion measured from spreads vs. returns



Mean reversion is observable in BBB index credit spreads, but not in BBB index excess returns

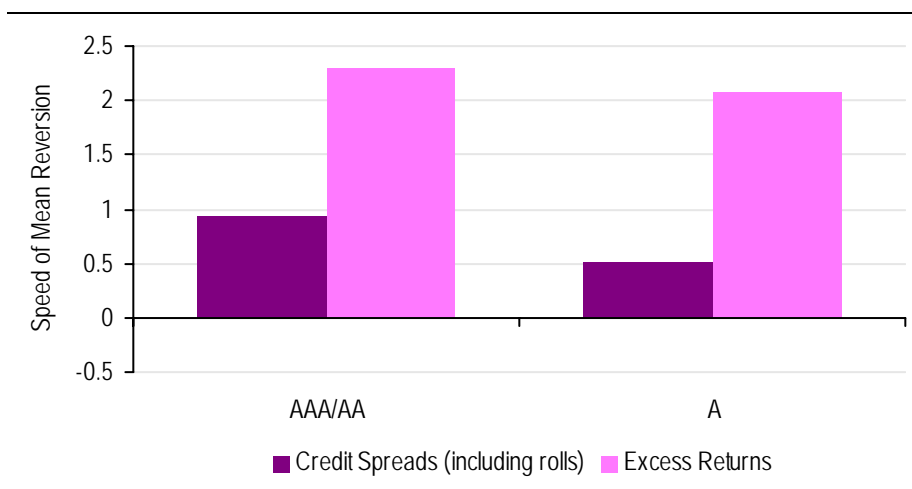
Source: UBS

Using unadjusted index spread histories, BBB indexes look mean reverting, as the speed of mean reversion is well above zero. But using excess returns, the speed of mean reversion declines to zero. If the speed of mean reversion is zero, there is no mean reversion.

### Higher-quality index mean reversion is more robust

Notice that higher-quality indexes provide a different result entirely. As shown in Chart 4, their mean reversion is solid, whether you measure it using returns or spreads. Hence, this higher quality credit exposure is much better suited to CPDO structures.

Chart 4: Higher-quality index mean reversion using spreads and returns



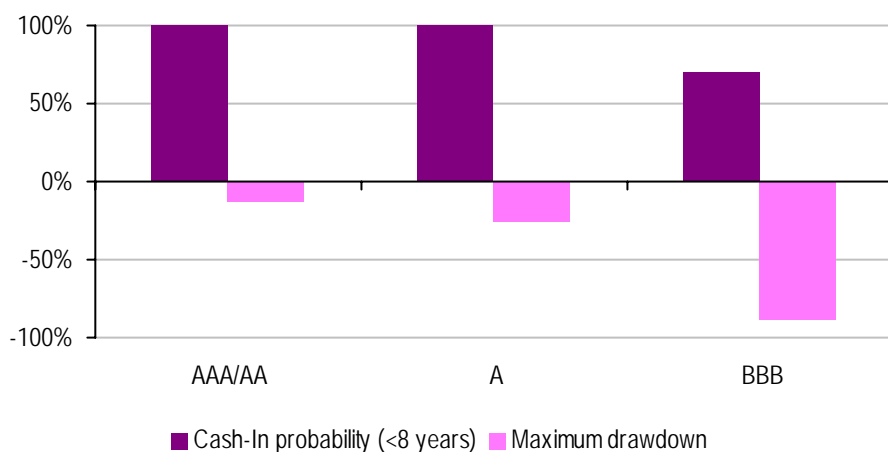
Higher-quality indexes (A, AA, AAA) show clear mean reversion in both spreads and excess returns, making them more suitable than BBB rated indexes for use in CPDO-style products

Source: UBS

## Historical data (not just a model) confirms BBB unsafe

While it is useful to examine risk in terms of forward-looking models, it is also helpful to consider historical data. A key advantage of historical data is that it can be used independent of modelling assumptions. Even the best models cannot hope to capture every last aspect of the real world. But using history, we can let the data speak for itself.

Chart 5: CPDO risk based on historical (not model-based) simulation of underlying



Historical simulation lets the data speak for itself, independent of modelling assumptions. The data shows clearly that BBB index exposure is risky in CPDO format

Source: UBS, Bloomberg, YieldBook. Using daily index data from 1995 to 2007.

Some of the results are shown in Chart 5. “Cash-In” is a state in which a CPDO product has achieved enough returns to unwind risk positions and still pay promised coupons. Clearly, it is good to achieve Cash-In as often as possible.

What historical simulation suggests is that a CPDO using the BBB index as an underlying portfolio would only achieve Cash-In within eight years of launch 71% of the time over this sample period. In contrast, a CPDO using a AAA/AA or Single-A index as underlying portfolio would have achieved Cash-In within eight years of launch 100% of the time. Similarly, the market value of a CPDO using the BBB index would have endured maximum drawdown of 89%, more than 3x as severe as the other categories. (Please see page 27ff for more details). Moreover, this simulation probably *understates* the risks, as it uses historical bond indexes, not CDS indexes. It is well known that CDS spreads widen faster and reach more extreme levels than bond credit spreads.

## Separating mirage from oasis, part 2

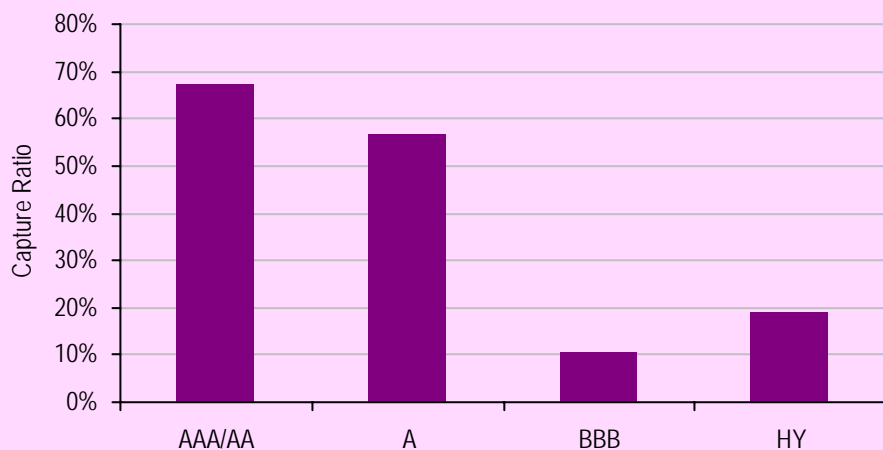
These results should not surprise anyone familiar with our previous research on credit indexes, “Separating mirage from oasis.”<sup>1</sup> There we showed that a big difference exists between BBB credit spreads and excess returns, especially when credit spreads are tight. What you see is not what you get. What some people call “carry” (as if it were almost certain to be captured) may be eaten away by fallen angel losses, even if no defaults occur.

<sup>1</sup> Anthony Morris, Separating mirage from oasis / Finding value in credit index exposure when spreads are tight, *UBS Investment Research*, 30 November 2005

## Separating mirage from oasis: highlights

Although we wrote this piece towards the end of 2005, almost two years ago, the analysis is long-term in nature and applies just as much today as then.

Chart 6: Excess return captured relative to average credit spread (1988-2007)



Source: UBS, Bloomberg. Capture Ratio measures the average excess return realized relative to average credit spread over LIBOR during the 1988-2007 period. HY is High Yield.

In particular we noted that

- Spreads are not the same as excess returns. What you see (spreads) is not what you get (excess returns), especially with respect to BBB indexes, as shown in Chart 6
- Fallen angel losses are more important than defaults in determining the performance of investment grade indexes
- BBB and High Yield indexes do not show statistically-significant evidence of outperforming LIBOR in the long-term
- High grade indexes—which typically have a high BBB weighting—may underperform even US Treasury indexes, much less LIBOR, over the long term
- Higher-quality credit indexes (AAA, AA, and A rated) perform better than BBB rated, High Yield, or even equity indexes in risk-adjusted terms

Table 1 shows not just that BBB index performance is surprisingly bad, but also that higher-quality indexes perform surprisingly well, even relative to equities.

Table 1: How higher-quality credit outperforms BBB, High Yield, and S&P 500

	AAA/AA	A	BBB	HY	S&P 500
Sharpe Ratio	0.44	0.40	0.06	0.13	0.31
Calmar Ratio	0.19	0.17	0.01	0.02	0.07

Source: UBS, Bloomberg. Sharpe ratio is excess return relative to volatility. Calmar ratio is excess return relative to maximum drawdown (the greatest percentage loss subsequent to a previous high).

So it is with mean reversion. As far as BBB indexes go, historical spreads suggest a sunny reality, while historical returns suggest something bleaker.

There is an additional point from our earlier research that applies here. We showed evidence that BBB and high yield credit indexes delivered particularly poor long-term performance (zero or negative excess returns relative to LIBOR) when starting from tight-spread environments.

Being long BBB index positions outright when spreads are tight does not make sense as a long term investment, even in vanilla format. Why should it make sense to leverage such a position in a structured product? No amount of leverage can turn a zero or a negative into a positive.

## Sensible CPDO design—focus on high quality

As such, we believe investors should get out of early CPDO products. Given that both risk-adjusted returns and mean reversion appear to be most robust in the higher-quality credit indexes, investors looking to take full advantage of CPDO technology should design exposure accordingly.

For example, a reference portfolio linked to higher-quality exposure makes sense in a structured format, especially with a lower-quality short position as a hedge, just as we argued in earlier research that it makes sense in a vanilla context. Higher-quality exposure includes the LoVol index (the standard indexes without the HiVol element) and highly-rated financials, for example. Lower-quality exposure includes HiVol, Crossover, or High Yield indexes.

## CPDO products and the dawn of the jet age

The hullabaloo surrounding early CPDO products reminds us of a lesson from the dawn of the jet age in commercial aviation. Sometimes the first mover in a new technology fails—even when the technology itself goes on to become a huge success.

Consider de Havilland's role in developing commercial jet aircraft. The de Havilland Comet was the first commercial jetliner in history, entering service in 1952. Unfortunately, de Havilland made a serious design flaw, underestimating the Comet's vulnerability to metal fatigue. Tragically, a series of fatal crashes occurred before the problem was identified.

While they were not first movers, Boeing and Douglas introduced better-designed jet aircraft—the 707 and DC-8 respectively. These subsequently became the most widely-used commercial aircraft of that era. The once-mighty de Havilland lost its edge and was eventually absorbed into another firm.

Though some of the first jet travellers met a horrific fate, millions of passengers subsequently benefited from commercial jet technology. As with the development of commercial jets, safety in new financial technology depends on appropriate design. It is easy to underestimate vulnerability when there is little precedent. And what ultimately succeeds may not be apparent at first glance. The evolution of CPDO products is a case in point.

Holding long BBB index positions outright when spreads are tight does not make sense as a long-term investment, even in vanilla format

Why should it make sense as the underlying of a structured product?

Sometimes the first mover in a new technology fails—even when the technology itself goes on to become a huge success

As with the development of commercial jets, safety in new financial technology depends on appropriate design

## Key features of early CPDOs

This section describes features of early CPDOs that are especially relevant for our current analysis. It does not attempt to provide a full description of all CPDO mechanics, features, or sensitivities. For more comprehensive coverage of CPDO characteristics than what is provided here, please see the work of [Etienne Varloot \*et al\*](#) and [Douglas Lucas](#) among those listed in the References section at the end of this document. Their work has been helpful to us.

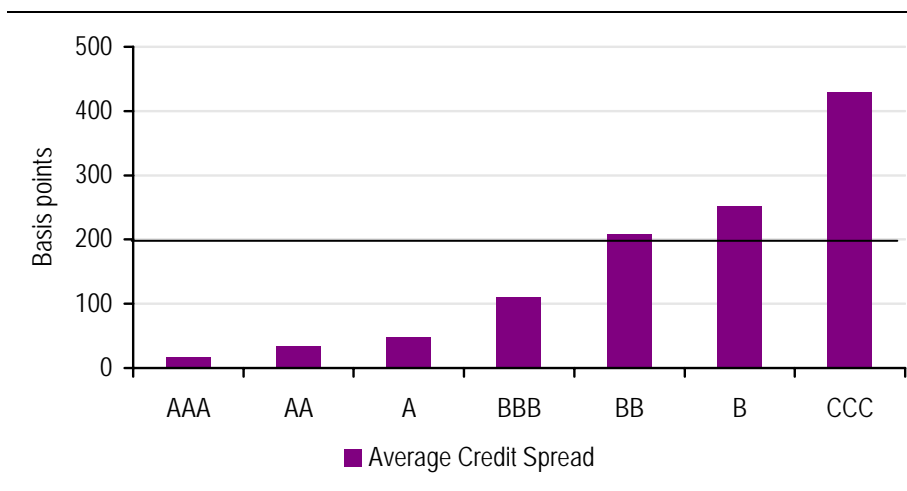
Here we want to focus on the following attributes:

- High coupons for a given rating
- Ratings depend on models
- On-the-run index exposure
- High BBB rated exposure weighting

### High coupons for a given rating

The first CPDO products appeared in the second half of 2006. They were rated AAA, had a 10-year maturity and paid coupons of LIBOR + 200 bppa. Such a spread was normally associated with bonds of much lower quality, even below investment grade, as shown in Chart 7.

Chart 7: Average 10-year credit spread over LIBOR from September to December, 2006



Source: UBS Delta

The average 10-year credit spread of BB-rated corporate bonds was about 200 bppa above LIBOR, while AAA-rated corporate bonds traded at around 15 bppa. So the AAA-rated CPDO was offering an enormous yield pick-up (approximately 185 bppa) for its given rating.

## Ratings depend on models

The high spread for the rating begs the question—just how is the CPDO rating determined? The answer to this question is not simple. A key point to remember is that CPDO ratings are different from ordinary bond ratings.

CPDO ratings depend on risk models and the choice of parameter values for these risk models

Traditional ratings of companies derive mainly from a process of fundamental analysis. CPDO ratings depend mainly on quantitative modelling. Any model has to make assumptions about the behaviour of relevant risk factors. And a key element to any modelling assumption is the choice of parameter values. Someone must decide what the appropriate level is for parameters such as volatility, correlation, rate of change, and mean reversion. As we have noted, mean reversion is a core assumption of CPDO rating models.

To use an analogy from option pricing, it is not enough to say that one will use the Black-Scholes model. One must also decide on which level of volatility to use as a parameter choice. As volatility is not directly observable like interest rates or underlying stock prices, determining the parameter value is a non-trivial exercise. Even an otherwise correct model can be rendered useless by poor choice of parameter values.

Even an otherwise correct model can be rendered useless by poor choice of parameter values

## On-the-run index exposure

Early CPDO products sell protection on a portfolio combining iTraxx Europe and CDX North America credit default swap indexes. These index swaps are market benchmarks and enjoy high liquidity. Like government bonds, they trade at a variety of maturities. The main tenors are 3, 5, 7, and 10 years.

### Index rolls create spread “tightening” that is spurious

Also like government bonds, the main CDS indexes have “on-the-run” (abbreviated here as “OTR”) instruments. These are newer and more liquid than the “off-the-run” instruments that were created earlier. The new series of each index is created twice a year, around the March and September IMM dates. The newest series will be OTR for the six months until the next new series is created.

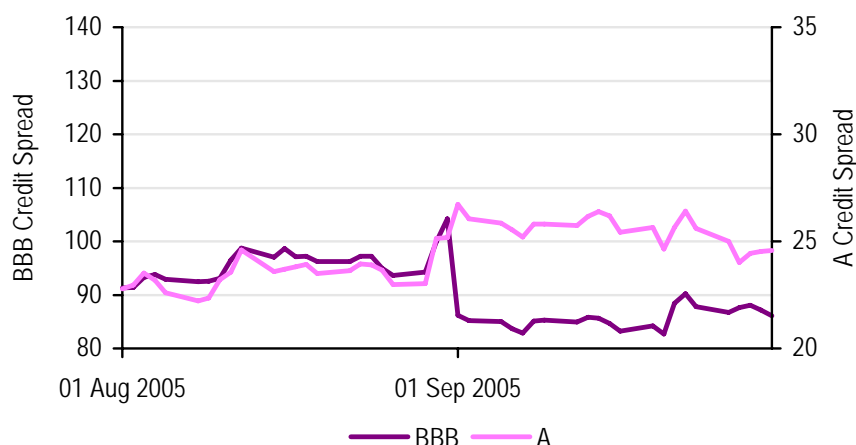
Early CPDO products, like many credit CPPI products, maintain exposure only to OTR indexes. That means they must trade out of the old OTR index and into the new OTR index. This process is known as “the roll”.

Early CPDOs, like traditional credit bond indexes, must unwind fallen angel exposure at prevailing prices as part of the roll

Since each new OTR index series can only include investment grade issuers, the composition of issuers in the each index series may be different. For example, Ford and GM are in the old CDX index series that were created when these automakers were still investment grade. But since they became fallen angels in 2005, they have not been eligible for inclusion in new high grade index series.

Hence, executing a roll can involve unwinding exposure to fallen angels, and replacing them with issuers that are investment grade. This is similar to the process of credit bond indexes, which must remove fallen angel bonds at the end of each calendar month at prevailing market prices, re-allocating exposure to bonds that are still high grade.

Chart 8: BBB bond index tightening given removal of fallen angels at month-end



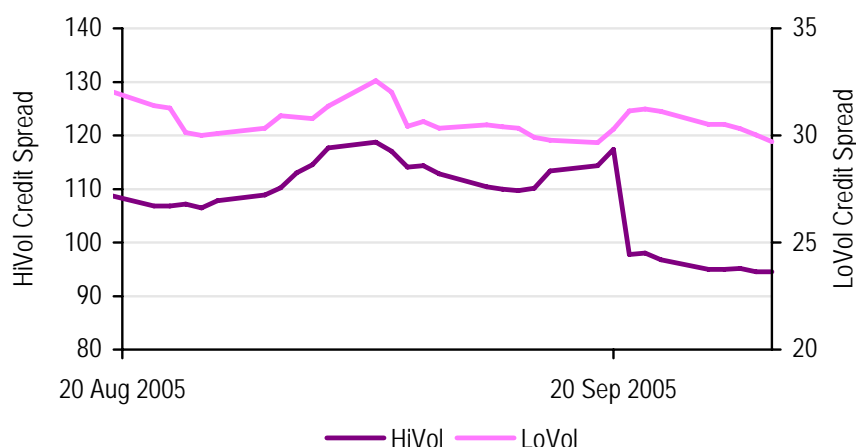
Source: UBS, YieldBook, USD BIG indexes.

Removing fallen angel exposure clearly has the highest impact on BBB rated indexes, as shown in Chart 8. Notice that at the end of August 2005, the BBB index spread “tightened” dramatically, falling about 20 basis points as fallen angels were removed. It is important to remember that declines in credit bond index spreads that occur around end-of-month usually have more to do with rebalancing than with actual investment returns. Indeed, single-A index spreads barely changed at this time. If the BBB “tightening” were a general market phenomenon, one would have expected to see tightening in other rating categories. But this fall in BBB index spreads is simply a function of removing fallen angels at the end of the month—not economically-meaningful returns.

If a BBB bond index shows tightening credit spreads at the end of the month, it may be entirely a function of removing fallen angels as part of the roll. It may have nothing to do with any actual gain in underlying value

This phenomenon is also evident in CDS indexes. Chart 9 below shows the behaviour of CDX North American high grade indexes over the same period as the USD high grade bond indexes shown in Chart 8 above. Note that the roll for the CDX indexes occurred on 20 September, rather than on 1 September as was the case with the bond indexes. We will revisit this important subject later.

Chart 9: OTR HiVol CDS index tightening given removal of fallen angels at the roll

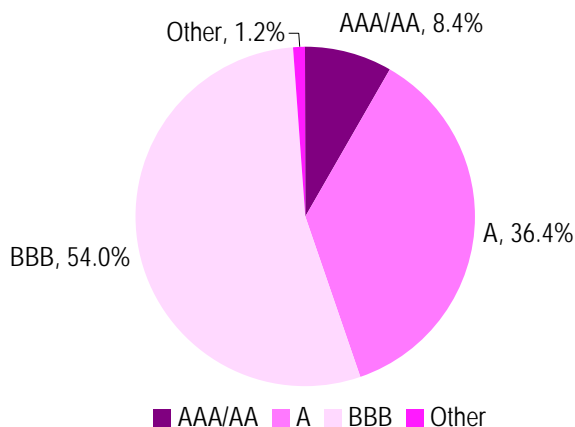


Source: UBS, Bloomberg. LoVol refers to the 95 issuers in the 125-member “main” index that are not part of HiVol.

## High BBB weighting

While the OTR CDX/iTraxx index portfolio that early CPDOs reference is investment grade at creation, more than 50% of the exposure is rated BBB—the lowest category of investment grade, just one step above speculative grade.

Chart 10: More than half the combined CDX/iTraxx index portfolio is BBB



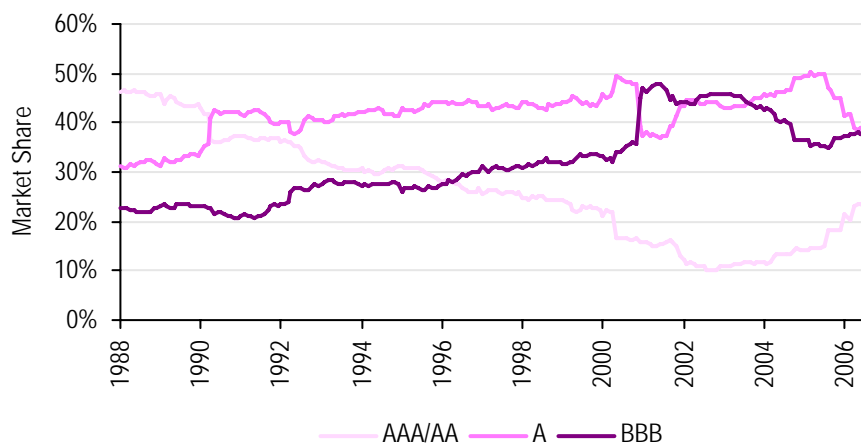
Source: UBS

As we have said, this high weighting on BBB exposure creates more dangers than is commonly realized. In fact, we argue that it constitutes a design flaw in early CPDOs.

## BBB weighting could go even higher in the future

There is no rule fixing the weight of BBB rated exposure in the main indexes. In fact, it seems likely that the share of BBB rated exposure in the index universe is cyclical, assuming a larger proportion of total exposure when credit conditions get worse. For example, Chart 11 shows that BBB rated market share was higher in the 2001-2002 period, when credit conditions were bad. Of course, the current phase of the credit cycle is benign. This suggests that BBB rated exposure now is probably lower than it will be in the future.

Chart 11: BBB rated index exposure gets larger when credit conditions worsen



Source: UBS, Bloomberg, Citigroup bond indexes. Market share is proportion of credit bond index market value.

## Why BBB indexes are not mean reverting

The title of this section may sound absurd at the outset. Is it not the case that “everyone” agrees that credit spreads are mean reverting?

Indeed, of all the material written about CPDOs, we are not aware of any analysis that questions the core assumption of mean reversion. Rather, there have been “stress tests” galore focusing on spread movements, defaults, etc. But typical CPDO analysis takes as given that credit spread indexes are mean reverting.

“Everyone” does not include us. We want to ask the simple question: is the assumption of mean reversion in credit indexes actually valid?

In this section we argue that the assumption of mean reversion

- Is generally correct for most rating categories of credit indexes
- But it is *not* empirically validated for BBB rated credit indexes

Our reasoning is methodological. In particular, we find that

- It is easy to mis-measure mean reversion by focusing on historical index credit spread time series, which all analyses to date seem to have done
- Historical index credit spread time series are biased samples, because they include a material amount of spread tightening that is economically irrelevant—an artefact of portfolio rebalancing practices in credit indexes
- After removing economically-irrelevant spread tightening from the sample, either by focussing on realized excess returns or removing rebalancing days from the sample, the estimated speed of mean reversion for BBB indexes is non-positive—i.e. BBB indexes are not mean reverting

We are aware that these claims are serious and will now go through each of them in more detail.

## What is mean reversion?

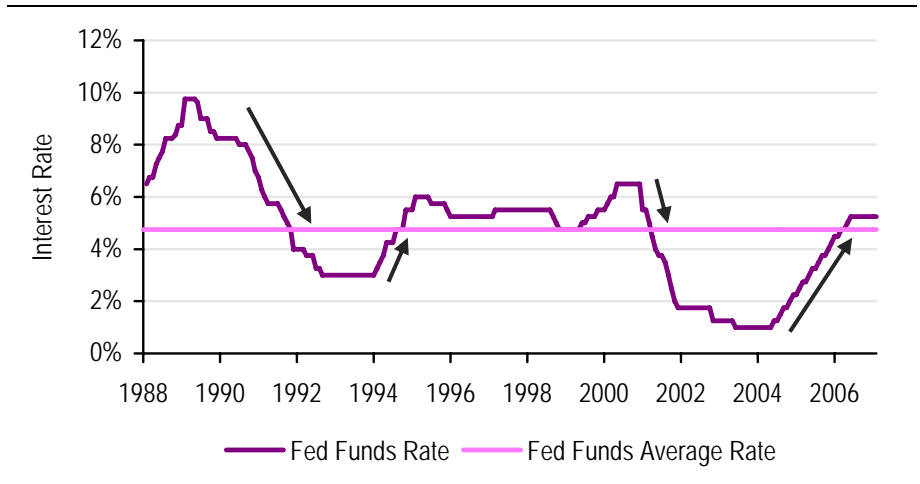
A random variable displays mean reversion if it has a tendency to come back to a long-term average level. Not all variables show such a trait.

### A tennis ball attached to a rubber string

As a rough analogy, think of a tennis ball attached to a rubber string. You may hit the ball hard, but it will be more likely to come back to you the further away it goes. If the ball were not attached to the rubber string, it would not be likely to come back to you. The ball on the string is mean reverting. The ball without a string attached is not. You are less likely to lose the ball attached to the string.

In financial markets, mean reversion is associated with models of interest rates. As shown in Chart 12, interest rates seem to return to a long term average level, though they can go far above or below it at times.

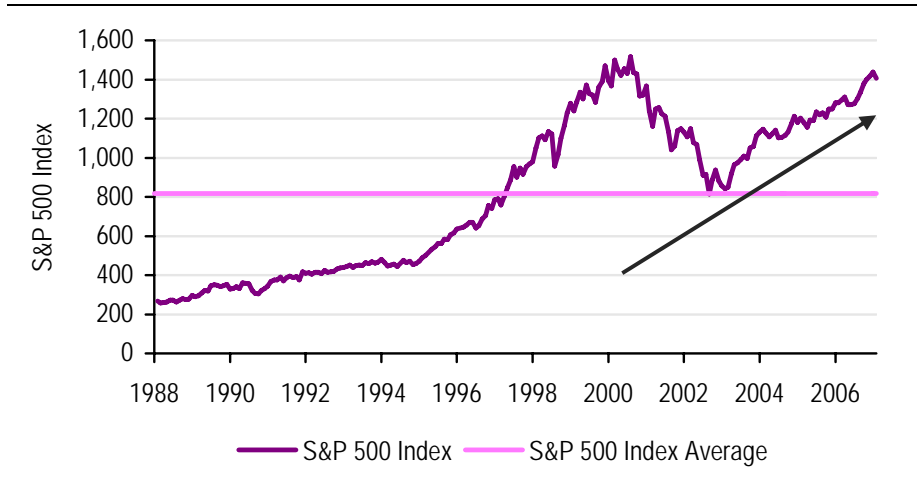
Chart 12: Fed Funds illustrate mean reversion in short-term interest rates



Source: UBS, Bloomberg

Equity prices do not share this characteristic, as shown in Chart 13.

Chart 13: S&P 500 index levels shows a lack of mean reversion in share prices



Source: UBS, Bloomberg

An asset that is mean reverting is like a tennis ball attached to a rubber string

Mean-reverting assets are well-behaved relative to non-mean-reverting ones

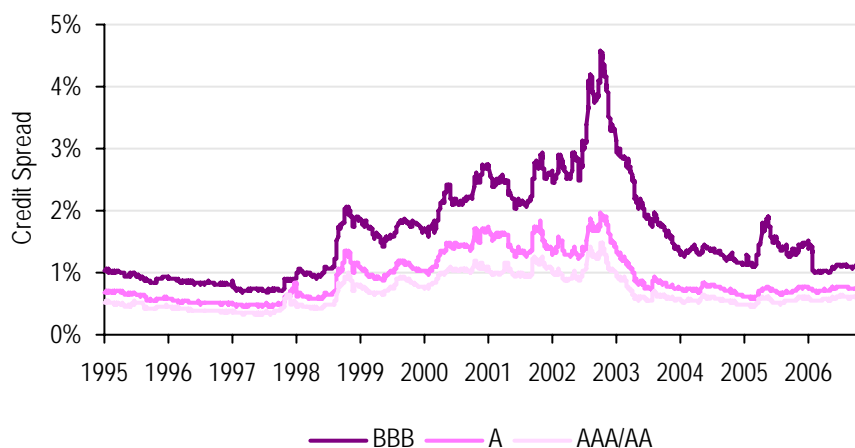
And you are less likely to lose a ball attached to a string than a ball that is not attached

As shown in Chart 13, equity prices do not seem to revert to any long term mean. Instead they tend to appreciate over time, getting further and further away from previous levels without returning. This is why equity option pricing models typically ignore mean reversion, and have done so since the Black-Scholes formula appeared in the early 1970s.

### Are credit spreads mean reverting?

What about credit spreads? Are they more like interest rates or more like equities? Intuitively, one might guess they are like equities, as both equities and credit exposure are claims on corporate balance sheets. But as shown in Chart 14, index credit spreads appear to be mean reverting like interest rates.

Chart 14: Credit index spreads appear to be mean reverting



If the appropriate question is whether historical bond index credit spreads are mean reverting or not, the answer is clearly that they are

Source: UBS, Bloomberg, YieldBook. Spreads are OAS over US Treasuries.

Indeed standard estimation techniques using historical index spread data would suggest that the speed of mean reversion is positive in a statistically significant manner for all major investment grade categories, as shown in Table 2.

Table 2: Estimating speed of mean reversion the usual way, on index credit spreads

	Estimated speed of mean reversion	T-statistics (value > 2 reflects high confidence)
AAA/AA	0.94	1.75
A	0.51	1.21
BBB	0.36	0.95

Source: UBS, Bloomberg

## Mean reversion in stochastic terms

In 1977, Oldrich Vasicek published a paper introducing one of the first mean reverting models of interest rates. Based on the Ornstein-Uhlenbeck process, the short-term interest rate was assumed to follow a process of the following type

$$dr_t = \kappa(\theta - r_t)dt + \sigma dW_t$$

In words,  $r_t$  refers to the short-term interest rate on date  $t$ . Sigma (“ $\sigma$ ”) is the volatility of the short-term interest rate  $r$ . Theta (“ $\theta$ ”) is the long-term average level of  $r$ . Kappa (“ $\kappa$ ”) is the speed of mean reversion, i.e. the rate at which  $r$  will revert to its long-term average level,  $\theta$ .  $\kappa$  must be greater than zero for the process to be mean reverting.

The items in the above equation have the following interpretation:

- The term on the left hand side of the equation,  $dr_t$ , refers to the total change in the level of  $r_t$  over a short period of time,  $dt$ . This total change has two components, a drift term and a stochastic term, which appear on the right hand side of the equation
- The first term on the right hand side of the equation is known as the “drift” term, describing the expected rate of change in the time increment  $dt$ .
- The second term in the right hand side of the equation is known as the “stochastic” term, describing a random shock with zero mean and volatility  $\sigma$ , where  $dW_t$  is the Brownian or Wiener increment

Hence, if  $r_t$  is higher than  $\theta$  (i.e. if the current short-term rate is higher than its long-term average), then the drift term will be negative, as  $\theta - r_t < 0$ . In other words, ignoring stochastic shocks, there will be a tendency for  $dr_t$  to be negative. Hence, the short-rate will tend to decline towards its long-term mean. But if the situation were reversed, with  $r_t$  lower than  $\theta$ , then the short-rate would tend to increase towards its long-term mean.

A key point about this mean reverting process is that the drift term is not constant. Rather it depends on where the current short-term interest rate is relative to the long-term interest rate.

Notice the difference between Vasicek’s formula and the classic Black-Scholes-Merton process, which we could write for the short-rate as follows:

$$dr_t = \mu dt + \sigma dW_t$$

The drift term here (“ $\mu$ ”) is constant. It does not depend on any notion of a long-term average and the position of the current level relative to that long-term average. Hence, it is not mean reverting.

## What you see vs. what you get

The problem with the preceding analysis is that bond index credit spreads are not investable assets. As such, the fact that they are mean-reverting is irrelevant. As we showed on page 10 and following, bond index credit spreads can tighten just because the index has removed fallen angels. This “tightening” does not mean index investors actually made money.

The only way to see the real economic behaviour of credit index investments is to look at returns, and in particular excess returns relative to LIBOR. Returns represent the net result of all spread changes and income once all costs, including fallen angels, are taken into account. Spreads are what you see, but returns are what you get. As we showed in “Separating mirage from oasis” back in 2005, spreads and returns behave very differently for BBB rated indexes. This is particularly true when starting from a tight spread environment, like the one that exists today.

## BBB mean reversion is zero using returns

If BBB index exposure really were mean reverting, the characteristic would be evident in *both* spreads *and* returns. We now consider returns.

In essence, mean reversion means spreads should tighten when they are above average, and widen when they are below average. Translating spreads into returns, excess returns should be higher when spreads are above average and lower when spreads are below average. This is because spread tightening leads to positive excess returns and spread widening leads to negative excess returns, ignoring coupon income which is relatively constant.

Chart 15: Using returns, mean reversion stronger for higher quality, weaker for BBB



Source: UBS, Bloomberg, YieldBook

We test this with the same regression methodology used in the last section. The results appear in Chart 15. They are striking. Measuring mean reversion on excess returns rather than spread leads to very different results. Whereas all investment grade categories appeared mean reverting using spreads, only A and AAA/AA appear mean reverting using returns. In fact, their mean reversion appears even stronger, while BBB mean reversion disappears.

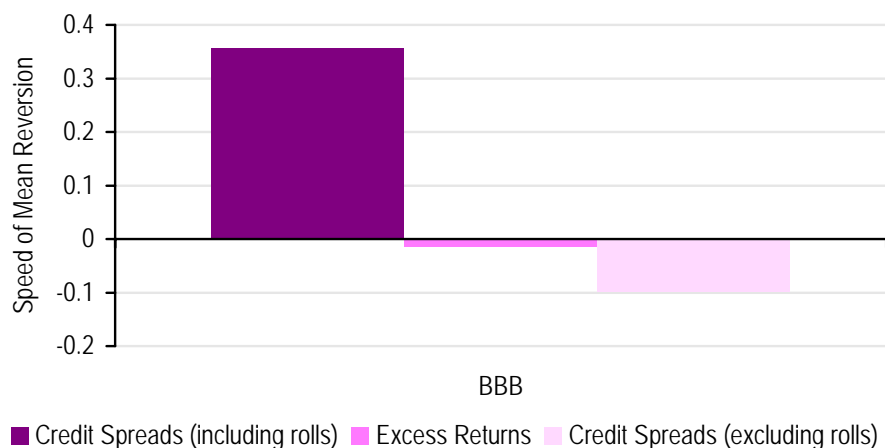
Bond index credit spreads are not investable assets, so whether or not they are mean-reverting is irrelevant

Measured on returns instead of spreads, mean reversion in AAA/AA and Single-A rated indexes is strong and positive, while in the BBB rated index it disappears

## Negative mean reversion using spreads ex rolls

Aside from measuring mean reversion on returns directly, we can also look at spread histories *without* the roll dates. In other words, since fallen angels are removed only at the end of the month, the changes from the last day of the previous month to the first day of the next month are most susceptible to bias. In essence, this technique involves using the same historical index credit spread data, but without the month-end changes. So index spread changes on every trading day except the first of each month provide the source data.

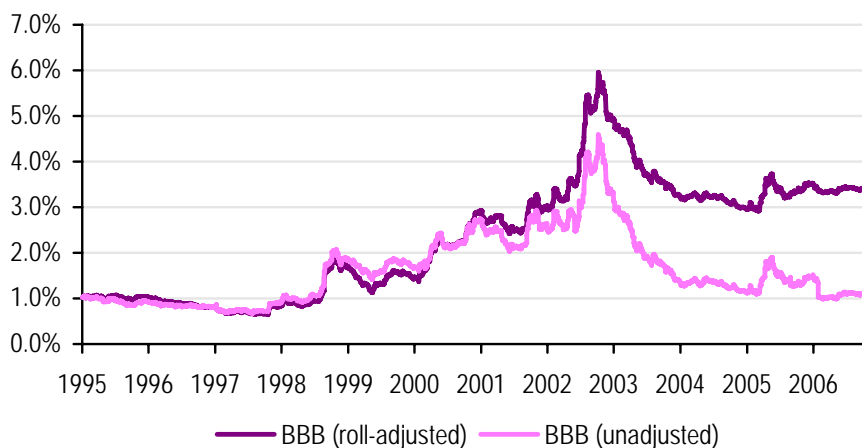
Chart 16: Using spreads ex rolls, mean reversion negative for BBB



Source: UBS, Bloomberg, YieldBook

As shown in Chart 16, BBB mean reversion measured this way looks even lower than when measured on returns. In fact the mean reversion speed is negative, suggesting an explosive process, once roll-driven changes are removed.

Chart 17: BBB spreads without month-end “tightening” are not mean-reverting



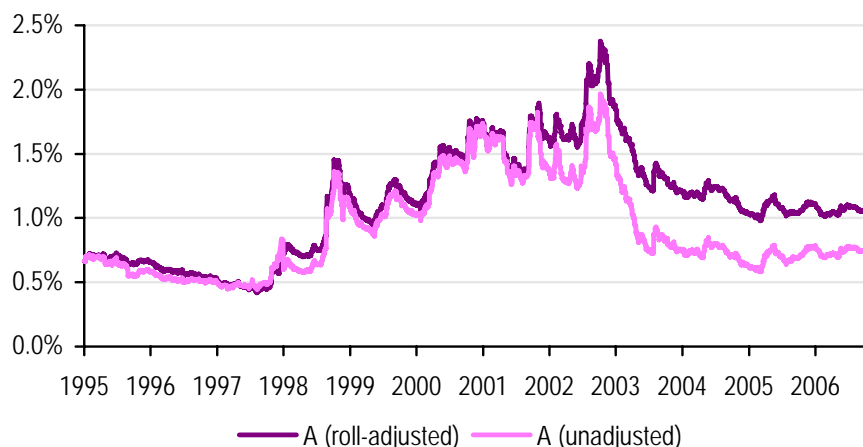
Source: UBS, Bloomberg, YieldBook. BBB roll-adjusted is a series constructed from all daily changes except those spanning the month-ends.

To gain more intuition on this topic, imagine redrawing the historical BBB index credit spreads without the month-end “tightening” driven by the rebalancing process. Chart 17 shows that this version looks less mean reverting (i.e. more like equities) than the usual spread series that includes rebalancing.

To be precise, the “roll-adjusted” series is created by adding together the spread changes of the “unadjusted” series, but leaving out the month-end spread changes. This provides an insight into just how important the month-end spread changes are in the BBB index spread history.

If we were to do same exercise with Single-A rated index exposure, the picture would look quite different. Chart 18 shows that Single-A rated index credit spreads show clear mean reversion whether or not they are roll-adjusted in the same manner.

**Chart 18: Unlike BBB, Single-A spreads are mean reverting, roll-adjusted or not**



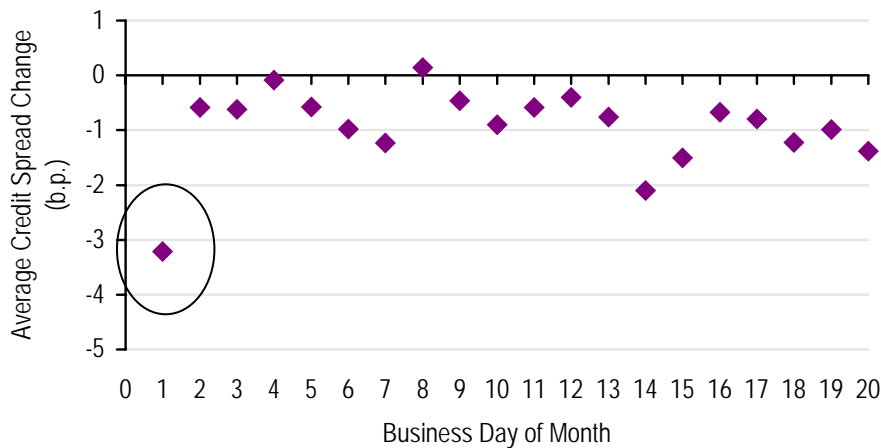
Source: UBS, Bloomberg, YieldBook. A (roll-adjusted) is a series constructed from all daily changes except those spanning the month-ends.

Note that in both cases, we are not saying that credit spreads in the roll-adjusted time series shown in the charts are equivalent to the actual *levels* observed at the time for the given rating category. Rather, our point is that the roll-adjusted data reflect economically-relevant *changes* in credit spreads more accurately. In other words, if one were to try to construct a spread time series that was more consistent with the time series of actually realized returns, this would be a start.

## Why returns are so different from spreads

We now consider in more detail what drives the difference between spreads and returns. We consider index spreads over LIBOR from 2000-2006, a time in which spreads tightened.

Chart 19: Average BBB spread change is much more negative on first day of the month



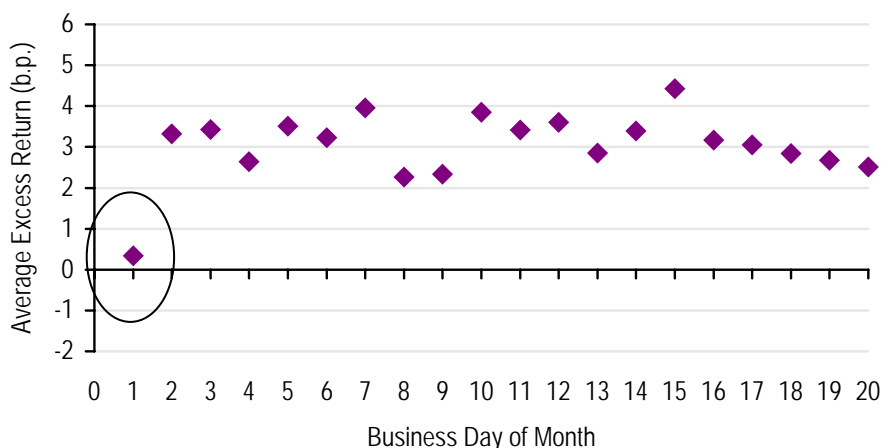
If the above-average spread tightening observed on the first day of the month were economically meaningful, we would expect to see above-average excess returns on the first day of the month...

Source: UBS, Bloomberg, YieldBook. Sample period is 2000-2006.

Chart 19 shows clearly that for most trading days of the month, the average change in credit spreads was slightly negative, consistent with tightening over the period. But the average tightening observed on the first trading day of the month is an outlier, at more than 3 basis points. That the first trading day of the month should show such extreme tightening is consistent with fallen angels being removed between the last day of the previous month and the first of the next.

Turning now to excess returns, we can see a similar difference between the first day and the rest. While credit spread changes on the first day were more negative than other days, excess returns were also *lower* than other days. If the Day 1 spread “tightening” were normal, excess returns would be *higher*.

Chart 20: Average BBB excess return is much more negative on first day of the month



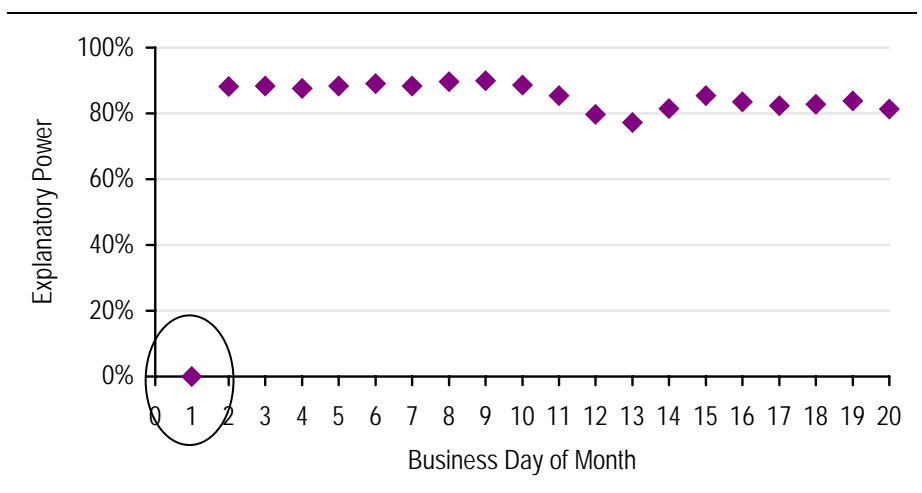
...but instead we see *below-average* excess returns on the first day of the month

Source: UBS, Bloomberg, YieldBook. Sample period is 2000-2006.

Putting the previous two charts together, we can make a general statement about how the economic relevance of credit spread changes varies during the month. Normally one would expect credit spread changes to have a decisive impact on excess returns for credit spread products.

Indeed, that is the case for all trading days except the first. The explanatory power of a regression of excess returns on credit spread changes runs at about 90% for all trading days of the month except the first. For the first day of the month, the explanatory power of credit spread changes for excess returns falls to 0%, as shown in Chart 21.

Chart 21: Explanatory power of BBB spread changes for excess returns by day



Index spread changes on the first day of the month are economically irrelevant

Source: UBS, Bloomberg, YieldBook. Sample period is 2000-2006.

In short, looking at average spread changes and excess returns for each day of the month confirms our earlier point. Spread changes on the first day of the month, reflecting month-end rebalancing and in particular removal of fallen angels, are very different from the rest of the days in the month. The first-day spread changes are economically irrelevant. The only ways to get real about understanding credit index dynamics is to focus on excess returns or look at spread changes excluding the first day of each month.

Our preference, as before, is to focus on excess returns. Only returns accurately capture the full economic impact of a strategy. Everything else needs translation, in which things are often lost. As the old accounting adage goes, follow the cash.

The only ways to really understand credit index dynamics is to focus on returns or look at spread changes excluding the first day of each month

## A similar phenomenon in commodity indexes

Commodity markets provide an interesting analogy to the phenomenon described in this report. The difference between credit spreads and excess returns in credit indexes is similar to the difference between spot prices and excess return in commodity indexes. What you see is not always what you get.

It is common to plot histories of commodity spot prices. For example, historical natural gas prices shown in Chart 22 suggest a market in bullish form.

Chart 22: Natural gas spot prices (non-investable) suggest a market in great health...



Source: UBS, Bloomberg, S&P GSCI. Natural Gas Spot Price is NG1 Index on Bloomberg.

But it is easy to forget that spot prices are not actually investable. Newcomers to commodity markets may believe it is possible to take exposure directly to the spot price, but it is not. Instead, one must own and roll relevant futures contracts. The net result of such a strategy is calculated as an excess return index, and the difference between spot prices and excess returns can be massive. Coming back to natural gas, Chart 23 shows that an actual investment in the S&P GSCI Natural Gas Excess Return Index, which rolls front-month natural gas futures, would have been a disaster, despite the spot price gains.

Chart 23: ...but the natural gas excess return index (investable) has been a disaster



Source: UBS, Bloomberg, S&P GSCI. Natural Gas Excess Return Index is GSCCNGER Index on Bloomberg.

The difference between credit spreads and excess return in credit indexes is similar to the difference between spot prices and excess return in commodity indexes

Spot prices are easy to graph, but not investable, just like index credit spreads

Spot prices may tell a very different story from an investable index linked to the same commodity

What you see is not always what you get

## A counterargument?

At this point one could raise an objection—is it fair to compare a dirty index with a pure index? One could argue that historical BBB index returns are “dirty,” combining the messy reality of BBB credits that stay BBB alongside with those that are upgraded or downgraded. In contrast, the BBB process in a CPDO model is “pure”, as it simulates the spread of an issuer that remains BBB, with neither upgrade nor downgrade mixed in.

### Isn't the analysis an apples-to-oranges comparison?

- Yes one can accept that BBB index excess returns are not mean reverting, but is that really the point? A CPDO risk model assumes mean reversion for a *pure* BBB exposure, while the analysis in this report focuses on *dirty* BBB exposure.
- It would be more appropriate to compare index returns with the simulated NAV process of the CPDO model, both of which are net of downgrades and upgrades. This is because a CPDO model takes the pure spread process, and then simulates rating migrations on top of it, resulting in simulated returns that include the effects of downgrades and upgrades.

We would answer that this does not make a difference in practice. The reason is that the mean-reverting spread process is more powerful than the migration process in determining the dynamics of the NAV process. The intuition is similar to what happens when adding a constant to a variable. The constant is not able to alter the dynamic properties of the variable.

### Demonstrating that it is in fact apples to apples

For those who prefer to see empirical proof rather than reasoning, we present evidence that our reasoning is correct. Table 3 shows results from analysis on simulated BBB spread changes and excess returns using a CPDO model. For example, looking at the simulated data for a pure BBB spread process, we estimate speed of mean reversion to be 0.37, positive and statistically significant, as expected.

In the CPDO risk model, mean reversion in credit spreads translates into mean reversion in excess returns

Table 3: Estimating mean reversion in BBB spreads and returns of a CPDO model

	Mean Reversion Speed	T-Value
Spreads	0.37	5.21
Excess Returns	18.82	4.80

Source: UBS

However, what is most interesting is the mean reversion speed of the excess return data. It is also positive and statistically significant. The introduction of migration does not alter the fundamental characteristic of mean reversion. In the CPDO risk model, mean reverting “pure” spread changes translate into mean reverting “dirty” excess returns. For the BBB index in the real world they do not, as we have shown.

## Early CPDOs are not safe

Having established that there is no evidence that BBB rated credit indexes are actually mean-reverting, we now consider the implications for early CPDO products.

This section considers these implications in two ways

- **Model-based testing:** taking standard CPDO risk models and adjusting the parameters for mean-reversion, what happens to expected defaults, losses and ratings?
- **Historical-data-driven testing:** ignoring standard CPDO models (i.e. letting the data “speak for itself”), what happens if standard CPDO strategies are backtested on actual credit index return data?

### Model-based testing

Model-driven ratings are highly sensitive to the speed of mean reversion for BBB rated indexes.

- Making just one change to a CPDO risk model parameter—making the speed of mean reversion for BBB rated credit equal to zero—is sufficient to drive a 10-notch downgrade
- This means a AA-rated CPDO product could become single B+, deep inside speculative grade category

### Historical-data-driven testing

Simulating CPDO performance based on historical index return data (i.e. independent of specific models) confirms our findings. We look at the probability of CPDO “Cash-In” events, i.e. the probability of a CPDO de-risking and paying full coupons and principal.

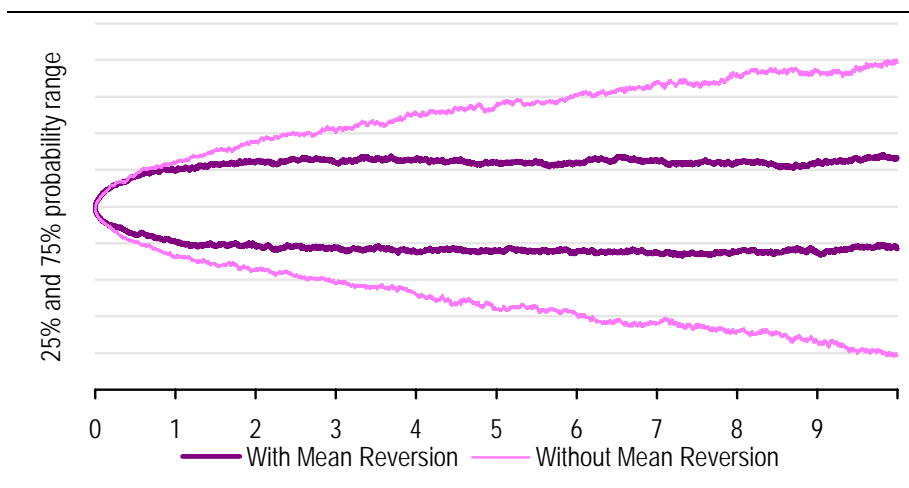
- Cash-In rates for CPDOs based on AAA/AA or Single-A rated index portfolios are indeed high, approaching 100%, consistent with high ratings for associated CPDO structures
- Cash-In rates for CPDOs based on BBB rated index portfolios are much lower, at only 71%, nowhere close to investment grade risk

We now examine each of these findings in more detail.

## Model-based testing

The assumption of mean reversion in a model acts to lower the assumed likelihood of extreme outcomes in the future. Chart 24 illustrates this effect, showing the range of upper and lower quartiles for two different processes—one with mean reversion and one without.

Chart 24: A mean-reverting process has a less extreme range of outcomes



Source: UBS. Based on 1000 simulations of a stochastic process.

Hence, it should be no surprise that dropping the assumption of mean reversion for BBB rated exposure leads to increased risk estimates for early CPDOs.

### Choice of model

Those who have been following CPDO developments might reasonably ask at this point, what is the standard risk model? It is a good question, as there are several different approaches to estimating CPDO risk.

#### Treating the index as a single underlying

Many approaches assume that CPDOs in effect reference a single underlying asset, the index. Hence, it is necessary to estimate volatility, mean reversion, etc. for the index as a whole. This has the virtue of simplicity. But simplicity is not the same as realism.

This approach seems reasonable when considering mean reversion measured from unadjusted credit spreads. All of the major high grade indexes show positive mean reversion according to this criterion, as we have seen. But returns tell a very different story.

#### Treating the index as multiple components

A different approach treats the index as a combination of multiple underlying indexes, each of which has its own parameters. For example, BBB follows a different stochastic process from that followed by AAA.

We prefer this approach, as it recognizes that the dynamics of rating categories within the investment grade space can be very different. This is exactly what we see in the data.

Modelling the index as a single underlying has the virtue of simplicity. But simplicity is not the same as realism

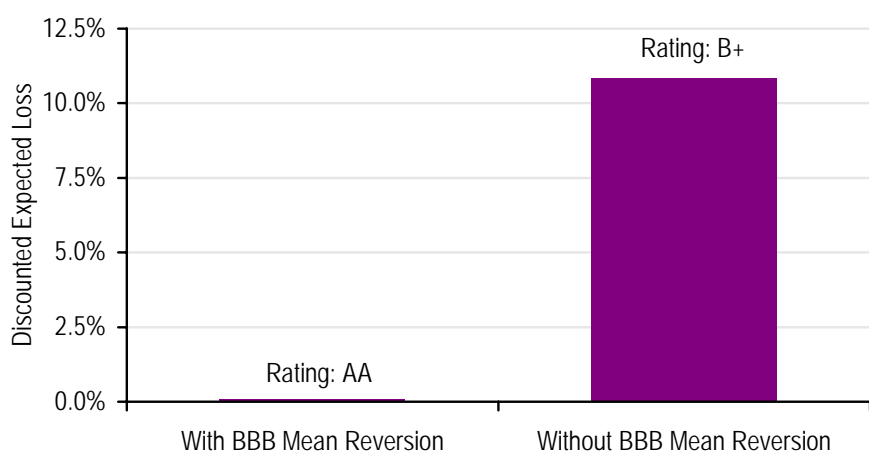
A multi-component approach recognizes that the dynamics of each rating category can be very different, as we see in the data

Moreover, to analyse the sensitivity of CPDO rating models to changes in BBB mean reversion alone, we have no choice. We have to use a multi-component model. A single-index model would be incapable of allowing such a test, as it would be impossible to change only BBB mean reversion, while leaving mean reversion estimates for other rating categories unchanged.

**What a difference BBB mean reversion makes**

With the multi-component model, removing the assumption of mean reversion from BBB component alone is enough to increase early CPDO default risk considerably, e.g. changing a rating from AA to B+, well inside “junk” territory. As shown in Chart 25, this one change is sufficient to drive a massive increase in discounted expected loss, from close to 0% to over 10%.

**Chart 25: Expected losses with and without assuming BBB mean reversion**



As early CPDOs are in fact equivalent to BB or B rated risk, the much-discussed LIBOR + 2.00% coupon becomes less surprising—that credit spread was perfectly consistent with speculative-grade risk pricing at the time of issue

Source: UBS

If the risk of early CPDOs is B or even BB-rated rather than investment grade, the LIBOR + 2.00% coupons that were much discussed become more understandable. As we showed in Chart 7 on page 9, such a coupon spread was perfectly consistent with BB-rated risk.

We next consider testing of CPDO structures without reference to a particular model. We do this by looking at simulated CPDO performance using historical index return data alone.

## Historical analysis, independent of models

Reality is complicated. Actual market behaviour is more complex than any model can capture. Even the best models can only approximate reality.

For this reason, it is good to get a second opinion. In addition to the view of a model, we want to seek out the view of history. Using historical index return data, we can avoid the need to make modelling assumptions. Rather, we let the data speak for itself. This is because unlike index spread data, index return data includes all costs and benefits associated with holding real credit index exposure. Assumptions about curve roll down, fallen angels, mean reversion etc. are unnecessary in this case. These are all implicit in the returns data.

Unlike index spread data, index return data includes all costs and benefits associated with holding actual credit index exposure

There are several key elements to this exercise:

- **Convert total return indexes to excess return indexes:** Historical credit bond indexes are calculated as total return indexes, reflecting fixed-coupon cash instruments. Hence, credit bond indexes incorporate both interest rate changes and credit spread changes. To simulate the behaviour of credit derivative index like the CDX or iTraxx, it is necessary to isolate the credit spread-driven component of the bond indexes. One way of doing this is to subtract the total return of a LIBOR-equivalent composite bond index from the total return of a credit bond index.
- **Duration-adjust the return series to reflect on-the-run 5-year risk exposure:** Bond indexes have non-constant duration. In fact the duration exposure of bond indexes can vary widely across time and across rating categories. To create a similar profile to the liquid CDS indexes, a proper analysis must duration-adjust the time series to maintain comparable duration profiles.
- **Incorporate CPDO structural features:** The details of early CPDOs include leverage levels, funding spreads, fixed fees, upfront fees, leverage fees, etc.

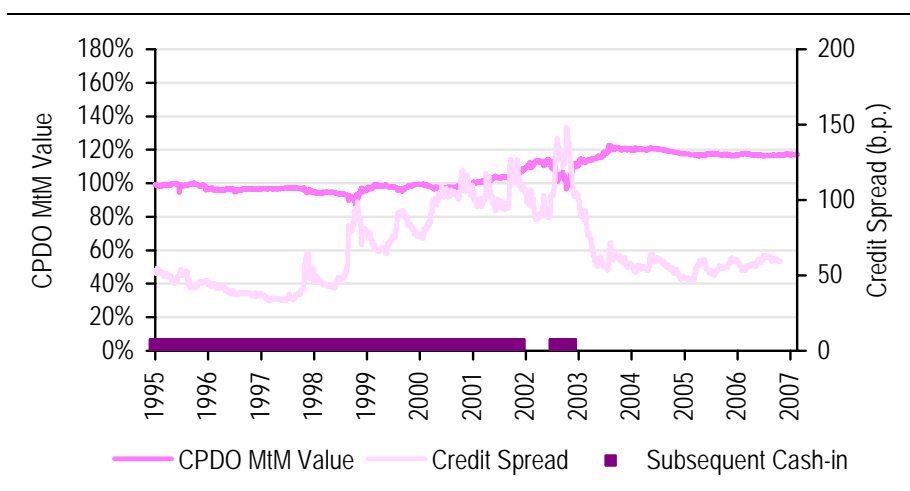
This is different from CPDO analysis to date, which uses historical data only to estimate parameters for a given modelling framework. But it is the simulated returns based on a given model and its parameters that drive CPDO risk estimates, e.g. default probability. To that extent, standard CPDO risk analysis to date is only partially influenced by history. In contrast, our purpose here is to create a simulation based entirely on history and independent of any specific modelling framework. Historical data allows us to do non-parametric analysis.

**CPDO structure details used in testing:** starting and maximum leverage of 15x, 1.00% upfront fee, 0.20% running fee, 0.035% per unit leverage fee, a cash deposit rate of LIBOR less 0.25%, coupon spread of 2.00%, and a 10-year maturity. We simulate the underlying performance of a strategy using the excess returns (relative to LIBOR) of the Citigroup AAA/AA, A, and BBB rated USD corporate bond indexes. Each index is duration-adjusted to reflect a 5-year average life, like the benchmark CDS indexes.

## Historical test: AAA/AA rated index underlying

First, consider a CPDO referencing an AAA/AA-rated credit index exposure.

**Chart 26: Cash-in given starting date in 10-year CPDO using AAA/AA index portfolio**

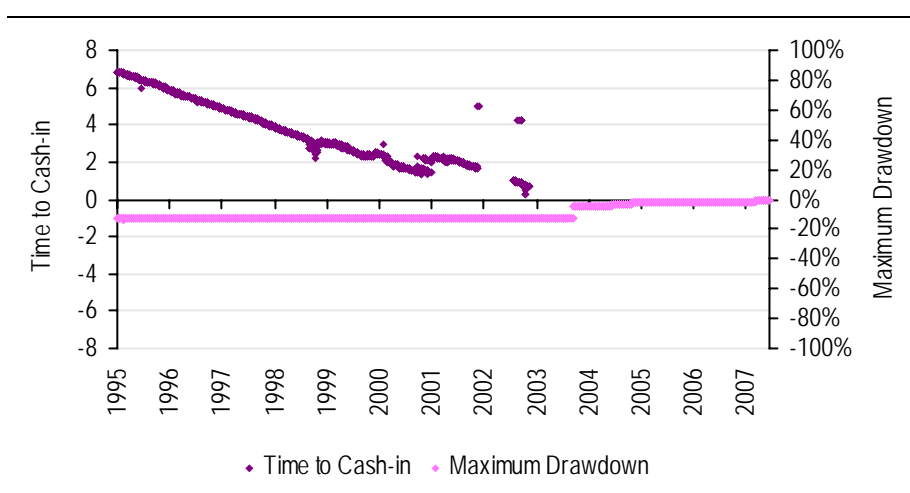


Source: UBS, Bloomberg, YieldBook. Credit Spread is OAS over US Treasuries.

Chart 26 shows the relevant information. The credit spread provides context as to market conditions. The MTM Index reflects the mark-to-market value of a deposit-style CPDO product, i.e. with negligible interest rate duration. The dark squares on the lower axis reflect starting dates for which subsequent Cash-In would have taken place. The fact that the squares on the lower axis stop around 2002 should not cause concern. CPDOs launched in 2002 would only be 5 years old by 2007, or halfway through their lifespan.

For example, if a CPDO investment had started in 1995, it would have achieved Cash-In, and hence 1995 has dark squares on the lower axis. The intuition is that the MTM Index eventually reached a point where Cash-In was possible, making substantial gains within the 10-year period starting in 1995. Chart 27 shows maximum drawdown and time to Cash-In for each starting point.

**Chart 27: Time-to-Cash-In and Maximum Drawdown by starting date (AAA/AA)**

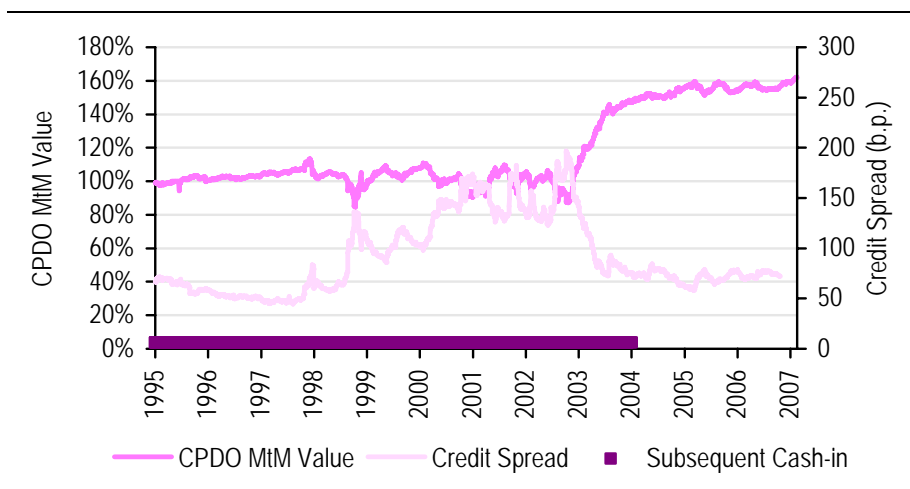


Source: UBS, Bloomberg, YieldBook.

## Historical test: single-A rated index underlying

A CPDO referencing single-A rated index exposure also looks strong.

Chart 28: Cash-in given starting date in 10-year CPDO using Single-A index portfolio



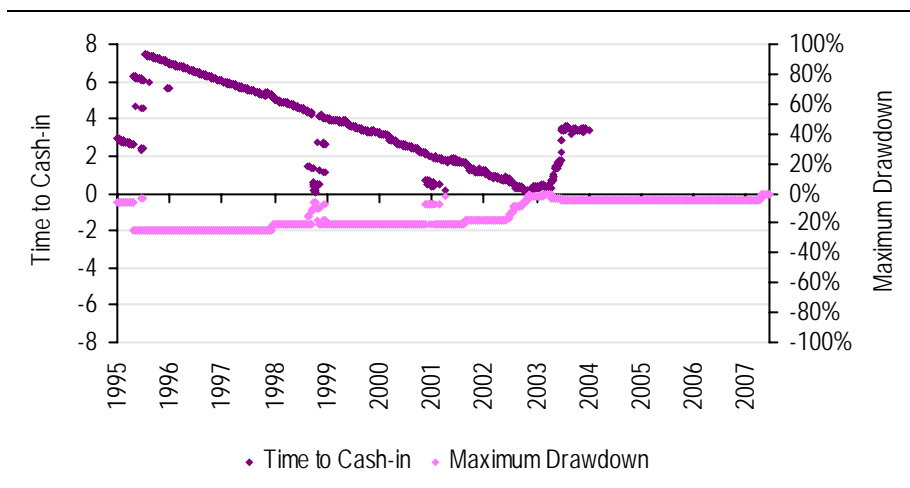
Source: UBS, Bloomberg, YieldBook. Credit Spread is OAS over US Treasuries.

If anything, the situation looks even better using the single-A index as the underlying than it does using AAA/AA indexes. As shown in Chart 28, Cash-In rates are high and steady.

The pattern of Cash-In times and Maximum Drawdown also shows a similar pattern to the AAA/AA index. Chart 29 illustrates that investors generally had to wait longer for Cash-In the closer they were to the low point in credit spreads, i.e. the peak in price terms of the credit bull market of the mid-1990s. For example an investor starting in 1996 had to wait almost eight years for Cash-In. An investor starting in 2002, when spreads were wider, hardly had to wait at all.

Capital gains from spread tightening are the quickest way to Cash-In. Investing when spreads are already tight requires a long-term perspective

Chart 29: Time-to-Cash-In and Maximum Drawdown by starting date (Single-A)



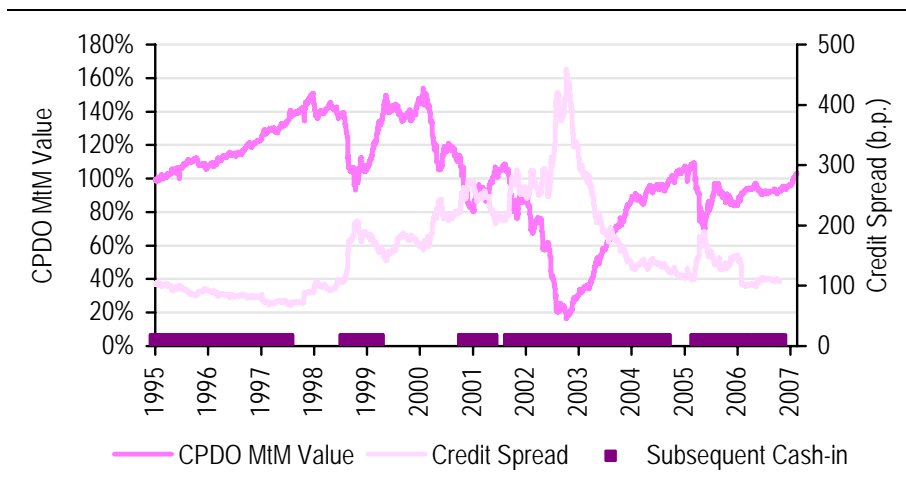
Source: UBS, Bloomberg, YieldBook.

This is intuitive. Capital gains are the quickest route to Cash-In, and they are more likely to occur when spreads are wide and have room to tighten. They are least likely to occur when spreads are already tight.

### Historical test: BBB rated index underlying

The situation is quite different using the BBB index as underlying. As shown in Chart 30, Cash-In occurs far less often.

Chart 30: Cash-in given starting date in 10-year CPDO using BBB rated index portfolio

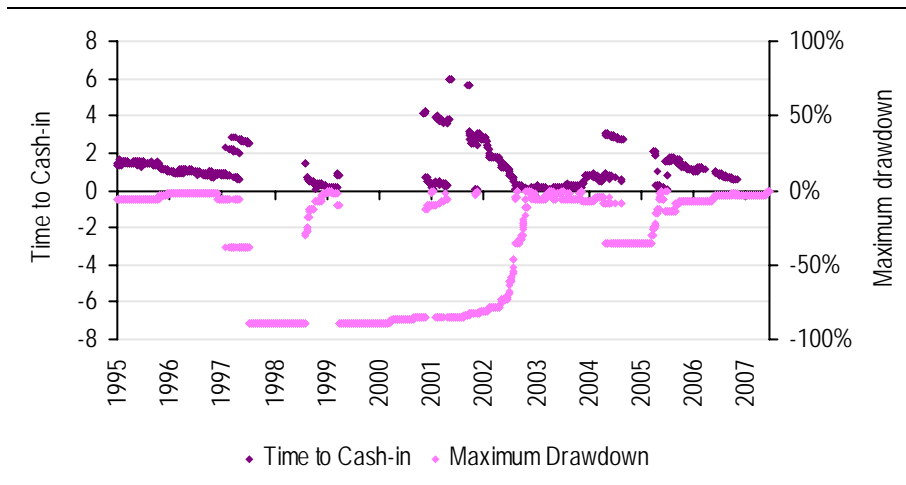


Source: UBS, Bloomberg, YieldBook. Credit Spread is OAS over US Treasuries.

In fact, a CPDO initiated in early 1997 linked to BBB index exposure would be trading about 30% below par in 2007, i.e. almost certain to default.

At a more basic level, comparing the evolution of MtM values between Chart 28 and Chart 30 is useful. The BBB index suffered far more from the 2000-2002 credit crisis than did the Single-A index. Moreover since CDS spreads are likely to reach more extreme levels than bond spreads in a crisis, this simulation probably *underestimates* real risk exposure that would result from using CDS-based index products like iTraxx and CDX.

Chart 31: Time-to-Cash-In and Maximum Drawdown by starting date (BBB)



Source: UBS, Bloomberg, YieldBook.

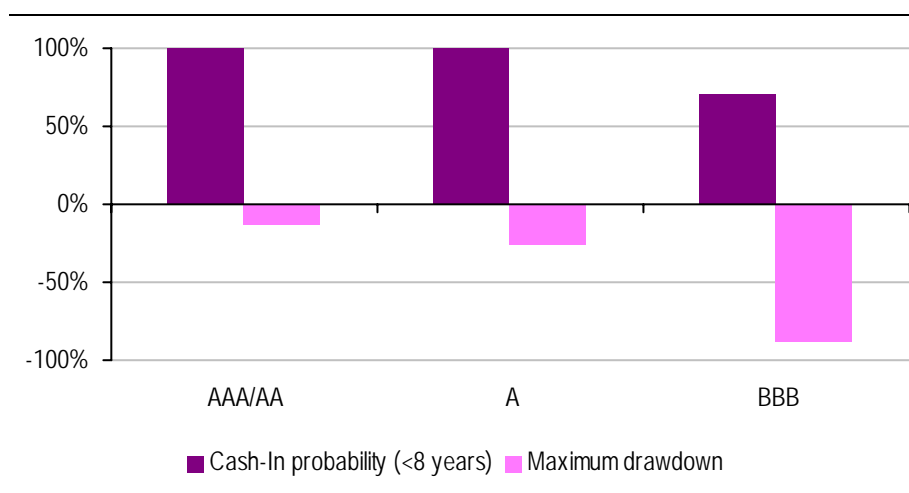
Chart 31 highlights the dangers of BBB index exposure relative to higher-quality indexes. Maximum Drawdown is much more extreme and Cash-In is

less frequent. But a relatively quick Cash-In is also more possible, given the volatility of the underlying portfolio.

## Higher quality indexes prove robust

We can summarize the results of the historical testing with the data shown in Chart 32. The data suggests that a CPDO using the BBB index as an underlying portfolio would only achieve Cash-In within eight years of launch 71% of the time over this sample period. In contrast, a CPDO using a AAA/AA or A index as underlying portfolio would have achieved Cash-In within eight years of launch 100% of the time.

Chart 32: CPDO risk based on historical (not model-based) simulation of underlying



Source: UBS, Bloomberg, YieldBook. Using daily index data from 1995 to 2007.

Similarly, the market value of a CPDO using the BBB index would have endured maximum drawdown of 89%, more than 3x as severe as the other categories. And as mentioned before, this simulation probably *understates* the risks, as it uses historical bond indexes, not CDS indexes. It is well known that CDS spreads widen faster and reach more extreme levels than bond credit spreads.

## What next?

So whether we investigate CPDO risk via model-based frameworks or via model-free testing on historical data, we reach the same conclusions. BBB rated exposure looks like the worst possible credit index category as the underlying for a CPDO, while higher quality indexes are good choices.

In the next section, we investigate how to take advantage of this information.

## Where to go from here

This section briefly considers practical steps forward given the results described earlier. We divide these into two broad categories:

- Methodologies
- Investments

We then add some points about structured product applications in general.

### Methodologies

There are several specific recommendations we would make in the area of risk modelling and analysis for CPDO products.

#### A. Multi-component models are essential

Above all, it should now be clear that high grade index exposure is not homogenous. BBB exposure has fundamentally different properties relative to AAA/AA/A rated exposure.

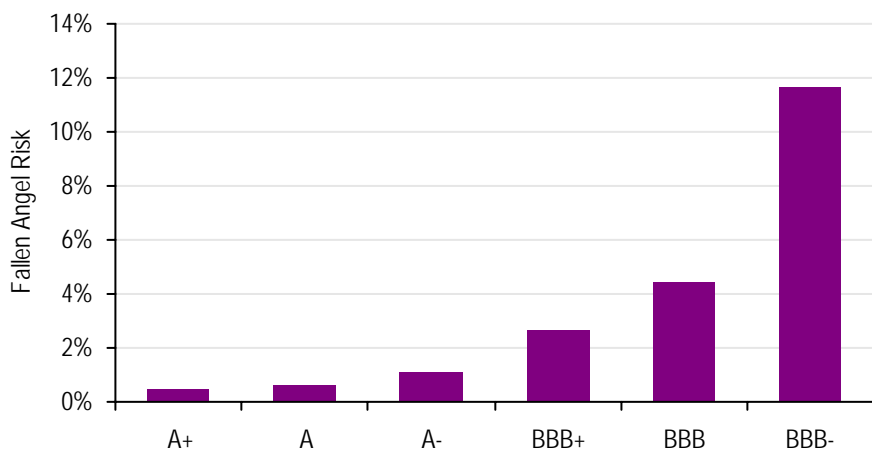
As such, the “single-underlying” models (described on page 25) used by many are inadequate. These models assume the entire index can be modelled as one variable with one set of parameters. Imposing one set of parameters on all categories of high grade implies the assumption that they are all similar. Nothing could be further from the truth.

Instead, multi-component models are preferable. These allow different rating categories to have different dynamic processes.

#### B. Recognize that not all BBB is the same

We would even go one step further and say there is probably a need to split up BBB sector itself. As shown in Chart 33, BBB+ has more in common with A-rated credit than with BBB- when it comes to fallen angel risk.

Chart 33: Fallen angel risk by sub-category (A+ through BBB-)



Source: UBS, Moody's. Fallen Angel Risk is the likelihood of migrating to sub-investment grade status within 1 year.

Imposing one set of parameters on all categories of high grade credit implies the assumption that they are all similar. Nothing could be further from the truth

BBB+ credit is closer to Single-A credit than it is to BBB- in terms of fallen angel risk

We have used indexes based on broad rating categories (e.g. BBB instead of BBB+, BBB, BBB-) because these were the only ones available to us. We believe, although we cannot yet show, that the properties of BBB+ index returns would look far more favourable than those of BBB-.

### C. Focus on returns as well as spreads

Returns are what ultimately drive CPDO performance and risk. As we have seen, returns can and do deviate from spread changes in credit indexes. It is important to recognize this explicitly.

Attempting to model the return process directly might be more straightforward than modelling it indirectly using the credit spread process. Choosing to model spreads forces one to model a host of other factors such as migration, curve roll down, bid offer, etc). Without these other factors, it would be impossible to convert spread changes into returns. But having to model all of these other inputs raises the chance of error, as a mistake in any of them will affect the outcome. All must be correct for the total result to be correct.

### D. Ask where and to what extent a risk premium actually exists

Another reason to focus on returns is that it is impossible to measure the extent to which a risk premium actually exists without looking at excess returns. A risk premium is an average excess return above zero, earned by taking exposure to systematic risk. Unless a risk premium exists, there is no reason to expect an investment strategy to perform over time.

With traditional buy-and-hold credit strategies, there is clear evidence of a risk premium, as credit spreads paid are systematically higher than average default losses. With index-based strategies, identifying risk premia is not as simple as comparing spreads with default losses. Ultimately, it is only by measuring historical excess returns that one can begin to ascertain whether a strategy is or is not earning a risk premium.

The fact that buy-and-hold credit positions earn a risk premium does not mean that strategies rolling credit index positions will earn a risk premium. The two strategies are very different from each other. Buy-and-hold means holding assets until they mature or default, whether or not they become fallen angels. On the other hand, rolling index positions are constantly unwinding positions that become fallen angels.

Our analysis here and in the earlier report suggests that higher-quality indexes do indeed seem to earn risk premia, i.e. positive excess returns that are statistically significant. However, our analysis also shows that BBB and High Yield index positions do not earn risk premia—on those occasions when average excess returns in these categories are positive, they are not statistically significant.

Index positions are very different from traditional buy-and-hold credit—for BBB exposure, buy-and-hold may earn a risk premium even if index positions do not

Again, this is not to say that buy-and-hold strategies in BBB and High Yield do not work. The evidence suggests that buy-and-hold credit positions in even lower quality credits may in fact pay a risk premium. But index positions are a different animal entirely.

## Investments

In many respects, nothing has changed since our 2005 report on credit index strategies. We still have the same fundamental convictions. We like high-quality indexes and dislike low-quality indexes. We believe rating agency actions and credit cycles in general provide clear signals that managers or even algorithms can use to optimally adjust the ratio of long-high-quality to short-low-quality index exposure.

### A. Go long (sell protection on) high quality indexes

Mean reversion is a fact in most credit indexes, but not in BBB. Hence applying a CPDO-style structure to higher quality indexes (e.g. AAA, AA, and A-rated) seems sensible, even with current tight spread levels.

In bond terminology, go long the higher quality indexes, i.e. the AAA/AA/A rated exposure or equivalent. In CDS terminology, sell protection on high quality indexes like the LoVol component of CDX or iTraxx. The LoVol is approximately equivalent to Single-A/BBB+ risk.

Using CDX and iTraxx as is, as early CPDOs have done, is a mistake since the HiVol component is heavily exposed to the BBB- section of the high-grade universe. That is exactly what we want to avoid, except as a short position.

As mentioned before, another way to implement this idea is to use higher-quality financials or sovereigns (e.g. rated BBB+ and above), rather than the LoVol per se.

### B. Go short (be flat or long protection on) lower quality indexes

As we suggested in our 2005 report, using High Yield or BBB indexes as short positions is probably less expensive than commonly assumed, at least over time. If these indexes offer poor long-term performance to long-only bond investors, the flip-side is that they make attractive short positions. In CDS terminology, it makes sense to be flat or long CDS protection on the HiVol or High Yield indexes.

### C. Adjust the ratio of long/short with the credit cycle

As we wrote in 2005, it makes sense to adjust positioning over time. A constant ratio of long to short will not be successful over time. However, it is possible to use relatively simple rules to adjust the ratio adequately as the credit cycle runs its course.

### D. Get out of early CPDO products

Sell while you can. Early CPDOs products are not for all markets, despite the advertising. If experience over the last 10 years is any guide, there is ample scope for underperformance and even default. Massive mark-to-market losses are likely in the event of reasonable spread widening.

Early CPDOs are not even a good short position, as the index position they reference is a mixture of good and bad. You want to be long the good (the higher-quality component) and short the bad (the low-quality component).

## The fundamental things apply

In this section we note a few points about structured products that should be obvious and yet are easily forgotten.

### A. Structured products are only as good as what goes into them

Structured products cannot create value out of nothing. Investors must always look through a product’s structural features and examine its underlying strategy. If the underlying strategy does not make sense, it is hard to imagine how even the most cleverly designed structured product linked to such a strategy can create value.

When it comes to CPDOs, the first question to ask should not be about the structure but about the underlying. Does it really make sense to hold a long credit index position, fully exposed to fallen angel risk, when spreads are tight? Does it even make sense as an unleveraged position? Back in 2005, that is the question we posed in “Separating mirage from oasis,” and is largely responsible for our current views.

### B. Leverage is not necessarily evil

Early CPDOs are an example of structured products that deliver leveraged exposure to an underlying. Some investors dismiss leverage as an unmitigated evil. This is not necessarily correct.

Whether leverage is good or bad depends on what is being leveraged and for what purpose. Leveraging an asset that is already quite volatile in its unleveraged state is not a good idea. Emerging market equities or natural gas futures come to mind as assets that do not need more leverage.

Whether leverage is good or bad depends on what is being leveraged and for what purpose

On the other hand, high grade credit indexes have very low volatility in their unleveraged state. Applying even 10x leverage to high-quality credit indexes may still result in an exposure that is less volatile than equities in their unleveraged state.

Table 4: Why leverage is not the same thing as risk

	AAA/AA	A	BBB	10x Lev A	High Yield	S&P 500
Volatility	0.33%	0.71%	2.10%	7.10%	7.40%	14.02%
Multiple of A	0.46	1.00	2.96	10.00	10.42	19.75

Source: UBS, Bloomberg. Volatility is of excess returns, annualized, measured from 1988-2007. 10x Lev A means a position that leverages the regular Single-A index by a factor of 10.

An example of this appears in Table 4 above. Applying 10x leverage to the regular Single-A index results in volatility of 7.10%, still lower than the volatility of unleveraged High Yield and about half the volatility of unleveraged S&P 500 exposure. In short, investors should not necessarily feel uneasy about using leverage, as the total volatility of a leveraged position in one asset may be lower than the total volatility of an unleveraged position in another. Furthermore, since Single-A exposure has better risk-adjusted performance than either High Yield or the S&P 500, it makes sense to leverage it.

One highly-leveraged asset may still have lower volatility than another asset that is unleveraged

## Conclusion

Sometimes the first mover in a new technology fails—even when the technology itself goes on to become a huge success.

Consider de Havilland's role in developing commercial jet aircraft. The de Havilland Comet was the first commercial jetliner in history, entering service in 1952. Unfortunately, de Havilland made a serious design flaw, underestimating the Comet's vulnerability to metal fatigue. Tragically, a series of fatal crashes occurred before the problem was identified.

While they were not first movers, Boeing and Douglas introduced better-designed jet aircraft—the 707 and DC-8 respectively. These subsequently became the most widely-used commercial aircraft of that era. The once-mighty de Havilland disappeared as a force.

Though some of the first jet travellers met a horrific fate, millions of passengers subsequently benefited from commercial jet technology.

### Moving beyond default risk—capturing other risk premia

Like jet aircraft, CPDO structures are a technological leap forward. For years, credit investors and rating agencies have focused narrowly on long-term default risk premia—credit spreads relative to expected default losses. But there are other sources of long-term risk premia that are just as significant and as historically verifiable as default risk premia. These include non-default risk premia in credit exposure as well as risk premia in foreign exchange, interest rates, and commodities.

CPDO products are an example of market-value structures, which provide a format in which ratings are not just based on default risk, but also on market value risk more broadly. As such, they create a vehicle in which investors can analyse and capture other sources of risk premia. Investors and rating agencies alike are correct to consider these other sources of return seriously.

### First versions of new technology can be vulnerable

But as with the development of commercial jets, safety in this new technology depends on appropriate design. It is easy to underestimate vulnerability in new technology. And what ultimately succeeds may not be apparent at first glance. The first-wave CPDO products are a case in point.

### Early CPDO products: more like the Comet or the 707?

Credit spreads have been at cyclical highs and default rates at cyclical lows. One might think that taking a 15x leveraged credit exposure at this point in the credit cycle is not exactly sensible. Moreover, some might question how any product paying LIBOR + 2.00% could possibly be rated AAA/Aaa. Yet these are among the features of early CPDO products.

## Sturdy like the 707—as long as BBB is mean reverting

Many structured credit specialists have claimed that early CPDO products are remarkably resilient, surviving almost every imaginable scenario of defaults and spread movements. We disagree. In particular, we argue that these products only look robust in light of the current assumption that BBB indexes are in fact mean reverting. This apparent robustness is spurious.

## Filmsy like the Comet—if BBB is not mean reverting

If you remove the assumption of mean reversion for BBB exposure alone, a standard risk model will show a materially higher risk for an early CPDO product. Ratings can fall 10-notches, e.g. from AA to B+, well into junk territory. As another test, if we ignore models altogether and simply test early CPDO strategies on historical index excess return data, we find BBB rated exposure experiences much higher failure rates than AAA, AA or A rated exposure.

## The way forward—focus on high-quality underlyings

What may seem obvious is all too often forgotten. Always look through to the underlying of any structured product. If there is evidence of a risk premium to be captured by the strategy, it has a good chance of performing. If there is no evidence of a risk premium, it is hard to see how it can succeed in the long term.

High-quality indexes (AAA, AA, A) seem to earn risk premia over time—their excess returns over LIBOR are greater than zero and statistically significant. BBB and High Yield indexes do not seem to earn risk premia that are statistically significant.

## Ordinary investors can capture new opportunities

We believe market-value structures have huge potential to add value because they allow ratings-sensitive investors to move beyond default risk.

Up until now, investors who needed a rating and yield had little choice but to take some kind of default risk. Market-value structures allow a much wider set of choices.

Particularly in an environment when credit spreads are tight and credit fundamentals appear to be in the beginning of cyclical deterioration, it makes sense to get out of ordinary credit risk exposure like BBB corporate bonds and move into products that have a better chance of delivering good performance.

When spreads are tight, investors should look to be generally long high-quality credit and short low-quality credit. Until recently, only proprietary traders and hedge funds were able to put such a strategy into action, as the technical and risk management requirements were beyond the reach of most investors. With market-value products, ordinary investors can take advantage of the same value-drivers in a convenient format.

## References

Black, Fischer, and Myron Scholes (1973), "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy* 81 (3): 637-654

Chandler, Cian (2006), "CPDOs Have Arrived In Global Derivatives Market," Ratings Direct, *Standard & Poor's*, 1 November

Gilbert, Mark (2006), "CPDOs are derivative market's new alchemy trick," *Bloomberg*, 15 November.

Jobst, Norbert, et al (2007), "CPDOs Laid Bare: Structure, Risk and Rating Sensitivity," *DBRS*, April

Linden, Alexandre, et al (2007), "First Generation CPDO: Case Study on Performance and Ratings," *Derivative Fitch*, 18 April

Lucas, Douglas (2007), "A CPDO Primer," CDO Insight, *UBS Investment Research*, 1 February

Morris, Anthony (2005), "Separating mirage from oasis," *UBS Investment Research*, 30 November

Morris, Anthony (2007), "Early CPDOs seem riskier than first thought," *UBS Investment Research*, 22 March

Toutain, Olivier, Mehdi Kheloufi-Trabaud, and Beryl Marjolin (2006), "CPDOs: A Primer," International Structured Finance, *Moody's Investors Services*, 8 November

Varloot, Etienne, Geraud Charpin, and Efrosyni Charalampidou (2006), "CPDO an asset class on its own or a glorified bearish Rated Equity?" *UBS Investment Research*, 8 December

Varloot, Etienne, Geraud Charpin, and Efrosyni Charalampidou (2007), "A Rating-floored 10yr Buy & Hold strategy makes better CPDOs," *UBS Investment Research*, 2 February

Varloot, Etienne, Geraud Charpin, and Efrosyni Charalampidou (2007), "CPDO insights on rating actions and manager impact using a new formula," *UBS Investment Research*, 12 April

Vasicek, Oldrich (1977), "An Equilibrium Characterisation of the Term Structure," *Journal of Financial Economics* 5: 177-188

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Company credit fundamentals	6 months	IMPROVING STABLE DETERIORATING	improve remain stable deteriorate	Credit fundamentals of the company are anticipated to <expectation> over the next six months
Company / bond	3 months	BUY HOLD SELL	outperform perform in line underperform	Company/Bond is anticipated to <expectation> other companies/bonds within a given peer group in the local currency investment universe* over a three-month horizon
Credit Default Swaps	3 months	BUY protection NEUTRAL protection SELL protection	widen by 5 bps or more neither widen nor tighten by more than 5 bps tighten by 5 bps or more	CDS level anticipated to <expectation>

Note: Recommendations for periods under 3 months are defined as "Tactical", as in Tactical Buy or Tactical Sell.

\* Europe - iBoxx NonSovereign € and NonGilt £ universe measured on a curve-adjusted, excess return basis

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