Extract from

"Credit Derivatives"

Prepared by the Derivatives Working Party
of the Faculty & Institute of Actuaries

and presented to the Faculty of Actuaries,
January 2007

A Working Party terms of reference and members

1   The Derivatives Working Party is a permanent working party set up by the Life Research Committee of the Faculty and Institute of Actuaries. The current terms of reference are as follows:

"The aim of the working party is to consider examples where life assurance companies are currently utilising derivatives and to establish if companies believe their use of derivatives is constrained."

2   The current members of the working party are:

Martin Muir (chairman)

Andrew Chase

Paul Coleman

Paul Cooper

Gary Finkelstein

Paul Fulcher

Chris Harvey

Richard Pereira

Albert Shamash

Tim Wilkins

B   The credit spread "puzzle"

1   The market level of spread payable on corporate bonds, relative to government bonds, is consistently much wider than would be implied by an analysis, from historic data, of expected default losses. This phenomenon is particularly marked for shorter-duration, investment grade bonds and is often referred to as the "credit spread puzzle".

2   One early study to highlight this effect was Altman (1989) who showed that, from historic data, an investor would have earned significantly higher returns from investing in corporate bonds, rather than risk-free bonds, even allowing for defaults.

3   To illustrate the credit risk puzzle we have used the data from Moody's 18th annual survey of global corporate bond defaults and recovery rates (Moody's (2005)). Using the data given on historic default and recovery rates for the 35 year period 1970 to 2004 we can compute the theoretical spread required on a corporate bond to compensate precisely for expected default losses, based on this historic experience, as explained below.
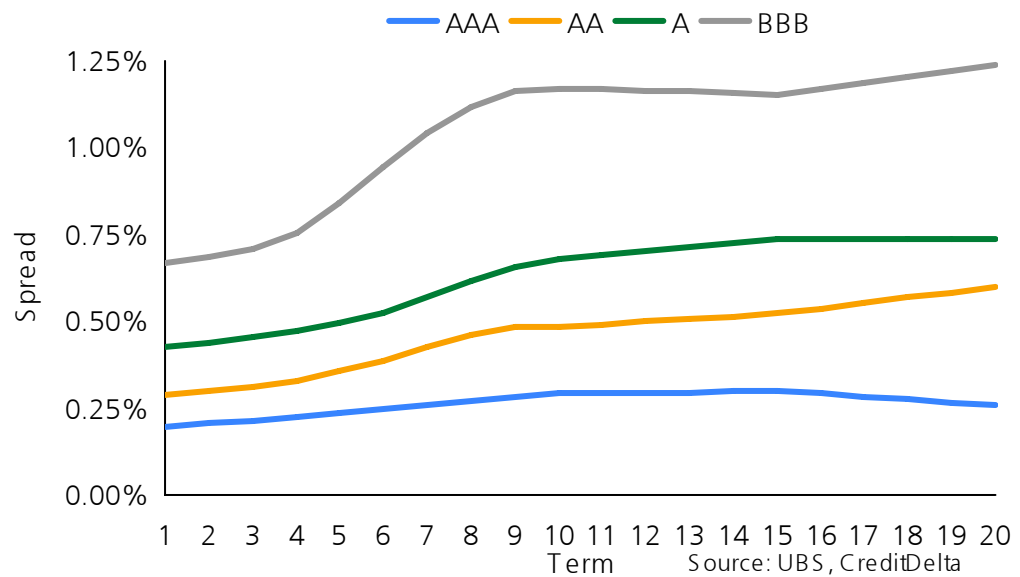
        The results are shown in Figure 1.

Figure 1: Spread to compensate for expected defaults
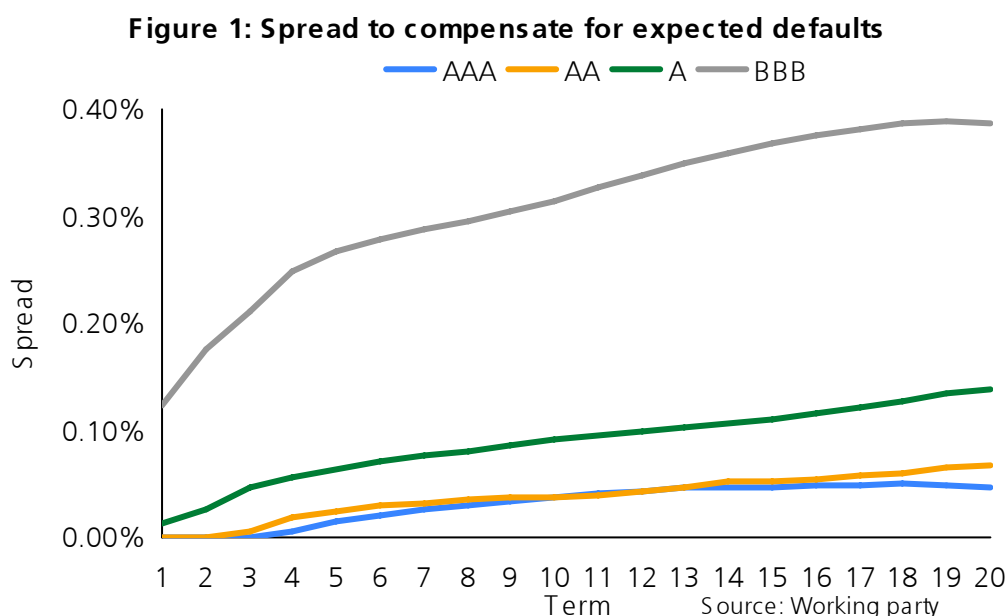
4   Figure 2 shows, by comparison, the market spread, relative to gilts, on the iboxx index of corporate bonds, as at 7 July 2005.

5   As can be seen, the spread payable is significantly in excess of that in Figure 1.

Figure 2: Market spreads 5th September 2005

AAA — AA — A — BBB

Spread (y-axis): 0.00%, 0.25%, 0.50%, 0.75%, 1.00%, 1.25%

Term (x-axis): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Source: UBS, CreditDelta

Resolving the credit spread puzzle

6   The "credit spread puzzle" is a currently active area of academic research. There is a detailed review of some key papers published from 2001 below.

7   A variety of factors have been investigated to explain the spread on corporate bonds. Researchers are yet to reach a definitive view on the magnitude of the different factors. However, a consensus is emerging as to the main sources of credit spread and, in particular, that it does not represent a free lunch, even for buy-and-hold investors.

8   The factors most typically cited as contributing to the credit spread in excess of expected defaults, from historic data, are:

- *Risk premium*

  If the credit spread only compensated for expected defaults, then it would be more attractive to hold gilts than corporate bonds, since gilts would offer the same expected return for less risk.

  Credit risk is also positively correlated with equity risk and, more generally, with the overall drivers of market risk. Hence, this cannot be diversified away and should command a risk premium.

- *Small sample bias*

  An analysis based on historic data for the period 1970 to 2004 may not be a good guide to extreme events. Moody's (2005) includes data back to the 1920s, which embraces the Great Depression, but analysis using these data, even based on the worst periods, does not explain the credit spread puzzle. It is likely that the market is pricing more extreme events than observed in the historic data, particularly given the skewed nature of the payoff of credit.

- *Skewed nature of payoff*

  The return from corporate bonds is highly negatively skewed with a capped upside but a very strong downside if the bond defaults. Given investors' risk preferences they may require an additional compensation for this risk profile, which is difficult to diversify away with realistically achievable bond portfolios.

- *Taxation*

  In different jurisdictions and for different investors corporate bonds may be taxed less favourably than government bonds.

- *Correlation effects with interest rates*

  Typically, credit spreads have negative correlation to interest rate risk on bonds, which might actually reduce the required credit spread.

- *Liquidity premium*

  Particularly illiquid bonds will typically offer higher yields than more liquid bonds as a compensation for the liquidity risk. If corporate bond spreads are measured relative to gilts then there would typically be a generic liquidity premium for the overall corporate bond universe.

  There is particular evidence of a "flight-to-liquidity" effect where government bonds command a premium, which is particularly high in times of market stress.

  If bond spreads are measured relative to swaps, as is standard practice in the financial markets, then there is much less evidence of any significant overall liquidity premium.

9   In addition, when comparing corporate and government bonds allowance must be made for differing features such as callable bonds, putable bonds, convertible bonds, sinking-funds and subordinated or hybrid bonds. The various academic studies correct for these features, largely by excluding such bonds from their analysis.

10   Overall the literature suggests that the credit risk premium is explainable. A liquidity premium effect is present but, in most studies, it does not account for a major portion of the total credit spread. A more significant component is due to compensation for the undiversifiable and skewed nature of credit risk.

11   One weakness of the literature is that it typically does not distinguish between credit spread risk and default risk. An investor measuring performance over a short-time horizon will be exposed to short-term noise from spread volatility whereas a long-term hold-to-maturity investor is primarily exposed to default risk and hence might conceivably be able to capture part of the risk premium. In practice, however, many life company portfolios are not held-to-maturity but are rebalanced to maintain a constant or minimum credit quality. In this case the risk is not primarily from defaults but from a gradual loss of return as bonds are sold on downgrade and it would seem less likely that a risk premium can be captured.

Relevance for credit derivatives

12   The CDS market provides a purer analysis of the cost of credit risk since it is less prone to various factors affecting the physical bond market (eg tax effects, limited supply, difficulty of taking short positions, liquidity squeezes). Indeed the CDS premium can be regarded as a measure of the cost of credit risk and the spread on a bond relative to swaps is typically close to the corresponding CDS premium.

13   For CDOs, the strong attraction to investors, in recent years, of mezzanine tranches has been driven, inter alia, by the same phenomena as the credit spread puzzle. The attachment point for the tranche is typically set as a multiple (perhaps 200% or 300%) of observed levels of historic defaults. Hence, even on a prudent analysis of historic data, the expected losses on the tranche are minimal.

14   On the other hand, the market prices for CDOs are determined using risk-neutral pricing based on the cost of the CDS premium. On a risk-neutral basis the expected level of default losses equates to the CDS premium and hence the expected losses on mezzanine tranches can be material. As a consequence, and particularly given the leveraged nature of the exposure to the underlying credits once losses reach the attachment point, a high spread is payable on these tranches.

Pricing example

15   The example below shows a typical CDO based on a portfolio of 100 A and BBB 7-year maturity credits, well diversified within the practical constraints of available issuers. We consider a mezzanine tranche exposed to losses between 5.5% and 6.5% on the overall portfolio.

16   Based on historic default levels, per Moody's (2005), there is a 99% chance that the holder of the mezzanine CDO tranche will receive full payment. However, the market will price the CDO based on expected losses consistent with the spread on the underlying bonds, which implies a much greater risk of losses and, consequently, a higher required spread. The graph below shows the distribution of recoveries on the underlying portfolio relative to the 94.5% point below which the mezzanine CDO tranche suffers losses on both a historic rating-based simulations and a risk-neutral simulation.

17 This mezzanine CDO tranche might, on these results, be expected to receive a credit rating of A from the agencies and yet receive a spread of around 125 basis points over LIBOR, around three times the spread on comparably rated corporate bonds.

Figure 3
Expected portfolio loss distribution

Source: Working Party
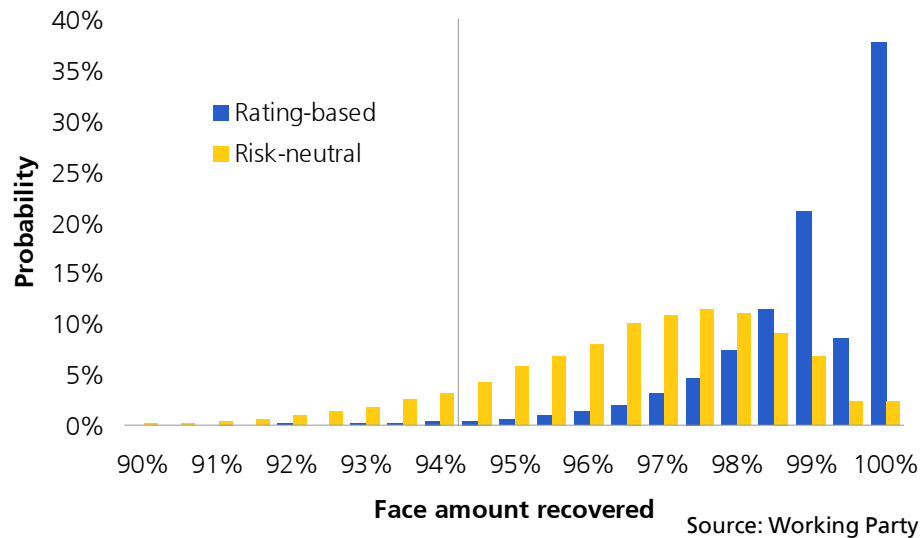
18 Therefore mezzanine CDOs offer attractively high spreads relative to losses simulated from historic data. This is effectively a leveraged play on the attractiveness of credit to held-to-maturity investors.

Computing default consistent spreads

19 This section describes how we computed the spread required on a bond in order to compensate an investor for investing in a particular credit class. Our analysis is based on the historic long-term default probability of assets from a particular rating category. Moody's publish such data annually, and we have used data from their 18th annual study covering the period 1970-2004 (Moody's (2005)). In particular this contains cumulative default probabilities over time and, for example, shows that a bond starting in credit

	1	2	3	4	5
AAA	0.00%	0.00%	0.00%	0.04%	0.12%
AA	0.00%	0.00%	0.03%	0.12%	0.20%
A	0.02%	0.08%	0.22%	0.36%	0.50%
BBB	0.19%	0.54%	0.98%	1.55%	2.08%
BB	1.22%	3.34%	5.79%	8.27%	10.72%
B	5.81%	12.93%	19.51%	25.33%	30.48%
CCC	22.43%	35.96%	46.71%	54.19%	59.72%

class BBB has a 2.08% chance of defaulting over 5 years.

20 Let c_t represent the cumulative default probability up to time t as per the above table. From this we can compute the marginal default probabilities m_t that the bond defaults in a particular time period using the relationship (with $c_0 = 0$):

$$c_t = c_{t-1} + (1 - c_{t-1}) m_t$$

21   The above data produces the following marginal probabilities:

	1	2	3	4	5
AAA	0.00%	0.00%	0.00%	0.04%	0.08%
AA	0.00%	0.00%	0.03%	0.09%	0.08%
A	0.02%	0.06%	0.14%	0.14%	0.14%
BBB	0.19%	0.35%	0.44%	0.58%	0.54%
BB	1.22%	2.15%	2.53%	2.63%	2.67%
B	5.81%	7.56%	7.56%	7.23%	6.90%
CCC	22.43%	17.44%	16.79%	14.04%	12.07%

22   The following notation is used:

p_t is the t-year par rate, i.e. the market coupon to pay on a risk-free bond maturing in t years;

d_t is the t-year discount factor, derived from the risk-free curve;

r is the assumed recovery rate given default; and

s_t is the spread to pay on a t-year bond to compensate the investor for credit risk.

23   If default occurs, then the investor will get back a percentage of the face of the bond (the recovery rate). We have assumed that r = 40% for all periods and classes of bond. This compares to historic recovery rates, per Moody's (2005) of 45% for senior unsecured bonds.

24   We assume, for simplicity, that the risk-free rate is 5% per annum, so $p_t = 5\%$, and $d_t = (1+5\%)^{-t}$.

25   To compute the spread applicable, s_t, we simply have to examine the cashflows that can occur, and with what probability, and solve for the appropriate spread such that the bond is valued at par.

26   For example, consider a 4-year bond. In the first year there is a probability m_1 that the bond defaults (in which case we get cashflow r), and a probability $1 - m_1$ that the bond does not default (when we get cashflow $p_4 + s_4$). The discounted probability weighted values of these cashflows is therefore:

$$d_1\left[(p_4 + s_4)(1 - m_1) + m_1 r\right]$$

27   In the second year, there is only a probability $1 - c_1$ that the bond is still alive. Therefore the discounted probability weighted values of the second year cashflows are:

$$(1 - c_1)d_2\left[(p_4 + s_4)(1 - m_2) + m_2 r\right]$$

28   Continuing in this manner we can derive all of the probability weighted cashflows. The sum of all these cash flows must sum to 100% to compensate the investor for the risk taken. Therefore we can solve the following equation for the correct spread s_4.

$$1 = d_1[(p_4 + s_4)(1 - m_1) + m_1 r]$$
$$+ (1 - c_1) d_2[(p_4 + s_4)(1 - m_2) + m_2 r]$$
$$+ (1 - c_2) d_3[(p_4 + s_4)(1 - m_3) + m_3 r]$$
$$+ (1 - c_3) d_4[(1 + p_4 + s_4)(1 - m_4) + m_4 r]$$

29   We have repeated this procedure for all credit classes and for durations of up to 20 years.

Review of the literature

30   Elton, Gruber, Agrawal & Mann (2001) provided an important analytical estimate of US corporate bond spreads based on three factors:

- expected default losses, estimated from historic data;
- beta premium for credit risk, estimated using the Fama-French model (Fama & French (1993)) to measure sensitivity to the risk factors driving the overall market risk premium; and
- differential taxation: in the US, corporate bond coupons are subject to state tax.

31   Elton et al's results suggest that the spread on corporate bonds over government bonds can be almost entirely explained by these three influences, although expected losses from default accounted for only a relatively limited proportion of the spread.

Figure 4

■	Unexplained
■	Taxes
■	Betapremia
■	Expected default loss
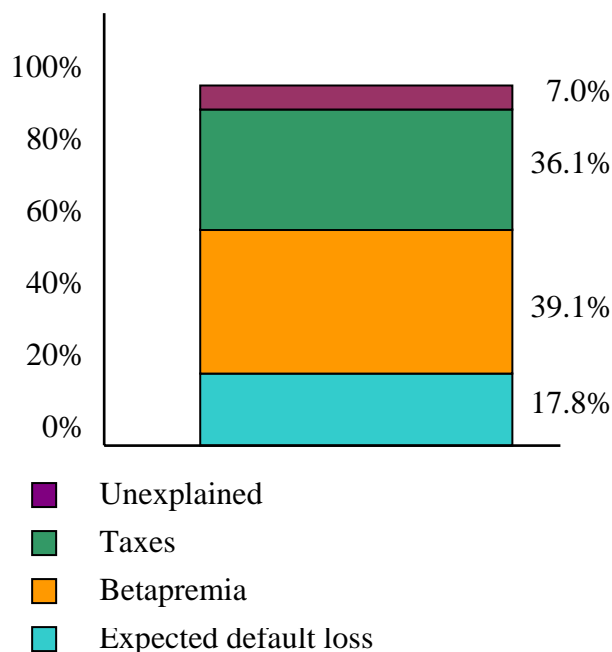
32 For example, Figure 4 above shows their decomposition of the spread on 10-year industrial (i.e. non-financial) A rated bonds versus US treasuries. Although only 17.8% can be explained by expected defaults, an additional 39.1% can be explained as a credit risk premium, giving a total of 56.9% for credit risk. The residual spread they largely explain as a tax effect.

33 Elton et al did not analyse any effect associated with a liquidity premium. Perraudin and Taylor (2003) extend their model to, inter alia, examine liquidity effects. They find spread differences of the order of 10 to 28 basis points due to liquidity effects between liquid and illiquid high quality (A to AAA) corporate bonds. However, this is a relative effect between different corporate bonds and does not explain the credit risk puzzle for liquid corporate bonds.

34 Huang & Huang (2003) produce a much lower estimate than Elton et al of the proportion of the credit premium that can be explained by credit risk. They survey a large class of structural credit models and conclude that only 20% to 30% of the spread can be explained by credit risk for investment grade bonds, although the proportion is much higher for junk bonds. Explaining a higher proportion would require higher risk premia for credit than they regard as empirically reasonable. However, a number of other studies focus on particular features of the bond market that might give rise to a higher required risk premium and hence are able to explain a higher proportion of credit spread.

35 Hull, Preduscu & White (2003) observe that historic default statistics typically cover only the period since 1970. Market participants may allow for the risk of more extreme events than observed in this period. Smith (2004) makes a similar observation relating to small-sample bias. This is also referred to as the "peso effect" after the experience of the Argentian peso, which commanded a significant interest rate premium over US dollars despite being historically pegged.

36 Hull et al also suggest that their may be an agency effect, with portfolio managers not incentivised to seek maximally diversified portfolios, particularly if this reduces expected returns.

37 Dionne, Gauthier, Hammami, Maurice & Simonato (2004) extend Elton et al's model to allow for the small-sample bias in the historic data and find that the expected defaults explain a much higher proportion of the credit spread – for example 37% (vs. 17.8% in Elton et al) for A bonds and 76% (vs. 34%) for BBB bonds.

38 Amato & Remolana (2003) and Smith (2004) observe that the payoff of corporate bonds is highly negatively skewed with limited upside (bond does not default, full spread captured) but strong downside (losses on default are typically 60% or more of nominal value). This negative skew is much more significant than for equities and as a consequence much larger portfolios of bonds are needed to diversify away this effect. Amato & Remolana suggest that even if individual issuers had uncorrelated default risk a portfolio of 300 bonds might be needed to diversify this downside risk, compared to say 30

for equities. In practice such large portfolios of uncorrelated bonds cannot be constructed and hence a higher risk premium is required.

39 Collin-Dufresne, Goldstein & Helvege (2003) focus on '"contagion" risk, whereby the default of one firm affects the market's perception of the risk in other firms. The default of Enron, with the concern raised about the quality of accounting and auditing across the market, is one example. Such risk can not be diversified away and their evidence suggests that this may account for a significant part of the credit spread eg up to 20 basis points per annum.

40 Collin-Dufresne et al suggest that the size of the contagion risk premium suggests it may relate to a "flight to liquidity" effect, as per Longstaff (2001), rather than a true updating of future default risk. Longstaff compares the prices of US Treasury bonds to those issued by Refcorp, a US Government Agency, which are effectively guaranteed by the US Treasury but are less liquid. He finds significant evidence of a "flight to liquidity" effect, whereby US Treasuries command a premium, particularly in times of uncertainty in the financial markets such as the Russian default in 1998. The premium averages around 10 basis points p.a., but has risen as high as 30-50 basis points p.a.

41 Longstaff, Mithal & Neis (2004) focus on evidence from the credit default swap market to quantify the credit risk premium. They find that the credit default related component accounts for 51% of the spread relative to government bonds for AAA/AA rated bonds, 56% for A bonds, 71% for BBB and 83% for BB. If spread is measured relative to swaps then the credit default related component accounts for close to 100% of the spread.

42 Longstaff, Mithal & Neis find lower estimates for the impact of tax than Elton et al, reflecting the fact that some marginal investors may be tax exempt. They find that the residual non-default related component is, overall, related to macroeconomic measures of liquidity, as per Longstaff's "flight to liquidity" effect, with bond-specific illiquidity measures important in accounting for differences between bonds.

43 Li, Shi and Wu (2005) directly estimate the liquidity effect for corporate bonds, using a liquidity risk factor based on data for liquid versus illiquid Treasury bonds. Their results show a significant liquidity premium which explains 25% of the spread for investment grade bonds and 30% to 40% for speculative grade bonds. Li, Shi and Wu have not analysed credit risk premia, in contrast to most of the papers above which started with the credit risk premium and then analysed only the residual spread for any liquidity effects. Li, Shi and Wu's "liquidity premium" may therefore have some overlap with the "risk premium" found by other researchers.

44 Driessen (2005) analyses the spread on corporate bonds into six components, which for a typical BBB bond (with spread of 95bpa) are split as follows:

Systematic risk in credit spreads (covers both expected defaults, and a beta effect)	33%
A default jump premium (reflects the skewed nature of credit risk and inability to diversify this effect)	24%
Firm specific risk factors	4%
Correlation with interest rate risk (negatively correlated, so reduces the risk premium)	-9%
Tax effects	33%
Liquidity premium	13%

C References

ALTMAN, E.I. (1989). Measuring Corporate Bond Mortality and Performance. *Journal of Finance, 44, 902-22.*

AMATO, J.D. & REMOLANA, E.M. (2003). The credit spread puzzle. *BIS Quarterly Review, 5, Dec 2003, 51-63.*

BAGGS, I., CANNON D., HOLMAN R., MIDDLETON P., PAGETT T. & WINCKLER A. (2003). Credit Derivatives. *Ernst & Young report.*

BRITISH BANKERS' ASSOCIATION (2003/2004). Credit Derivatives Survey.

BANK FOR INTERNATIONAL SETTLEMENTS (September 2005). Quarterly Review.

COLLIN-DUFRESNE, P., GOLDSTEIN, R.S. & HELWEGE J. (2003). Is Credit Event Risk Priced? Modelling Contagion via the Updating of Beliefs. *Working Paper, Carnegie Mellon University.*

DIONNE G., GAUTHIER, G., HAMMAMI, K., MAURICE, M. & SIMONATO, J.G. (2004).
Default risk on corporate yield spreads. *Working Paper, HEC Montreal.*

DOREY, M and JOUBERT, P. (2005). Modelling Copulas: An Overview. *Presented to Staple Inn Actuarial Society, October 2005.*

DRIESSEN, J. (2005). Is Default Event Risk Priced in Corporate Bonds? *Review of Financial Studies 18, 165-195.*

DYER, D, CROUCH, S, EASON, S, FULCHER, P & JOLLY P. (2004). Fixed Interest Investment for Life Insurers - Driven by Investment Principles or Regulation? *Presented to the Joint Faculty and Institute of Actuaries Investment Conference, 2004.*

ELTON, E.J., GRUBER, M.J., AGRAWAL, D. & MANN C. (2001). Explaining the Rate Spread on Corporate Bonds. *The Journal of Finance Vol. LVI No 1.*

FAMA, F. & FRENCH, K. (1993). Common Risk Factors in the Returns on Stocks and Bonds. *Journal of Financial Economics, 33, 3-56.*

HUANG, J. & HUANG M. (2003). How Much of the Corporate-Treasury Yield Spread is Due to Credit Risk. *Working Paper, Stamford University.*

HULL, J.C. (2004). Options, Futures and Other Derivatives. *Published by Prentice Hall.*

HULL, J.C., PREDESCU, M. & WHITE, A. (2003). Bond Prices, Default Probabilities and Risk Premiums, *Working Paper, University of Toronto*

LI, H., SHI, J. & WU, C. (2005). Estimating Liquidity Premium of Corporate Bonds Using the Spread Information in On- and Off- The Run Treasury Securities. Working Paper

LONGSTAFF, F.A. (2004). The flight-to-liquidity premium in US Treasury Bond Prices. *Journal of Business, 77, 511-526.*

LONGSTAFF, F.A., MITHAL, S. & NEIS E. (2004). Corporate Yield Spreads: Default Risk or Liquidity? New Evidence from the Credit-Default Swap Market, *Working Paper, UCLA*

MOODY'S (2005). Default and Recovery Rates of Corporate Bond Issuers, 1920-2004. *Moody's Investor Services, January 2005*

PERRUADIN, R.M. & TAYLOR A.P. (2003), Liquidity and Bond Market Spreads, *Working Paper, Bank of England*

SMITH, A.D. (2004). Modelling corporate bonds. *Presented to Institute and Faculty of Actuaries Current Issues in Life Assurance Conference, 2004.*