Valuing credit assets

By Charles Smithson and Gene D Guill

This is the second of Charles Smithson's third series of Class Notes, a series that will run in alternate issues of *Risk* through to the end of 2004. Class Notes is an educational series, designed to pull together the threads of recent developments and thinking about issues in risk management.

This month, Gene D Guill joins Charles to examine the valuation of loans and other credit assets.

Banks and other holders of various types of loans and credit assets are under increasing pressure to move to 'market-value accounting', where the value of an asset would be either the value it would realise if sold today ('mark-to-market') or the present value of its cashflows discounted at a market-implied discount rate ('mark-to-model').[1]

Using observable market prices to value credit assets

The prices used directly to mark credit assets to market or indirectly to mark credit assets to model are obtained from bond prices, secondary loan prices and credit default swap spreads. Both internal and external (vendor-supplied) data are currently being used to mark credit assets to market or model.

Table A provides some insight into the degree to which a portfolio of credit assets can be marked-to-market using observable market prices. This table is the result of discussions with five multinational banks about loans to large corporate credits and represents a hierarchy where the bank first attempts to use secondary loan prices to value the credit asset and, if unsuccessful, turns next to credit default swap spreads, and then to bond prices, before resorting to valuation models. It indicates that approximately 25% of the facilities or 55% of the notional committed amounts to these large corporates can be marked-to-market/model using observable secondary loan prices, credit default swap spreads or bond spreads.

Even for portfolios of loans to large corporates, a significant percentage of the portfolio cannot be marked to market/model using observable prices. For those credit assets, the holder of the credit assets will have to rely on some kind of valuation model.

Using valuation models to value credit assets

To value a credit asset, it is necessary to value both the default-risky claims (that is, the credit-risky cashflows from the asset) and the options embedded in the credit asset (that is, option to prepay, option to draw, term-out option[2] and grid re-pricing option[3]).

☐ **Valuing default-risky claims.**[4] Table B relates some of the more widely cited valuation models by arranging them in a 'family tree'. Models on the left branch of the 'family tree' are called 'structural models' because they require data on the assets and liabilities of individual firms and because they hypothesise a triggering event that causes default. In contrast, the 'reduced-form models' on the right branch of the 'family tree' ignore the specific economic circumstances that trigger default. These models estimate the risk-neutral probability of default from prevailing credit spreads and use that probability to value the credit-risky cashflows.

☐ **Structural models.** In the structural models in table B, default occurs when the value of a firm's assets declines such that it can no longer pay its fixed claims. The point at which the value of assets is deemed insufficient for the firm to continue is called the 'default point' or 'default threshold'. One distinguishing characteristic of the models on this branch is the approach to determining the default point.

In the original Merton model, the firm's only debt is a single zero-coupon issue. The default point is the face value of the debt. In this simple framework, the post-default value of the debt is equal to the value of the firm's remaining assets. Hence, at maturity of the debt, the value of the default-risky debt is:

$$D(T) = F - \begin{cases} 0 & \text{if } V(T) > F \\ F - V(T) & \text{if } V(T) < F \end{cases}$$

where F is the face value of the debt issue and $V(T)$ is the value of the firm's assets at maturity. In such a model, the value of the default-risky debt is equivalent to the value of a risk-free zero coupon of equal maturity minus the value of the 'default option':

$$\begin{aligned} D(t) &= \textit{Value of risk-free debt} - \\ &\quad \textit{Value of default option} \\ &= F \times DF_t - f\left[V(t), F, T, r, \sigma_V\right] \end{aligned}$$

where DF_t is the discount factor. So, pricing credit risk is an exercise in valuing the default option. As the preceding equation implies, this valuation could be accomplished using standard option-valuation techniques where the price of the underlying asset is replaced by the value of the firm's assets, $V(t)$; the exercise price is replaced by the face value of the zero-coupon debt, F; the maturity of the option is set equal to the maturity of the single, zero-coupon debt issue, T; the risk-free interest rate, r, is of the same maturity as the maturity of the zero-coupon debt; and the volatility used is that of the market value of the firm's assets, σ_V. This list of data requirements points out problems with the structural models in general and with the first-generation models specifically:

☐ the market value of the firm's asset value and the volatility of that number are unobservable;

☐ the assumption of a constant interest rate is counter-intuitive; and

☐ assuming a single zero-coupon debt issue is too simplistic. Implementing a first-generation model for a firm with multiple debt issues, junior and senior structures, bond covenants, coupons or dividends would be extremely difficult.

In addition, in the first-generation structural models, default cannot occur before maturity.

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1 Note that, in either case, the value is dependent upon liquidity in the market

2 If a revolving credit facility has a 'term-out option', the customer has the option, at the end of the revolving period, to convert the amount outstanding into a term loan that is to be repaid at the end of the term-out period

3 Some credit agreements include a provision to periodically adjust spreads and fees based on changes in financial ratios or credit ratings

4 A recent survey of credit risk pricing models can be found in Ammann (2001)

Second-generation structural models address some of the limitations of the first-generation models. For example, Longstaff & Schwartz (1995) specify an exogenous 'default threshold', instead of considering the debt structure of the firm. When that threshold (boundary) is reached, all debt is assumed to default and pay an exogenous percentage of its face value (that is, the recovery rate).

☐ **Reduced-form models.** The model proposed by Jarrow & Turnbull (1995) relies on a simple economic argument: The price of any security – a bond, an interest rate swap, a credit default swap – can be expressed as the expected value of its future cashflows. The expected value is obtained by multiplying each possible future cashflow by the risk-neutral probability of its occurrence, where the risk-neutral probability is determined by the spread on a default-risky bond. For example, consider the following relation:

$$CORP_1 = BENCH_1 \times \left[(1-q)\times 1 + q \times RR\right]$$

$CORP_1$ is the price today of a zero-coupon bond issued by company X that will mature in one period. This price can be interpreted as the present value (using risk-free discount rates) of the risk-adjusted expected cashflows on the bond. The discounting is accomplished with $BENCH_1$, the price today of a zero-coupon treasury that also matures in one period. The expected value is calculated from the cashflows on Company X bonds and the risk-adjusted probability of default, q. Thus, either company X defaults, paying a known percentage of the face value, RR, with probability q, or it does not default, and pays 100% of the face value with probability $(1 – q)$.

Assuming the recovery rate, RR, is known, and with market prices for $CORP_1$ and $BENCH_1$, we can solve for the 'market's' assessment of the default probability, q:

$$q = \frac{1 - CORP_1 / BENCH_1}{1 - RR}$$

Expressing interest rates in continuously compounded form, the price today of the one-year, risk-free zero-coupon bond and the risky one-year, zero-coupon bond are:

$$BENCH_1 = e^{-r}$$

$$CORP_1 = e^{-(r+s)}$$

where r is the risk-free rate and s is the credit spread. Incorporating these into the equation for the risk-neutral probability of default for Company X, we obtain:

$$q = \frac{1 - e^{-s}}{1 - RR}$$

If we assume that the credit spread is small ($e^{-s} \approx 1 - s$), this equation becomes:

$$q \approx \frac{s}{1 - RR}$$

To value a credit asset, one could obtain a term structure of the credit spreads (for example, across maturities, ratings or industries), then use the implied risk-neutral default probabilities, with an assumed recovery rate.

The second-generation reduced-form models provide extensions in various directions. Duffie & Singleton (1994) incorporate a variable (albeit deterministic) recovery amount. Madan & Unal (1998) introduce both stochastic recovery rates and stochastic default intensities. Jarrow, Lando & Turnbull (1997) expand the analysis from default/no-default to credit rating states (requiring a risk-neutral framework for modelling transition probabilities) and eliminate the assumption of constant default intensities over time. Das & Tufano (1996) remove the restriction that default intensities and interest rates are independent and introduce a stochastic mean-reverting process for recoveries. Duffie & Singleton (1999) make the default intensities a stochastic, mean-reverting process.

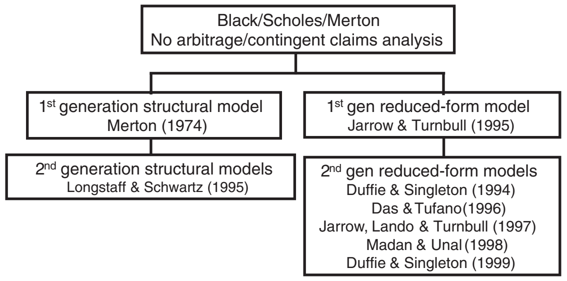
☐ **Valuation of the embedded options.** Options that are commonly embedded in bank loans include the option to prepay, the option to increase or pay-down the amount of outstandings under a revolving credit facility, the option to convert the outstandings at the end of a 'revolving period' into a bullet term loan, and the option to re-price the facility on the basis of some type of pricing grid. While common, these options are negotiated on a case-by-case basis between the bank (or agent bank) and the borrower.

Options embedded in credit assets are normally evaluated using a lattice model. The financial institution would construct

A. Representative distribution of valuation methods

Credit assets valued using:	% of facilities	% of notional
Internal secondary loan prices	2.6	5.0
Vendor-supplied secondary loan prices	1.7	2.7
Internal CDS spread curves	16.3	40.2
Vendor-supplied CDS spread curves	2.0	5.5
Bond credit curves	2.3	3.7
Valuation models	75.1	43.0

B. 'Family tree' of pricing models for default-risky claims



C. Vended models for valuing credit assets

Model provider	Model name	What credit assets will the model value?	Model's approach to valuing credit-risky cashflows	Which embedded options does the model value? Term-out	Prepay	Draw	Grid pricing
Algorithmics	Credit eValuator	Term loans, revolving credit agreements and other credit instruments[1]	Hybrid model – multi-state model, along lines of Jarrow-Lando-Turnbull	✓	✓	✓	✓
Moody's KMV	CreditMark	Term loans, revolving credit agreements and other credit instruments	Structural model – uses MKMV's equity-market based EDFs, RiskCalc EDFs or spread-implied default probabilities. Model is embedded in a valuation framework that also supports the use of secondary loan market prices	✓	✓	✓	✓
Interval	Corporate Loan Pricing Model	Term loans and revolving credit agreements	Reduced-form model – Markovian risk rating migration simulation and arbitrage-free discounting algorithm to value loan's (contingent) cashflows	✓[2]	✓		

[1] Letters of credit (guarantees), multi-option facilities (any combination of term loan/revolving credit/letter of credit/bond), bonds, credit default swaps
[2] Revolving credit agreements that covert to a term loan at a predetermined date

D. Credit assets that are or are planned to be marked to market or model

Credit products	Currently mark-to-market	Currently mark-to-model	Plan to mark-to-market or model
Syndicated bank loans	10%	22%	34%
Bilateral bank loans	na	29%	34%
Undrawn lines (committed revolvers, CP back-up facilities, uncommitted lines)	na	32%	34%
Counterparty credit risk	na	41%	7%
Credit derivatives	44%	20%	17%
Senior or subordinated CDO secs	22%	17%	15%
CDO equity	12%	7%	12%

a lattice of rating states throughout the life of the facility. Initially, the lattice would be populated with the cashflows (obtained from the pricing and amortisation schedules), permitting the financial institution to calculate the expected net present value of the facility over time. To value the embedded options in loans, borrower behaviour would be incorporated into the lattice structure, for example, the impact on the cashflows if the customer's creditworthiness improved and the customer prepaid the loan.

□ **Vended credit asset valuation models.** We are aware of three vended models for valuing credit assets. These models are summarised in table C (see previous page). Relating table C to the discussion of the credit asset valuation models earlier in this column:

□ The foundation of Moody's KMV (MKMV) CreditMark is the structural model (Merton model) that MKMV uses to obtain its expected default frequency (EDF) and in Portfolio Manager, its credit capital model. However, this model also incorporates default probabilities implied by credit spreads. MKMV indicated that CreditMark comprises multiple valuation models, including a risk-neutral, multi-credit-state model.[5]

□ Interval's Corporate Loan Pricing model appears to be a reduced-form model, based on a credit rating migration process. CLP constructs a lattice of a loan's risk rating states throughout its life and populates the lattice with the cashflows according to the loan pricing and amortisation schedules. The discount factors to calculate the present values of the cashflows are determined in the calibration process.

□ Algorithmics' eValuator is a hybrid, combining the structural and reduced-form approaches.[6] It is a multi-state (credit rating) model that uses three factors to characterise the credit assets: borrower creditworthiness; default-free short rate or continuous forward rate; and a systemic factor describing stochastic credit spreads.

Current market practice and challenges

The 2002 *Survey of Credit Portfolio Management Practices*[7] asked banks and other financial institutions whether they mark various credit assets to market or model and, if not, whether they intend to do so in the future. Table D provides an interpretation of the state of practice in 2002.

Proponents of market valuation argue that, to successfully intermediate risk, financial institutions must use market prices to drive their decisions to originate, hold, hedge or sell individual loans, and the accounting systems must support these decisions. Moreover, they argue that provisioning and write-offs would become more gradual and ultimately less severe.

Opponents of market valuation point out that few secondary loan prices currently exist; so most prices would be 'made-up'. And, they argue, market valuation would take away banks' control over provisioning and introduce significant profit and loss volatility.

Market valuation is the norm for investment banks and investment managers, but switching to market valuation is much more problematic for commercial banks. It appears to us that bank management must confront and overcome three significant obstacles:

□ Management must be willing to 'accept the mark'. In practically all cases, the adoption of market valuation would result in a significant mark-down in the value of a loan portfolio.

□ Management must be willing to rethink strategies. Commercial banks have used their lending capacity as a competitive tool to sell higher value-added products. Market valuation will reveal the economic cost of this strategy, which must be put against the expected profit to determine whether or not the business is a good business.

□ Management must be willing to reinvent the bank. Management of a mark-to-market loan portfolio requires a different organisational structure and responsibilities, different IT infrastructure, and different skill set from managing an accrual accounting book. ■

Charles Smithson is widely recognised as an expert in risk management. In 1999, he founded Rutter Associates, an education and advisory firm dealing with all aspects of the measurement and management of risk. Rutter Associates' research is currently focused on questions dealing with economic capital and the management of portfolios of credit assets.

Gene D Guill is a managing director in the Loan Exposure Management Group of Deutsche Bank's global investment banking division. He is based in New York, and is responsible for the strategy and procedures used in managing the global investment-grade lending portfolio. In this position, he has pioneered the introduction and use of credit risk models, developed procedures to screen assets for entry into the portfolio, and conducted transactions to manage the true risk and regulatory capital of lending portfolios

[5] *In conversations with MKMV as we prepared this column, MKMV stressed that CreditMark is currently installed at three financial institutions*
[6] *The Algo model framework is described in detail in Aguais, Forest & Rosen (2000)*
[7] *For an overview of this survey, see* Risk *January 2003, pages 78–80*

References

Aguais S, L Forest and D Rosen, 2000
Building a credit risk valuation framework for loan instruments
Algo Research Quarterly 3(3), pages 21– 46

Ammann M, 2001
Credit risk valuation
Springer-Verlag, Berlin

Das S and P Tufano, 1996
Pricing credit-sensitive debt when interest rates, credit ratings and credit spreads are stochastic
Journal of Financial Engineering 5(2), June, pages 161–198

Duffie D and K Singleton, 1994
Modeling term structures of defaultable bonds
Discussion paper, Graduate School of Business, Stanford University

Duffie D and K Singleton, 1999
Modeling term structures of defaultable bonds
Review of Financial Studies 12(4), pages 687–720

Jarrow R, D Lando and S Turnbull, 1997
A Markov model for the term structure of credit risk spreads
Review of Financial Studies 10(2), pages 481–523

Jarrow R and S Turnbull, 1995
Pricing derivatives on financial securities subject to credit risk
Journal of Finance 50(1), March

Longstaff F and E Schwartz, 1995
A simple approach to valuing risky fixed and floating rate debt
Journal of Finance, March

Madan D and H Unal, 1998
Pricing the risks of default
Review of Derivatives Research 2(2/3), pages 121–160

Merton R, 1973
Theory of rational option pricing
Bell Journal of Economics and Management Science, spring

Merton R, 1974
On the pricing of corporate debt
Journal of Finance 29, pages 6–22