

# Use of options theory in credit evaluation

In the first of two articles, Dr Andrew Bagley of [www.FirstKnow.It](http://www.FirstKnow.It) discusses the theoretical background to credit analysis and practical aspects in its implementation.

Evaluation of credit risk has long been a part of treasury, both in respect of the company in negotiations with banks and in analysis of customer or supplier credit risks. Derivatives techniques, based on a characterisation of credit risk as a put option written by the creditor in favour of the debtor, have been recognised since Black, Scholes & Merton's ground-breaking work on options theory.

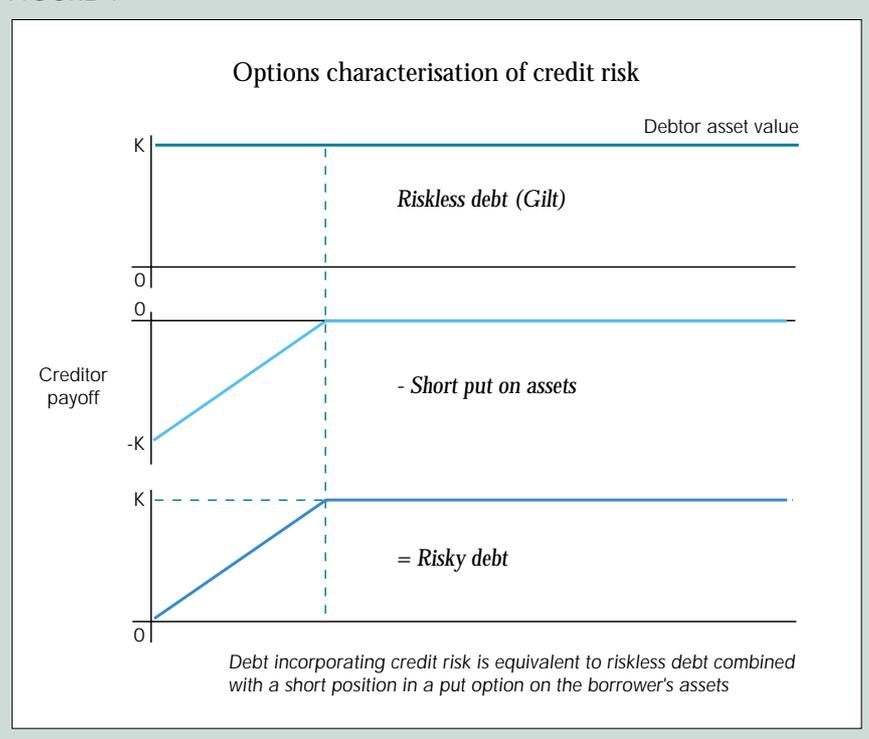
A number of organisations have marketed valuation systems based on this approach, and this article outlines the theoretical background of this approach to credit analysis and discusses some practical aspects in its implementation.

## Characterising the event of default

Traditional credit analysis techniques such as Z-Scoring (Altman) and cash-flow analysis are substantially founded in accounting principles, whereas the options methodology is firmly based in financial definitions of asset valuation.

The core concept behind the financial definition of default is that the economic value of a company's assets is less than the value of its liabilities. The minutiae of negotiations with banks and accounting niceties are subsumed into the insight that if the assets of a business are greater than its liabilities, some means can be found to generate external finance. The veracity of this argument, for example, is supported by companies in the biotech or telecoms sectors, which were able to generate external finance, despite often having weak financial statements, because the perceived economic value of their future earnings was so great. Therefore, the financial approach characterises the event of default as occurring when the economic value of a company's assets falls below the value of its liabilities and does not concern itself with the structure of company financials *per se*.

FIGURE 1



In the event of default, limited liability protects a company's shareholders from claims from creditors. When default occurs, administrators acting on the creditors' behalf are appointed to take control of the company's assets and



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maximise recoveries from their disposal. The shareholders effectively hand the assets over to the creditors, who are left to minimise their losses. Any shortfall from the disposal is for the creditors' account, they obtain no further compensation from the shareholders<sup>1</sup>.

The financial approach characterises this event of default as exercise by the debtor of a put option on its assets, written in its favour by the creditors, which permits full settlement of the debts. Therefore, the assets are 'put' on the creditors at a value that settles the debt, and the creditors lose the difference between the value of the debt and the liquidation value of the assets.

The debt with credit risk can therefore be divided into two components:

- the put option which incorporates the credit risk; and

- riskless debt which has no credit risk, being paid off with the funds generated by exercise of the put option.

Figure 1 plots creditor payoff against debtor asset value at maturity for these two components and shows the options characterisation of credit risk. Clearly, the riskless debt payoff (K) is independent of asset value at maturity. The put option permits the debtor to put their assets at value K and will be exercised if the asset value is less than K. On maturity, the riskless debt plus option give a net payoff of:

$$K \quad - \quad \text{Max}(0, K - S) \quad = \quad \text{Min}(K, S)$$

(Riskless debt)      (Option payoff)      (Net payoff)

Where S is the asset value on maturity

If the assets are worthless,  $S = 0$  and the net payoff is zero, if  $S \geq K$ , the net payoff is K. The combined riskless component plus short option position reproduces the payoff profile of the risky debt.

As the risky debt can be partitioned in this way, evaluating the put option is equivalent to quantifying the credit risk.

Finally, is this a European or a US put option? A European put option would suggest that the borrower could not default before maturity of the debt, which is clearly incorrect. A US put option would suggest the discretion to declare default lies with the option beneficiary, the debtor, whereas, in practice, it is usually creditors which declare the default.

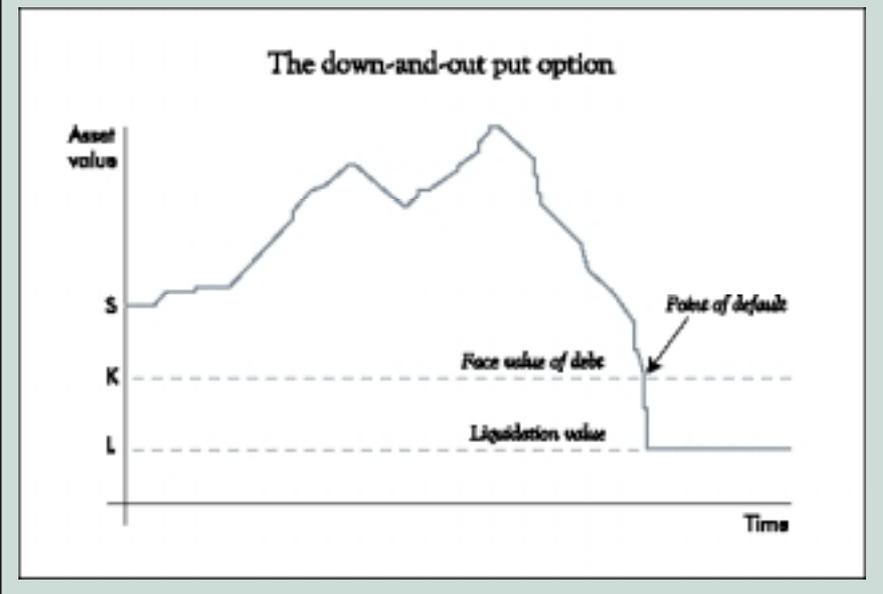
A group of options (known as 'barrier options') have the correct characteristics to capture accurately the conditions of default, specifically the European down-and-out put option.

### The down-and-out put

Barrier options incorporate a barrier that can be used either to create or cancel an option with pre-defined characteristics. The down-and-out put leads to the put option being cancelled in the event that the asset value falls to the value of the barrier, at which time a pre-determined cancellation rebate is paid by the writer of the option to the beneficiary.

If the assets of the company are the underlying of the option, the barrier is the firm's total indebtedness and the pre-determined rebate is the write-down cost through fire-sale liquidation of the assets<sup>2</sup>, it can be seen that the down-and-out option accurately encapsulates

FIGURE 2



the credit risk on risky debt. The position is shown in Figure 2 where:

- S is the asset value of the firm;
- K is the strike and default barrier and equals the face value of debt; and
- (K-L) is the cancellation rebate.

Again, if the down-and-out put option provides an accurate representation of the credit situation, then by evaluating it we can accurately quantify the credit risk.

### What about interest?

Assuming interest is payable on maturity, in the analysis, the barrier and strike can gradually be increased over time by the amount of accruing interest.

Here, we have discussed the key theoretical elements in the options analysis of credit risk and provided a sufficient theoretical base for the informed use of the credit ratings produced by either California-based KMV or [www.FirstKnow.It](http://www.FirstKnow.It), whose UK services are marketed by the author's company. The remainder of this first article discusses the practical variable definitions which enable the put option to be evaluated.

### Option evaluation

The data to evaluate the option for listed companies is reasonably accessible through stock market data. Recall that the put option is on the total asset value of the firm, and in this sense differs from equity options which are on the listed equity of the firm.

Therefore, the economic value of assets, which is the underlying of the option, is not directly measurable but can be inferred. There are two central tenets of this process:

- that the total economic value of the assets of a company (immeasurable) is equal to the sum of the economic value of its liabilities – its debts plus equity<sup>3</sup>; and
- that the stockmarket capitalisation of a company measures accurately the economic value of the equity of the firm.

Added to these is a further practical assumption:

- that the nominal value of the debts quantifies accurately the economic value of the debt of the firm.

The first point is similar to balance sheet accounting. All assets of a company are subject to claim either by creditors or shareholders, therefore the sum of the economic value of the claims must equal the economic value of the assets.

We have focused so far on the abstract notion of 'economic value'. The second tenet states that the stock market capitalisation of a company is equal to the economic value of its equity: a statement of stock market efficiency. Much academic work has tested this question and the stock market is generally considered to be

very efficient at pricing securities. This efficiency and the fact that the stock market is forward-looking are key benefits of the options approach to credit evaluation in comparison with traditional approaches that are primarily backward-looking.

The final assumption breaks a cyclical argument. We need to know the economic value of the liabilities of the firm, but these liabilities incorporate credit risk so their economic value is less than their nominal value. However, this credit risk is precisely what we are seeking to calculate. Furthermore, with the exception of particular securities such as bonds, most liabilities are not quoted and therefore no market value is available. The cyclical argument can be broken by assuming that the put value is small relative to the total assets of the business<sup>4</sup>. This is an excellent assumption for companies with reasonable credit quality (low put value) and improved accuracy can be obtained by iterative calculation of the debt put value to produce a deduced market value.

The three points above permit calculation of current market value of assets and historical asset volatility, which together with readily available data provide accurate estimates of the primary inputs for calculating the down-and-out put value.

The final item in evaluating the option is the magnitude of cancellation rebates – the write-down due to fire-sale of assets. Two examples highlight the importance of this issue. Compare two companies: an investment trust which invests in FTSE 100-quoted securities and an advertising agency. Clearly, the FTSE 100 trust can be liquidated quickly and at virtually zero discount. The primary assets of the advertising agency, however, are its personnel and its client relationships. On default, the personnel leave usually taking the clients with them and there is a drastic write-down on default. These are extremes, but demonstrate the point that asset write-downs on liquidation can have a dramatic effect on credit quality. The credit risk of the investment trust is virtually zero because, even in the event of default, the assets are resilient and creditors would stand to be repaid virtually in full.

Despite the evident importance of asset resilience in default, credit rating agencies focus almost exclusively on the probability of default and timeliness of payments in credit evaluation. The rating agencies are certainly aware of the resilience issue and are eager to investigate. In a recent study of 120 defaults, Moody's (November 2000) found no evidence that industries have different LGD (Loss Given Default). However, Altman and Kishmore (1996) in a much larger study of 700 bond defaults over 24 years found significant variations in recoveries across sectors. Altman & Kishmore's work and a study by Asarnow and Edward (1995) of 850 bank loan defaults at Citibank over a similar period provide an excellent base for estimating sector-based asset write-downs in default.

Specifying the cancellation rebate completes the specification of the analysis inputs. The necessary data to calculate the put option can then be obtained from publicly available sources and a

suitably specified historical database for volatility calculations. A combination of these variables with real-time stock price data permits production of real-time ratings for quoted firms. ■

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#### NOTES

<sup>1</sup> In the absence of fraudulent trading and the like.

<sup>2</sup> For the down-and-out put, the cancellation rebate is paid to the beneficiary of the option, whereas in the case of default the debtor does not actually receive a rebate. The recipient of the rebate is irrelevant for the purpose of evaluating the down-and-out put option, it is purely to specify the write-down caused by default. Arguably, there is no recipient because the economic cost of default is an irrecoverable loss to all parties.

<sup>3</sup> The logical complement of this statement is that the economic value of the equity is the total economic value of the assets of the firm less the economic value of its debts.

<sup>4</sup> KMV resolve this by using a second theoretical relationship between the volatility of the equity and the volatility of the assets, and by hypothesising a functional form and solving by iteration.

<sup>5</sup> Note, LGD and fire-sale write-downs of assets (discount on sale compared with their value) should be identical if the company is liquidated as soon as the economic value of its assets falls to the value of its debts. ■

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