APPLICATION OF TO VALUATION

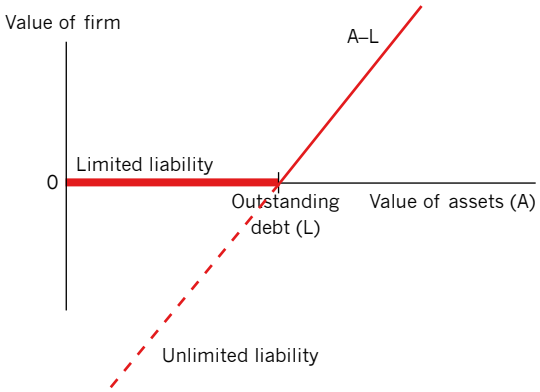
RELEVANT TO ACCA QUALIFICATION PAPER P4

THE USE OF THE BLACK SCHOLES MERTON (BSM) MODEL, TO VALUE THE REAL OPTIONS EMBEDDED IN CAPITAL INVESTMENT PROJECTS, IS AN IMPORTANT PART OF THE PAPER P4 SYLLABUS.

The use of the Black Scholes Merton (BSM) model, to value the real options embedded in capital investment projects, is an important part of the Paper P4 syllabus. An aspect of the Paper P4 syllabus is the emphasis on company valuation and, in particular, on how to deal with companies that are difficult to value in the normal way. The BSM model provides a general framework for company valuation and helps in those situations where conventional techniques cannot be used, or where they do not fully reflect the risks involved. In this article we will explore the insights that the model provides.

When you or I borrow money to purchase a car, a house, or some other valuable asset, we enter into a forward contract to purchase from the lender, when the loan matures, the asset concerned for the face value of the debt. If the asset has risen in value above the amount we owe at the maturity of the loan, then we keep that surplus value; if not we must make good the difference. This is exactly the position of the owner of a firm who has unlimited liability for the debts of their business. With limited liability, however, the shareholders are not liable for their firm's debts in the event of default. If, when the loan matures, the value of the assets are greater than the value of the firm's debts (A–L in **Figure 1**), then the equity shareholders are entitled to the difference. If the value of the assets falls below the value of the firm's debts, the firm can liquidate the business and walk away. Therefore, the price a firm pays for its shares in the company represents the premium on a call option written by the lenders on the underlying assets of the business.

FIGURE 1: THE PAYOFF ON LIMITED VERSUS UNLIMITED LIABILITY



In practice, of course, complexities arise. Lenders do not collect their premium directly. They might do it by means of a zero coupon bond (ie the amount they lend is lower than the amount to be repaid, but no interest is charged). More often they do it by charging interest which includes a premium to cover the risk that the business will default and leave them with assets worth less than the value of the loan. However, none of these complexities undermine the logic of the argument that we should value equity as a derivative.

OPTION PRICING OF FIRMS

THE VALUATION VARIABLES

Black, Scholes and Merton taught us that the premium on a call or put option is defined by five variables:

- the value of the underlying asset
- its volatility
- the exercise price
- the time to settlement
- the risk free rate of interest.

In **Table 1** we translate these generic variables into what must be measured for conventional share options, and when valuing corporate equity as a call option.

TABLE 1

	Share option	Value of firm
Value of underlying asset	Equity share price	Value of firm assets in use
Volatility of the underlying asset	Standard deviation of continuously generated share returns	Standard deviation of asset value
Exercise price	Contract price for settlement	Redemption value of outstanding debt
Time	As agreed	Term to maturity of debt
Risk-free rate	Term of option	Term of debt

THE VOLATILITY OF ASSETS IS PROBABLY THE MOST DIFFICULT VARIABLE TO ESTIMATE ACCURATELY. ONE APPROACH IMPLIES THE ASSET VALUE AND THE VOLATILITY FROM THE BSM MODEL.

Where the assets of a firm are actively traded and easily liquidated then their current market value should be used. For example, in March 2007, the assets of Northern Rock – a UK mortgage bank – were shown at fair value of £113.2bn. In the case of a bank, the majority of its assets are actively traded and hence the fair value in the balance sheet will represent their economic value. In the case of other companies, value in use will normally be based on the present value of the future cash flows that the firm's assets are expected to generate over their useful lives.

The volatility of assets is probably the most difficult variable to estimate accurately. One approach implies the asset value and the volatility from the BSM model. Another approach is to project and simulate the expected future cash flows of the business, generating a distribution of present values from which the volatility can be obtained.

In the early applications of the BSM model to the problem of valuation, the firm was assumed to have issued debt in the form of a single, zero coupon bond. In practice, firms issue debt of all sorts – some variable term, some fixed interest, some with convertibility and so on. The simplest approach to identifying the effective exercise price is to go through the following steps:

1 Estimate the average term to maturity of the company's outstanding long-term debt.
2 Estimate the average coupon rate (rate of interest paid on the debt).
3 Using the current yield on the company's debt (this could be the quoted rate on any variable debt in issue or that given for the company's credit rating), estimate the market value of a notional £100 bond.
4 Estimate the repayment value of an equivalent bond where no interest is paid.

Note that under IFRS, the company's debt may be shown at fair value and so steps 2 and 3 are not required.

EXAMPLE 1

A company has $100 of debt in issue carrying 5% interest and with five years to maturity. The company's current cost of debt capital is 8%.

The market value of the debt is estimated as follows:

Year	1	2	3	4	5
Interest and repayment (assume annual payments)	5	5	5	5	105
Discounted at 8%	5	4	4	4	71
Present value of the debt	$88				

The repayment value on a zero coupon bond of the same current market value is calculated by finding the unknown future value which, when discounted at 8% over five years, gives a present value of $88.

$$\$88 = \frac{FV}{1.08^5}$$

Therefore

$$FV = \$88 * 1.08^5 = £129$$

Thus $129 would be the redemption value of a zero coupon bond of the same value as the debt currently in issue.

An alternative approach is to use the redemption value as quoted in the accounts but use the duration of the debt in place of the term to maturity. This should give comparable results to the method shown above.

THE LOGIC OF OPTION PRICING IS THAT THE VALUE OF AN OPTION RISES WITH THE LEVEL OF RISK, AND THAT THIS IS PARTICULARLY THE CASE WHEN THE OPTION IS NEAR THE MONEY, IE WHEN ITS LEVEL OF GEARING APPROACHES 100%.

BRINGING IT ALL TOGETHER

Let us assume that we have achieved good estimates of the input variables – the next task is to bring it all together in the BSM model. The model has a number of assumptions that restrict its application, but for our purposes it demonstrates the problem of corporate valuation quite nicely. To illustrate, a very interesting application of this approach occurred with respect to the value of the previously mentioned, distressed UK bank, Northern Rock. In March 2007, the company reported assets and liabilities at fair value of £113.2bn and £110.7bn respectively. The average term to maturity on the bank's liabilities was approximately 100 trading days. This is not unusual for a bank whose liabilities are in the form of short-term money market borrowing and deposits. At that point, the risk free rate of interest was 3.5%.

The logic of option pricing is that the value of an option rises with the level of risk, and that this is particularly the case when the option is near the money, ie when its level of gearing approaches 100%. Taking two test values, of 5% and 10%, for the volatility of the bank's assets, the BSM model gives the following valuation:

Volatility	5%	10%
Firm asset value (£bn)	113.20	113.20
Liability value (£bn)	110.70	110.70
Risk free rate	0.035	0.035
Time to exercise (days)	100	100
d1	1.16474	0.60609
d2	1.13312	0.54284
N(d1)	0.87794	0.72777
N(d2)	0.87142	0.70638
Equity value (£bn)	4.26	5.27
Share price (£)	8.59	10.64

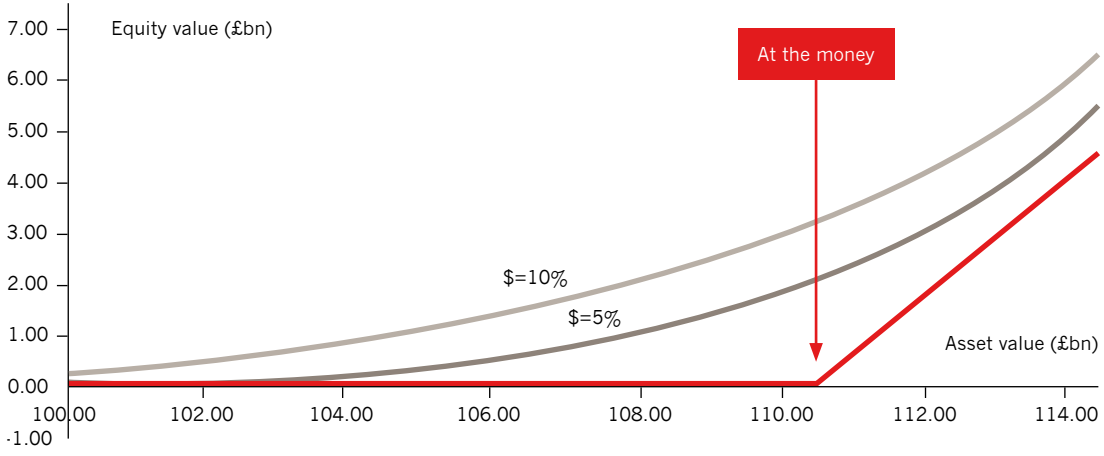
WHEN A COMPANY IS NEAR THE MONEY, IE WHEN ITS LEVEL OF GEARING APPROACHES 100%, THE EQUITY INVESTORS WILL BECOME MORE AND MORE RISK AGGRESSIVE. SIMPLE AGENCY ARGUMENTS SUGGEST THAT THEY WILL INCENTIVISE MANAGEMENT TO TAKE RISK RATHER THAN REDUCE IT.

In fact, the share price of the bank in March 2007 was around £9.50 per share (based on 495.6m shares in issue). Now let us see what happens to the valuation if the asset value falls to £110.7bn. On the balance sheet the value of the firm's equity should be zero. However, the BSM model gives a quite different result. At a volatility of 5%, the equity is still worth £2.29bn or £4.62 per share – almost exactly its value in September 2007. At this point the information coming from the company suggested that its assets had shrunk in value as the bank's mortgage book was written down in line with falling house prices and potential defaults. In **Figure 2** below we can see how the value of the bank's equity is predicted to change with changing asset value.

It was only when the threat of nationalisation became a live issue in the last months of 2007 that the equity value started to collapse, and this again is easily explained within the BSM framework. Nationalisation has the effect of eliminating the chance of asset recovery for the shareholders, effectively depriving them of the time value of their call option on the underlying assets of the business.

So what is the rationale for this rather odd result – that the equity of a business can still have substantial positive value even though the balance sheet shows a nil balance on a fair value basis? The answer is that the presence of limited liability protects the investors from loss, and indeed they have everything to gain if the asset values should recover. This leads us to another inescapable conclusion: when a company is near the money, ie when its level of gearing approaches 100%, the equity investors will become more and more risk aggressive. Simple agency arguments suggest that they will incentivise management to take risk rather than reduce it – and hence the very high levels of rewards paid to bank staff and particularly to those in the risk-taking part of the business.

FIGURE 2: EQUITY VALUE VERSUS ASSET VALUE (NORTHERN ROCK PLC, MARCH 2007)



CONCLUSION

The insights of the work of Black, Scholes and Merton provide us with a framework for the valuation of companies that are financed, in part, by borrowing. Where shareholders are protected by limited liability, the shareholders have a call option on the underlying assets of the business. Using the BSM model, we can estimate the value of a firm's equity on the basis of the value of its assets and their volatility. For companies that are deep in the money then their time value will be small and the intrinsic value of the business (ie the present value of its assets less its liabilities) will dominate the value of its equity. In this situation, normal risk aversion is expected to apply as the intrinsic value will be equally exposed to both positive and negative movements in the values of the firm's assets.

The situation changes dramatically when we have companies that are near the money. This can occur with high growth start-ups financed by debt, leveraged buyouts, and indeed companies that are moving the other way and are in risk of default.

WHERE SHAREHOLDERS ARE PROTECTED BY LIMITED LIABILITY, THE SHAREHOLDERS HAVE A CALL OPTION ON THE UNDERLYING ASSETS OF THE BUSINESS. USING THE BSM MODEL, WE CAN ESTIMATE THE VALUE OF A FIRM'S EQUITY ON THE BASIS OF THE VALUE OF ITS ASSETS AND THEIR VOLATILITY.

However, one class of company – banks – always operate near the money. In valuing such businesses, time value will be more important than intrinsic value in setting the value of the firm's equity. We also learn that when time value dominates investors become risk aggressive, as the more risk that is taken on by management the greater the value of their equity. As a result a bank will incentivise its management to take risk, and will also reward management who can push the bank closer and closer to the money by expanding its assets and liabilities without increasing its capital.

REFERENCES

1 Black and Scholes first published their famous model in 1971. However, Robert Merton was a key member of the research team, and it is now becoming accepted that the model was their combined work.

Professor Bob Ryan is examiner for Paper P4