Technical Factsheet 169

Valuing options

CONTENTS

1. INTRODUCTION

1.1 This Fact Sheet firstly aims to provide the practitioner with guidance on simple tax based option schemes such as Enterprise Management Initiative ("EMI") schemes and the like. It does not however provide advice with regard to the rules of such schemes, but concentrates solely on the valuation aspects.

1.2 The Factsheet then goes on to look at the Black Scholes Option Pricing Model ("BSOPM") and its application, before going on to provide an overview of more complex models such as barrier options, binomial and trinomial approaches. Finally the Factsheet looks at other types of valuation that can be considered to be of the nature of options such as chose in action, new intellectual property and the like.

1.3 This is one of a series of technical factsheets numbered 167 to 171 looking at various valuation issues.

1.4 For matters to consider when reporting on valuations refer to technical factsheet 170 section 7.

2. SIMPLE TAX BASED OPTIONS

2.1 The valuation methodologies described under this heading will include revenue approved schemes such as Save as You Earn option schemes, Approved Company Share Option Plans, Share Incentive Plans and Enterprise Management Incentive Scheme options.

2.2 In all of the above types of share scheme, where options over shares in non-quoted companies are granted the options are usually treated for valuation purposes as being of equivalent value to a small un-influential minority interest in the shares of the subject company and are valued as such. The BSOPM is not commonly used in such scenarios. This is because in valuing options over shares in private companies many of the inputs that are necessary in such models (such as current share price, volatility and the like) are not ascertainable with any degree of accuracy.

2.3 The valuation of options in private companies for UK tax purposes will therefore usually proceed along the same lines as a valuation of the company shares. Please see Factsheets 167 and 168 for further information on the valuation of interests in small private companies.

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2.4 Frequently, however, the valuation will be on the basis of a Price Earnings ("P/E") ratio derived from the market and applied to the earnings of the company. This P/E ratio can be used to value the entirety of the company and then this value is discounted to reflect the disadvantages of owning small minority interests in private companies.

2.5 An example showing the valuation of a simple tax option is given below.

Simple Tax Based Example
A small manufacturing company – established for many years and with stable financial performance - has an issued share capital of 10,000 £1 Ordinary shares and wishes to issue options over a further 5% of the company shares. Normalised post tax profits are £200,000 and net assets total £500,000. No dividends have been paid historically nor are any intended in the foreseeable future. A suitably adjusted Price Earnings ("P/E") ratio derived from the market (see Factsheet 167) is 5.

The company valuation is therefore £1million (£200,000*5= £1million). The net asset value is not of relevance as the earnings basis gives a higher value (see Factsheet 167). The value per share is therefore £100, but this is then adjusted to reflect the diluting effect of the options to be granted, effectively increasing the issued share capital plus options to 10,500 and reducing the value per share to £95.23.

A significant discount is then applied to reflect the locked in nature of the investment, the lack of any control and the lack of any likely ongoing dividend income (say 70% - see Factsheet 167) to give a value for the options of **£28.57 per share**.

3. BLACK SCHOLES OPTION PRICING MODEL

3.1 In 1973 Fischer Black and Myron Scholes, two American economists, published a paper entitled "The Pricing of Options and Corporate Liabilities" in *The Journal of Political Economy*. This paper contained an analytical model now known as the BSOPM used commonly to value derivatives including options, financial assets and the like. This model has been much extended and has proved the basis to most other formulas for pricing exotic option models.

3.2 The model was designed to derive the price of a European call option on non-dividend paying stock, although it was later expanded by Merton to include the receipt of an annual dividend yield.

3.3 The mathematics behind the model is extremely complex. Those interested in such matters can look at a number of sites on the worldwide web giving further detail, such as that provided at www.global-derivatives.com.

3.4 Whilst the model may be mathematically difficult, there are in fact only six basic assumptions. These are:

a. No dividends are paid out on the stock during the option life.
b. The option can only be exercised at expiry (a European option).
c. Markets are efficient and market movements cannot be predicted.
d. There are no commissions.
e. Interest rates do not change over the life of the option.
f. The stock returns will follow a log-normal distribution.

Log-normal distribution means a statistical distribution of random variables which have a normally distributed logarithm. Log-normal distributions can model a random variable (x) where log(x) is normally distributed.

3.5 Assuming the non-payment of dividends, the basic inputs to the BSOPM to price European options are only five in number, as follows:

a. The stock price.
b. The strike price.
c. The risk-free rate.
d. The volatility.

e. The time to maturity.

3.6 Each of these inputs is briefly addressed in the following paragraphs. In addition, if a dividend is likely to be paid then this will be a further factor that can be entered into the model.

3.7 The **stock price** in the valuation of an option over quoted stock is simply taken from the stock market price on the day of valuation. For a non-quoted company however it will be necessary to either derive a value via a hypothetical valuation exercise, or take the value from an event such as a sale or other transfer of the stock or the sale or transfer of the entire business.

3.8 The **strike price** is usual a given in the option agreement and requires no further adjustment.

3.9 The **risk-free rate** of interest is the return on an investment with such low risk that the risk is considered not to exist and is usually taken by reference to the time to maturity of the option.. Interest rate swap rates are often used as the risk-free rate (these can be obtained from sources such as www.ft.com/marketsdata, a web site which will provide to two decimal places the rates for interest rate swaps in periods ranging from a single year up to ten years, and then twelve year, fifteen year, twenty year, twenty-five year and thirty year rates in Euros, Sterling, Swiss Francs, US Dollars and Yen). Other possibilities are bank base rates and the like.

3.10 In practice because of the way in which the BSOPM works, the risk free rate has only a small effect on value.

3.11 **Volatility** is also straightforward when valuing options in quoted companies. The volatility is provided pre-calculated on a number of websites, including Thomson, Bloomberg and Yahoo Finance. For non-quoted companies however the position is more difficult. As no active market exists, volatility cannot be calculated specifically for stock in the target company. Instead, a proxy figure for volatility must be arrived at using, for example, the average volatility for a basket of say four or five quoted companies with similar activities, or using the average volatility for companies in the same sector provided by sources such as the London Business School Risk Measurement Service.

3.12 The **time to maturity** is non-contentious, and will be found within the option documentation.

3.13 A typical example of the use of the BSOPM in valuing options in a non-quoted company is given below.

BSOPM Example

A small trading company has recently raised capital via a share issue at £2 per share. It operates in the Business Support Services sub sector of the broader Support Services sector and wished to grant options to employees that vest in 7 years and that have a strike price of £2.50. The company does not pay any dividends. Research shows that the average volatility for a small basket of quoted comparator companies is 56%, in line with the average of volatility in the sector. Interest rate swaps for 7 years are currently showing 2.7%.

The BSOPM inputs are therefore as follows:

a. Stock price - £2.00.
b. Strike price - £2.50.
c. Risk-free rate – 2.7%.
d. Volatility – 56%.
e. Time to maturity – 7years.

The model and calculation is therefore (using the free online model provided by global derivatives.com):

The Simple Black-Scholes European Option Pricing Sheet
No Dividends

Inputs		Outputs	
Start Date	01-Jun-10	Option	Price
Maturity Date	01-Jun-17	Call Option	1.0669
Days Remaining	2556 days	Put Option	1.1362
Risk Free Rate	2.70%		
Stock Volatility	56.00%		
Current Price	2.0000		
Exercise Price	2.5000		

Calculations		Greeks	Call	Put
Time to Maturity	7.003 yrs	Delta	0.7636	(0.2364)
d_1	0.7180	Gamma	0.1040	0.1040
d_2	(0.7639)	Theta	(0.0777)	(0.0218)
Normalised d_1	0.7636106	Vega	4.3179	4.3179
Normalised d_2	0.2224498	Rho	3.2235	(11.2674)
Normalised $-d_1$	0.2363894			
Normalised $-d_2$	0.7775502			
$N'(d_1)$	0.3083021 coefficient			

http://www.global-derivatives.com
By: Kevin Cheng (Apr 28, 2003)

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The value of the call options is therefore ***£1.07.***

The Black Scholes option pricing Model Formula is as follows and further information on this can be found at http://www2.accaglobal.com/students/student_accountant/archive/2002/26/456433
Call price for a European Option =
Ps N(d1) - Xe -rT N(d2)

d1 = ln (Ps/X) + rT + 0.5 sÖ T
sÖ T

d2 = d1 - sÖ T

4. MORE COMPLEX MODELS

4.1 Under this heading we look briefly at more complex valuation models and their application; including barrier options, binomial and trinomial approaches.

4.2 Barrier options come in many differing types. They all however have as one of their key characteristics the fact that the option is either initiated or exterminated upon a particular event coming to pass.

4.3 One of the more common applications of a barrier option would be where an employee receives the right to shares in a company but only on the achievement of a particular performance target, such as earnings or turnover level. If that level is not achieved within the timeframe then the option lapses.

4.4 Much of the ground-breaking work on the mathematics was undertaken by Reiner and Rubinstein in their 1991 paper "Breaking down the Barriers" and their 1992 working paper "Exotic Options".

4.5 As with the BSOPM the mathematics of barrier options is extremely complex, but the practical application is very similar, and various models can be found on the web which can be accessed free of charge (e.g. from the following address) www.global-derivatives.com.

4.6 Barrier options are, like the BSOPM, best suited to the valuation of options within a quoted entity, as many of the inputs become subjective when applied to non-quoted companies.

4.7 It is also possible to value options via binomial and trinomial approaches. Both of these approaches are via lattice trees The original concept of the Binomial model for pricing stock options was introduced by Cox, Ross and Rubinstein in 1979. Whilst further discussion of these methodologies is outside the scope of this Factsheet, further information is available on the web from sites such as that provided by Global Derivatives and mentioned above.

In a lattice tree each node in the lattice represents a possible price of the underlying instrument at a given point in time. Further details on the Binomial Options Pricing Model can be found at the following address: http://en.wikipedia.org/wiki/Binomial_options_pricing_model

5. OTHER OPTION TYPE VALUATIONS

5.1 Frequently option-based approaches are used in the valuation of difficult issues such as new technology and intellectual property rights (IPRs) and in circumstances such as that of a chose in action. Whilst the use of option modelling in the valuation of early stage technology and other IPRs is beyond the scope of this Factsheet, we discuss below the application of valuation methodology most commonly met with regard to chose in action.

5.2 Perhaps the most common valuation scenario regarding a chose in action will be by reference to unascertainable deferred consideration, where future deferred consideration is dependent upon an event taking place (such as a level of earnings or turnover) which cannot be definitely ascertained at the date of valuation.

5.3 In these circumstances the valuer must calculate the maximum amount that is capable of being paid under the chose in action and then discount this amount for the risk that the event necessary to trigger the payment (often a particular level of turnover or earnings) will simply not be achieved, and the time value of money over the period in which the consideration is to be paid. Much will depend upon the quality of the forecasts going forward, and these will need to be looked at critically in the light of historic performance and the levels of investment necessary in things such as new premises, plant machinery and workforce.

5.4 Needless to say, exercises of this nature are of necessity extremely subjective and much will depend on the exact circumstances of each individual case. A simple example showing the most usual approach is given below.

Chose in Action Example
A company is sold for cash consideration of £4million, £1million of which is contingent on the achievement of set EBITDA (earnings before interest, taxation, depreciation and amortisation) margins in each of the next 3 years; a hurdle EBITDA margin of 20% in year 1 will pay £300,000, a hurdle of 30% EBITDA margin in year 2 will pay £300,000 and a hurdle of 40% EBITDA margin in year 3 will pay £400,000.

The business has historically made an EBITDA margin of between 15% and 25%, with the last year being 17%. Forecasts show the margins being achieved in all of the years, but there does not appear to be any material capital expenditure to support the growth, nor is there any detailed explanation as to how exactly the growth is to be achieved. The time value of money is estimated at 5% per annum.

The valuation approach might be as follows:

	Year 1	**Year 2**	**Year 3**
	£'000	**£'000**	**£'000**
Maximum Realisable	300	300	400
Estimated risk of failure	10%	50%	75%
Likely realisable	270	150	100
Less time value of money	(14)	(15)	(14)
Value of Contingency	**256**	**135**	**86**

Estimated risk of failure means the estimated chance that £nil will be realised.

The total value of the contingency payments can therefore be estimated as at the date of grant at **£477,000**, a discount of some 52.3% from the full value of £1million.

Technical Factsheet 169
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