CHAPTER 4

APPLICATION OF OPTION PRICING THEORY TO INVESTMENT DECISIONS

LIMITATIONS OF TRADITIONAL DCF ANALYSIS

- Some investments have an added attraction because they offer **real options/strategic flexibility**, the value of which is ignored in traditional DCF analysis – this can lead to potentially lucrative investments being rejected.

- Real options can be **valued using** the Black–Scholes option valuation model (**BSOP**).

- The value of an option can then be added to the traditional NPV to give a revised and (arguably) more accurate assessment of the value created by a project.

TYPES OF REAL OPTIONS

Option to expand

If successful, other projects will follow (eg due to brand name or technology)

Option to delay

Could mean that valuable new business information is available

Option to redeploy

Assets can easily be switched from one project to another

Option to withdraw

Easy to sell assets if the project fails, or low clear-up costs

COMPONENTS OF OPTION VALUE

An option gives the holder the right (but not the obligation) to buy or sell an asset at a pre-agreed price; there are two main types of option.

1. **Call option - Right to buy -** (money is spent)
2. **Put option - Right to sell -** (money is received)

INTRODUCTION TO THE DETERMINANTS OF OPTION VALUATION

- There are two main components to the value of an option, **intrinsic value** and **time value.**

ILLUSTRATION 1

- Consider a **call option** giving the holder the right to buy a share for $4 in three years' time; the share price today is $5. In recent years the share price has been highly variable. Interest rates are currently high.
- **Intrinsic value** is the difference between the **current** value of the asset and the exercise price of the option.
- In this example the intrinsic value is the difference between the current share price of $5 and the exercise price of $4; so the intrinsic value is $1. This is also referred to as the option being 'in-the-money'.
- However, this option will be worth more than the intrinsic value because it will have a **time value**.
- **Time value** reflects the possibility of an increase in intrinsic value between now and the expiry of the option; it is influenced by the variability in the value of the asset, the time until the option expires and interest rates.

RELEVANT FACTORS

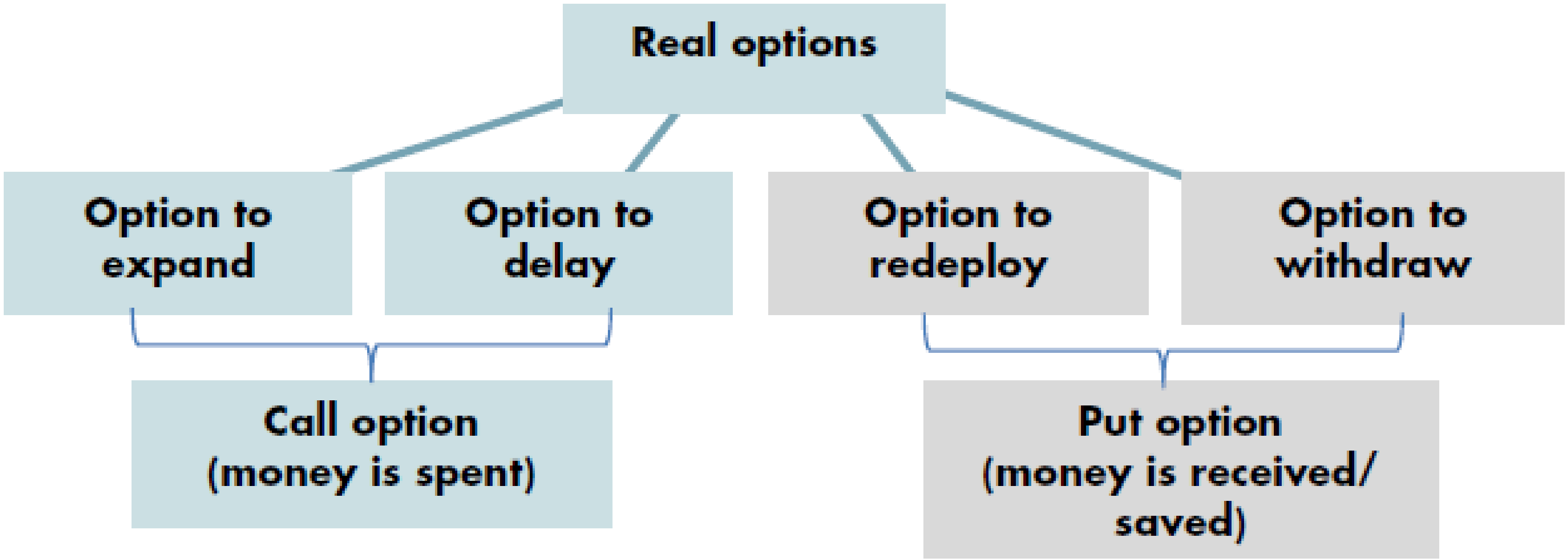
In the case of the call option, relevant factors are:

- (a) Variability **adds to the value** of an option: this is because if the share price rises this will result in a gain for the option holder but if the share price falls below the exercise price of $4 the option holder does not make losses (because the option does not have to exercised).

- (b) Time until expiry of the option is three years, this gives considerable scope for variability as above. If this was longer the option would be **more valuable** because there would greater potential for variability.

- (c) Interest rates; if interest rates are high then it will be less attractive to buy the share itself (because funds are earning an attractive rate of interest), so demand for options will be higher. So the higher interest rates are then the higher the value of a call option.

BLACK–SCHOLES OPTION PRICING MODEL (BSOP)



CALL OPTIONS

Formula provided

Value of a **call option** at time 0

$$C_0 = P_a N(d_1) - P_e N(d_2) e^{-rt}$$

$N(d_x)$ is the cumulative value from the **normal distribution tables** for the value d_x

$$d_1 = \frac{\ln(P_a / P_e) + (r + 0.5s^2)t}{s\sqrt{t}}$$

$$d_2 = d_1 - s\sqrt{T}$$

P_a	=	PV of the cash inflows	P_e	=	Cost of the investment
r	=	Risk-free rate of return	t	=	Time to expiry of option in years
s	=	Standard deviation of the project			

D1 & D2

- N(**d1**) is the factor by which the discounted expected value of future receipt of the stock exceeds the current value of the stock.

$$d_1 = \frac{\ln(P_a / P_e) + (r + 0.5s^2)t}{s\sqrt{t}}$$

- **N(d2)** is a statistical measure (normal distribution) corresponding to the probability that the call option will be exercised at expiration.

$$d_2 = d_1 - s\sqrt{T}$$

IMPORTANT POINTS TO NOTE

- Pa is shown in present value terms but Pe is **not discounted back to a present value** (this is because in the first formula shown it is multiplied to e–rt which is a form of discount factor)
- r is the **risk-free rate not the cost of capital** of the company
- t is the **time to expiry of the option, not of the project**
- **s is standard deviation,** you may have to **calculate this as the square root of the variance**

VALUING A CALL OPTION

- Project 1 has an NPV of –$10,000; it will **also** develop expertise so that Entraq would be ready to penetrate the European market with an improved product in four years' time. The expected cost at time 4 of the investment is $600,000.

- Currently the European project is valued at 0 NPV but management believe that economic conditions in four years' time may change and the NPV could be positive. The standard deviation is 30%, the risk-free rate is 4% and the cost of capital is 10%.

FORMULA

$$C_0 = P_a N(d_1) - P_e N(d_2) e^{-rt}$$

1 **Initial variables**

P_a =	$600,000 discounted back to time 0 at 10% = $409,800.	r=	0.04 (risk free rate)
P_e =	$600,000	t =	4 (expiry of option)
		e^{-rT} =	$e^{-(0.04 \times 4)}$ = 0.852

Note. That if P_a had been given in present value terms then you would not have discounted this value.

2 **Calculation of d_1 and d_2, starting with d_1.**

$\ln(P_a/P_e) =$	ln (409,800/600,000) = –0.381	$(r+0.5s^2)t =$	$(0.04 + 0.5 + 0.3^2) \times 4 = 0.340$
s =	0.30	$s\sqrt{t}$ =	$0.3 \times 2 = 0.6$
$d_1 =$	$\frac{-0.381+0.34}{0.6} = -0.07$		

$d_2 =$ $-0.07 - 0.3 \times 2 = -0.67$

$N(d_1) = 0.5 - 0.0279 = 0.4721$

$N(d_2) = 0.5 - 0.2486 = 0.2514$

Co= $(409,800 \times 0.4721) - (600,000 \times 0.2514 \times 0.852) = \$193,467 - \$128,516 =$ **$64,951**

- **Project A now becomes a +NPV project ($64,951 – $10,000 = $54,951)**

- We can now see the value of the real options approach. Here a project originally showed a negative NPV of $10,000 and would therefore be rejected. However, by valuing a real option associated with the project we can see that the project now has a positive NPV and can therefore be justified.

PUT OPTIONS

Formula provided

$$P = C - P_a + P_e e^{-rt}$$

C = value of a call option   P = value of a put option

OPTION TO WITHDRAW

- An option to withdraw involves receiving money, so it is a put option.
- In the option pricing formula, the value of Pa is the present value of the estimated net cash inflows
- from the project **AFTER the exercise of the option to withdraw**.

LIMITATIONS OF THE BLACK–SCHOLES MODEL

- The most significant limitation of the Black–Scholes model is the **estimation of the standard deviation** of the asset. Historical deviation is often a poor guide to expected deviation in the future, so in reality the standard deviation is based on judgement.

- The formulae also **assume that the options are 'European'**, ie exercisable on a fixed date.

- An alternative model (the binomial model) can be used to value 'American' style options which are exercisable over a range of dates; this model is beyond the scope of this syllabus. If using the BSOP model to value an American style option in the exam then you should note that the BSOP model will **undervalue American style options** because it does not take into account this time flexibility (this is the case in the preceding activity).

ASSUMPTIONS

1. There are no dividends paid during the life of the option.
2. The option can only be exercised at maturity.
3. The markets operate under a Markov process in continuous time.
4. No commissions are paid.
5. The risk-free interest rate is known and constant.
6. Returns on the underlying stocks are lognormally distributed.