Question 01

(a) **Appraisal of alternative 2**

Exchange rates

The future dollar/pound exchange rates for years 1 to 3 can be predicted using the purchasing power parity formula.

Future exchange rate \$/£ = current exchange rate \$/£ × [(1 + US inflation rate)/(1 + UK inflation rate)] ^{n} where n is the number of years in the future.

Thus, future exchange rate \$/£ = 1.600 × [1.04/1.03] ^{n}

Year	*0*	*1*	*2*	*3*
Exchange rate forecast US\$ / £	1.600	1.616	1.631	1.647

Net present value

Year	*0*	*1*	*2*	*3*
US\$m real cash flows	(25.00)	2.60	3.80	4.10
US\$m nominal cash flows (inflation 4% p.a.)	(25.00)	2.70	4.11	4.61
Exchange rate	1.600	1.616	1.631	1.647
US nominal cash flows in £m	(15.63)	1.67	2.52	2.80
£m real cash flows		3.70	4.20	4.60
£m nominal cash flows (inflation 3% p.a.)		3.81	4.46	5.03
Total nominal cash flows in £m	(15.63)	5.48	6.98	7.83
9% discount factors	1	0.917	0.842	0.772
Present value £m	(15.63)	5.03	5.88	6.04
Net present value £m	1.32			

The NPV of the project is **£1.32 million** positive.

Payback

Year	*0*	*1*	*2*	*3*
Total nominal cash flows in £m	(15.63)	5.48	6.98	7.83
Cumulative cash flow £m	(15.63)	(10.15)	(3.17)	4.66

Payback = 2 + (3.17/7.83) = 2.40 years

Discounted payback

Year	*0*	*1*	*2*	*3*
Present value £m	(15.63)	5.03	5.88	6.04
Cumulative present value £m		(10.60)	(4.72)	1.32

Discounted payback = 2 + (4.72/6.04) = 2.78 years

Internal rate of return

The IRR can be found by trial discount rates and interpolation. If the discount rate is 15%, the NPV is £(0.43) million.

Year	*0*	*1*	*2*	*3*
Total nominal cash flows in £m	(15.63)	5.48	6.98	7.83
15% factors	1	0.870	0.756	0.658
PV	(15.63)	4.77	5.28	5.15
NPV	(0.43)			

By interpolation the IRR is 9% + (15% – 9%) × 1.32/(1.32 + 0.43) = **13.5% pa.**

Modified internal rate of return

We can find MIRR using the formula given in the formula sheet.

$$MIRR = \left[\frac{PV_R}{PV_I}\right]^{\frac{1}{n}}(1+r_e)-1$$

Year	*0*	*1*	*2*	*3*
Total nominal cash flows in £m	(15.63)	5.48	6.98	7.83
9% factors	1	0.917	0.842	0.772
PV	(15.63)	5.03	5.88	6.04
NPV	1.32			

PV (return phase – years 1 – 3) = £16.95m

PV (investment phase) = £(15.63)m

MIRR = $(16.95m/15.63m)^{1/3} \times (1 + 0.09) - 1 = 12\%$

(b) **Project duration for Alternative 2**

Present value of cash flows = NPV + initial investment = £1.32m + £15.63m = £16.95m

Year	*1*	*2*	*3*
PV of cash flow	5.03	5.88	6.04
% of total PV	30%	35%	36%
Year × %	1 × 30% = 0.3	2 × 35% = 0.7	3 × 36% = 1.08

Duration = 0.3 + 0.7 + 1.08 = 2.08 years

Significance of results

On average alternative 2 delivers value over 2.08 years. Compared with alternative one this is a good result as alternative 1 takes over one year longer to deliver value. The longer the duration, the more risky the project as there is greater uncertainty attached to future returns.

(c) **Evaluation of the two alternatives**

Summary of the appraisal results

Alternative	*1*	*2*
NPV at 9%	£1.45 m	£1.32 m
IRR	10.5%	13.5%
MIRR	13.2%	12.0%
Duration	3.2 years	2.08 years
Payback	2.6 years	2.40 years
Disc. payback	3.05 years	2.78 years

All other things being equal, the project to be accepted should be the one with the higher NPV, which is Alternative 1. NPV shows the absolute amount by which the project is forecast to **increase shareholders' wealth**, and is theoretically sounder than the IRR and MIRR methods.

In this case the MIRR method backs up the NPV, but the IRR gives the opposite indication. This 'conflict' arises because IRR makes the wrong **assumption** about reinvestment rates (see (ii) above).

The duration of the alternatives shows that alternative 1 is more risky as it takes longer to recover half the present value. This is also backed up by the payback figures showing that Alternative 1 takes longer to recover the original outlay.

Before making a decision, however, there are a number of other important factors that must be taken into consideration.

Alternative 1

- Alternative 1 has a high risk of lowering the firm's reputation for quality and causing confusion among the customer base. The overall effect may be to **lose existing customers** but not to gain many new ones.
- It also removes the **focus** from the business. Marketing a wider range of products may be more difficult than is anticipated and may stretch resources.
- Duration is longer, which might put management off, particularly if they are averse to risk.

Alternative 2

- Alternative 2 represents a fundamental change in the nature of the business from a niche manufacturer to a **value added** distributor.
- The firm may be able to add successfully its **brand reputation for quality** to mass market products, but this will only be possible if the US 'flat packs' are of guaranteed quality and consistency, and the varnishing and assembly work are carried out to a high standard.
- The change in the nature of the firm's work may require **substantial new equipment**.
- This alternative may also result in a **loss of skilled workers**, with the risk of lower quality.
- However, the shorter duration of the project suggests lower financial risk to the firm, which may be a deciding factor if management are struggling to distinguish between the alternatives in other ways.

Given the similarity in the NPVs between the two projects, the decision will almost certainly depend on non-financial factors.

Question 02

(a) **Capital investment plan**

Restrictions:

(i) Project P0801 cannot be scaled down – this project cannot be varied.
(ii) No project can be scaled up.
(iii) Capital budget is $1.2 million.

In capital rationing situations, projects should be ranked according to the profitability index (PI) which is the NPV per $ of invested capital at year zero. Before we can rank the projects, we must calculate the PI for each.

Project	*Initial investment*	*NPV*	*IRR*	*PI*	*Ranking*
	$'000	$'000			
P0801	(620)	55	16%	0.0887	3
P0802	(640)	69	13%	0.1078	2
P0803	(240)	20	15%	0.0833	4
P0804	(1,000)	72	13%	0.072	6
P0805	(120)	19	17%	0.1583	1
P0806	(400)	29	15%	0.0725	5

Now that we have established the order in which investments should be made, we have to determine how many of the projects we can afford, subject to the restrictions above.

Project	*Initial investment*	*NPV*	*IRR*	*PI*	*Cumulative investment*
	$'000	$'000			$'000
P0805	(120)	19	17%	0.1583	(120)
P0802	(640)	69	13%	0.1078	(760)
P0801	(620)	55	16%	0.0887	(1,380)
P0803	(240)	20	15%	0.0833	(1,620)
P0806	(400)	29	15%	0.0725	(2,020)
P0804	(1,000)	72	13%	0.072	(3,020)

The marginal project is P0801. Our problem is that this project cannot be scaled down – it is the supermarket project that cannot be varied. We now have two choices. We can move P0801 above P0802 (which can be scaled down) in the ranking – this would allow us to undertake the supermarket project in its entirety. Alternatively, we could remove P0801 from the problem completely and ignore it. This would move the other projects up the rankings. The choice with the higher overall NPV should be undertaken.

Choice 1 – move P0801 above P0802

Project	*Initial investment*	*NPV*	*Cumulative investment*	*Proportion of project*	*NPV from investment*
	$'000	$'000	$'000		$'000
P0805	(120)	19	(120)	1	19.00
P0801	(620)	55	(740)	1	55.00
P0802	(640)	69	(1,380)	0.71875	49.59
				Total NPV	123.59

Note: the proportion of P0802 that is undertaken is calculated as follows:

Proportion = (Capital budget – cumulative investment to date) / investment required
= ($1,200 – $740) / $640
= 0.71875

Choice 2 – ignore P0801

Project	*Initial investment*	*NPV*	*Cumulative investment*	*Proportion of project*	*NPV from investment*
	$'000	$'000	$'000		$'000
P0805	(120)	19	(120)	1	19.00
P0802	(640)	69	(760)	1	69.00
P0803	(240)	20	(1,000)	1	20.00
P0806	(400)	29	(1,400)	0.5	14.50
				Total NPV	122.50

Choice 1 is preferable as it earns the higher NPV. P0801 should therefore be ranked above P0802 to allow the entire project to go ahead.

NPV per $ invested (PI) = $123.59 / $1,200 = 0.1030

Internal rate of return

IRR must be calculated on the NPV of the full projects – it cannot be calculated on proportions of projects. Therefore we must determine the IRR of the optimum investment plan on the assumption that we can invest in the whole of P0802.

We'll try calculating NPV at 14%.

Project	*Now*	*20X0*	*20X1*	*20X2*	*20X3*	*20X4*	*20X5*
	$'000	$'000	$'000	$'000	$'000	$'000	$'000
P005	(120)	25	55	75	21		
P001	(620)	280	400	120			
P002	(640)	80	120	200	210	420	(30)
Total cash flow	(1,380)	385	575	395	231	420	(30)
Discount factor	1.000	0.877	0.769	0.675	0.592	0.519	0.456
DCF	(1,380)	337.65	442.18	266.63	136.75	217.98	(13.68)

NPV = 7.51

We'll now try calculating NPV at 17% using the same method as above.
NPV = (80.84)
Using interpolation we can now estimate the IRR of the optimum investment plan.

$$IRR = a + \left(\left(\frac{NPV_a}{NPV_a - NPV_b}\right)(b - a)\right)\%$$

where a = the lower of the two rates of return used
b = the higher of the two rates of return used
NPV_a = the NPV obtained using rate a
NPV_b = the NPV obtained using rate b

IRR = 14 + [7.51 / (7.51 + 80.84)] × (17 – 14) = 14.26%

b) **Maximum rate for additional financing**

We cannot use the IRR here as this is the rate that results in NPV = 0 for investment over the life of the projects themselves, ie it tells us the maximum additional cost over the life over the life of the project. Here we wil only need additional finance for a year.

We can again make use of the profitability index, based on the NPVs of the rejected projects (including the proportion of P0802 that had to be foregone).

Project	*Now*	*20X0*	*20X1*	*20X2*	*20X3*	*20X4*	*20X5*
	$'000	$'000	$'000	$'000	$'000	$'000	$'000
P0802 (balance)	(180)	22.50	33.75	56.25	59.06	118.04	(8.44)
P0803	(240)	120.00	120.00	60.00	10.00		
P0806	(400)	245.00	250.00				
P0804	(1,000)	300.00	500.00	250.00	290.00		
Cash flow of rejected projects	(1,820)	687.50	903.75	366.25	359.06	118.04	(8.44)
Discount factor 10%	1.000	0.909	0.826	0.751	0.683	0.621	0.564
DCF	(1,820)	623.94	746.50	275.05	245.24	73.30	(4.76)

NPV of 'rejected' projects = 139.27
PI = 139.27 / 1,820 = 0.07652

Current cost of capital = 10%
Maximum cost of capital acceptable for the additional finance required = 10% + 7.652% = 17.652%

(c) The option to delay project PO804 will have no effect on the answer to part (a) as the project would not have been undertaken as it had the lowest profitability index. It could now be undertaken in the second year when capital is not restricted, although the net present value would be lower than $72,000, as all associated cash flows would be delayed by one year.

PO802 can now be delayed until the second year, which would allow the whole of project PO803 to be undertaken as well as (220/400 = 55%) of Project PO806. Again the NPV from project PO802 will be lower than $69,000 as all cashflows are delayed, but Slow Fashions Co is highly likely to generate additional overall shareholder wealth from undertaking the two extra projects. Detailed calculations would need to be performed to support this analysis.

Question 03

(a) The first thing to do in this question is to determine how to correct the errors of principle.

(1) Interest should not be included as this is already accounted for in the discount rate. The annual interest charge of $4 million (less tax of 30%) should be added back to the cash flow in each year.

(2) Depreciation is **not** a cash flow and should be ignored in NPV calculations. The annual charge of $4 million (less tax at 30%) should be added back to the cash flow in each year.

(3) Indirect allocated costs are not relevant. These should be added back to the annual cash flows (net of tax). Corporate infrastructure costs are relevant to the project and should have been included. These costs should be deducted from annual cash flow figures (net of tax), as should the estimates for site clearance.

(4) Capital allowances in year 6 should be accounted for.

Corrected project evaluation

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*
	$m	$m	$m	$m	$m	$m	$m
Project post-tax cash flow	(127.50)	(36.88)	44.00	68.00	60.00	35.00	20.00
Add: net interest			2.80	2.80	2.80	2.80	2.80
Add: depreciation net of tax			2.80	2.80	2.80	2.80	2.80
Add: indirect costs			5.60	5.60	5.60	5.60	5.60
Add: capital allowances (W1)							3.68
Less: site clearance costs							(3.50)
Less: infrastructure costs			(2.80)	(2.80)	(2.80)	(2.80)	(2.80)
Revised cash flows	(127.50)	(36.88)	52.40	76.40	68.40	43.40	28.58
Discount factor 10%	1.000	0.909	0.826	0.751	0.683	0.621	0.564
DCF	(127.50)	(33.52)	43.28	57.38	46.71	26.95	16.12

NPV = $29.42m

Working 1 (W1) – Calculation of unclaimed capital allowances

		Tax benefit at 30%
	$m	$m
Year 0: Capital investment	150.00	
First year allowance (50%)	(75.00)	
Tax written down value	75.00	
Year 1: New investment	50.00	
First year allowance on new investment	(25.00)	
WDA on year 0 investment (25%)	(18.75)	
Tax written down value	81.25	
Year 2: WDA	(20.31)	
Tax written down value	60.94	
Year 3: WDA	(15.24)	
Tax written down value	45.70	
Year 4: WDA	(11.43)	
Tax written down value	34.27	
Year 5: WDA	(8.57)	
Tax written down value	25.70	
Year 6: WDA	6.43	
Tax written down value	19.27	
Proceeds from sale	7.00	
Balancing allowance	12.27	3.68

Sensitivity analysis of project to a $1m increase in initial capital expenditure

Extra capital expenditure will affect not only the cash outflow of the project but also the capital allowances.

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*
	$m	$m	$m	$m	$m	$m	$m
Purchase cost/Tax WDV	(1.0)	0.5	0.37	0.28	0.21	0.16	0.12
FYA (50%)	(0.5)						
WDA (25%)		(0.13)	(0.09)	(0.07)	(0.05)	(0.04)	(0.03)
Balance	0.5	0.37	0.28	0.21	0.16	0.12	0.09
Impact on cap ex	(1.0)						
Tax saved on capital allowances	0.15	0.039	0.027	0.021	0.015	0.012	0.009
Unrecovered allowance at year 6							0.027
Impact on cash flow	(0.85)	0.039	0.027	0.021	0.015	0.012	0.036
DCF at 10%	(0.85)	0.0355	0.0223	0.0158	0.0102	0.0075	0.0203

Net impact on NPV = $(0.738)m

This means that every additional $1m spent on capital equipment will only cost the project $0.738m due to tax savings resulting from capital allowances.

(b) **Discounted payback and duration**

Discounted payback is used to determine how long it will take the project to repay its original investment. As the name suggests this method uses discounted cash flows in the calculations.

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*
	$m	$m	$m	$m	$m	$m	$m
Discounted cash flow	(127.50)	(33.52)	43.28	57.38	46.71	26.95	16.12
Cumulative DCF	(127.50)	(161.02)	(117.74)	(60.36)	(13.65)	13.30	29.42

The discounted payback period is approximately 4.5 years.

Project duration is the average time it takes the project to deliver its value. It is calculated by weighting each year of the project by the percentage of the present value recovered in that year.

Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*
	$m	$m	$m	$m	$m	$m	$m
Discounted cash flow			43.28	57.38	46.71	26.95	16.12
PV of return phase	190.44						
Proportion of PV			0.2273	0.3013	0.2453	0.1415	0.0846
Weighted years			0.4546	0.9039	0.9812	0.7075	0.5076

Duration = sum of weighted years = 3.55 years

Discounted payback overcomes one of the problems of the ordinary payback technique – that is, it uses discounted cash flows rather than ignoring the time value of money. However the problem with payback (discounted or not) is that it **ignores** cash flows that occur beyond the payback period. Thus projects that have very high initial cash flows but few (if any) in later years may be favoured over those projects that might add greater value to the firm but over a longer period.

The advantage of **duration** is that it considers the cash flows over the **entire life** of the project. It measures how long it will be before the project recovers the bulk of its present value. However it can be more **difficult to understand** the concept behind duration and for this reason it may not be widely used.

(c) **Recommendation on capital investment project**

The current project under review has a net present value (NPV) of **$29.42m** which means that the value of the business will be increased by this amount if the project is undertaken. It has also been found that for every additional $1m spent on capital equipment for this project, the project's NPV will be reduced by $0.738m (due to tax savings made on the capital allowances available on capital expenditure). However given the size of the NPV it is expected that any variations in capital expenditure should not significantly affect the value added to the firm.

By using **discounted payback**, it has been found that the project will wholly recover its investment within 4.5 years. As the majority of the cash flows occur in the earlier years of the project's life, there is an average recovery of total present value of 3.55 years.

On the basis of the above analysis, it is recommended that the Board **approves** this project for commencement.

Investment appraisal techniques

Payback is a technique that has been employed in the appraisal of this project. However, although the discounted version of payback reflects the cost of finance in the results, there is still the problem that it ignores any cash flows that occur after the payback period has been reached. This may result in vital information being missed, such as very few or no cash flows beyond the payback point. **Duration** removes this problem as it focuses on all cash flows of the project, regardless of when they occur. It is a measure of the average time taken for a project to deliver its value. It is a superior technique to payback and its implementation should be considered for future investment appraisal exercises.

Whilst sensitivity analysis is highly useful, there is the problem of **high degrees of correlation** between variables. There is a risk that concentrating too much on one variable will be at the expense of other variables whose movements may be more critical to the project's profitability. The use of **simulation** would help to alleviate this problem. This technique generates thousands of values for the variables of interest and uses those variables to derive the NPV for each possible simulated outcome. The priority of each individual variable in the determination of the overall NPV can then be established.

It is therefore recommended that simulation is incorporated into the investment appraisal in future.

Question 04

(a) **All figures are in $ million – corrections are numbered**

Year	*0*	*1*	*2*	*3*	*4*
(error 1) Sales revenue (inflated, 8% p.a.)		24.87	42.69	61.81	36.92
(error 1) Costs (inflated, 4% p.a.)		(14.37)	(23.75)	(33.12)	(19.05)
Incremental profit		10.50	18.94	28.69	17.87
(error 2) Interest (not relevant)		n/a	n/a	n/a	n/a
(error 3) Tax (W1)		(0.50)	(3.39)	(5.44)	(3.47)
(error 4) Working capital (W2)	(4.97)	(3.57)	(3.82)	4.98	7.38
Investment/sale of machinery	(38.00)				4.00
Cash flows	(42.97)	6.43	11.73	28.23	25.78
(error 5) Discount factors (12%, W3)	1	0.893	0.797	0.712	0.636
Present values	(42.97)	5.74	9.35	20.10	16.40

Base case net present value is approximately $8.62 million.

W1 **All figures are in $ million**

Year	*0*	*1*	*2*	*3*	*4*
Incremental profit		10.50	18.94	28.69	17.87
Capital allowances		8.00	2.00	1.50	0.50
Taxable profit		2.50	16.94	27.19	17.37
Tax (20%)		0.50	3.39	5.44	3.47

W2 **All figures are in $ million**

Year	*0*	*1*	*2*	*3*	*4*
Working capital (20% of sales revenue)		4.97	8.54	12.36	7.38
Working capital required/(released)	4.97	3.57	3.82	(4.98)	(7.38)

W3 $$\beta a = \left(\frac{Ve}{(Ve + Vd\,(1-t))}\right)\beta e + \left(\frac{Vd\,(1-t)}{(Ve + Vd\,(1-t))}\right)\beta d$$

Assuming the beta of debt = 0, Lintu Co's asset beta =

[$128m/($128m + $31.96m × 0.8] × 1.5 approx. = 1.25

Using the CAPM $E(ri) = R_f + \beta\,(E(R_m - R_f))$

So the all-equity financed discount rate = 2% + 1.25 × 8% = 12%

(error 6) Financing side effects

	$'000
Issue costs 2/98 × $42.97m	(876.94)
Tax shield	
Annual tax relief =	
On the subsidised loan = $42.97m × 60% × 0.015 × 20% = $77,346	
On the rest of the loan = $42.97m × 40% × 0.04 × 20% = $137,504	
Total = 77,346 + 137,504 = $214,850m p.a. for 4 years	
This is discounted at the normal cost of debt which is 1.5% above the risk free rate of 2.5% ie = 4%.	
The present value of the tax relief annuity = 214.85 × 3.63	779.91
Annual subsidy benefit	
$42.97m × 60% × 0.025 × 80% = 515.64 (000s)	
The present value of the subsidy benefit annuity = 515.64 × 3.63	1,871.77
Total benefit of financing side effects	1,774.74

Financing the project entirely by debt would add just under $1.78 million to the value of the project, or approximately, an additional 20% to the all-equity financed project.

The adjusted present value (APV) of the project is just under $10.4 million and therefore it should be accepted.

Note. In calculating the present values of the tax shield and subsidy benefits, instead of the discount factor being based on the normal borrowing/default risk of the company, alternatively, 2% or 2.5% could be used depending on the assumptions made. Credit will be given where these are used to estimate the annuity factor, where the assumption is explained.

(b) **Corrections made to the original net present value (numbers are referenced in the above calculations)**

(1) Cash flows are inflated and the nominal rate based on Lintu Co's all-equity financed rate is used (see below). Where different cash flows are subject to different rates of inflation, applying a real rate to non-inflated amounts would not give an accurate answer because the effect of inflation on profit margins is being ignored.

(2) Interest is not normally included in the net present value calculations. Instead, it is normally imputed within the cost of capital or discount rate. In this case, it is included in the financing side effects.

(3) The approach taken to exclude depreciation from the net present value computation is correct, but capital allowances need to be taken away from profit estimates before tax is calculated, reducing the profits on which tax is payable.

(4) The impact of the working capital requirement is included in the estimate as, although all the working capital is recovered at the end of the project, the flows of working capital are subject to different discount rates when their present values are calculated.

Approach taken (relates to errors 5 & 6)

The value of the project is initially assessed considering only the business risk involved in undertaking the project. The discount rate used is based on Lintu Co's asset beta which measures only the business risk of that company. Since Lintu Co is in the same line of business as the project, it is deemed appropriate to use its discount rate, instead of 11% that Burung Co uses normally.

The impact of debt financing and the subsidy benefit are then considered. In this way, Burung Co can assess the value created from its investment activity and then the additional value created from the manner in which the project is financed.

Assumptions made

It is assumed that all figures used are accurate and any estimates made are reasonable. Burung Co may want to consider undertaking a sensitivity analysis to assess this.

It is assumed that the initial working capital required will form part of the funds borrowed but that the subsequent working capital requirements will be available from the funds generated by the project. The validity of this assumption needs to be assessed since the working capital requirements at the start of years 2 and 3 are substantial.

It is assumed that Lintu Co's asset beta and all-equity financed discount rate represent the business risk of the project. The validity of this assumption also needs to be assessed. For example, Lintu Co's entire business may not be similar to the project, and it may undertake other lines of business. In this case, the asset beta would need to be adjusted so that just the project's business risk is considered.

It is also assumed that there are no adverse side-effects of taking on the extra debt eg a worsening credit rating which could impact Burung's trading position.

(Note. Credit will be given for alternative, relevant explanations.)

Question 05

(a) Conventional investment appraisal techniques such as net present value analysis often do not capture the full strategic benefits of a project either in terms of features of a project that allow risk to be managed or in terms of features that allow further follow-on gains to be made.

For example a situation may exist where a project is easy to abandon, or uses assets that are easy to switch to another use if the project fails. This **abandonment / redeployment option** adds value to a project because it limits the project's downside risk.

With this project Faoilean Co could negotiate a get-out clause which gives it the right to **sell the project back** to the government at a later date at a pre-agreed price. Alternatively, it could build facilities in such a way

that it can **redeploy** them to other activities, or scale the production up or down more easily and at less cost. These options give the company the opportunity to step out of a project at a future date, if uncertainties today become negative outcomes in the future.

Another type of real option is the **option to delay**. A project can be structured to allow a company to react to improved information about the prospects of the project eg by staggering the capital expenditure over a period of time instead of investing in one block at the start of the project.

In the situation which Faoilean Co is considering, the initial **exploration rights** may give it the **option to delay** the decision of whether to undertake the **extraction** of oil and gas to a later date. In that time, using previous knowledge and experience, it can estimate the quantity of oil and gas which is present more accurately. It can also use its knowledge to assess the variability of the likely quantity. Faoilean Co may be able to negotiate a longer time scale with the government of Ireland for undertaking the initial exploration, before it needs to make a final decision on whether and how much to extract.

Finally, some projects may create an **option to expand into other areas** using the benefit of the experience gained during the project. For example, Faoilean Co can explore whether or not applying for the rights to undertake this exploration project could give it priority in terms of future projects, perhaps due to the new knowledge or technologies it builds during the current project. These opportunities would allow it to gain competitive advantage over rivals, which, in turn, could provide it with greater opportunities in the future, but which are uncertain at present.

Faoilean Co can use the Black Scholes option valuation formulae to assess the value of any real options associated with the project. This value can be added to the conventional net present value computation to give a more accurate assessment of the project's value.

The option price formula used with investment decisions is based on the Black-Scholes Option Pricing (BSOP) model. The BSOP model makes a number of assumptions as follows:

- The option is assumed to be exercised at a specific point in time (ie a European option), this may not be true in reality eg an option to redeploy may be exercised at any time.
- The BSOP model uses the risk-free rate of interest. It is assumed that this is known and remains constant, which may not be the case where the time it takes for the option to expire is long;
- The most significant drawback of the Black-Scholes model is the **estimation of the standard deviation** of the price of the asset. The BSOP model assumes that volatility can be assessed and stays constant throughout the life of the project; again with long-term projects these assumptions may not be valid;
- The BSOP model assumes that the underlying asset can be traded freely. This is probably not accurate where the underlying asset is an investment project.

These assumptions mean that the value based around the BSOP model is indicative and not definitive.

(**Note**. Credit will be given for alternative relevant comments.)

(b) The value of a firm can be thought of in these terms:

- If the firm fails to generate enough value to repay its loans, then its value = 0; shareholders have the **option** to let the company die at this point.
- However, if the firm does generate enough value then the extra value belongs to the shareholders and in this case shareholders can pay off the debt (this is the **exercise price**) and continue in their **ownership** of the company.

Therefore, the Black-Scholes model can be applied because shareholders have a **call option** on the business. The protection of limited liability creates the same effect as a call option because there is an upside if the firm is successful, but shareholders lose nothing other than their initial investment if it fails. So the value of a company can be calculated as the amount that you would pay as a **premium for this call option**.

If at expiry of the debt, the value of the company is greater than the face value of debt, then the option is in-the-money, otherwise if the value of the firm is less than the face value of debt, then the option is out-of-the-money and equity is worthless.

Prior to expiry of the debt, the call option (value to holders of equity) will also have a time value attached to it.

The BSOP model can be used to assess the value of the option to the equity holders, the value of equity, which can consist of both time value and intrinsic value if the option is in-the-money, or just time value if the option is out-of-money.

Within the BSOP model, N(d1), the delta value, shows how the value of equity changes when the value of the company's assets change. N(d2) depicts the probability that the call option will be in-the-money (i.e. have intrinsic value for the equity holders).

Debt can be regarded as the debt holders writing a put option on the company's assets, where the premium is the receipt of interest when it falls due and the capital redemption. If N(d2) depicts the probability that the call option is in-the-money, then 1 – N(d2) depicts the probability of default.

Therefore the BSOP model and options are useful in determining the value of equity and default risk.

Option pricing can be used to explain why companies facing severe financial distress can still have positive equity values. A company facing severe financial distress would presumably be one where the equity holders' call option is well out-of-money and therefore has no intrinsic value. However, as long as the debt on the option is not at expiry, then that call option will still have a time value attached to it. Therefore, the positive equity value reflects the time value of the option, even where the option is out-of-money, and this will diminish as the debt comes closer to expiry. The time value indicates that even though the option is currently out-of-money, there is a possibility that due to the volatility of asset values, by the time the debt reaches maturity, the company will no longer face financial distress and will be able to meet its debt obligations.

(Note. Credit will be given for alternative relevant comments.)

(c) According to the BSOP model, the value of an option is dependent on five variables: the value of the underlying asset, the exercise price, the risk-free rate of interest, the implied volatility of the underlying asset, and the time to expiry of the option. These five variables are input into the BSOP formula, in order to compute the value of a call or a put option. The different risk factors determine the impact on the option value of the changes in the five variables, and collectively these are known as the 'Greeks'.

In the case of a call option the option will be more valuable if:

- The exercise price is lower, or
- The value of the underlying asset, the risk free rate of interest, the volatility, or the time period is higher.

The 'vega' determines the sensitivity of an option's value to a change in the implied volatility of the underlying asset. Implied volatility is what the market is implying the volatility of the underlying asset will be in the future. The value of an option will rise as volatility increases because it will increase the potential extent to which an option may be in the money which will benefit the option holder – but if an option is out of the money it will simply not be exercised and therefore if the extent to which an option is out of the money rises then it has no impact on the option holder. Therefore as the 'vega' increases, so will the value of the option.

(**Note.** Credit will be given for alternative relevant comments.)