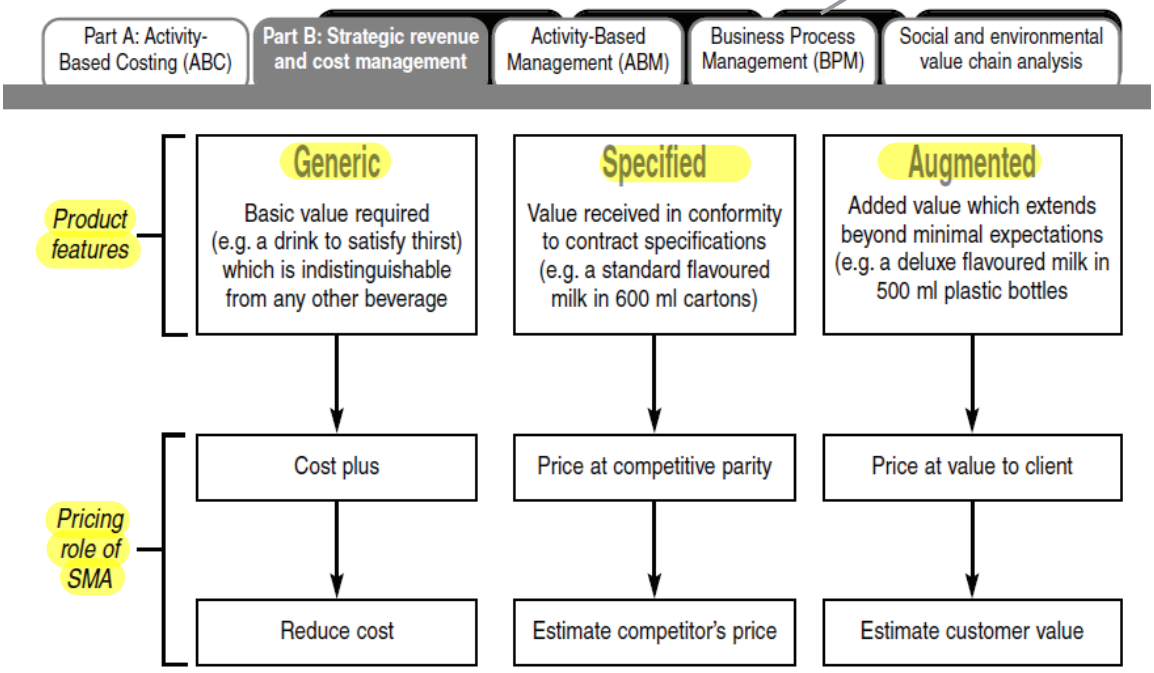
There are two forms of product functionality of interest to customers: hard functions and soft functions



5

Pricing decisions

Topic list	Syllabus reference
1 Pricing policy and the market	B4 (a)
2 Demand	B4 (b), (c)
3 Decisions to increase production and sales	B4 (e)
4 The profit-maximising price/output level	B4 (d), (f)
5 Price strategies	B4 (g), (h)

Introduction

All profit organisations and many non-profit organisations face the task of setting a price for their products or services. Proper pricing of an organisation's products or services is essential to its profitability and hence its survival.

In this chapter we will begin by looking at the **factors which influence pricing** policy. Perhaps the most important of these is the **level of demand** for an organisation's product and how that demand changes as the price of the product changes (its **elasticity of demand**).

We will then turn our attention to the **profit-maximising price/output level** and a range of different **price strategies.**

Study guide

		Intellectual level
B4	**Pricing decisions**	
(a)	Explain the factors that influence the pricing of a product or service	2
(b)	Explain the price elasticity of demand	1
(c)	Derive and manipulate a straight line demand equation. Derive an equation for the total cost function (including volume-based discounts)	2
(d)	Calculate the optimum selling price and quantity for an organisation, equating marginal cost and marginal revenue	2
(e)	Evaluate a decision to increase production and sales levels, considering incremental costs, incremental revenues and other factors	2
(f)	Determine prices and output levels for profit maximisation using the demand based approach to pricing (both tabular and algebraic methods)	1
(g)	Explain different price strategies, including: (i) All forms of cost-plus (ii) Skimming (iii) Penetration (iv) Complementary product (v) Product-line (vi) Volume discounting (vii) Discrimination (viii) Relevant cost	2
(h)	Calculate a price from a given strategy using cost-plus and relevant cost	2

Exam guide

Exam questions on pricing are likely to be a mixture of calculation and discussion and the examiner will expect a **practical application** of pricing theories.

1 Pricing policy and the market

FAST FORWARD

In the modern world there are many more **influences on price** than cost (eg competitors, product range, quality).

1.1 Influences on price

Influence	Explanation/Example
Price sensitivity	Sensitivity to price levels will vary amongst purchasers. Those that can pass on the cost of purchases will be the least sensitive and will therefore respond more to other elements of perceived value. For example, a business traveller will be more concerned about the level of service in looking for an hotel than price, provided that it fits the corporate budget. In contrast, a family on holiday are likely to be very price sensitive when choosing an overnight stay.
Price perception	Price perception is the way customers react to prices. For example, customers may react to a price increase by buying more. This could be because they expect further price increases to follow (they are 'stocking up').

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Influence	Explanation/Example
Quality	This is an aspect of price perception. In the absence of other information, customers tend to judge quality by price. Thus a price rise may indicate improvements in quality, a price reduction may signal reduced quality.
Intermediaries	If an organisation distributes products or services to the market through independent intermediaries, such intermediaries are likely to deal with a range of suppliers and their aims concern their own profits rather than those of suppliers.
Competitors	In some industries (such as petrol retailing) pricing moves in unison; in others, price changes by one supplier may initiate a price war. Competition is discussed in more detail below.
Suppliers	If an organisation's suppliers notice a price rise for the organisation's products, they may seek a rise in the price for their supplies to the organisation.
Inflation	In periods of inflation the organisation may need to change prices to reflect increases in the prices of supplies, labour, rent and so on.
Newness	When a new product is introduced for the first time there are no existing reference points such as customer or competitor behaviour; pricing decisions are most difficult to make in such circumstances. It may be possible to seek alternative reference points, such as the price in another market where the new product has already been launched, or the price set by a competitor.
Incomes	If incomes are rising, price may be a less important marketing variable than product quality and convenience of access (distribution). When income levels are falling and/or unemployment levels rising, price will be more important.
Product range	Products are often interrelated, being complements to each other or substitutes for one another. The management of the pricing function is likely to focus on the profit from the whole range rather than the profit on each single product. For example, a very low price is charged for a loss leader to make consumers buy additional products in the range which carry higher profit margins (eg selling razors at very low prices whilst selling the blades for them at a higher profit margin).
Ethics	Ethical considerations may be a further factor, for example whether or not to exploit short-term shortages through higher prices.

1.2 Markets

FAST FORWARD

The price that an organisation can charge for its products will be determined to a greater or lesser degree by the **market** in which it operates.

Here are some familiar economic terms that might feature as background for a question or that you might want to use in a written answer.

Key terms

Perfect competition: many buyers and many sellers all dealing in an identical product. Neither producer nor user has any market power and both must accept the prevailing market price.

Monopoly: one seller who dominates many buyers. The monopolist can use his market power to set a profit-maximising price.

Monopolistic competition: a large number of suppliers offer similar, but not identical, products. The similarities ensure elastic demand whereas the slight differences give some monopolistic power to the supplier.

Oligopoly: where relatively few competitive companies dominate the market. Whilst each large firm has the ability to influence market prices, the unpredictable reaction from the other giants makes the final industry price indeterminate. Cartels are often formed.

1.3 Competition

In **established industries** dominated by a few major firms, it is generally accepted that a price initiative by one firm will be countered by a price reaction by competitors. In these circumstances, prices tend to be **fairly stable**, unless pushed upwards by inflation or strong growth in demand.

If a rival **cuts its prices** in the expectation of increasing its market share, a firm has several options.

(a) It will **maintain its existing prices** if the expectation is that only a small market share would be lost, so that it is more profitable to keep prices at their existing level. Eventually, the rival firm may drop out of the market or be forced to raise its prices.

(b) It may maintain its prices but respond with a **non-price counter-attack**. This is a more positive response, because the firm will be securing or justifying its current prices with a product change, advertising, or better back-up services.

(c) It may **reduce its prices**. This should protect the firm's market share so that the main beneficiary from the price reduction will be the consumer.

(d) It may **raise its prices** *and respond with a* **non-price counter-attack**. The extra revenue from the higher prices might be used to finance an advertising campaign or product design changes. A price increase would be based on a campaign to emphasise the quality difference between the firm's and the rival's products.

Question **Pricing in the modern business environment**

What technique might be used to relate prices to cost in the modern business environment?

Answer

The answer, of course, is **target costing,** which you met in Chapter 2b. Price is determined by the market. Costs have to come below this price.

2 Demand

FAST FORWARD

Economic theory argues that the **higher the price of a good**, the **lower** will be the **quantity demanded**.

2.1 The economic analysis of demand

You know from your personal experience as a consumer that the theory of demand is essentially true, the higher the price of a good, the less will be demanded. We have already seen that in practice it is by no means as straightforward as this (some goods are bought *because* they are expensive, for example).

There are two extremes in the relationship between price and demand. A supplier can either **sell a certain quantity, Q, at any price** (as in graph (a)). Demand is totally unresponsive to changes in price and is said to be **completely inelastic**. Alternatively, **demand might be limitless at a certain price** P (as in graph (b)), but there would be no demand above price P and there would be little point in dropping the price below P. In such circumstances demand is said to be **completely elastic**.

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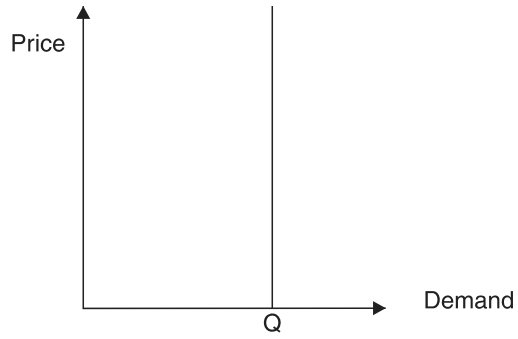
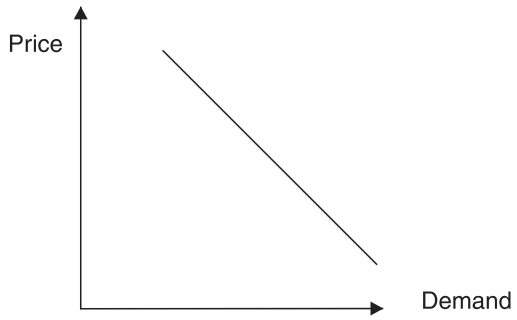
(a)



(b)

A more **normal situation** is shown below. The **downward-sloping** demand curve shows that demand will increase as prices are lowered. Demand is therefore **elastic**.



2.1.1 Price elasticity of demand (η)

FAST FORWARD

The **price elasticity of demand (PED)** is a measure of the extent of change in demand for a good in response to a change in its price.

Key term

Price elasticity of demand (η) is a measure of the extent of change in market demand for a good in response to a change in its price. It is measured as:

$$\frac{\text{The change in quantity demanded, as a \% of demand}}{\text{The change in price, as a \% of the price}}$$

Since the demand goes up when the price falls, and goes down when the price rises, the elasticity has a negative value, but it is usual to ignore the minus sign.

2.1.2 Example: Price elasticity of demand

The price of a good is \$1.20 per unit and annual demand is 800,000 units. Market research indicates that an increase in price of 10 cents per unit will result in a fall in annual demand of 75,000 units. What is the price elasticity of demand?

Solution

Annual demand at \$1.20 per unit is 800,000 units.

Annual demand at \$1.30 per unit is 725,000 units.

% change in demand	=	(75,000/800,000) × 100% = 9.375%
% change in price	=	(0.10/1.20) × 100% = 8.333%
Price elasticity of demand	=	(–9.375/8.333) = –1.125

Ignoring the minus sign, price elasticity is 1.125.

The demand for this good, at a price of \$1.20 per unit, would be referred to as **elastic** because the **price elasticity of demand is greater than 1**.

2.1.3 Elastic and inelastic demand

The value of demand elasticity may be anything from zero to infinity.

Key terms

Demand is referred to as **inelastic** if the absolute value is less than 1 and **elastic** if the absolute value is greater than 1.

Think about what this means.

(a) Where demand is **inelastic**, the **quantity demanded falls by a smaller percentage than the percentage increase in price**.

(b) Where demand is **elastic, demand falls** by a **larger percentage than the percentage rise in price**.

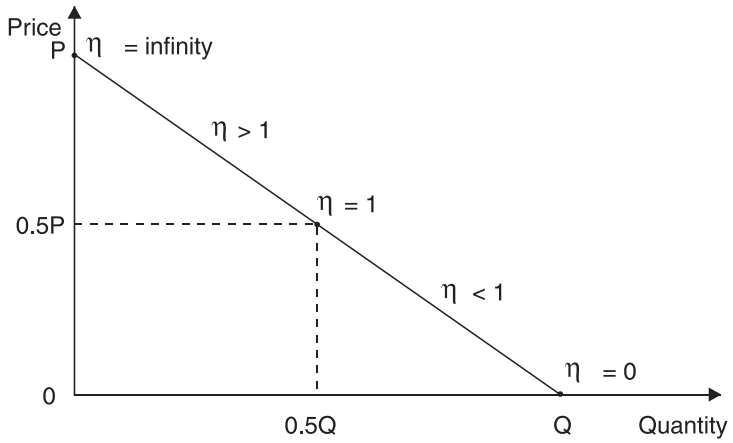
2.1.4 Price elasticity and the slope of the demand curve

Generally, **demand curves slope downwards**. Consumers are willing to buy more at lower prices than at higher prices. In general, **elasticity** will **vary** in value **along the length of a demand curve**.

(a) If a downward sloping demand curve becomes **steeper** over a particular range of quantity, then demand is becoming **more inelastic**.

(b) A **shallower** demand curve over a particular range indicates **more elastic** demand.

The ranges of price elasticity at different points on a downward sloping straight line demand curve are illustrated in the diagram below.



(a) At **higher prices** on a straight line demand curve (the **top** of the demand curve), **small percentage price reductions** can bring **large percentage increases in the quantity** demanded. This means that **demand is elastic** over these ranges, and **price reductions** bring **increases in total expenditure** by consumers on the commodity in question.

(b) At **lower prices** on a straight line demand curve (the **bottom** of the demand curve), **large percentage price reductions** can bring **small percentage increases in quantity**. This means that **demand is inelastic** over these price ranges, and **price increases** result in **increases in total expenditure**.

2.1.5 Special values of price elasticity

There are two special values of price elasticity of demand.

(a) **Demand is perfectly inelastic ($\eta = 0$).** There is **no change in quantity** demanded, **regardless of the change in price**. The demand curve is **a vertical straight line** (as in graph (a) in Section 2.1).

(b) **Perfectly elastic demand ($\eta = \infty$).** Consumers will want to **buy an infinite amount**, but **only up to a particular price** level. Any price increase above this level will reduce demand to zero. The demand curve is a **horizontal straight line** (as in graph (b) in Section 2.1).

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2.1.6 Elasticity and the pricing decision

In practice, organisations will have only a rough idea of the shape of their demand curve: there will only be a limited amount of data about quantities sold at certain prices over a period of time *and,* of course, factors other than price might affect demand. Because any conclusions drawn from such data can only give an indication of likely future behaviour, management skill and expertise are also needed. Despite this limitation, an **awareness of the concept of elasticity can assist management with pricing decisions**.

(a) (i) In circumstances of **inelastic demand**, **prices should be increased** because revenues will increase and total costs will reduce (because quantities sold will reduce).

(ii) In circumstances of **elastic demand**, increases in prices will bring decreases in revenue and decreases in price will bring increases in revenue. Management therefore have to **decide** whether the **increase/decrease in costs will be less than/greater than the increases/decreases in revenue**.

(b) In situations of **very elastic demand**, overpricing can lead to a massive drop in quantity sold and hence a massive drop in profits whereas underpricing can lead to costly stock outs and, again, a significant drop in profits. **Elasticity must therefore be reduced by creating a customer preference which is unrelated to price** (through advertising and promotional activities).

(c) In situations of **very inelastic demand**, customers are **not sensitive to price**. **Quality, service, product mix and location** are therefore **more important** to a firm's pricing strategy.

Question — Elasticity

Read the four statements below. Where the statement is expressed in layman's terms, rephrase it using the appropriate variant of the term *elasticity.* Where it is already phrased in terms of elasticity, translate it into layman's terms.

(a) We doubled sales of product A by dropping the price from $1.99 to $1.75.
(b) Price elasticity of product B is low.
(c) Demand for product C is highly inelastic.
(d) A large reduction in price will be necessary to stimulate further demand for product D.

Answer

Situation (a) is an example of elastic demand; (b) is a case of *inelasticity* and should be appropriately worded; (c) is the same as (b); (d) is also an example of inelasticity.

2.2 Variables which influence demand

Here are some **variables which determine both the degree of elasticity and the volume of demand for a good in the market as a whole**.

Variable	Detail
Price of other goods	For some goods the market demand is connected to the price of other goods Such goods are of two types. (a) Substitutes, so that an increase in demand for one version of a good is likely to cause a decrease in demand for others. Common examples are rival brands of the same commodity (like Coca-Cola and Pepsi-Cola), bus journeys versus car journeys, or different forms of entertainment. (b) Complements, so that an increase in demand for one is likely to cause an increase in demand for the other. Examples are cups and saucers, cars and components, audits and tax consultancy.

Variable	Detail
Income	A rise in income gives households more to spend and they will want to buy more goods. However this phenomenon does not affect all goods in the same way. (a) Normal goods are those for which a rise in income increases the demand. (b) Inferior goods are those for which demand falls as income rises, such as cheap wine. (c) For some goods demand rises up to a certain point and then remains unchanged, because there is a limit to what consumers can or want to consume. Examples are basic foodstuffs such as salt and bread.
Tastes or fashion	A change in tastes or fashion will alter the demand for a good, or a particular variety of a good. Changes in taste may stem from psychological, social or economic causes. There is an argument that tastes and fashions are created by the producers of products and services. There is undeniably some truth in this, but the modern focus on responding to customers' needs and wants suggests otherwise.
Expectations	If consumers have expectations that prices will rise or that shortages will occur they will attempt to stock up on the product, thereby creating excess demand in the short term.
Obsolescence	Many products and services have to be replaced periodically because of obsolescence. (a) In early 2011 there will be substantial demand for audits for the year ended 31 December 2010. Demand will dry up once the statutory time limit for filing audited accounts is passed. In other words many services need to be bought repeatedly for reasons beyond the control of the consumer. A haircut is another example. (b) Physical goods are literally 'consumed'. Carpets become threadbare, glasses get broken, foodstuffs get eaten, children grow out of clothes. (c) Technological developments render some goods obsolete. Manual office equipment has been replaced by electronic equipment, because it does a better job, more quickly, quietly, efficiently and effectively.

2.3 Demand and the individual firm

We have looked at demand in the market as a whole. We also need to consider **factors that influence demand for one organisation's goods rather than another's**.

2.3.1 Product life cycle

FAST FORWARD

Most products pass through the five stages of the **product life cycle.**

To some extent this is an aspect of general demand and obsolescence: if you like we are talking about **built-in obsolescence** although this a rather cynical point of view. That aside, we can say that most products pass through the phases described in Chapter 2c.

Different versions of the same product may have **different life cycles**, and consumers are often aware of this. For example, the prospective buyer of a new car is more likely to purchase a recently introduced Ford than a Vauxhall that has been on the market for several years, even if there is nothing to choose in terms of quality and price.

2.3.2 Quality

One firm's product may be perceived to be better quality than another's, and may in some cases actually be so, if it uses sturdier materials, goes faster or does whatever it is meant to do in a 'better' way. Other things being equal, the **better quality good** will be **more in demand** than other versions.

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2.3.3 Marketing

You may be familiar with the 'four Ps' of the marketing mix, all of which influence demand for a firm's goods.

(a) **Price**

(b) **Product**

(c) **Place** refers to the place **where a good can be purchased**, or is likely to be purchased.

  (i) If potential buyers find that a particular version of a good is difficult to obtain, they will turn to substitutes.

  (ii) Some goods have no more than local appeal.

(d) **Promotion** refers to the various means by which firms draw attention to their products and services.

  (i) A good **brand name** is a strong and relatively permanent influence on demand.

  (ii) Demand can be stimulated by a variety of **promotional tools**, such as free gifts, money off, shop displays, direct mail and media advertising.

In recent years, emphasis has been placed, especially in marketing, on the **importance of non-profit factors** in demand. Thus the roles of product quality, promotion, personal selling and distribution and, in overall terms, brands, have grown. Whilst it can be relatively easy for a competitor to copy a price cut, at least in the short term, it is much **more difficult to copy a successful brand image based on a unique selling proposition.** Successful branding can even imply premium pricing.

2.4 Deriving the demand equation 6/11

FAST FORWARD

You need to be able to derive the **demand equation** $P = a - bQ$.

Exam formulae

When demand is linear the equation for the demand curve is:

$P = a - bQ$

where P = the price

Q = the quantity demanded

a = the price at which demand would be nil

$b = \dfrac{\text{change in price}}{\text{change in quantity}}$

The constant a is calculated as follows.

$$a = \$(\text{current price}) + \left(\frac{\text{Current quantity at current price}}{\text{Change in quantity when price is changed by } \$b} \times \$b \right)$$

Note that 'b' represents the gradient of the demand curve. Since the demand goes up when the price falls, and goes down when the price rises, the elasticity has a negative value, but it is usual to ignore the minus sign.

This looks rather complicated in words, but it is very easy once the numbers are substituted.

2.4.1 Example: Deriving the demand equation

The current price of a product is $12. At this price the company sells 60 items a month. One month the company decides to raise the price to $15, but only 45 items are sold at this price. Determine the demand equation.

Solution

Step 1 **Find the price at which demand would be nil**

Assuming demand is linear, each increase of $3 in the price would result in a fall in demand of 15 units. For demand to be nil, the price needs to rise from its current level by as many times as there are 15 units in 60 units (60/15 = 4) ie to $12 + (4 × $3) = $24.

Using the formula above, this can be shown as a = $12 + ((60/15) × $3)= $24

Step 2 **Calculate b**

$$b = \frac{\text{change in price}}{\text{change in quantity}} = \frac{\$15 - \$12}{60 - 45} = \frac{3}{15} = 0.2$$

The demand equation is therefore P = 24 – 0.2Q

Step 3 **Check your equation**

We can check this by finding Q when P is $12.

$12 = 24 - (0.2Q)$
$0.2Q = 24 - 12$
$0.2Q = 12$
$Q = \frac{12}{0.2} = 60$

An alternative approach is to find 'b' first, then substitute the known value for 'b' into the demand function.

Step 1 **Calculate b**

$$b = \frac{\text{change in price}}{\text{change in quantity}} = \frac{\$15 - \$12}{60 - 45} = \frac{3}{15} = 0.2$$

Step 2 **Substitute the known value for 'b' into the demand function to find 'a'**

$P = a - (0.2Q)$

$12 = a - (0.2 \times 60)$

$12 = a - 12$

$a = 24$

The demand equation is therefore P = 24 – 0.2Q

Step 3 **Check your equation**

We can check this by finding Q when P is $12.

$12 = 24 - (0.2Q)$
$0.2Q = 24 - 12$
$0.2Q = 12$
$Q = \frac{12}{0.2} = 60$

Question — **Deriving the demand equation**

The current price of a product is $30 and the producers sell 100 items a week at this price. One week the price is dropped by $3 as a special offer and the producers sell 150 items. Find an expression for the demand curve.

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Answer

a = \$30 + (100/50 × \$3) = \$36

b = $\frac{\$3}{150 - 100}$ = 0.06

P = 36 – 0.06Q

Check

27 = 36 – 0.06Q

0.06Q = 36 – 27

Q = $\frac{9}{0.06}$ = 150

2.5 The total cost function

FAST FORWARD

Cost behaviour can be **modelled** using equations.

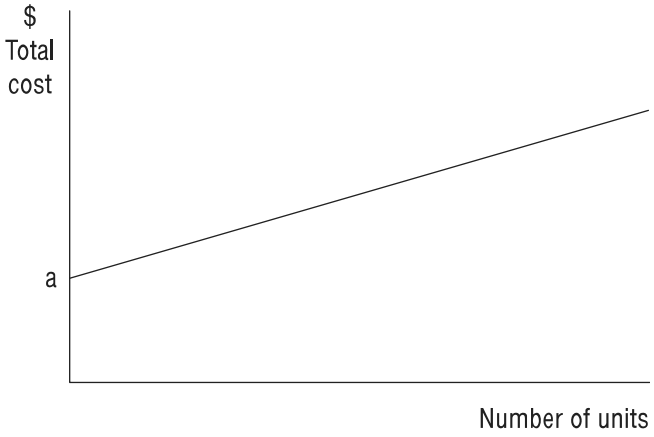
Determining the optimum price and output level requires that **cost and revenue behaviour** can be **modelled using equations**. These equations can range from simple to complex, although those you encounter in the exam will tend towards the 'simple' end of the range.

An organisation's total costs (TC) might be modelled by the equation TC = 6,500 + 0.75Q, where Q is the number of units sold.

Here the cost model is a simple linear equation of the form y = a + bx, where a (\$6,500) represents the fixed costs and b (\$0.75) represents the unit variable cost.

In your earlier studies, you will have covered how this equation can be derived using **linear regression analysis.** As you will remember, 'a' is the intercept of the line on the y axis and 'b' is the slope of the line.

The following graph demonstrates the total cost function.



There are a number of **problems** associated with using such models.

(a) The cost model assumes fixed costs remain unchanged over all ranges of output. (Think about the possibility of step costs, say.)

(b) The cost model assumes a constant unit variable cost over all ranges of output (Think about the implications of economies and diseconomies of scale.)

2.5.1 Volume based discounts

Key term

A **volume-based discount** is a discount given for buying in bulk.

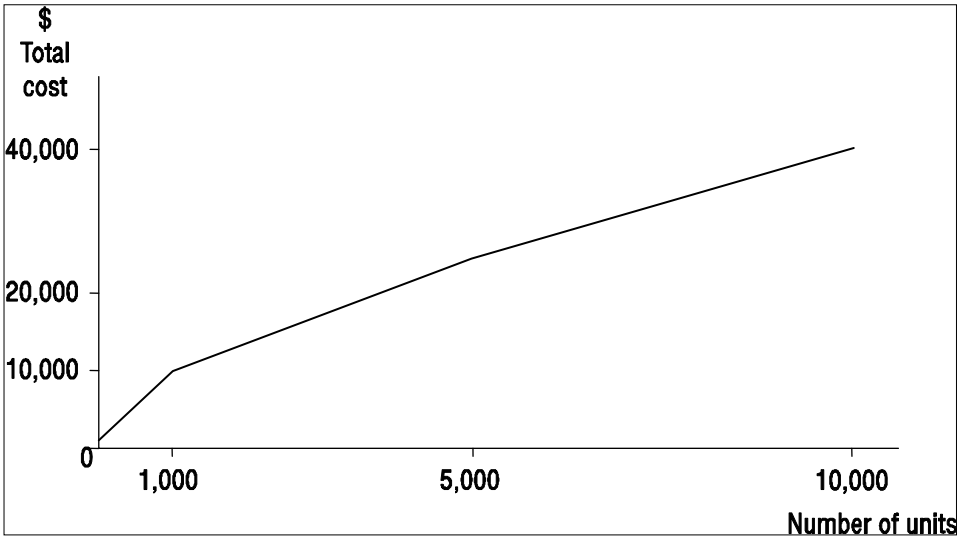
A volume-based discount will **reduce** the variable cost per unit. The value of b will therefore be lower the more units are purchased.

For example, the price of a unit of material used in production is $5 for the first 1,000 units, $4.50 for 1,001 to 5,000 units and $4 for 5,001 to 10,000 units.

If fixed costs remain at $1,000 up to 10,000 units of production and only material costs vary, there will be three cost equations to consider.

0 →	1,000 units:	y = 1,000 + 5x
1,001 →	5,000 units:	y = 1,000 + 4.5x
5,001 →	10,000 units:	y = 1,000 + 4x

This can be shown on a graph as:



Notice how the slope of the line becomes **less steep** as more units are made and the variable cost per unit **falls**.

3 Decisions to increase production and sales 12/07

FAST FORWARD

If you are required to evaluate a decision to increase production and sales levels, you will need to consider **incremental costs, incremental revenues** and other factors.

Key term

Incremental costs and revenues are the difference between costs and revenues for the corresponding items under each alternative being considered. *Drury*

The **incremental cost** of increasing production from 500 to 600 units per month is the additional cost of producing an extra 100 units each month. If fixed costs increase as a result of the decision, they are an incremental cost together with the increased variable costs of production.

3.1 Example: A decision to increase production

George manufactures a product which uses two types of material, A and B. Each unit of production currently sells for $10. A local trader has expressed an interest in buying 5,000 units but is only prepared to pay $9 per unit.

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Current costs and revenues are as follows.

	$'000	$'000
Sales		350
Less production costs		
Material A – 1 kg per unit	25	
Material B – 1 litre per unit	50	
Labour – 1 hour per unit	75	
Variable overhead	50	
Fixed overhead	25	
Non-production costs	25	
Total cost		250
Budgeted profit		100

The following additional information has also been made available.

(a) There is minimal inventory of material available and prices for new material are expected to be 5% higher for Material A and 3% higher for Material B.

(b) George has been having problems with his workforce and is short of labour hours. He currently has the capacity to produce 36,000 units but would have to employ contract labour at $3.50 per hour to make any additional units.

(c) Included in the fixed production overhead is the salary of the production manager. He is stressed and exhausted and has threatened to leave unless he receives a pay rise of $5,000. George would not be able to fulfil any new orders without him.

Required

Evaluate whether George should accept the new order.

Solution

Workings

Current production = 350,000/10 = 35,000 units

$$\text{Current cost per unit of Material A} = \frac{\$25,000}{35,000} = \$0.71$$

$$\text{Current cost per unit of Material B} = \frac{\$50,000}{35,000} = \$1.43$$

$$\text{Current cost of labour} = \frac{\$75,000}{35,000} = \$2.14$$

	$	$
Incremental revenue (5,000 × $9)		45,000
Incremental costs		
Material A (1.05 × $0.71 × 5,000)	3,728	
Material B (1.03 × $1.43 × 5,000)	7,365	
Labour [(1,000 × $2.14) + (4,000 × $3.50)]	16,140	
Fixed overhead	5,000	
		32,233
Incremental profit		12,767

The new order would produce an additional $12,767 so is probably worthwhile but other factors may need to be considered. For example, the effect of a price cut on existing customer expectations and whether the workforce and production manager will be able to fulfil the new order with the same labour efficiency.

4 The profit-maximising price/output level

FAST FORWARD

Profits are maximised using marginalist theory when **marginal cost (MC) = marginal revenue (MR)**. The **optimal selling price** can be determined using equations (ie when MC = MR). The **optimum selling price** can also be determined using tabulation.

The overall objective of an organisation should be **profit maximisation**. In this section we look at how the profit-maximising price and output levels can be derived. Remember that, in microeconomic theory, profits are maximised when marginal revenue = marginal cost.

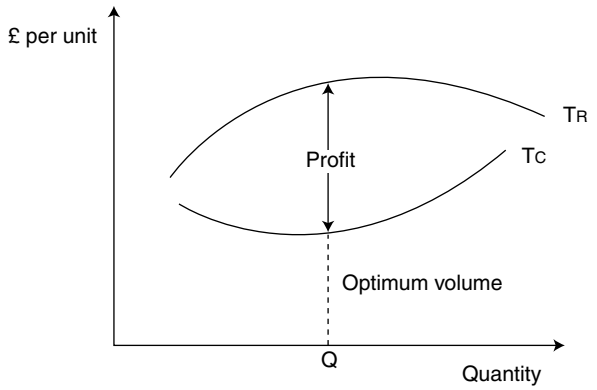
4.1 Microeconomic theory and profit maximisation

In economics, **profit maximisation** is the process by which a firm determines the price and output level that returns the greatest profit. There are two common approaches to this problem.

(a) The **Total revenue (TR) – Total cost (TC)** method is based on the fact that profit equals revenue minus cost.

(b) The **Marginal revenue (MR) – Marginal cost (MC)** method is based on the fact that total profit in a perfect market reaches its maximum point where marginal revenue equals marginal cost.

To obtain the profit maximising output quantity under the TR – TC method, we start by recognising that profit is equal to total revenue minus total cost.



From the graph above it is evident that the difference between **total costs** and **total revenue** is greatest at point Q. This is the profit maximising output quantity.

4.2 MC = MR 6/11

Microeconomic theory suggests that as output increases, the marginal cost per unit might rise (due to the law of diminishing returns) and whenever the firm is faced with a downward sloping demand curve, the **marginal revenue per unit will decline**.

Eventually, a level of output will be reached where the **extra cost** of making one extra unit of output is greater than the **extra revenue** obtained from its sale. It would then be unprofitable to make and sell that extra unit.

Profits will continue to be maximised only up to the output level where marginal cost has risen to be exactly equal to the marginal revenue.

Profits are maximised using marginalist theory when **marginal cost (MC) = marginal revenue (MR)**.

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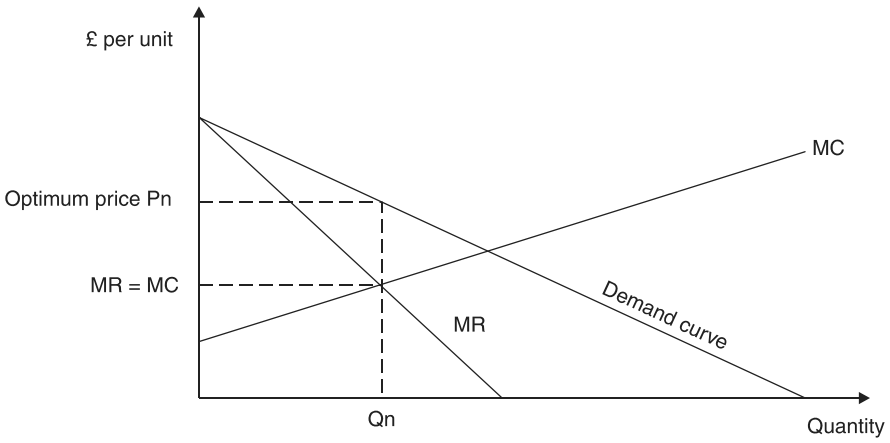

Profits are **maximised** at the point where **MC = MR**, ie at a volume of Qn units. If we add a demand curve to the graph, we can see that at an output level of Qn, the sales price per unit would be Pn.

It is important to make a clear distinction in your mind between the **sales price** and **marginal revenue**. In this example, the optimum price is Pn, but the marginal revenue is much less. This is because the 'additional' sales unit to reach output Qn has only been achieved by reducing the unit sales **price** from an amount higher than Pn for all the units to be sold, not just the marginal extra one. The increase in sales volume is therefore partly offset by a reduction in unit price; hence MR is lower than Pn.

Exam focus point

The examiner has noted that many candidates struggle to equate marginal cost and marginal revenue in order to calculate optimum price and quality.

4.3 Determining the profit-maximising selling price: using equations

The **optimal selling price** can be determined using equations (ie when **MC = MR**).

You could be **provided with equations for marginal cost and marginal revenue** and/or have to **devise them from information** in the question. By **equating the two equations** you can determine the optimal price. Remember, **marginal cost** is the **extra cost of producing one extra unit, marginal revenue** is the **extra revenue from producing one extra unit**. **Marginal revenue may not be the same as** the **price** charged for all units up to that demand level, as to increase volumes the price may have to be reduced.

Section 2.4 outlined the demand curve equation. The **marginal revenue equation** can be found by doubling the value of *b*. The **marginal cost** is the variable cost of production.

Exam formulae

$MR = a - 2bQ$

where P = the price
Q = the quantity demanded
a = the price at which demand would be nil
b = $\frac{\text{change in price}}{\text{change in quantity}}$

The constant 'a' is calculated as follows.

$$a = \$(\text{current price}) + \left(\frac{\text{Current quantity at current price}}{\text{Change in quantity when price is changed by \$b}} \times \$b \right)$$

The following step-by-step approach can be applied to most questions involving algebra and pricing.

Step 1 Establish the demand function (find the values for 'a' and 'b')

Step 2 Establish MC (the marginal cost). This will simply be the variable cost per unit

Step 3 State MR, assuming MR = a – 2bQ

Step 4 To maximise profit, equate MC and MR to find Q

Step 5 Substitute Q into the demand function and solve to find P (the optimum price)

You will need to be able to solve simple examples like those that follow.

4.3.1 Example: MC = MR

MOC makes and sells a copyrighted, executive game for two distinct markets, in which it has a monopoly. The fixed costs of production per month are $20,000 and variable costs per unit produced, and sold, are $40. (The monthly sales can be thought of as X, where $X = X_1 + X_2$, with X_1 and X_2 denoting monthly sales in their respective markets.) Detailed market research has revealed the demand functions in the markets to be as follows, with prices shown as P_1, P_2.

Market 1:	$P_1 = 55 – 0.05X_1$
Market 2:	$P_2 = 200 – 0.2X_2$

(Note. These formulae are simply **linear equations**. They show how the price (P) can be determined for a given level of demand (X). So in market 1, at a level of demand of 100, the price (P) will be $55 – (0.05 \times 100) = 50$.)

From these, the management accountant has derived that the marginal revenue functions in the two markets are as follows.

Market 1:	$MR_1 = 55 – 0.1X_1$
Market 2:	$MR_2 = 200 – 0.4X_2$

(Note. In market 1, the marginal revenue if 100 units are sold is $55 – (0.1 \times 100) = 45$.)

The management accountant believes there should be price discrimination; the price is currently $50 per game in either market.

Required

Analyse the information for the executive game and, given the management accountant's belief, do the following.

(a) Calculate the price to charge in each market, and the quantity to produce (and sell) each month, to maximise profit.

(b) Determine the revenue function for each market and the maximum monthly profit in total.

(c) Calculate and comment on the change in total profitability and prices.

Solution

(a) In both markets, **marginal cost = variable cost per unit** = $40

Profit is maximised when **marginal revenue = marginal cost**.

Market 1

$55 – 0.1X_1 = 40$
$0.1X_1 = 15$
$X_1 = 15/0.1 = 150$

and price $P_1 = 55 – (0.05 \times 150) = \$47.5$.

Hence the price in market 1 should be $47.50 per unit and 150 units should be produced.

Market 2

$200 – 0.4X_2 = 40$
$0.4X_2 = 160$
$X_2 = 160/0.4 = 400$

and price $P_2 = 200 – (0.2 \times 400) = \$120$.

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Hence the price in market 2 should be \$120 per unit and 400 units should be produced.

Total number of items to be produced per month is 550.

(b) **Revenue = unit price × number of units sold**

Market 1

Revenue = $P_1X_1 = 55X_1 - 0.05X_1^2$

Market 2

Revenue = $P_2X_2 = 200X_2 - 0.2X_2^2$

From (a), profit is maximised when

$X_1 = 150$ and $X_2 = 400$

$P_1 = 47.5$ and $P_2 = 120$

At maximum profit:

Total revenue = $(47.5 \times 150) + (120 \times 400) = \$55,125$

Total costs = $20,000 + (40 \times 550) = \$42,000$

Total maximum monthly profit = \$13,125

(c) Currently the price is \$50 in both markets.

Market 1 $50 = 55 - 0.05X_1$
$0.05X_1 = 55 - 50 = 5$
$X_1 = 5/0.05 = 100$

Market 2 $50 = 200 - 0.2X_2$
$0.2X_2 = 200 - 50 = 150$
$X_2 = 150/0.2 = 750$

Therefore the **total number of units** = 100 + 750 = 850.

Total revenue = $\$50 \times 850 = \$42,500$.

Total cost = $20,000 + (40 \times 850) = \$54,000$.

So the game **currently makes a loss** of \$11,500.

Hence, if the prices are changed to \$47.50 in market 1 and \$120 in market 2, the company can expect to turn a monthly loss of \$11,500 into a profit of \$13,125.

You will be provided with equations representing MC and MR if they are needed. Note, however, that if a question states that the extra cost of producing one extra item is \$20, say, you will be expected to realise that the MC is \$20. Likewise, if you are told that **100 units are sold for \$10 each**, but **101 can only be sold for \$9.99**, the **MR of the 101st item is (101 × \$9.99) – (100 × \$10) = \$8.99**.

Question

Deriving a MR equation from the demand curve

AB has used market research to determine that if a price of \$250 is charged for product G, demand will be 12,000 units. It has also been established that demand will rise or fall by 5 units for every \$1 fall/rise in the selling price. The marginal cost of product G is \$80.

Required

If marginal revenue = a –2bQ when the selling price (P) = a – bQ, calculate the profit-maximising selling price for product G.

Answer

$$b = \frac{\text{change in price}}{\text{change in quantity}} = \frac{\$1}{5} = 0.2$$

$a = \$250 + ((12{,}000/5) \times \$1) = \$2{,}650$

$MR = 2{,}650 - (2 \times 0.2)Q \quad = 2{,}650 - 0.4Q$

Profits are maximised when MC = MR, ie when $80 = 2{,}650 - 0.4Q$

$$2{,}650 - 80 = 2{,}570 \times \frac{10}{4} = 6{,}425$$

Profit-maximising demand = 6,425

Now, substitute the values into the demand curve equation to find the profit-maximising selling price

$P = a - bQ$

$P = 2{,}650 - (0.2 \times 6{,}425)$

$\therefore$ Profit-maximising price = $\$(2{,}650 - 1{,}285)$

= $1,365

4.4 Determining the profit-maximising selling price: visual inspection of a tabulation of data

The **optimum selling price** can also be determined using tabulation.

To determine the profit-maximising selling price:

(a) Work out the **demand curve** and hence the **price** and the **total revenue** (PQ) at various levels of demand.

(b) Calculate **total cost** and hence **marginal cost** at each level of demand.

(c) Finally calculate **profit** at each level of demand, thereby determining the price and level of demand at which profits are maximised.

Question

Tabulation approach to find profit-maximising price

An organisation operates in a market where there is imperfect competition, so that to sell more units of output, it must reduce the sales price of all the units it sells. The following data is available for prices and costs.

Total output	*Sales price per unit (AR)*	*Average cost of output (AC)*
Units	$	$ per unit
0	–	–
1	504	720
2	471	402
3	439	288
4	407	231
5	377	201
6	346	189
7	317	182
8	288	180
9	259	186
10	232	198

The total cost of zero output is $600.

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Required

Complete the table below to determine the output level and price at which the organisation would maximise its profits, assuming that fractions of units cannot be made.

Units	*Price* $	*Total revenue* $	*Marginal revenue* $	*Total cost* $	*Marginal cost* $	*Profit* $
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Answer

The correct answer is that profit is maximised at seven units of output and a price of $317, when MR is most nearly equal to MC.

Units	*Price* $	*Total revenue* $	*Marginal revenue* $	*Total cost* $	*Marginal cost* $	*Profit* $
0	0	0	0	600	-	(600)
1	504	504	504	720	120	(216)
2	471	942	438	804	84	138
3	439	1,317	375	864	60	453
4	407	1,628	311	924	60	704
5	377	1,885	257	1,005	81	880
6	346	2,076	191	1,134	129	942
7	317	2,219	143	1,274	140	945
8	288	2,304	85	1,440	166	864
9	259	2,331	27	1,674	234	657
10	232	2,320	(11)	1,980	306	340

5 Price strategies 6/10

FAST FORWARD

The price to be charged for a product or service is often one of the most important decisions made by managers. There are a number of alternative pricing strategies.

5.1 Cost-plus pricing

FAST FORWARD

Full cost-plus pricing is a method of determining the sales price by calculating the full cost of the product and adding a percentage mark-up for profit.

In practice cost is one of the most important influences on price. Many firms base price on simple **cost-plus rules** (costs are estimated and then a profit margin is added in order to set the price).

The 'full cost' may be a fully absorbed production cost only, or it may include some absorbed administration, selling and distribution overhead.

A business might have an idea of the percentage profit margin it would like to earn, and so might **decide on an average profit mark-up** as a general guideline for pricing decisions.

Businesses that carry out a large amount of **contract work or jobbing work**, for which individual job or contract prices must be quoted regularly would find this a useful method to adopt. The percentage profit **mark-up**, however, **does not have to be rigid and fixed**, but can be varied to suit different circumstances.

5.1.1 Example: Full cost-plus pricing

Markup has begun to produce a new product, Product X, for which the following cost estimates have been made.

	$
Direct materials	27
Direct labour: 4 hrs at $5 per hour	20
Variable production overheads: machining, ½ hr at $6 per hour	3
	50

Production fixed overheads are budgeted at $300,000 per month and because of the shortage of available machining capacity, the company will be restricted to 10,000 hours of machine time per month. The absorption rate will be a direct labour rate, however, and budgeted direct labour hours are 25,000 per month. It is estimated that the company could obtain a minimum contribution of $10 per machine hour on producing items other than product X.

The direct cost estimates are not certain as to material usage rates and direct labour productivity, and it is recognised that the estimates of direct materials and direct labour costs may be subject to an error of ± 15%. Machine time estimates are similarly subject to an error of ± 10%.

The company wishes to make a profit of 20% on full production cost from product X.

Required

Ascertain the full cost-plus based price.

Solution

Even for a relatively 'simple' cost-plus pricing estimate, some problems can arise, and certain assumptions must be made and stated. In this example, we can identify two problems.

- Should the opportunity cost of machine time be included in cost or not?
- What allowance, if any, should be made for the possible errors in cost estimates?

Different assumptions could be made.

(a) **Exclude machine time opportunity costs: ignore possible costing errors**

	$
Direct materials	27.00
Direct labour (4 hours)	20.00
Variable production overheads	3.00
Fixed production overheads (at $\frac{\$300,000}{25,000}$ = $12 per direct labour hour)	48.00
Full production cost	98.00
Profit mark-up (20%)	19.60
Selling price per unit of product X	117.60

(b) **Include machine time opportunity costs: ignore possible costing errors**

	$
Full production cost as in (a)	98.00
Opportunity cost of machine time: contribution forgone (½ hr × $10)	5.00
Adjusted full cost	103.00
Profit mark-up (20%)	20.60
Selling price per unit of product X	123.60

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(c) **Exclude machine time opportunity costs but make full allowance for possible under-estimates of cost**

	$	$
Direct materials	27.00	
Direct labour	20.00	
	47.00	
Possible error (15%)	7.05	
		54.05
Variable production overheads	3.00	
Possible error (10%)	0.30	
		3.30
Fixed production overheads (4 hrs × $12)	48.00	
Possible error (labour time) (15%)	7.20	
		55.20
Potential full production cost		112.55
Profit mark-up (20%)		22.51
Selling price per unit of product X		135.06

(d) **Include machine time opportunity costs and make a full allowance for possible under-estimates of cost**

	$
Potential full production cost as in (c)	112.55
Opportunity cost of machine time:	
Potential contribution forgone (½ hr × $10 × 110%)	5.50
Adjusted potential full cost	118.05
Profit mark-up (20%)	23.61
Selling price per unit of product X	141.66

Using different assumptions, we could arrive at any of four different unit prices in the range $117.60 to $141.66.

5.1.2 Disadvantages of full cost-plus pricing

(a) It fails to recognise that since demand may be determining price, there will be a profit-maximising combination of price and demand.

(b) There may be a need to **adjust prices to market and demand conditions**.

(c) **Budgeted output volume** needs to be established. Output volume is a key factor in the overhead absorption rate.

(d) A **suitable basis for overhead absorption** must be selected, especially where a business produces more than one product.

5.1.3 Advantages of full cost-plus pricing

(a) It is a **quick, simple and cheap** method of pricing which can be delegated to junior managers.

(b) Since the size of the profit margin can be varied, a decision based on a price in excess of full cost should ensure that a company working at normal capacity will **cover all of its fixed costs and make a profit.**

Question — **Full cost-plus method**

A company budgets to make 20,000 units which have a variable cost of production of $4 per unit. Fixed production costs are $60,000 per annum. If the selling price is to be 40% higher than full cost, what is the selling price of the product using the full cost-plus method?

Answer

Full cost per unit = variable cost + fixed cost

Variable cost = $4 per unit

Fixed cost = $\frac{\$60{,}000}{20{,}000}$ = $3 per unit

Full cost per unit = $(4 + 3) = $7

$\therefore$ Selling price using full cost-plus pricing method $= \$7.00 \times \frac{140\%}{100}$

$= \$9.80$

5.2 Marginal cost-plus pricing

5.2.1 Introduction

FAST FORWARD

Marginal cost-plus pricing/mark-up pricing involves adding a profit margin to the marginal cost of production/sales.

Whereas a full cost-plus approach to pricing draws attention to net profit and the net profit margin, a variable cost-plus approach to pricing **draws attention to gross profit** and the **gross profit margin**, or **contribution**.

Question

Profit margin

A product has the following costs.

	$
Direct materials	5
Direct labour	3
Variable overheads	7

Fixed overheads are $10,000 per month. Budgeted sales per month are 400 units to allow the product to break even.

Required

Determine the profit margin which needs to be added to *marginal* cost to allow the product to break even.

Answer

Breakeven point is when total contribution equals fixed costs.

At breakeven point, $10,000 = 400 (price – $15)

$\therefore$ $25 = price – $15
$\therefore$ $40 = price
$\therefore$ Profit margin = (40 – 15) / 15 × 100% = 166%

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5.2.2 Advantages of marginal cost-plus pricing

(a) It is a **simple and easy** method to use.

(b) The **mark-up percentage can be varied**, and so mark-up pricing can be adjusted to reflect demand conditions.

(c) It **draws management attention to contribution**, and the effects of higher or lower sales volumes on profit. For example, if a product costs $10 per unit and a mark-up of 150% ($15) is added to reach a price of $25 per unit, management should be clearly aware that every additional $1 of sales revenue would add 60 cents to contribution and profit ($15 ÷ $25 = $0.60).

(d) In practice, mark-up pricing is **used** in businesses **where there is a readily-identifiable basic variable cost**. Retail industries are the most obvious example, and it is quite common for the prices of goods in shops to be fixed by adding a mark-up (20% or 33.3%, say) to the purchase cost.

5.2.3 Disadvantages of marginal cost-plus pricing

(a) Although the size of the mark-up can be varied in accordance with demand conditions, it does not ensure that sufficient attention is paid to demand conditions, competitors' prices and profit maximisation.

(b) It **ignores fixed overheads** in the pricing decision, but the sales price must be sufficiently high to ensure that a profit is made after covering fixed costs.

5.3 Full cost pricing versus marginal cost pricing

Perhaps the most important **criticism** of full cost pricing is that it **fails to recognise** that since sales demand may be determined by the sales price, there will be a **profit-maximising combination** of price and demand. A full cost based approach to pricing will be most unlikely, except by coincidence or 'luck', to arrive at the profit-maximising price. In contrast, a marginal costing approach to looking at costs and prices would be more likely to help with identifying a profit-maximising price.

5.3.1 Example: Full cost versus profit-maximising prices

Tigger has budgeted to make 50,000 units of its product, timm. The variable cost of a timm is $5 and annual fixed costs are expected to be $150,000.

The financial director of Tigger has suggested that a profit margin of 25% on full cost should be charged for every product sold.

The marketing director has challenged the wisdom of this suggestion, and has produced the following estimates of sales demand for timms.

Price per unit	*Demand*
$	Units
9	42,000
10	38,000
11	35,000
12	32,000
13	27,000

Required

(a) Calculate the profit for the year if a full cost price is charged.
(b) Calculate the profit-maximising price.

Assume in both (a) and (b) that 50,000 units of timm are produced regardless of sales volume.

Solution

(a) (i) The full cost per unit is $5 variable cost plus $3 fixed costs, ie $8 in total. A 25% mark-up on this cost gives a selling price of $10 per unit so that sales demand would be 38,000 units. (Production is given as 50,000 units.)

	$	$
Profit (absorption costing)		
Sales		380,000
Costs of production (50,000 units)		
Variable (50,000 × $5)	250,000	
Fixed (50,000 × $3)	150,000	
	400,000	
Less increase in inventory (12,000 units × 8)	(96,000)	
Cost of sales		304,000
Profit		76,000

(ii) **Profit using marginal costing** instead of absorption costing, so that fixed overhead costs are written off in the period they occur, would be as follows. (The 38,000 unit demand level is chosen for comparison.)

	$
Contribution (38,000 × $(10 – 5))	190,000
Fixed costs	150,000
Profit	40,000

Since the company cannot go on indefinitely producing an output volume in excess of sales volume, this profit figure is more indicative of the profitability of timms in the longer term.

(b) A **profit-maximising price** is one which gives the greatest net (relevant) cash flow, which in this case is the **contribution-maximising price**.

Price	*Unit contribution*	*Demand*	
$	$	Units	$
9	4	42,000	168,000
10	5	38,000	190,000
11	6	35,000	210,000
12	7	32,000	224,000
13	8	27,000	216,000

The profit maximising price is $12, with annual sales demand of 32,000 units.

This example shows that a **cost based price** is **unlikely to be the profit-maximising** price, and that a **marginal costing approach**, calculating the total contribution at a variety of different selling prices, will be **more helpful** for establishing what the profit-maximising price ought to be.

5.3.2 Cost plus pricing versus target costing

As you should remember from Chapter 2b, **target prices** are set in order to achieve a desired market share. Deduction of a desired profit margin produces the cost that has to be achieved. Design specifications and production methods are examined to establish ways in which the target cost can be met without reducing the value of the product to the customer.

Such an approach is likely to **offer greater competitive advantage** than cost plus pricing, being far more **strategically orientated** as it **takes account of the external environment**.

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5.4 Market skimming pricing 6/11

FAST FORWARD

New product pricing strategies include **market skimming** and **market penetration pricing.**

Key term

Price skimming involves charging high prices when a product is first launched in order to maximise short-term profitability. Initially there is heavy spending on advertising and sales promotion to obtain sales. As the product moves into the later stages of its life cycle (growth, maturity and decline) progressively lower prices are charged. The profitable 'cream' is thus skimmed off in stages until sales can only be sustained at lower prices.

The aim of market skimming is to gain **high unit profits** early in the product's life. High unit prices make it more likely that **competitors** will enter the market than if lower prices were to be charged.

Such a policy may be appropriate in the cases below.

(a) The product is **new and different**, so that customers are prepared to pay high prices so as to be one up on other people who do not own it.

(b) The strength of **demand** and the sensitivity of demand to price are **unknown**. It is better from the point of view of marketing to start by charging high prices and then reduce them if the demand for the product turns out to be price elastic than to start by charging low prices and then attempt to raise them substantially if demand appears to be insensitive to higher prices.

(c) High prices in the early stages of a product's life might generate **high initial cash flows**. A firm with liquidity problems may prefer market-skimming for this reason.

(d) The firm can identify **different market segments** for the product, each prepared to pay progressively lower prices. It may therefore be possible to continue to sell at higher prices to some market segments when lower prices are charged in others. This is discussed further below.

(e) Products may have a **short life cycle**, and so need to recover their development costs and make a profit relatively quickly.

Products to which the policy has been applied include:

- Calculators
- Video recorders
- Desktop computers

5.5 Market penetration pricing 6/11

Key term

Penetration pricing is a policy of low prices when a product is first launched in order to obtain sufficient penetration into the market.

A penetration policy may be appropriate in the cases below.

(a) The firm wishes to **discourage new entrants** into the market.

(b) The firm wishes to **shorten the initial period** of the product's life cycle in order to enter the growth and maturity stages as quickly as possible.

(c) There are significant **economies of scale** to be achieved from a high volume of output.

(d) Demand is **highly elastic** and so would respond well to low prices.

Penetration prices are prices which aim to secure a substantial share in a substantial total market. A firm might therefore deliberately build **excess production capacity** and set its prices very low. As demand builds up the spare capacity will be used up gradually and unit costs will fall; the firm might even reduce prices further as unit costs fall. In this way, early losses will enable the firm to dominate the market and have the lowest costs.

5.6 Complementary product pricing

Key term

Complementary products are goods that tend to be bought and used together.

Complementary products are sold separately but are **connected** and dependent on each other for sales, for example, an electric toothbrush and replacement toothbrush heads. The electric toothbrush may be priced competitively to attract demand but the replacement heads can be relatively expensive.

A **loss leader** is when a company sets a very low price for one product intending to make consumers buy other products in the range which carry higher profit margins. Another example is selling razors at very low prices whilst selling the blades for them at a higher profit margin. People will buy many of the high profit items but only one of the low profit items – yet they are 'locked in' to the former by the latter. This can also be described as **captive product pricing**.

5.7 Product-line pricing

Key term

A **product line** is a group of products that are related to one another.

A **product line** is the marketing strategy of offering for sale several related products. A line can comprise related products of various sizes, types, colours, qualities, or prices. Demand for and costs of the products are likely to be **interrelated.**

There is a range of product line pricing strategies.

(a) Set prices proportional to full or marginal cost with the same percentage profit margin for all products. This means that prices are dependent on cost and ignore demand.

(b) Set prices reflecting the demand relationships between the products so that an overall required rate of return is achieved.

5.8 Volume discounting

Key term

A **volume discount** is a reduction in price given for larger than average purchases.

The aim of a volume discount is to increase sales from large customers. The discount acts as a form of **differentiation** between types of customer (wholesale, retail and so on).

The reduced costs of a large order will hopefully compensate for the loss of revenue from offering the discount.

5.9 Price discrimination

FAST FORWARD

The use of **price discrimination** means that the same product can be sold at different prices to different customers. This can be very difficult to implement in practice because it relies for success upon the continued existence of certain market conditions.

In certain circumstances the **same product** can be sold at different prices to **different customers**.

Key term

Price discrimination is the practice of charging different prices for the same product to different groups of buyers when these prices are not reflective of cost differences.

There are a number of bases on which such discriminating prices can be set.

(a) **By market segment**. A cross-channel ferry company would market its services at different prices in England and France, for example. Services such as cinemas and hairdressers are often available at lower prices to old age pensioners and/or juveniles.

(b) **By product version**. Many car models have 'add on' extras which enable one brand to appeal to a wider cross-section of customers. The final price need not reflect the cost price of the add on extras directly: usually the top of the range model would carry a price much in excess of the cost of provision of the extras, as a prestige appeal.

(c) **By place**. Theatre seats are usually sold according to their location so that patrons pay different prices for the same performance according to the seat type they occupy.

(d) **By time**. This is perhaps the most popular type of price discrimination. Off-peak travel bargains, hotel prices and telephone charges are all attempts to increase sales revenue by covering variable but not necessarily average cost of provision. Railway companies are successful price discriminators, charging more to rush hour rail commuters whose demand is inelastic at certain times of the day.

Price discrimination can only be effective if a number of **conditions** hold.

(a) The market must be **segmentable** in price terms, and different sectors must show different intensities of demand. Each of the sectors must be identifiable, distinct and separate from the others, and be accessible to the firm's marketing communications.

(b) There must be little or **no** chance of a **black market** developing (this would allow those in the lower priced segment to resell to those in the higher priced segment).

(c) There must be little or **no** chance that **competitors** can and will undercut the firm's prices in the higher priced (and/or most profitable) market segments.

(d) The cost of segmenting and **administering** the arrangements should not exceed the extra revenue derived from the price discrimination strategy.

Try the following question which, although it has a few 'tricks', **looks more daunting than it is** if you keep your head and take care.

Question

Differential pricing

Curltown Cinemas operates a chain of 30 cinemas. Standard admission price is $7 per person, but this is subject to certain discounts. Average attendance at a cinema per month on normal price days is 5,000 people, but this is expected to be subject to seasonal variation, as follows.

Month	J	F	M	A	M	J	J	A	S	O	N	D
%	+10	–2	0	+5	–5	–5	+10	+7	–4	–4	0	+12

In December, January, July and August audiences are made up of 60% under-14s, who pay half-price admission. For the rest of the year under 14s represent only 10% of the audience. One day per month all tickets are sold at a special offer price of $1, irrespective of the age of the customer. This invariably guarantees a full house of 200 customers.

Required

(a) What is Curltown Cinemas' total revenue from cinema admissions for a year?

(b) If Curltown puts up prices for over-14s (other than the $1 special offer price) to $8 what will its total revenue from cinema admissions be for the year?

(c) Should the special offer be continued?

Answer

(a) This is simply a matter of reading the question carefully and patiently tabulating the data using a **different layout** to the one given in the question. Note that you save yourself potential error if you convert percentages into decimals as you transfer the question information into your own table. Don't forget that there are 30 cinemas.

Month	*Variation*	*Average no*	*Adjusted no*	*Full price*	*Revenue @ $7.00*	*Half price*	*Revenue @ $3.50*
					$		$
Jan	+0.10	5,000	5,500	0.4	15,400.00	0.6	11,550.00
Feb	-0.02	5,000	4,900	0.9	30,870.00	0.1	1,715.00
Mar	+0.00	5,000	5,000	0.9	31,500.00	0.1	1,750.00
Apr	+0.05	5,000	5,250	0.9	33,075.00	0.1	1,837.50
May	-0.05	5,000	4,750	0.9	29,925.00	0.1	1,662.50
Jun	-0.05	5,000	4,750	0.9	29,925.00	0.1	1,662.50
Jul	+0.10	5,000	5,500	0.4	15,400.00	0.6	11,550.00
Aug	+0.07	5,000	5,350	0.4	14,980.00	0.6	11,235.00
Sept	-0.04	5,000	4,800	0.9	30,240.00	0.1	1,680.00
Oct	-0.04	5,000	4,800	0.9	30,240.00	0.1	1,680.00
Nov	0.00	5,000	5,000	0.9	31,500.00	0.1	1,750.00
Dec	+0.12	5,000	5,600	0.4	15,680.00	0.6	11,760.00
					308,735.00		59,832.50

	$
Total normal price ($308,735.00 + $59,832.50)	368,567.50
Special offer (12 × $1 × 200)	2,400.00
Total per cinema	370,967.50
Total per 30 cinemas	11,129,025.00

(b) **There is no need to work out all the numbers again at the new prices.**

	$
Total as calculated above	11,129,025.00
Less: current adult normal price ($308,735 × 30)	(9,262,050.00)
Add: revised adult normal price ($308,735 × 30 × 8/7)	10,585,200.00
	12,452,175.00

(c) If the income of $200 per cinema on the twelve special offer days is compared with an average of, say, $368,567.50/(365 – 12 days) = over $1,000, then it is clearly not worthwhile. The cinemas get average attendances of (5000 × 12)/365 = about 164 people in any case, even without special offers. (You could do **rough calculations** to estimate the overall loss of revenue per annum. Try it, making any **assumptions** you need, if you haven't done so, but not at the expense of written comments.)

However, the offer is a **loss-leader** which probably has other benefits. It will be liked by customers, and if the film they see is a good one they will recommend it to their friends. It may help to encourage the cinema-going habit amongst potential new regular customers. You may have thought of other relevant comments, either in favour of the policy or against it.

Exam focus point

An exam question on this topic would have less calculations and more interpretation so make sure you really think about the implications of continuing the special offer.

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5.10 Relevant cost pricing

FAST FORWARD

Special orders require a **relevant cost** approach to the calculation of the price.

A special order is a **one-off** revenue earning opportunity. These may arise in the following situations.

(a) When a business has a regular source of income but also has some **spare capacity** allowing it to take on extra work if demanded. For example a brewery might have a capacity of 500,000 barrels per month but only be producing and selling 300,000 barrels per month. It could therefore consider special orders to use up some of its spare capacity.

(b) When a business has **no regular source of income** and relies exclusively on its ability to respond to demand. A building firm is a typical example as are many types of sub-contractors. In the service sector consultants often work on this basis.

The reason for making the distinction is that in the case of (a), a firm would normally attempt to cover its longer-term running costs in its prices for its regular product. Pricing for special orders need therefore take no account of unavoidable fixed costs. This is clearly not the case for a firm in (b)'s position, where special orders are the only source of income for the foreseeable future.

Exam focus point

Examination questions featuring pricing for special orders could present a scenario in which a firm has to decide whether to bid for a contract.

5.10.1 Minimum pricing

The basic approach in both situations is to determine the price at which the firm would break even if it undertook the work, that is, the **minimum price** that it could afford to charge.

A minimum price is the minimum price that would have to be charged so as to cover the following two groups of cost.

(a) The **incremental costs** of producing and selling the item
(b) The **opportunity costs** of the resources consumed in making and selling the item

A minimum price would leave the business no better or worse off than if it did not sell the item.

Two essential points to understand immediately about a minimum price are as follows.

(a) It is based on **relevant** costs, that is the incremental costs plus the opportunity costs of making and selling the product or providing the service. You have covered this in your earlier studies and we will look at this aspect again in Chapter 6.

(b) It is **unlikely that a minimum price would actually be charged**, because if it were it would not provide the business with any incremental profit. However, the minimum price for an item shows the following.

  (i) An **absolute minimum** below which the price should not be set.
  (ii) The **incremental profit** that would be obtained from any price that is actually charged in excess of the minimum. For example, if the minimum price is $200 and the actual price charged is $240, the incremental profit on the sale would be $40.

If there are no **scarce resources**, and a company has **spare capacity**, the **minimum price** of a product would be an amount which equals the **incremental cost of making it**. Any price in excess of this minimum would provide an incremental contribution towards profit.

If there are scarce resources and a company makes more than one product, minimum prices would include an allowance for the **opportunity cost** of using the scarce resources to make and sell the product (instead of using the resources on the next most profitable product).

Where a firm also has to consider its **long-term costs** in the decision because it has no other way of recovering them it would have to **add a proportion of estimated unattributable costs to the price of each order**. This could be calculated on a time basis (if the job is expected to take one month, $^1/_{12}$ of unavoidable costs would be included), but this might lead to inconsistencies if, say, the unavoidable costs were all borne by one customer in one month and shared between several customers in another month.

Question

Relevant cost pricing

Ennerdale has been asked to quote a price for a one-off contract. The following information is available:

Materials

The contract requires 3,000 kg of material K, which is a material used regularly by the company in other production. The company has 2,000 kg of material K currently in stock which had been purchased last month for a total cost of $19,600. Since then the price per kilogram for material K has increased by 5%.

The contract also requires 200 kg of material L. There are 250 kg of material L in stock which are not required for normal production. This material originally cost a total of $3,125. If not used on this contract, the stock of material L would be sold for $11 per kg.

Labour

The contract requires 800 hours of skilled labour. Skilled labour is paid $9.50 per hour. There is a shortage of skilled labour and all the available skilled labour is fully employed in the company in the manufacture of product P. The following information relates to product P:

	$ per unit	$ per unit
Selling price		100
Less:		
Skilled labour	38	
Other variable costs	22	
		(60)
		40

Required

Prepare on a relevant cost basis, the lowest cost estimate that could be used as the basis for a quotation.

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Answer

Relevant cost – Material K

Since the material is regularly used by the company, the relevant cost of material K is the current price of the material.

$$\text{Cost last month} = \frac{\$19{,}600}{2{,}000\,\text{kg}}$$

= $9.80

Revised cost (+5%) = $9.80 × 1.05

= $10.29

∴ Relevant cost of Material K = 3,000 kg × $10.29 per kg

= $30,870

Relevant cost – Material L

Since the material is not required for normal production, the relevant cost of this material is its net realisable value if it were sold.

∴ Relevant cost of Material L = 200 kg × $11 per kg

= $2,200

Relevant cost – Skilled labour

Skilled labour is in short supply and therefore the relevant cost of this labour will include both the actual cost and the opportunity cost of the labour employed.

	$
Cost of skilled labour (800 hours × $9.50)	7,600
Opportunity cost of skilled labour (see working)	8,000
Relevant cost – skilled labour	15,600

Working

Skilled labour cost per unit of Product P = $38

Cost per skilled labour hour = $9.50

∴ Number of hours required per unit of Product P $= \frac{\$38}{\$9.50}$

= 4 hours

Contribution per unit of Product P = $40

∴ Contribution per skilled labour hour $= \frac{\$40}{4\,\text{hours}}$

= $10 per hour

∴ Opportunity cost of skilled labour = 800 hours × $10 per hour

= $8,000

The total relevant costs of this contract are therefore $(30,870 + 2,200 + 15,600) = $48,670

Chapter Roundup

- In the modern world there are many more **influences on price** than cost (eg competitors, product range, quality).
- The price that an organisation can charge for its products will be determined to a greater or lesser degree by the **market** in which it operates
- **Economic theory** argues that the **higher the price of a good**, the **lower** will be the **quantity demanded**.
- The **price elasticity of demand (PED)** is a measure of the extent of change in demand for a good in response to a change in its price.
- Most products pass through the five stages of the **product life cycle.**
- You need to be able to derive the **demand equation** $P = a - bQ$.
- Cost behaviour can be **modelled** using equations.
- If you are required to evaluate a decision to increase production and sales levels, you will need to consider **incremental costs, incremental revenues** and other factors.
- **Profits are maximised** using marginalist theory when **marginal cost (MC) = marginal revenue (MR)**.
- The **optimal selling price** can be determined using equations (ie when MC = MR).
- The **optimum selling price** can also be determined using tabulation.
- The price to be charged for a product or service is often one of the most important decisions made by managers. There are a number of alternative pricing strategies.
- **Full cost-plus pricing** is a method of determining the sales price by calculating the full cost of the product and adding a percentage mark-up for profit.
- **Marginal cost-plus pricing/mark-up pricing** involves adding a profit margin to the marginal cost of production/sales.
- New product pricing strategies include **market skimming** and **market penetration pricing**.
- The use of **price discrimination** means that the same product can be sold at different prices to different customers. This can be very difficult to implement in practice because it relies for success upon the continued existence of certain market conditions.
- Special orders require a **relevant cost** approach to the calculation of the price.

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Quick Quiz

1 *Fill in the blanks.*

Demand is said to be elastic when a …………………… change in price produces a …………………..

change in quantity demanded. PED is ………………………. than 1.

Demand is said to be inelastic when a ……………………… change in price produces a ……………….

change in quantity demanded. PED is ……………………….. than 1.

2 Fill in the blanks in the formula below for the variable 'a' in the equation for a demand curve.

$$a = \$(\ldots\ldots\ldots\ldots\ldots\ldots\ldots) + \left(\frac{\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots}{\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots} \times \$\ldots\ldots\right)$$

3 Cost-based approaches to pricing take more account of the external environment than target costing. **True or false?**

4 *Fill in the blanks.*

(a) One of the problems with relying on a full cost-plus approach to pricing is that it fails to recognise that since price may be determining demand, there will be a …………………….. combination of …………. and …………….

(b) An advantage of the full cost-plus approach is that, because the size of the profit margin can be varied, a decision based on a price in excess of full cost should ensure that a company working at …………….. capacity will cover ……………..… and make a ………………..

5 Pricing based on mark-up per unit of limiting factor is particularly useful if an organisation is not working to full capacity. **True or false?**

6 *Fill in the blank.*

The ………………. price is the price at which an organisation will break even if it undertakes particular work.

7 *Choose the correct word from those highlighted.*

Market **skimming/penetration** pricing should be used if an organisation wishes to discourage new entrants into a market.

Answers to Quick Quiz

1 (a) Demand is said to be elastic when a **small change** in the price produces a **large change** in the quantity demanded. PED is **greater** than 1.

(b) Demand is said to be **inelastic** when a small change in the price produces only a **small change in the quantity** demanded. **PED is less than 1**.

2 $$a = (\text{current price}) + \left(\frac{\text{Current quantity at current price}}{\text{Change in quantity when price is changed by \$b}} \times \$b \right)$$

3 False

4 (a) profit-maximising combination of price and demand

(b) working at normal capacity will cover all of its fixed costs and make a profit

5 False. It is useful if the organisation is working at full capacity.

6 Minimum

7 Market penetration

Now try the question below from the Exam Question Bank

Number	Level	Marks	Time
Q9	Examination	20	36 mins

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More money can be spent on marketing for the most profitable groups.

Aim to:

- Eliminate unprofitable customer groups.
- **Or** change the way sales are made to them.

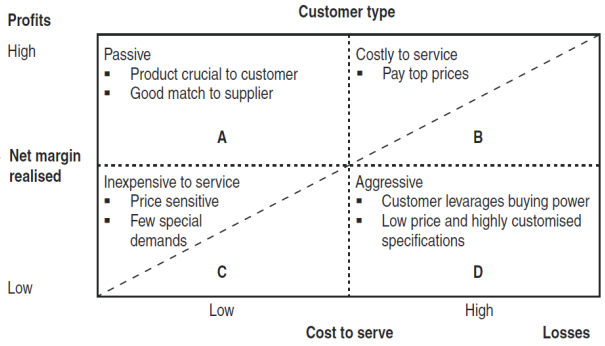
Customer profitability analysis (CPA)

The analysis of the revenues and costs associated with specific customers or customer groups.

The relative profitability of specific customers/ customer groups can be assessed, and strategies aimed at attracting and retaining the most profitable customers implemented.

Customers can be categorised using this grid.

- The aim is to attract as many accepting customers as possible.
- Many large retail organisations fall into the demanding category.



The extent of customer profitability is dependent on the amount by which the net margin realised from sale exceeds the customer-specific costs.

Limitations of CPA

- The allocation of common costs is arbitrary
- The treatment of unavoidable or committed costs

Advantages of CPA

- Identifies unprofitable customers and products.
- Identifies whether poorly performed customer service causes some customers to become unprofitable.
- Focuses management attention on improving profitability for both customers and products.

Due to their very stringent product and order turnaround requirements.

Costs are then linked into individual customers or customer groups to determine their profitability.

CPA and ABC

The necessary analysis of costs can be successfully carried out using ABC cost drivers.

Examples

Cost:	Cost driver:
■ Delivery.	■ Kilometres travelled.
■ After sales service and support.	■ Number of visits.

Unprofitable customers identified by CPA should be persuaded to alter their buying behaviour (eg discouraged from placing lots of small orders).

The ABC approach also highlights where cost reduction efforts should be focused (eg reduce ordering cost).

Example

	$'000	$'000
Revenue at list prices		X
Less: discounts given		X
Net revenue		X
Less cost of goods sold		X
Gross margin		X
Less customer specific costs		X
Less financing costs		
credit period	X	
customer specific inventory	X	
		X
Net margin from customer		X

Customer life cycles

Customers can be costed over their life cycle and expected future cash flows discounted.

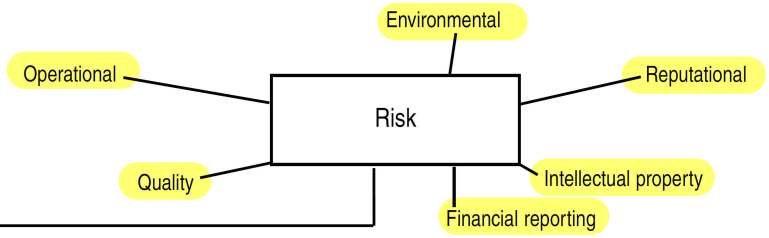
Managing and retaining unprofitable customers

- Ideally, transform an unprofitable customer into a profitable one by:
  - Increasing the realised net margin.
  - Reducing the service cost.
- Usually an organisation will choose to focus only on profitable customers, and those that have been made profitable.
- But may choose to retain unprofitable customers if:
  - Currently loss-making but new and growing: potentially profitable in future.
  - Provide qualitative benefits eg leading edge technology or marketing.
  - Highly reputed.

Could maybe give discounts for bulk buying.

Promotional expense is front loaded; sales grow with time and later purchases may be more differentiated.

Overarching corporate governance systems in an organisation require **risk** to be addressed in a structured manner.



MAS:
- Captures information.
- Identifies issues.
- Implements internal controls.

Risk Management System
- Risk identification.
- Risk classification: severity/probability.
- Measuring and monitoring risk.
- Managing risk:
  - Avoidance.
  - Reduction.
  - Transfer.
  - Acceptance.

Risk classification matrix

When to start managing/mitigating a risk: classify probability of occurrence and severity of outcome if it does occur

PROBABILITY	Severity			
	Low	Medium	High	Catastrophic
Low	L	L	L	L
Medium	L	M	M	H
High	L	H	H	H
Certain	M	H	H	H

H = higher risk – act immediately to eliminate/mitigate
M = medium risk – act to reduce risk
L = lower risk – periodic reviews

MAS produces information to identify particular risks across all areas.

Internal accounting controls help to reduce/eliminate risk:
- separation of duties
- independent verification
- physical security
- document design and handling
- cash control.

7

Risk and uncertainty

Topic list	Syllabus reference
1 Risk and uncertainty	B6 (a)
2 Allowing for uncertainty	B6 (a)
3 Probabilities and expected values	B6 (b), (c)
4 Decision rules	B6 (d)
5 Decision trees	B6 (e)
6 The value of information	B6 (f)
7 Sensitivity analysis	B6 (b), (c)
8 Simulation models	B6 (b)

Introduction

Decision making involves making decisions now about what will happen in the future. Obviously, decisions can turn out badly, or actual results can prove to be very different from the estimates on which the original decision was made. **Ideally** the decision maker would **know with certainty** what the future consequences would be for each choice facing him. But the real world is not normally so helpful, and decisions must be made in the knowledge that their **consequences**, although probable perhaps, are **rarely 100% certain**.

Various **methods of bringing uncertainty and risk analysis** into the evaluation of decisions will be described in this chapter. You may well think that some methods are more sensible or practical than others but you should **judge** each method on its merits, and be able to **apply** it if necessary in an examination.

Study guide

		Intellectual level
B6	**Dealing with risk and uncertainty in decision-making**	
(a)	Suggest research techniques to reduce uncertainty eg Focus groups, market research	2
(b)	Explain the use of simulation, expected values and sensitivity	1
(c)	Apply expected values and sensitivity to decision-making problems	2
(d)	Apply the techniques of maximax, maximin, and minimax regret to decision-making problems including the production of profit tables	2
(e)	Draw a decision tree and use it to solve a multi-stage decision problem	1
(f)	Calculate the value of perfect and imperfect information	2

Exam guide

Management accounting exams have increasingly expected candidates to have a good understanding of risk. Questions are likely to be a mixture of calculations and explanation.

1 Risk and uncertainty

FAST FORWARD

An example of a **risky situation** is one in which we can say that there is a 70% probability that returns from a project will be in excess of $100,000 but a 30% probability that returns will be less than $100,000. If we cannot predict an outcome or assign probabilities, we are faced with an **uncertain** situation.

Key terms

Risk involves situations or events which may or may not occur, but whose probability of occurrence can be calculated statistically and the frequency of their occurrence predicted from past records. Thus insurance deals with risk.

Uncertain events are those whose outcome cannot be predicted with statistical confidence.

In everyday usage the terms risk and uncertainty are not clearly distinguished. If you are asked for a definition, do not make the mistake of believing that the latter is a more extreme version of the former. It is not a question of degree, it is a question of whether or not sufficient information is available to allow the lack of certainty to be quantified. As a rule, however, the terms are used interchangeably.

1.1 Risk preference

FAST FORWARD

People may be **risk seekers**, **risk neutral** or **risk averse**.

Key terms

A **risk seeker** is a decision maker who is interested in the best outcomes no matter how small the chance that they may occur.

A decision maker is **risk neutral** if he is concerned with what will be the most likely outcome.

A **risk averse** decision maker acts on the assumption that the worst outcome might occur.

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This has clear implications for managers and organisations. A **risk seeking manager** working for an **organisation** that is characteristically **risk averse** is likely to make decisions that are **not congruent with the goals of the organisation**. There may be a role for the management accountant here, who could be instructed to present decision-making information in such a way as to ensure that the manager considers *all* the possibilities, including the worst.

2 Allowing for uncertainty

FAST FORWARD

Management accounting directs its attention towards the **future** and the future is **uncertain**. For this reason a number of methods of taking **uncertainty** into consideration have evolved.

2.1 Research techniques to reduce uncertainty

FAST FORWARD

Market research can be used to reduce uncertainty.

Key term

Market research is the systematic process of gathering, analysing and reporting data about markets to investigate, describe, measure, understand or explain a situation or problem facing a company or organisation.

Market research involves **tackling problems**. The assumption is that these problems can be solved, no matter how complex the issues are, if the researcher follows a line of enquiry in a **systematic** way, without losing sight of the main objectives. Gathering and analysing all the facts will ultimately lead to **better decision making.**

2.1.1 The role of market research

In the last 20 years or so market research has become a much more widespread activity. Organisations – in the private sector, the public sector and the not-for-profit sector – rely on research to inform and improve their **planning and decision making**.

Market research enables organisations to understand the needs and opinions of their customers and other stakeholders. Armed with this knowledge they are able to make better quality decisions and provide better products and better services.

Thus, research influences what is provided and the way it is provided. It **reduces uncertainty and monitors performance.** A management team which possesses accurate information relating to the marketplace will be in a strong position to make the best decisions in an increasingly competitive world.

Decision-makers need data to reduce **uncertainty** and **risk** when planning for the future and to monitor business performance. Market researchers provide the data that helps them to do this.

2.1.2 Types of data collected

Data can be either **primary** (collected at first hand from a sample of respondents), or **secondary** (collected from previous surveys, other published facts and opinions, or from experts). Secondary research is also known as **desk research**, because it can be carried out from one's desk.

More importantly for research practice and analysis, data can be either quantitative or qualitative.

Quantitative data usually deals with numbers and typically provides the decision maker with information about **how many** customers, competitors etc act in a certain way. Quantitative data can, for example, tell the researcher **what** people need or consume, or **where**, **when** and **how** people buy goods or consumer services.

Qualitative data tells us **why** consumers think/buy or act the way they do. Qualitative data is used in **consumer insight** (eg understanding what makes consumers prefer one brand to another), **media awareness** (eg how much of an advertisement is noticed by the public), **new product development** studies and for many other reasons.

Qualitative research has as its specific purpose the uncovering and understanding of thought and opinion. It is carried out on relatively small samples and unstructured or semi-structured techniques, such as individual in depth interviews and group discussions (also known as **focus groups**), are used.

2.2 Conservatism

This approach simply involves estimating outcomes in a conservative manner in order to provide a built-in safety factor.

However, the method fails to consider explicitly a **range** of outcomes and, by concentrating only on conservative figures, may also fail to consider the **expected** or most likely outcomes.

Conservatism is associated with **risk aversion** and prudence (in the general sense of the word). In spite of its shortcomings it is probably the **most widely used** method in practice.

2.3 Worst/most likely/best outcome estimates

A more scientific version of conservatism is to measure the most likely outcome from a decision, and the worst and best possible outcomes. This will show the **full range of possible outcomes** from a decision, and might help managers to reject certain alternatives because the worst possible outcome might involve an unacceptable amount of loss. This requires the preparation of **pay-off tables.**

2.3.1 Pay-off tables

Pay-off tables **identify and record all possible outcomes (or pay-offs)** in situations where the action taken affects the outcomes.

2.3.2 Example: Worst/best possible outcomes

Omelette Co is trying to set the sales price for one of its products. Three prices are under consideration, and expected sales volumes and costs are as follows.

Price per unit	*$4*	*$4.30*	*$4.40*
Expected sales volume (units)			
Best possible	16,000	14,000	12,500
Most likely	14,000	12,500	12,000
Worst possible	10,000	8,000	6,000

Fixed costs are $20,000 and variable costs of sales are $2 per unit.

Which price should be chosen?

Solution

Here we need to prepare a pay-off table showing **pay-offs** (contribution) **dependent on different levels of demand and different selling prices.**

Price per unit	*$4*	*$4.30*	*$4.40*
Contribution per unit	$2	$2.30	$2.40
Total contribution towards fixed costs	$	$	$
Best possible	32,000	32,200	30,000
Most likely	28,000	28,750	28,800
Worst possible	20,000	18,400	14,400

(a) The highest contribution based on **most likely** sales volume would be at a price of $4.40 but arguably a price of $4.30 would be much better than $4.40, since the most likely profit is almost as good, the worst possible profit is not as bad, and the best possible profit is better.

(b) However, only a price of $4 guarantees that the company would **not make a loss,** even if the worst possible outcome occurs. (Fixed costs of $20,000 would just be covered.) A risk averse management might therefore prefer a price of $4 to either of the other two prices.

We consider pay-off tables and expected values in paragraph 3.1.2 below.

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3 Probabilities and expected values 6/11

FAST FORWARD

Expected values indicate what an outcome is likely to be in the long term with repetition. Fortunately, many business transactions do occur over and over again.

Although the outcome of a decision may not be certain, there is some likelihood that probabilities could be assigned to the various possible outcomes from an analysis of previous experience.

3.1 Expected values

Where probabilities are assigned to different outcomes we can evaluate the worth of a decision as the **expected value**, or weighted average, of these outcomes. The principle is that when there are a number of alternative decisions, each with a range of possible outcomes, the optimum decision will be the one which gives the highest expected value.

3.1.1 Example: Expected values

Suppose a manager has to choose between mutually exclusive options A and B, and the probable outcomes of each option are as follows.

Option A		*Option B*	
Probability	*Profit*	*Probability*	*Profit*
	$		$
0.8	5,000	0.1	(2,000)
0.2	6,000	0.2	5,000
		0.6	7,000
		0.1	8,000

The expected value (EV) of profit of each option would be measured as follows.

Option A					*Option B*				
Prob		*Profit* $		*EV of profit* $	*Prob*		*Profit* $		*EV of profit* $
0.8	×	5,000	=	4,000	0.1	×	(2,000)	=	(200)
0.2	×	6,000	=	1,200	0.2	×	5,000	=	1,000
		EV	=	5,200	0.6	×	7,000	=	4,200
					0.1	×	8,000	=	800
							EV	=	5,800

In this example, since it offers a higher EV of profit, option B would be selected in preference to A, unless further risk analysis is carried out.

3.1.2 Example: Expected values and pay-off tables

IB Newsagents stocks a weekly lifestyle magazine. The owner buys the magazines for $0.30 each and sells them at the retail price of $0.50 each.

At the end of the week unsold magazines are obsolete and have no value. The estimated probability distribution for weekly demand is shown below.

Weekly demand in units	*Probability*
20	0.20
30	0.55
40	0.25
	1.00

Required

What is the expected value of demand?

If the owner is to order a fixed quantity of magazines per week how many should that be?

Assume no seasonal variations in demand.

Solution

EV of demand (units per week) = (20 × 0.20) + (30 × 0.55) + (40 × 0.25) = 30.5 units per week

The next step is to set up a decision matrix of possible strategies (numbers bought) and possible demand.

The 'pay-off' from each combination of action and outcome is then computed.

No sale = cost of $0.30 per magazine

Sale = profit of $0.20 per magazine ($0.50 – $0.30)

Probability	*Outcome (number demanded)*	*Decision (number bought)*		
		20	30	40
		$	$	$
0.20	20	4.00	1.00*	(2.00)
0.55	30	4.00	6.00	3.00
0.25	40	4.00	6.00	8.00
1	EV	4.00	5.00**	3.25

* Buy 30 and sell only 20 gives a profit of (20 × $0.5) – (30 × $0.3) = $1

** (0.2 × 1) + (0.55 × 6) + (0.25 × 6) = 5

The strategy which gives the highest expected pay-off is to stock 30 magazines each week.

Exam focus point

The examiner has noted in that candidates often struggle to construct an accurate payoff table. Make sure that you understand the above example which demonstrates this technique.

Question

EVs

A manager has to choose between mutually exclusive options C and D and the probable outcomes of each option are as follows.

Option C		*Option D*	
Probability	*Cost*	*Probability*	*Cost*
	$		$
0.29	15,000	0.03	14,000
0.54	20,000	0.30	17,000
0.17	30,000	0.35	21,000
		0.32	24,000

Both options will produce an income of $30,000. Which should be chosen?

Answer

Option C. Do the workings yourself in the way illustrated above. Note that the probabilities are for *costs* not profits.

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3.1.3 Limitations of expected values

The preference for B over A on the basis of expected value is marred by the fact that A's **worst possible** outcome is a profit of $5,000, whereas B might incur a loss of $2,000 (although there is a 70% chance that profits would be $7,000 or more, which would be more than the best profits from option A).

Since the decision must be made **once only** between A and B, the expected value of profit (which is **merely a weighted average** of all possible outcomes) has severe limitations as a decision rule by which to judge preference. The expected value will **never actually occur**.

Expected values are used to support a **risk-neutral attitude**. A risk-neutral decision maker will ignore any variability in the range of possible outcomes and be concerned only with the expected value of outcomes.

Expected values are more valuable as a guide to decision making where they refer to outcomes which will occur **many times over**. Examples would include the probability that so many customers per day will buy a can of baked beans, the probability that a customer services assistant will receive so many phone calls per hour, and so on.

4 Decision rules 12/08, 6/11

FAST FORWARD

The 'play it safe' basis for decision making is referred to as the **maximin basis**. This is short for '**maximise the minimum achievable profit**'.

A basis for making decisions by looking for the best outcome is known as the **maximax basis**, short for **'maximise the maximum achievable profit'**.

The 'opportunity loss' basis for decision making is known as **minimax regret**.

4.1 The maximin decision rule

Key term

The **maximin decision rule** suggests that a decision maker should select the alternative that offers the least unattractive worst outcome. This would mean choosing the alternative that *maximises* the *minimum* profits.

Suppose a businessman is trying to decide which of three mutually exclusive projects to undertake. Each of the projects could lead to varying net profit under three possible scenarios.

		Profits		
		Project		
		D	*E*	*F*
	I	100	80	60
Scenarios	II	90	120	85
	III	(20)	10	85

The maximin decision rule suggests that he should select the 'smallest worst result' that could happen. This is the decision criterion that managers should 'play safe' and either minimise their losses or costs, or else go for the decision which gives the higher minimum profits. If he selects project D the worst result is a loss of 20. The worst results for E and F are profits of 10 and 60 respectively. The best worst outcome is 60 and project F would therefore be selected (because this is a better 'worst possible' than either D or E).

4.1.1 Criticisms of maximin

(a) It is **defensive** and **conservative**, being a safety first principle of avoiding the worst outcomes without taking into account opportunities for maximising profits.

(b) It ignores the **probability** of each different outcome taking place.

4.2 Maximax

Key term

> The **maximax criterion** looks at the best possible results. Maximax means 'maximise the maximum profit'.

Using the information in Section 4.1 above, the maximum profit for D is 100, for E is 120 and for F is 85.

Project E would be chosen if the maximax rule is followed.

4.2.1 Criticisms of maximax

(a) It ignores probabilities.
(b) It is **over-optimistic**.

Question — Maximax and maximin

A company is considering which one of three alternative courses of action, A, B and C to take. The profit or loss from each choice depends on which one of four economic circumstances, I, II, III or IV will apply. The possible profits and losses, in thousands of pounds, are given in the following payoff table. Losses are shown as negative figures.

		Action		
		A	*B*	*C*
Circumstance	I	70	60	70
	II	–10	20	–5
	III	80	0	50
	IV	60	100	115

Required

State which action would be selected using each of the maximax and maximin criteria.

Answer

(a) The **best possible outcomes** are as follows.

A (circumstance III): 80
B (circumstance IV): 100
C (circumstance IV): 115

As 115 is the highest of these three figures, action C would be chosen using the maximax criterion.

(b) The **worst possible outcomes** are as follows.

A (circumstance II): –10
B (circumstance III): 0
C (circumstance II): –5

The best of these figures is 0 (neither a profit nor a loss), so action B would be chosen using the maximin criterion.

4.3 Minimax regret rule

Key term

> The **minimax regret rule** aims to minimise the regret from making the wrong decision. **Regret** is the opportunity lost through making the wrong decision.

We first consider the extreme to which we might come to regret an action we had chosen.

Regret for any combination of action and circumstances = Profit for best action in those circumstances – Profit for the action actually chosen in those circumstances

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The minimax regret decision rule is that the decision option selected should be the one which **minimises the maximum potential regret** for any of the possible outcomes.

Using the example in Section 4.1, a table of regrets can be compiled as follows.

		Project		
		D	*E*	*F*
	I	0	20*	40**
Scenario	II	30***	0	35
	III	105	75	0
Maximum regret		105	75	40

* 100 – 80 ** 100 – 60 *** 120 – 90

The **lowest** of maximum regrets is 40 with project F so project F would be selected if the minimax regret rule is used.

4.4 Contribution tables

Questions requiring application of the decision rules often incorporate a **number of variables, each with a range of possible values**. For example these variables might be:

- Unit price and associated level of demand
- Unit variable cost

Each variable might have, for example, three possible values.

Before being asked to use the decision rules, exam questions could ask you to **work out contribution** for each of the possible outcomes. (Alternatively profit figures could be required if you are given information about fixed costs.)

The **number of possible outcomes** = number of values of variable 1 × number of values of variable 2 × number of values of variable 3 etc

So, for example, if there are **two** variables, each with **three** possible values, there are **3 × 3 = 9 outcomes.**

Perhaps the easiest way to see how to draw up contribution tables is to look at an example.

4.4.1 Example: Contribution tables and the decision rules

Suppose the budgeted demand for product X will be 11,500 units if the price is $10, 8,500 units if the price is $12 and 5,000 units if the price is $14. Variable costs are estimated at either $4, $5, or $6 per unit. A decision needs to be made on the **price** to be charged.

Here is a contribution table showing the budgeted contribution for each of the nine possible outcomes.

Demand	*Price*	*Variable cost*	*Unit contribution*	*Total contribution*
	$	$	$	$'000
11,500	10	4	6	69.0
11,500	10	5	5	57.5
11,500	10	6	4	46.0
8,500	12	4	8	68.0
8,500	12	5	7	59.5
8,500	12	6	6	51.0
5,000	14	4	10	50.0
5,000	14	5	9	45.0
5,000	14	6	8	40.0

Once the table has been drawn up, the decision rules can be applied.

Solution

Maximin

We need to maximise the minimum contribution.

Demand/price	*Minimum contribution*
11,500/$10	$46,000
8,500/$12	$51,000
5,000/$14	$40,000

Set a price of $12.

Maximax

We need to maximise the maximum contribution.

Demand/price	*Maximum contribution*
11,500/$10	$69,000
8,000/$12	$68,000
5,000/$14	$50,000

Set a price of $10.

Minimax regret

We need to minimise the maximum regret (lost contribution) of making the wrong decision.

Variable cost		*Price*	
$	$10	$12	$14
4	–	$1,000	$19,000
5	$2,000	–	$14,500
6	$5,000	–	$11,000
Minimax regret	$5,000	$1,000	$19,000

Minimax regret strategy (**price of $12**) is that which minimises the maximum regret ($1,000).

Sample working

At a variable cost of $4, the best strategy would be a price of $10. Choosing a price of $12 would mean lost contribution of $69,000 – $68,000, while choosing a price of $14 would mean lost contribution of $69,000 – $50,000.

Exam focus point

Decision rules ware a popular exam topic. The examiner has commented that candidates struggle to justify decisions with supporting calculations.

5 Decision trees

FAST FORWARD

Decision trees are diagrams which illustrate the choices and possible outcomes of a decision.

Rollback analysis evaluates the EV of each decision option. You have to work from right to left and calculate EVs at each outcome point.

A probability problem such as 'what is the probability of throwing a six with one throw of a die?' is fairly straightforward and can be solved using the basic principles of probability.

More complex probability questions, although solvable using the basic principles, require a clear logical approach to ensure that all possible choices and outcomes of a decision are taken into consideration. **Decision trees** are a useful means of interpreting such probability problems.

Key term

A **decision tree** is a pictorial method of showing a sequence of interrelated decisions and their expected outcomes. Decision trees can incorporate both the probabilities of, and values of, expected outcomes, and are used in decision-making.

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Exactly how does the use of a decision tree permit a clear and logical approach?

- All the possible **choices** that can be made are shown as **branches** on the tree.
- All the possible **outcomes** of each choice are shown as **subsidiary branches** on the tree.

5.1 Constructing a decision tree

There are two stages in preparing a decision tree.

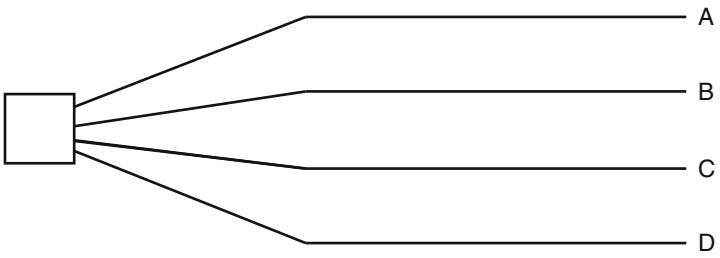
- Drawing the tree itself to show all the choices and outcomes
- Putting in the numbers (the probabilities, outcome values and EVs)

Every **decision tree starts** from a **decision point** with the **decision options** that are currently being considered.

(a) It helps to identify the **decision point**, and any subsequent decision points in the tree, with a symbol. Here, we shall use a **square shape**.

(b) There should be a **line**, or **branch**, for each **option** or **alternative**.

It is conventional to draw decision trees from left to right, and so a decision tree will start as follows.



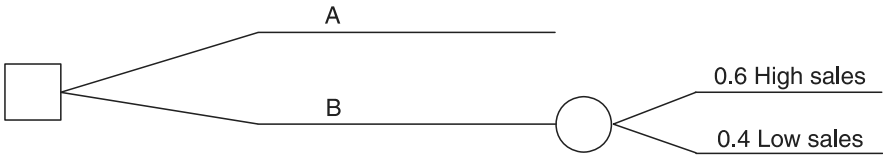
The **square** is the **decision point**, and A, B, C and D represent **four alternatives** from which a choice must be made (such as buy a new machine with cash, hire a machine, continue to use existing machine, raise a loan to buy a machine).

If the outcome from any choice is certain, the branch of the decision tree for that alternative is complete.

If the outcome of a particular choice is uncertain, the various possible outcomes must be shown.

We show the various possible outcomes on a decision tree by inserting an **outcome point** on the **branch** of the tree. Each possible outcome is then shown as a **subsidiary branch**, coming out from the outcome point. The probability of each outcome occurring should be written on to the branch of the tree which represents that outcome.

To distinguish decision points from outcome points, **a circle will be used as the symbol for an outcome point**.



In the example above, there are two choices facing the decision-maker, A and B. The outcome if A is chosen is known with certainty, but if B is chosen, there are two possible outcomes, high sales (0.6 probability) or low sales (0.4 probability).

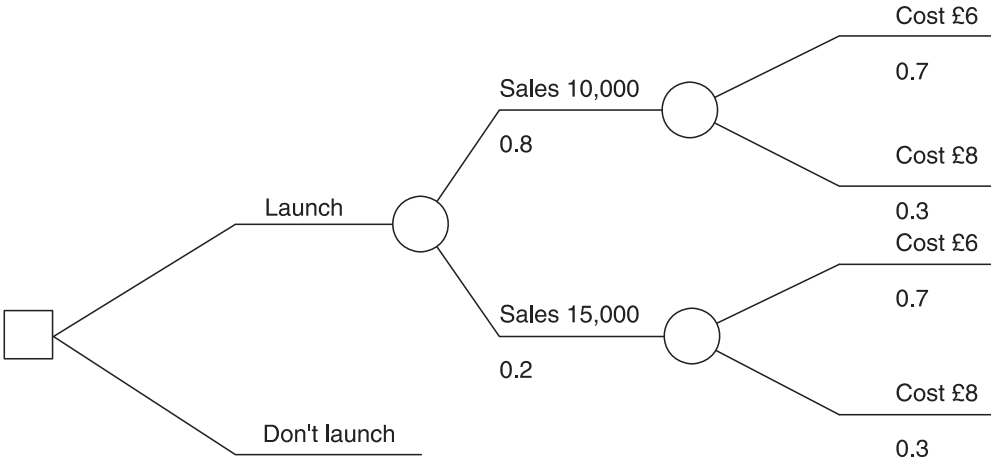
When several outcomes are possible, it is usually simpler to show two or more stages of outcome points on the decision tree.

5.2 Example: Several possible outcomes

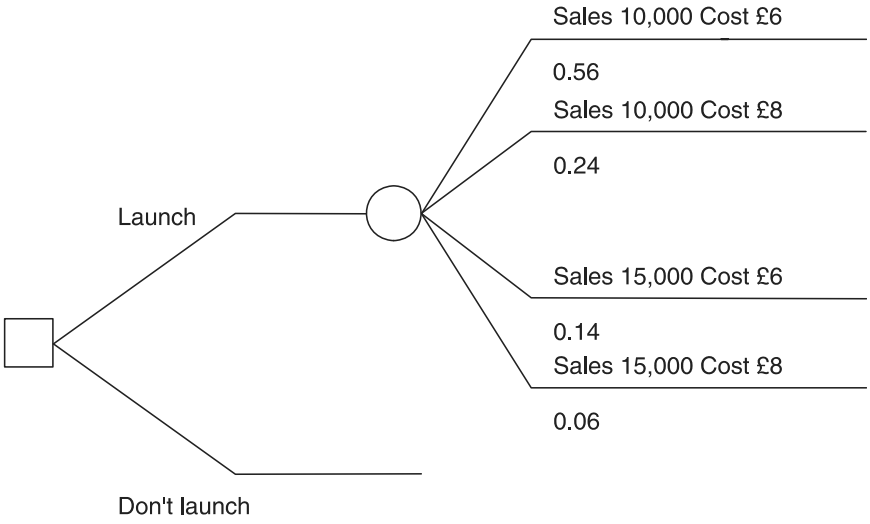
A company can choose to launch a new product XYZ or not. If the product is launched, expected sales and expected unit costs might be as follows.

Sales		*Unit costs*	
Units	*Probability*	£	*Probability*
10,000	0.8	6	0.7
15,000	0.2	8	0.3

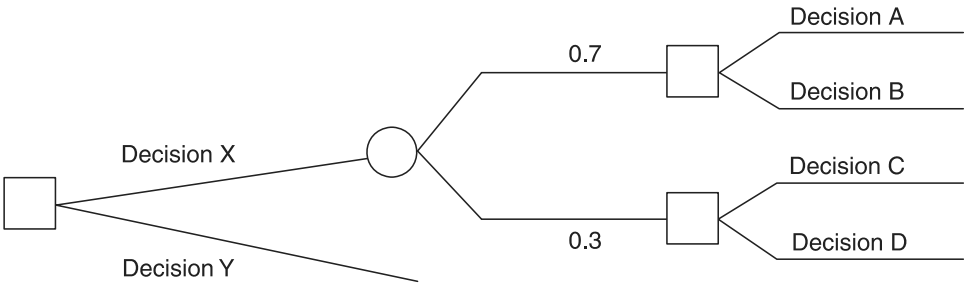
(a) The decision tree could be drawn as follows.



(b) The layout shown above will usually be easier to use than the alternative way of drawing the tree, which is as follows.



Sometimes, a **decision taken now** will lead to **other decisions to be taken in the future**. When this situation arises, the decision tree can be drawn as a **two-stage tree**, as follows.



In this tree, either a choice between A and B or else a choice between C and D will be made, depending on the outcome which occurs after choosing X.

The decision tree should be in **chronological order** from **left to right**. When there are two-stage decision trees, the first decision in time should be drawn on the left.

5.3 Example: A decision tree

Beethoven has a new wonder product, the vylin, of which it expects great things. At the moment the company has two courses of action open to it, to test market the product or abandon it.

If the company test markets it, the cost will be $100,000 and the market response could be positive or negative with probabilities of 0.60 and 0.40.

If the response is positive the company could either abandon the product or market it full scale.

If it markets the vylin full scale, the outcome might be low, medium or high demand, and the respective net gains/(losses) would be (200), 200 or 1,000 in units of $1,000 (the result could range from a net loss of $200,000 to a gain of $1,000,000). These outcomes have probabilities of 0.20, 0.50 and 0.30 respectively.

If the result of the test marketing is negative and the company goes ahead and markets the product, estimated losses would be $600,000.

If, at any point, the company abandons the product, there would be a net gain of $50,000 from the sale of scrap. All the financial values have been discounted to the present.

Required

(a) Draw a decision tree.
(b) Include figures for cost, loss or profit on the appropriate branches of the tree.

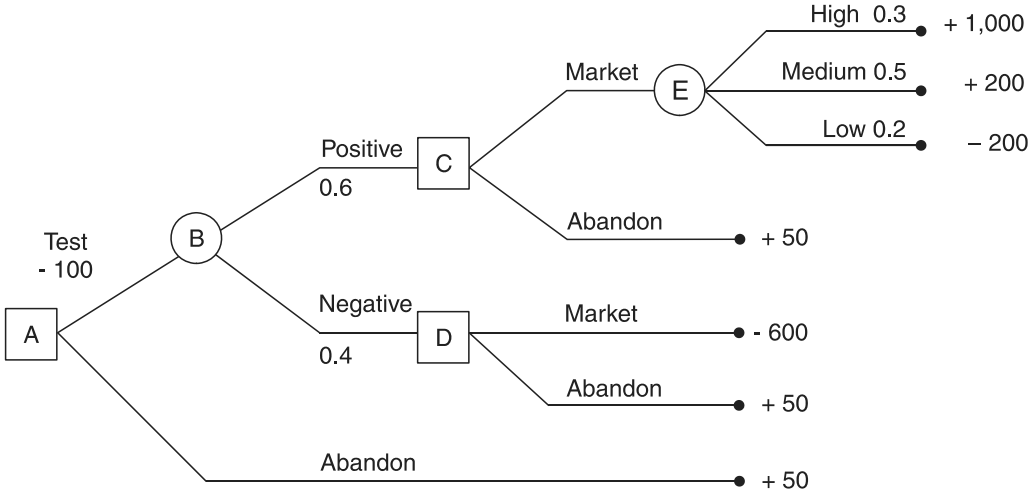
Solution

The starting point for the tree is to **establish what decision has to be made now**. What are the options?

(a) To test market
(b) To abandon

The outcome of the 'abandon' option is known with certainty. There are two possible outcomes of the option to test market, positive response and negative response.

Depending on the outcome of the test marketing, another decision will then be made, to abandon the product or to go ahead.



Exam focus point

In an examination, remember to draw decision trees (and *all* diagrams) neatly, using a pen and ruler. Remember also to label decision points and branches as clearly as possible.

5.4 Evaluating the decision with a decision tree

Rollback analysis evaluates the EV of each decision option. You have to work from right to left and calculate EVs at each outcome point.

The EV of each decision option can be evaluated, using the decision tree to help with keeping the logic on track. The basic rules are as follows.

(a) We start on the **right hand side** of the tree and **work back** towards the left hand side and the current decision under consideration. This is sometimes known as the **'rollback' technique** or '**rollback analysis**'.

(b) Working from **right to left**, we calculate the **EV of revenue, cost, contribution or profit** at each outcome point on the tree.

In the above example, the right-hand-most outcome point is point E, and the EV is as follows.

	Profit	*Probability*	
	x	*p*	*px*
	$'000		$'000
High	1,000	0.3	300
Medium	200	0.5	100
Low	(200)	0.2	(40)
		EV	360

This is the EV of the decision to market the product if the test shows positive response. It may help you to write the EV on the decision tree itself, at the appropriate outcome point (point E).

(a) **At decision point C**, the **choice** is as follows.

(i) Market, EV = + 360 (the EV at point E)
(ii) Abandon, value = + 50

The choice would be to market the product, and so the EV at decision point C is +360.

(b) **At decision point D**, the **choice** is as follows.

(i) Market, value = – 600
(ii) Abandon, value = +50

The choice would be to abandon, and so the EV at decision point D is +50.

The second stage decisions have therefore been made. If the original decision is to test market, the company will market the product if the test shows positive customer response, and will abandon the product if the test results are negative.

The evaluation of the decision tree is completed as follows.

(a) **Calculate the EV at outcome point B.**

0.6 × 360 (EV at C)
\+ 0.4 × 50 (EV at D)
= 216 + 20 = 236.

(b) **Compare the options at point A**, which are as follows.

(i) Test: EV = EV at B minus test marketing cost = 236 – 100 = 136
(ii) Abandon: Value = 50

The choice would be to test market the product, because it has a **higher EV of profit**.

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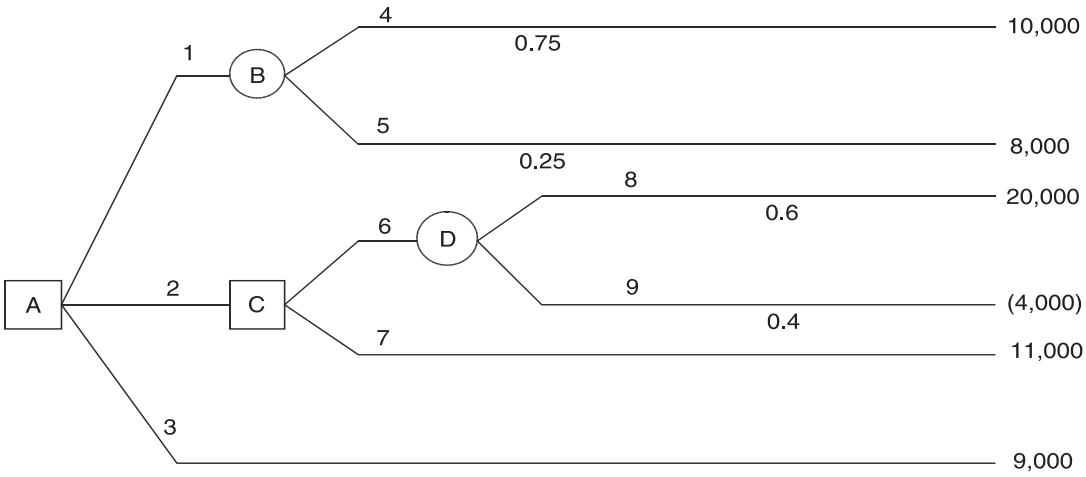
Question

Simple decision tree

Consider the following diagram.



If a decision maker wished to maximise the value of the outcome, which options should be selected?

A Option 2 and option 7
B Option 3
C Option 1 and option 4
D Option 2, option 6 and option 8

Answer

The correct answer is A.

The various outcomes must be evaluated using expected values.

EV at point B: (0.75 × 10,000) + (0.25 × 8,000) = 9,500

EV at point D: (0.6 × 20,000) + (0.4 × (4,000)) = 10,400

EV at point C: Choice between 10,400 and 11,000

EV at point A: Choice between B (9,500), C (10,400 or 11,000) and choice 3 (9,000).

If we are trying to maximise the figure, option 2 and then option 7 are chosen to give 11,000.

Evaluating decisions by using **decision trees has a number of limitations**.

(a) The time value of money may not be taken into account.

(b) Decision trees are not very suitable for use in complex situations.

(c) The outcome with the highest EV may have the greatest risks attached to it. Managers may be reluctant to take risks which may lead to losses.

(d) The probabilities associated with different branches of the 'tree' are likely to be estimates, and possibly unreliable or inaccurate.

6 The value of information

FAST FORWARD

Perfect information is guaranteed to predict the future with 100% accuracy. **Imperfect information** is better than no information at all but could be wrong in its prediction of the future.

The **value of perfect information** is the difference between the EV of profit with perfect information and the EV of profit without perfect information.

Key term

Perfect information removes all doubt and uncertainty from a decision, and enables managers to make decisions with complete confidence that they have selected the optimum course of action.

6.1 The value of perfect information

Step 1 If we **do not have perfect information** and we must choose between two or more decision options, we would **select** the decision option which offers the **highest EV** of profit. This option will not be the best decision under all circumstances. There will be some probability that what was really the best option will not have been selected, given the way actual events turn out.

Step 2 With **perfect information**, the **best decision option will always be selected**. The profits from the decision will depend on the future circumstances which are predicted by the information; nevertheless, the EV of profit with perfect information should be higher than the EV of profit without the information.

Step 3 The **value of perfect information** is **the difference between these two EVs**.

6.2 Example: The value of perfect information

The management of Ivor Ore must choose whether to go ahead with either of two mutually exclusive projects, A and B. The expected profits are as follows.

	Profit if there is strong demand	*Profit if there is moderate demand*	*Profit/(loss) if there is weak demand*
Option A	$4,000	$1,200	$(1,000)
Option B	$1,500	$1,000	$500
Probability of demand	0.2	0.3	0.5

Required

(a) Ascertain what the decision would be, based on expected values, if no information about demand were available.

(b) Calculate the value of perfect information about demand.

Solution

Step 1 If there were **no information** to help with the decision, the project with the higher EV of profit would be selected.

Probability	*Project A*		*Project B*	
	Profit	*EV*	*Profit*	*EV*
	$	$	$	$
0.2	4,000	800	1,500	300
0.3	1,200	360	1,000	300
0.5	(1,000)	(500)	500	250
		660		850

Project B would be selected.

This is clearly the better option if demand turns out to be weak. However, if demand were to turn out to be moderate or strong, project A would be more profitable. There is a 50% chance that this could happen (30% + 20%).

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Step 2 **Perfect information** will indicate for certain whether demand will be weak, moderate or strong. If demand is forecast 'weak' project B would be selected. If demand if forecast as 'moderate' project A would be selected, and perfect information would improve the profit from $1,000, which would have been earned by selecting B, to $1,200.

If demand is forecast as 'strong', project A would again be selected, and perfect information would improve the profit from $1,500, which would have been earned by selecting B, to $4,000.

Forecast demand	*Probability*	*Project chosen*	*Profit*	*EV of profit*
			$	$
Weak	0.5	B	500	250
Moderate	0.3	A	1,200	360
Strong	0.2	A	4,000	800
		EV of profit with perfect information		1,410

Step 3

	$
EV of profit without perfect information (ie if project B is always chosen)	850
EV of profit with perfect information	1,410
Value of perfect information	560

Provided that the information does not cost more than $560 to collect, it would be worth having.

Question

Decision based on EV of profit

WL must decide at what level to market a new product, the urk. The urk can be sold nationally, within a single sales region (where demand is likely to be relatively strong) or within a single area. The decision is complicated by uncertainty about the general strength of consumer demand for the product, and the following conditional profit table has been constructed.

		Demand		
		Weak	*Moderate*	*Strong*
		$	$	$
Market	nationally (A)	(4,000)	2,000	10,000
	in one region (B)	0	3,500	4,000
	in one area (C)	1,000	1,500	2,000
Probability		0.3	0.5	0.2

Required

Option B should be selected, based on EVs of profit. True or false?

Answer

The correct answer is option B and so the statement is true.

Without perfect information, the option with the highest EV of profit will be chosen.

	Option A (National)		*Option B (Regional)*		*Option C (Area)*	
Probability	*Profit*	*EV*	*Profit*	*EV*	*Profit*	*EV*
	$	$	$	$	$	$
0.3	(4,000)	(1,200)	0	0	1,000	300
0.5	2,000	1,000	3,500	1,750	1,500	750
0.2	10,000	2,000	4,000	800	2,000	400
		1,800		2,550		1,450

Marketing regionally (option B) has the highest EV of profit, and would be selected.

Question

Perfect information

Use the information in your answer to the question above (Decision based on EV of profit).

Required

Calculate the value of perfect information about the state of demand.

Answer

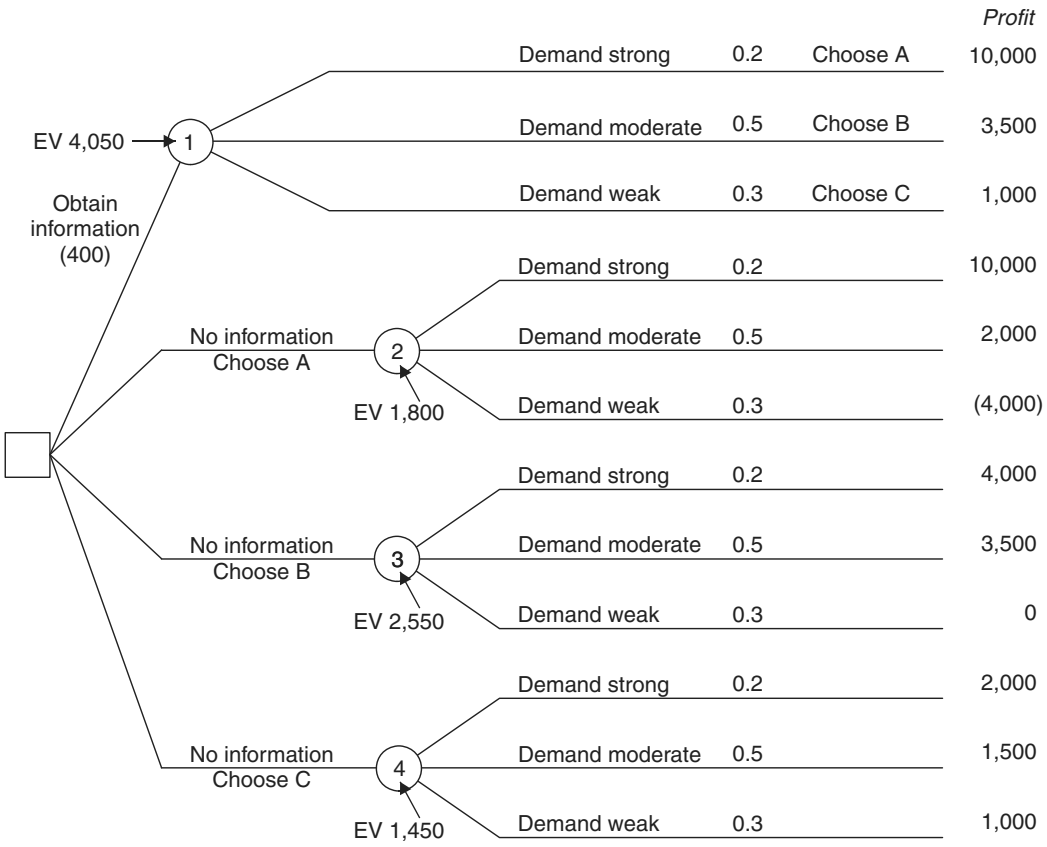
The correct answer is $1,500.

If perfect information about the state of consumer demand were available, option A would be preferred if the forecast demand is strong and option C would be preferred if the forecast demand is weak.

Demand	*Probability*	*Choice*	*Profit*	*EV of profit*
			$	$
Weak	0.3	C	1,000	300
Moderate	0.5	B	3,500	1,750
Strong	0.2	A	10,000	2,000
EV of profit with perfect information				4,050
EV of profit, selecting option B				2,550
Value of perfect information				1,500

6.3 Perfect information and decision trees

When the option exists to obtain information, the decision can be shown, like any other decision, in the form of a decision tree, as follows. We will suppose, for illustration, that the cost of obtaining perfect information is $400.



The decision would be to obtain perfect information, since the EV of profit is $4,050 – $400 = $3,650.

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You should check carefully that you understand the logic of this decision tree and that you can identify how the EVs at outcome boxes 1, 2, 3 and 4 have been calculated.

6.4 The value of imperfect information

There is one serious drawback to the technique we have just looked at: in practice, **useful information is never perfect** unless the person providing it is the sole source of the uncertainty. Market research findings or information from pilot tests and so on are likely to be reasonably accurate, but they can still be wrong: they provide imperfect information. It is possible, however, to arrive at an assessment of **how much it would be worth paying for such imperfect information, given that we have a rough indication of how right or wrong it is likely to be**.

Suppose we are considering the sex and hair colour of people in a given group or population consisting of 70% men and 30% women. We have established the probabilities of hair colourings as follows.

	Men	*Women*
Brown	0.60	0.35
Blonde	0.35	0.55
Red	0.05	0.10

This shows, for example, that 5% of men in such a sample have red hair. These probabilities of sex and hair colouring might be referred to as **prior probabilities**.

Posterior probabilities consider the situation in reverse or retrospect, so that we can ask the question: 'Given that a person taken at random from the population is brown-haired what is the probability that the person is male (or female)?'

The information can be presented in a table. Let's suppose that the population consists of 1,000 people.

	Male	*Female*	*Total*
Brown	420 (W3)	105 (W4)	525 (W5)
Blonde	245	165	410
Red	35	30	65
	700 (W1)	300 (W2)	1,000

Workings

1 1,000 × 70%
2 1,000 – 700
3 700 × 60% (the other two values in the column being calculated in a similar way)
4 300 × 35% (the other two values in the column being calculated in a similar way)
5 420 + 105 (the other two values in the column being calculated in a similar way)

∴ P(Person selected is a male, given that that person is brown-haired) = 420/525 = 0.8

6.4.1 Example: The value of imperfect information

Suppose that the Small Oil Company (SOC) is trying to decide whether or not to drill on a particular site. The chief engineer has assessed the probability that there will be oil, based on past experience, as 20%, and the probability that there won't be oil as 80%.

It is possible for SOC to hire a firm of international consultants to carry out a complete survey of the site. SOC has used the firm many times before and has estimated that if there really is oil, there is a 95% chance that the report will be favourable, but if there is no oil, there is only a 10% chance that the report will indicate that there is oil.

Required

Determine whether drilling should occur.

Solution

Read the information given carefully. We are given *three* sets of probabilities.

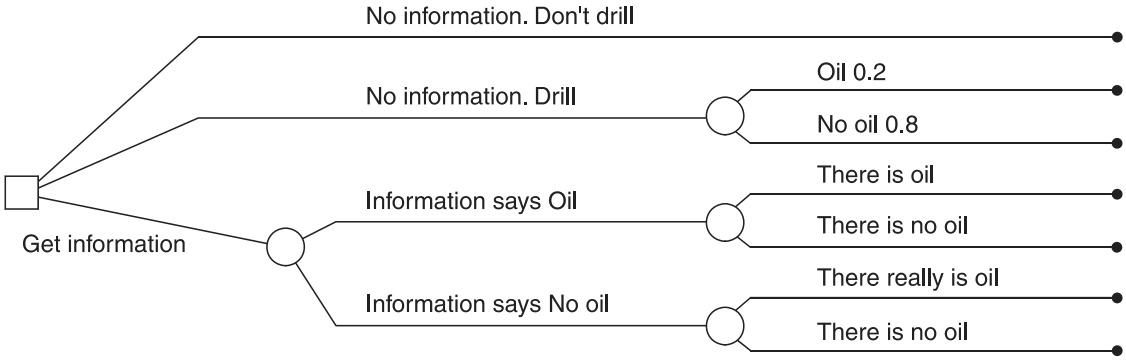
(a) The probability that there will be oil (0.2) or there will not be (0.8). These outcomes are mutually exclusive.

(b) The probability that, if there is oil, the report will say there is oil (0.95) or say there is no oil (0.05).

(c) The probability that, if there is no oil, the report will say there *is* oil (0.1) or say there is no oil (0.9).

Both (b) and (c) describe conditional events, since the existence of oil or otherwise influences the chances of the survey report being correct.

SOC, meanwhile faces a number of choices which we can show as a decision tree.



We must now calculate the probabilities of the following outcomes.

- The information will say 'oil' or 'no oil'
- The information will be right or wrong if it says 'oil'
- The information will be right or wrong if it says 'no oil'

If you check the information given in the problem, you will find that these probabilities are not given.

(a) We are told that the engineer has assessed that there is a 20% chance of oil and an 80% chance of no oil (ignoring information entirely). These are the **prior probabilities** of future possible outcomes.

(b) The **probabilities that there will be oil or no oil once the information has been obtained are posterior probabilities**.

Step 1 We can tabulate the various probabilities as percentages.

		Actual outcome					
		Oil		*No oil*		*Total*	
Survey	oil	19	(W2)	8	(W3)	27	(W4)
result:	no oil	1		72		73	
Total		20	(W1)	80		100	

Workings

1 The engineer estimates 20% probability of oil and 80% of no oil.

2 If there is oil, ie in 20 cases out of 100, the survey will say so in 95% of these cases, ie in $20 \times 0.95 = 19$ cases. The 1 below the 19 is obtained by subtraction.

3 In the 80 per 100 cases where there is in fact no oil, the survey will wrongly say that there is oil 10% of the time; ie $80 \times 0.10 = 8$ cases. The 72 below the 8 is obtained by subtraction.

4 The horizontal totals are given by addition.

Step 2 We can now provide all the probabilities needed to complete the tree.

P (survey will say there is oil) = 27/100 = 0.27

P (survey will say there is no oil) = 73/100 = 0.73

If survey says oil	P (there is oil)	= 19/27 = 0.704
	P (there is no oil)	= 8/27 = 0.296 (or 1–0.704)
If survey says no oil	P (there is oil)	= 1/73 = 0.014
	P (there is no oil)	= 72/73 = 0.986 (or 1–0.014)

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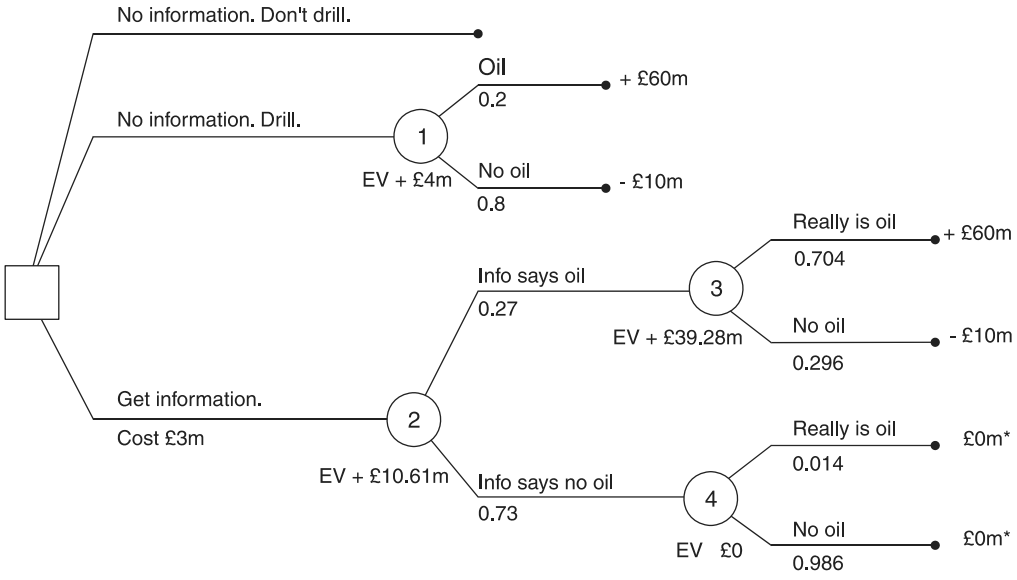
Step 3 We can now go on to complete the decision tree. Let us make the following assumptions. (In an exam question such information would have been given to you from the start.)

- The cost of drilling is $10m.
- The value of the benefits if oil is found is $70m, giving a net 'profit' of $60m.
- The cost of obtaining information from the consultants would be $3m.

An assumption is made that the decision maker will take whichever decision the information indicates is the best. If the information says 'oil', the company will drill, and if the information says 'no oil' it will not drill.



* The information is 'no oil', so the company won't drill, regardless of whether there really is oil or not.

Step 4 We can now perform rollback analysis.

		$m
EV at point 3 =	$0.704 \times \$60m$	42.24
	$0.296 \times (\$10m)$	(2.96)
		+ 39.28

		$m
EV at point 2 =	$0.27 \times \$39.28m$	10.61
	$0.73 \times \$0$	0.00
		+ 10.61

Step 5 There are three choices.

		EV
(a)	Do not obtain information and do not drill	$0
(b)	Do not obtain information and drill	+$4 million
(c)	Obtain information first, decide about drilling later ($(10.61m – 3m))	+$7.61 million

The decision should be to obtain the information from a survey first.

Step 6 The value of the imperfect information is the difference between (b) and (c), $3.61 million.

7 Sensitivity analysis 12/08

FAST FORWARD

Sensitivity analysis can be used in any situation so long as the relationships between the key variables can be established. Typically this involves changing the value of a variable and seeing how the results are affected.

7.1 Approaches to sensitivity analysis

Key term

> **Sensitivity analysis** is a term used to describe any technique whereby decision options are tested for their vulnerability to changes in any 'variable' such as expected sales volume, sales price per unit, material costs, or labour costs.

Here are three useful approaches to sensitivity analysis.

(a) To estimate by **how much costs and revenues would need to differ** from their estimated values before the decision would change.

(b) To estimate whether a decision would change if estimated costs were **x% higher** than estimated, or estimated revenues **y% lower** than estimated.

(c) To estimate by how much costs and/or revenues would need to differ from their estimated values before the decision maker would be **indifferent** between two options.

The essence of the approach, therefore, is to carry out the calculations with one set of values for the variables and then substitute other possible values for the variables to see how this affects the overall outcome.

(a) From your studies of information technology you may recognise this as **what if analysis** that can be carried out using a **spreadsheet**.

(b) From your studies of **linear programming** you may remember that sensitivity analysis can be carried out to determine over which ranges the various constraints have an impact on the optimum solution.

(c) **Flexible budgeting** can also be a form of sensitivity analysis.

7.2 Example: Sensitivity analysis

Sensivite has estimated the following sales and profits for a new product which it may launch on to the market.

		$	$
Sales	(2,000 units)		4,000
Variable costs:	materials	2,000	
	labour	1,000	
			3,000
Contribution			1,000
Less incremental fixed costs			800
Profit			200

Required

Analyse the sensitivity of the project.

Solution

(a) If incremental **fixed costs** are more than 25% above estimate, the project would make a loss.

(b) If **unit costs of materials** are more than 10% above estimate, the project would make a loss.

(c) Similarly, the project would be sensitive to an **increase in unit labour costs** of more than $200, which is 20% above estimate, or else to a drop in the **unit selling price** of more than 5%.

(d) The **margin of safety**, given a breakeven point of 1,600 units, is (400/2,000) × 100% = 20%.

Management would then be able to judge more clearly whether the product is likely to be profitable. The items to which profitability is most sensitive in this example are the selling price (5%) and material costs (10%). Sensitivity analysis can help to **concentrate management attention** on the most important factors.

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8 Simulation models 12/08

FAST FORWARD

Simulation models can be used to deal with decision problems involving a number of uncertain variables. **Random numbers** are used to assign values to the variables.

One of the chief problems encountered in decision making is the uncertainty of the future. Where only a few factors are involved, probability analysis and expected value calculations can be used to find the most likely outcome of a decision. Often, however, in real life, there are so **many uncertain variables** that this approach does not give a true impression of possible variations in outcome.

To get an idea of what will happen in real life one possibility is to use a **simulation model** in which the **values and the variables are selected at random**. Obviously this is a situation **ideally suited to a computer** (large volume of data, random number generation).

The term 'simulation' model is often used more specifically to refer to modelling which **makes use of random numbers**. This is the **'Monte Carlo'** method of simulation. In the business environment it can, for example, be used to examine inventory, queuing, scheduling and forecasting problems.

Random numbers are allocated to each possible value of the uncertain variable in proportion to the probabilities, so that a probability of 0.1 gets 10% of the total numbers to be assigned. These random numbers are used to assign values to the variables.

Exam focus point

You will **not** be required to develop a simulation model in your exam. The following example is provided so that you can **understand** how simulation models are developed.

8.1 Example: Simulation and spreadsheets

A supermarket sells a product for which the daily demand varies. An analysis of daily demand over a period of about a year shows the following probability distribution.

Demand per day Units	*Probability*
35	0.10
36	0.20
37	0.25
38	0.30
39	0.08
40	0.07
	1.00

To develop a simulation model in which one of the variables is daily demand, we would **assign a group of numbers to each value for daily demand**. The probabilities are stated to two decimal places, and so there must be 100 random numbers in total, 00 – 99 (we use 00-99 rather than 1-100 so that we can use two-digit random numbers.) Random numbers are assigned in proportion to the **probabilities**, so that a probability of 0.1 gets 10% of the total numbers to be assigned, that is 10 numbers: 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9.

The assignments would therefore be as follows.

Demand per day Units	*Probability*	*Numbers assigned*
35	0.10	00 – 09
36	0.20	10 – 29
37	0.25	30 – 54
38	0.30	55 – 84
39	0.08	85 – 92
40	0.07	93 – 99

When the simulation model is run, random numbers will be generated to derive values for daily demand. For example, if the model is used to simulate demand over a ten day period, the random numbers generated might be as follows.

19007174604721296802

The model would then **assign values** to the demand per day as follows.

Day	*Random number*	*Demand*
		Units
1	19	36
2	00	35
3	71	38
4	74	38
5	60	38
6	47	37
7	21	36
8	29	36
9	68	38
10	02	35

You might notice that on none of the ten days is the demand 39 or 40 units, because the random numbers generated did not include any value in the range 85 – 99. When a simulation model is used, there must be a long enough run to give a good representation of the system and all its potential variations.

8.2 Uses of simulation

In the supermarket example above, the supermarket would use the information to minimise inventory holding without risking running out of the product. This will reduce costs but avoid lost sales and profit.

A supermarket can also use this technique to estimate queues with predicted length of waiting time determining the number of staff required.

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Chapter Roundup

- An example of a **risky situation** is one in which we can say that there is a 70% probability that returns from a project will be in excess of $100,000 but a 30% probability that returns will be less than $100,000. If we cannot predict an outcome or assign probabilities, we are faced with an **uncertain** situation.
- People may be **risk seekers**, **risk neutral** or **risk averse**.
- Management accounting directs its attention towards the **future** and the future is **uncertain**. For this reason a number of methods of taking **uncertainty** into consideration have evolved.
- **Market research** can be used to reduce uncertainty.
- **Expected values** indicate what an outcome is likely to be in the long term with repetition. Fortunately, many business transactions do occur over and over again.
- The 'play it safe' basis for decision making is referred to as the **maximin basis**. This is short for '**maximise the minimum achievable profit**'.
- A basis for making decisions by looking for the best outcome is known as the **maximax basis**, short for **'maximise the maximum achievable profit'**.
- The 'opportunity loss' basis for decision making is known as **minimax regret**.
- **Decision trees** are diagrams which illustrate the choices and possible outcomes of a decision.
- **Rollback analysis** evaluates the EV of each decision option. You have to work from right to left and calculate EVs at each outcome point.
- **Perfect information** is guaranteed to predict the future with 100% accuracy. **Imperfect information** is better than no information at all but could be wrong in its prediction of the future.
- The **value of perfect information** is the difference between the EV of profit with perfect information and the EV of profit without perfect information.
- **Sensitivity analysis** can be used in any situation so long as the relationships between the key variables can be established. Typically this involves changing the value of a variable and seeing how the results are affected.
- **Simulation models** can be used to deal with decision problems involving a number of uncertain variables. **Random numbers** are used to assign values to the variables.

Quick Quiz

1 *Match the terms to the correct definitions.*

Terms

(a) Risk seeker
(b) Risk neutral
(c) Risk averse

Definitions

1 A decision maker concerned with what will be the most likely outcome
2 A decision maker interested in the best outcomes no matter how small the chance that they may occur
3 A decision maker who acts on the assumption that the worst outcome might occur

2 *Fill in the blanks.*

(a) Maximin decision rule: choosing the alternative that ……..…... the ……..…..……..
(b) Minimax decision rule: choosing the alternative that ……..… the ……..…..……....
(c) Maximax decision rule: choosing the alternative that …….…… the……...……...
(d) Minimin decision rule: choosing the alternative that …….…….. the…....……

3 How is expected value calculated?

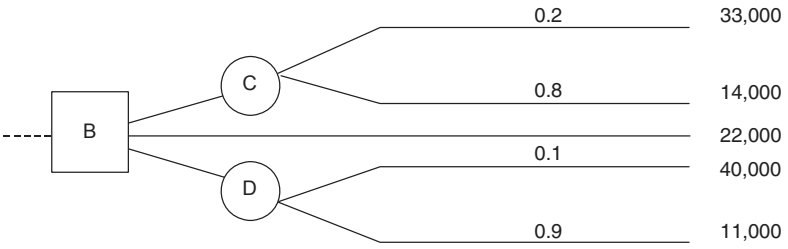
A Σpx
B $p\Sigma x$
C $e\Sigma px$
D $x\Sigma p$

4 *Tick the correct boxes to indicate the usefulness of expected values as a guide to decision making in the following decisions.*

	Most useful	Not as useful
(a) Whether to change the logo painted on the window of 700 retail outlets		
(b) Whether to purchase machine X or machine Y		
(c) Whether to launch product A		
(d) Deciding on the optimum daily purchases of a perishable item		

5 If the decision maker is trying to maximise the figure, what figure would the decision maker choose at point B in the diagram below?

A 40,000
B 11,800
C 13,900
D 22,000



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Answers to Quick Quiz

1 (a) 2; (b) 1; (c) 3

2 (a) Maximise, minimum profits
(b) Minimise, maximum costs/losses
(c) Maximise, maximum profits
(d) Minimise, minimum costs/losses

3 A

4 Expected values would be useful for decisions (a) and (d) because they are repeated several times.

5 D Choice between ((0.2 × 33,000) + (0.8 × 14,000)) = 17,800 at C, 22,000, and ((0.1 × 40,000) + (0.9 × 11,000)) = 13,900 at D.

Now try the question below from the Exam Question Bank

Number	Level	Marks	Time
Q11	Examination	20	36 mins

RISK

The capital investment decision is necessarily a long-term decision. When forecasting potential benefits there will always be an element of risk and uncertainty in the figures to be achieved. This makes any **result** uncertain i.e. A positive or negative NPV may not be a reliable estimate of the attractiveness of a project. We may consider the impact of risk on a project using the following techniques:

1. **Expected values**
2. **Payback Period**
3. **Adjusted discount rates**
4. **Sensitivity analysis**

Expected values

Where there are a range of possible outcomes which can be identified and a probability distribution can be attached to those values. In this situation then we may use a variety of techniques to establish some sort of '**average**' return. The measure of average return is then assumed to be the value that we should use. The expected value is the arithmetic mean of the outcomes as expressed below:

$$EV = \Sigma px$$

Where P = the probability of an outcome
x = the value of an outcome

Payback Period

Estimates of cash flows several years ahead are quite likely to be inaccurate and unreliable. It may be difficult to control capital projects over a long period of time. Risk may be limited by selecting projects with short payback periods.

Adjusted discount rates

The discount rate we have assumed so far is that reflecting the cost of capital of the business. In simple terms this means that the rate reflects either the cost of borrowing funds in the form of a loan rate or it may reflect the underlying return of the business (i.e. the return required by the shareholder), or a mix of both.

An individual investment or project may be perceived to be more risky than existing investments. In this situation the increased risk could be used as a reason to adjust the discount rate up to reflect the additional risk. Such a technique does not consider risk directly, but the application of increased discount rate is often successful in eliminating marginal projects. These projects often are the self-same projects that would not achieve the required return. The addition to the usual discount rate is called the **Risk Premium**.

Although a slightly rough and ready technique, it has an underlying logic and in practice is very useful.

Sensitivity Analysis

Where the variables of the project are identified, if we are looking at investment appraisal this may include the following:

- Initial investment
- Discount rate
- Future expected sales or revenues
- Cost base per annum

A NPV is calculated for a project. This NPV is then altered by changing a single variable of the sum. The idea is to see by how much the value must change before the decision changes (say from accept to reject).

A single variable is changed in isolation from the original sum.

This maximum possible change is often expressed as a percentage;

$$\text{Sensitivity margin} = \frac{\text{NPV}}{\text{PV of flow under consideration}}$$

Example

An investment of $40,000 in year 0 is expected to give rise to annual contribution of $25,000 and annual fixed cost of $10,000 for each of years 1 to 4; the discount rate is 10%

Required

(a) Should we accept or reject the investment based on NPV analysis?

(b) By how much would the values have to change for the decision to alter for:

(i) Initial investment?
(ii) Contribution?
(iii) Fixed costs?
(iii) Discount rate?