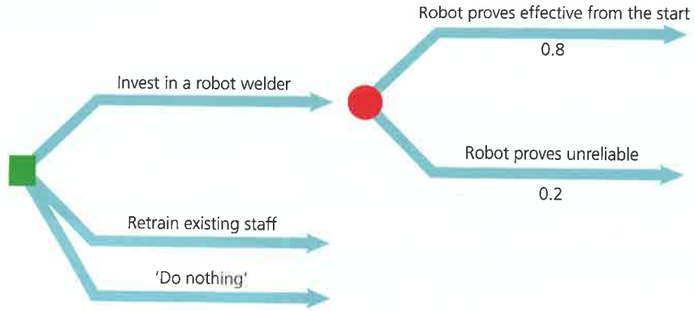

Figure 13.3

Note carefully that a square means a decision and a circle means a chance event, i.e. one of two or more events may follow. Therefore:

- there must be a probability attached to each of the chance events or alternatives
- these probabilities must add up to 1 as one of them must happen.

In Figure 13.2, the decision-maker has allowed for an 80 per cent (0.8) chance that the robot will work well and a 20 per cent (0.2) chance that it will prove unreliable. These figures could be arrived at from experience with robots in the past.

At any square, the decision-maker has the power to choose which branch to take, but at the circles chance takes over. You can choose whether or not to invest in a robot. But there is a chance that the robot may prove unreliable. The full tree so far is shown in Figure 13.3.

The decision-maker will choose which branch provides the better or best value.

If buying costs a net cash outflow of £1,000 per year while hiring costs £800, it is better to hire (see Figure 13.4).

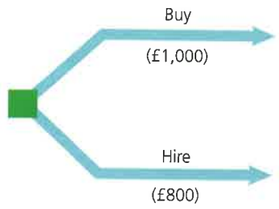

Figure 13.4

Note that the branch not taken is crossed out, as shown in Figure 13.5.

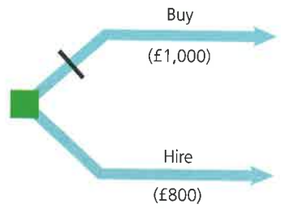

Figure 13.5

Step 2: drawing a decision tree

Bantox plc must decide whether to launch a new product (see Figure 13.6).

Figure 13.6

Research suggests there will be a 70 per cent chance of success in a new product launch. This would be shown as a probability of 0.7 (see Figure 13.7).

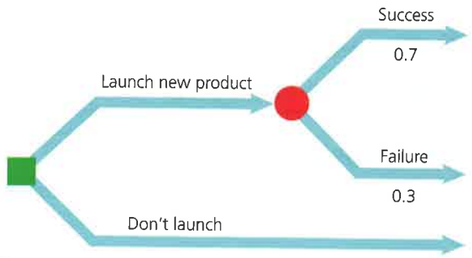

Figure 13.7

Note that, because probabilities must add up to 1, the implied chance of failure is 0.3.

To make a decision based on the above tree, estimates are needed of the financial costs and returns. In this case, let's assume:

- the new product launch will cost £10 million
- a new product success will generate £15 million of positive net cash flows
- a new product failure will generate only £3 million
- no launch means no movements in net cash.

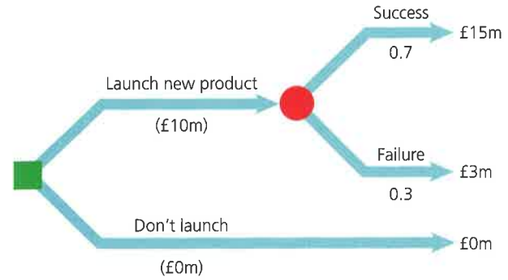

Figure 13.8

The full decision tree now looks like Figure 13.8.

Step 3: making calculations

At each probability circle, a calculation is required of the average outcome, given the probabilities involved. If a launch costing £10 million will generate either £15 million or £3 million, what will be the average result if the same circumstances happened several times over? Sometimes the firm would get £15 million and sometimes £3 million. Usually, to work out an average, you would add the numbers and divide by 2; that is:

$$\frac{£15m + £3m}{2} = £9m$$

That assumes, though, that there is an equal chance of £15 million and £3 million. In fact, the probabilities are not 50/50, they are 70/30. There is a 70 per cent chance of £15 million. So the correct (weighted) average **expected value** is:

£15m × 0.7	= £10.5m
£3m × 0.3	= £0.9m
Total	£11.4m

In decision trees, the expected values at probability circles are always calculated by weighted averages.

Calculations on decision trees are carried out from right to left, that is, working backwards through the tree, making calculations at each probability circle.

In the case of Bantox, only one calculation is needed. If there are several circles, it is helpful to number them, and show your weighted average calculations clearly (see Figure 13.9).

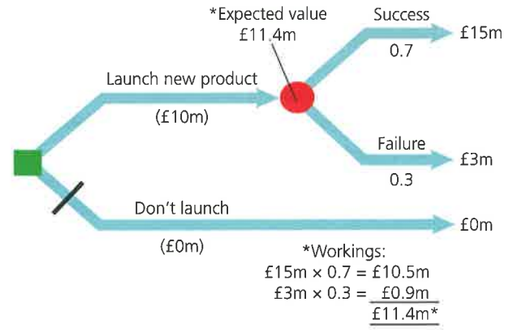

Figure 13.9

Step 4: showing your decisions

Having calculated the expected value (weighted average) at each probability circle, a rational decision can be made. As Figure 13.9 shows, launching the new product will, on average, turn £10 million into £11.4 million, i.e. generate a **net gain** of £1.4 million. Therefore it is preferable to launch. The decision to launch is indicated by crossing out the 'don't launch' option.

13.3 Summary of key points

A decision tree is a diagrammatic presentation of a problem involving decisions (squares) and chance events (circles).

1 The problem is laid out from left to right. Decisions are shown as squares, chance events as circles.

2 Each chance event has a probability estimated for it. The probabilities must add up to 1 since one of them must happen.

3 Two money values are shown:

   a) the cost of the decision (shown as a negative number, i.e. in brackets)

   b) the benefit or cost of a specific outcome occurring. These are shown at the end of each branch of the tree.

4 Working from right to left, the decision-maker calculates the expected value at each circle. These values are calculated by multiplying the money value by the probability, then adding the results.

5 Still working from right to left, the decision-maker decides at each square which branches to cross off, leaving only the better or best alternative open.

Real business

In 2014, the Head of Volkswagen America learned that the company's diesel cars were showing artificially low emissions data to the US regulators. He then faced a choice: go public, with the near-certain consequence of bad publicity and falling sales; or keep quiet, with a high chance that no one would ever know, but a huge scandal if the company were caught out. So the probability of being caught was perhaps as low as 0.2, but the cost might be huge if it became public knowledge. In September 2015 the diesel emissions scandal burst on the world; quite quickly analysts were talking of an eventual cost to the company of perhaps $50 billion.

Figure 13.10

The US Head of Volkswagen was caught out. It might be said that he was unlucky. Or perhaps he should have ignored probabilities and chosen the morally correct option of stopping the manipulation of the data.

'Probability is the very guide of life.'

Thomas Hobbes, seventeenth-century philosopher

'We should never allow ourselves to be bullied by an either-or. There is often the possibility of something better than either of these two alternatives.'

Mary Parker Follett, business writer (1868–1933)

'Compromise is usually bad ... listen to both sides then pick one or the other.'

Robert Townsend, author of Up the Organisation

13.4 Advantages and limitations of decision trees

Advantages of using decision trees

1 The most important advantage of the technique is allowing for uncertainty. The most common technique for business decision-making is investment appraisal. This is based upon a single forecast of future cash flows, giving a bogus impression of certainty. In reality, every decision can result in a range of possible outcomes, not just one. The decision tree allows for this. By focusing firms on uncertainty, decision trees can help to ensure that managers' decisions are more carefully considered.

2 Decision trees also demand that managers consider all the possible alternative outcomes. Although it is important to be single-minded, too many managers adopt a strategy without fully considering the alternatives. They perhaps choose the approach that worked last time, or the one adopted by their competitors. Decision trees not only encourage careful consideration of the options, but also require an estimate of the actual outcome for each. This allows 'best case' and 'worst case' scenarios to be costed and considered.

Further advantages of decisions trees are set out below.

1 Decision trees set out problems clearly and encourage a logical approach. The discipline of setting out the problem in a decision tree requires logical thinking and can also generate new ideas and approaches.

2 Decision trees encourage a quantitative approach and force assessments of the chances and implications of success and failure.

3 Decision trees not only show the average expected values for each decision but also set the probability of a specific outcome occurring.

4 Decision trees are most useful when similar scenarios have occurred before so that good estimates for probabilities and predicted **actual values** exist.

5 Decision trees are most useful in tactical or routine decisions, rather than strategic decisions.

Limitations of using decision trees

All quantitative methods can be biased, consciously or unconsciously. Optimism is often a virtue in an executive, but it may lead to exaggerated sales figures or excessively high probabilities for success. This does not mean quantitative methods should be rejected, only that it is sensible to ask who provided the figures and assess whether they had any reason to want a particular outcome. Cynicism about decision trees is out of place; scepticism is wholly valid.

Further limitations of decision trees are set out below.

1 It may be difficult to get meaningful data, especially for estimated probabilities of success or failure.

2 Decision trees are less useful in the case of completely new problems or one-off strategic problems.

3 It can be relatively easy for a manager seeking to prove a case to manipulate the data. A biased approach to the estimated probabilities or values could 'prove' the pre-desired result rather than the logically determined outcome.

4 Decision trees may divert managers from the need to take account of qualitative as well as quantitative information when making a decision.

Five whys and a how

Questions	Answers
Why may decision tree analysis be more useful than investment appraisal?	Because it takes into account alternative possible outcomes and the probability of them occurring (investment appraisal is misleadingly 'certain').
Why are expected values calculated using a 'weighted' rather than a straight average?	Because it's the only way to gain accuracy when there are different probabilities of the possible outcomes occurring.
Why may the decision tree technique be useful even if you have no sound basis for estimating the probabilities?	The tree diagram will still indicate the best and worst possible outcomes – a vital part of decision-making (if the worst outcome would threaten the firm's survival, you'd say no).
Why may there be dangers in the apparent 'scientific' precision of the decision tree technique?	People may assume that the technique delivers more accuracy than is true given the degree of estimation involved.
Why may decision trees risk side-lining qualitative factors?	Because people are swayed by a 'definite', numerical 'answer' to a problem – so they subconsciously play down qualitative factors.
How are calculations done after the decision tree is drawn up?	Working back from right to left, calculating the weighted average at every chance node, then cutting off the less profitable decisions.

'One accurate measurement is worth a thousand expert opinions.'

Grace Hopper, computer scientist and US Navy Rear Admiral

'Exactitude is not truth.'

Henri Matisse, post-impressionist painter

'Human decisions affecting the future .... cannot depend on strict mathematical expectation.'

John Maynard Keynes, economist

13.5 Decision trees – evaluation

Small firms run by one person benefit from clear, speedy decision-making. The entrepreneur knows the customers, the competition and the staff. Therefore he or she can make effective decisions quickly, with no need to justify them to others. Some may prove faulty, but the quick responses of a small firm should ensure that damage is limited. The business will stand or fall on the hunches and judgements of the boss.

In large firms, the same rules do not apply. A successful career path at a company such as Mars or Unilever often depends upon avoiding mistakes. Therefore it is important to be able to justify why a decision was made. Even if it proves to be wrong, that should not matter as long as the method for making the decision was thorough and analytic. After all, if four out of five new products prove to be failures, what would be the reason for firing a manager who has just launched a flop?

It can be a matter for regret that methods such as decision trees are used to 'protect the back' of decision-makers. In other words, they may not be valued for themselves, only for their value as a protector. Often, though, the process of trying to protect themselves encourages managers to think hard about their decision-making methods. Those who use decision trees positively may find an improvement in their record of success, and help the big firms to compete with the faster-moving small firms.

Key terms

Actual values: although known as 'actual values' or 'payoffs', these are the forecasts of the net cash flow which result from following a sequence of decisions and chance events through a decision tree. They should always be shown at the ends of the branches of the tree.

Expected values: these are the forecast actual values adjusted by the probability of their occurrence. Although called 'expected', they are not the actual cash flows which result. Expected equals actual times probability.

Net gains (or losses): subtracting the initial outlay from the expected value to find out whether or not a decision is likely to produce a surplus.

Node: a point in a decision tree where chance takes over. It is denoted by a circle, and at that point it should be possible to calculate the expected value of this pathway.

Probability: the likelihood of something occurring. This can be expressed as a numerical value, which can be a percentage (for example 50 per cent chance), a fraction (for example $\frac{1}{2}$), or a decimal (for example 0.5). The probability of something certain is 100 per cent or 1. The probability of something impossible is zero. So probabilities range from 1 to zero.

13.6 Workbook

Revision questions

(30 marks; 30 minutes)

1 When drawing a decision tree, what symbol is used to show:
   - **a)** when a decision must be made
   - **b)** when chance takes over? (2)

2 If the probability of the successful launch of a new product is estimated to be 0.72, the probability of a failed launch must be 0.28. Explain why. (3)

3 State whether each of the following is a decision or a chance event:
   - **a)** choosing between three different new product options
   - **b)** a new product succeeding or failing in the marketplace
   - **c)** good weather on the day of the open air concert
   - **d)** whether to advertise or to cut the price. (4)

4 Explain the difference between an expected value and an actual value. (3)

5 State three advantages and three potential pitfalls of using decision trees. (6)

6 Explain the circumstances when decision trees are least useful. (4)

7 If the chance of achieving £200,000 is 0.2 and the chance of £20,000 is 0.8, what is the expected value of a decision? (4)

8 Explain how decision trees may help managers to assess the best decision by 'what if?' analysis. (4)

Revision activity

Look at the tree diagram below. Calculate the expected values at nodes 1–4 and state your decisions at decision points A–C. Indicate your decisions on the tree diagram.

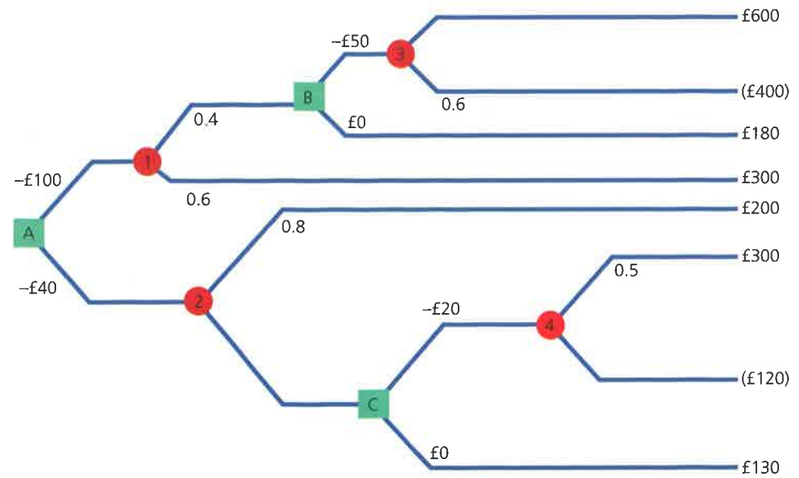

Figure 13.11

Revision activities

Data response 1

Denham Potteries has a capital spending budget of £100,000. The production manager has put in a bid for £100,000 for a new tunnel kiln. The marketing manager has countered with a proposal to spend £80,000 on launching a new product. This new product is in line with the firm's objective of diversifying, but may be rather risky given the firm's past record of only one success for every five new products.

Ken Coton, the marketing manager, has provided a handy table of figures to summarise the information. This is set out in Table 13.1.

Outcome	Probability (surplus over next 5 years)	Actual value (£)
New product		
Big success	0.1	900,000
Modest success	0.1	500,000
Failure	0.8	30,000
Tunnel kiln		
Success	0.8	200,000
Failure	0.2	60,000

Table 13.1 Denham Potteries

Questions (25 marks; 30 minutes)

1 Draw a fully labelled decision tree to set out the options. (10)

2 What decision should the firm make on purely numerical grounds? (3)

3 Outline the qualitative factors the board should take into account before making the decision. (12)

Data response 2

Mansfield Town FC is considering buying a South American centre forward player for its team. The club knows statistics show that only one in four overseas forwards succeeds in the lower divisions. But things are desperate. The player's contract will cost £500,000 and, if successful, could increase home attendances sufficiently to be worth £1.2 million over the three-year contract. Even if the player is unsuccessful, attendances should rise by £200,000.

Questions (20 marks; 15 minutes)

1 Draw a decision tree and label it carefully. (12)

2 On the basis of the tree, what decision should the club take? (4)

3 Outline two reasons why the club might decide to proceed. (4)

Data response 3

The research and development department in Gregson plc has just invented a new higher-quality version of the product sold by a rival business, Winder plc. The product is code-named 'Copycat'. At present Gregson lacks the technology to manufacture the product itself. After further research, it decides there are three immediate choices:

1 buy the technology to manufacture the product itself

2 sell all rights to Winder plc

3 sell all rights on a royalty basis to a third company.

The marketing department believes that Copycat, as it stands, has a 50 per cent chance of success, with no further development.

However, the research and development department in Gregson believes it could improve Copycat still further by some design enhancements. However, it only wants to do so if Copycat had already succeeded and if choice 2 above had not been taken. After design enhancement, the chance of a successful launch is estimated to be 60 per cent.

The forecast actual values are shown in Table 13.2.

Questions (25 marks; 30 minutes)

1 Prepare a decision tree to illustrate this situation, showing branches, probabilities, and actual values. (9)

2 Calculate the expected values. (4)

3 Explain the optimal decision strategy based on these calculations. (4)

4 Assess two other factors which Gregson may take into account before making the final decision. (8)

Decision outcome	Manufacture	Sell all rights to Winder	Sell on a royalty basis to a third company
Fails before design enhancement	–262.5	15	7.5
Succeeds after design enhancement	375	–	300
Succeeds but no design enhancement	150	15	82.5
Fails after design enhancement	–412.5	–	–142.5

Table 13.2 Forecast actual values for Gregson (all figures in £000s)

Extended writing

1 Whitbread plc made the brilliant decision in 2000 to move out of the beer market and concentrate on coffee (Costa) and hotels (Premier Inn). Evaluate the importance of decision trees when making long-term strategic decisions such as this. (20)

2 A restaurant business is considering opening its first outlet in America. Evaluate whether investment appraisal or decision trees are more likely to be useful on this occasion. (20)

14 Critical Path Analysis (CPA)

Definition

Critical Path Analysis is based on a network diagram that sets out which activities within a project can be done simultaneously and which must be done consecutively. A network diagram helps to identify the critical path – the activities that require the most careful management scrutiny.

Linked to: Corporate strategy, Ch 2; Human resources, Ch 21; Scenario planning, Ch 4

14.1 Introduction

Time has become an increasingly important competitive advantage, such as when two rivals are each trying to be first to market with a new product or business idea. To be first requires careful planning. The plan is turned into a critical path diagram to show supervisors and workers exactly what they should be doing: what, when and how. This provides the basis for monitoring and controlling actual progress to make sure the project is completed on time.

Network analysis is a way of showing how a complex project can be completed in the shortest possible time. It identifies the activities that must be finished on time to avoid delaying the whole project. These activities represent the **critical path**. Management effort can be concentrated on ensuring that these key activities are completed on time. This leaves greater flexibility in timing the non-critical items. The objectives are to ensure customer satisfaction through good timekeeping and to minimise the wastage of resources, thereby boosting the profitability of the project.

A **network** shows:

- the order in which each task must be undertaken
- how long each stage should take
- the earliest date at which the later stages can start.

If a house-building firm can predict with confidence that it will be ready to put roof beams in place 80 days after the start of a project, a crane can be hired and the beams delivered for exactly that time. This minimises costs, as the crane need only be hired for the day it is needed, and improves cash flow by delaying the arrival of materials (and invoices) until they are really required.

Figure 14.1 Network analysis can help building firms estimate when they will need materials and equipment

'In preparing for battle I have always found that plans are useless, but planning is indispensable.'

Dwight Eisenhower, former US General and US President

14.2 Drawing Critical Path Analysis diagrams

A Critical Path Analysis (CPA) network consists of two components.

1 An 'activity' is part of a project that requires time and/or resources. Therefore waiting for delivery of parts is an 'activity', as is production. Activities are shown as arrows running from left to right. Their length has no significance.

2 A 'node' is the start or finish of an activity and is represented by a circle. All network diagrams start and end on a single node.