Decision trees assume that there are only two types of situation that a manager can encounter. The first is where the manager has the power to determine what happens next. This is known as a decision. He can do what he wants when faced with a decision, but we expect him to behave rationally. In a business, he will choose the most profitable course of action. In a not-for-profit organisation, the lowest-cost choice is rational. The second situation is where the manager has no control over what happens next. This is known as an event. For each event, the manager needs to know both what the possible outcomes are and the probability of each outcome. Determining the outcomes and their probabilities can be tricky. Past experience may provide some guidance, but judgment is usually also required.

Let’s consider how a decision tree can help to solve a problem. A CIMA student is deciding how to get to college one morning. One alternative is to take public transport and pay a £5 fare. The other is to walk to college and avoid having to pay the fare. If this were all that there was to the problem, the decision would be simple: the student would be £5 better off by walking. But, of course, there are some more factors to consider. At this time of year there is a 25 per cent chance that it will rain during his journey. A downpour isn’t a problem if the student takes public transport. But if it rains while he’s walking, his clothes will get wet and he’ll need to spend £10 on dry-cleaning.

This example contains one decision (to walk or take public transport) and one event (whether or not it rains). Panel 1 shows a decision tree to show this decision and event, together with the numbers that have also been provided. Note that a decision is represented by a rectangle (a decision node) and an event by a circle (an event node). From this we can see that the key decision is whether the student will take public transport or walk. If he takes public transport, there is an immediate financial impact: a cost of £5, which has been marked on the diagram in red. Walking has no immediate financial impact, so for completeness this has been marked as £0. The diagram also recognises the key issue of whether or not it will rain. As you can see, this has been shown twice as an event node: once for the “public transport” branch and once for the “walk” branch. In each case the two possible outcomes (“yes” and “no”) have been noted, together with their respective probabilities in green. On the right-hand side of the tree, the data to the right of every node is the consequence of a decision node and marked in red. We will soon see how these blue and red values are brought together.

At this stage the decision tree provides a useful visual representation of the problem facing our student. But it allows us to go further: we can use it to evaluate the data to make a decision. Two further values, one each under the two event nodes, can be added in orange. Before reading on, see if you can identify how these two values have been calculated.

If you recall your earlier studies of probabilities and expected values (EVs), you may have spotted that these additional values are the expected values of each of the two event nodes. The two EVs are calculated as follows:

- On the “public transport” branch: (£5 x 0.25) + (£0 x 0.75) = 0
- On the “walk” branch: (-£10 x 0.25) + (£0 x 0.75) = -£2.50

For each of the event nodes, all of the data to the right of the node has been simplified into a single figure by using EVs. This is the way that decision trees are evaluated. Starting from the right-hand side of the tree, the data to the right of every node is simplified into a single figure based on EVs. When we have evaluated the node at the left-hand side of the tree, we then have the information we require to make the decision.

With decision nodes, we make a rational choice based on the data to the right of the node. Should our student walk or use public transport? If we examine the “public transport” branch, we see that there is a cost of £5 but that the EV of the event node is zero. If we total these two amounts, the cost to our student is £5.
The "walk" branch has no cost, but the EV of the event node is a cost of £2.50. If we add these two amounts, the cost is £2.50, which is less than the cost of using public transport. So, if it’s based on these financial issues only, the decision will be to walk. We can finish off the diagram by ticking the decision branch we have chosen and crossing out the other one.

This example is very simple – our student could have solved it in his head. It’s when the scenario is more complex that decision trees can be particularly useful. So let’s give our student something more to think about. Suppose that he can take an umbrella if he decides to walk. If he does this and it rains, the umbrella will keep him dry and there’ll be no need to spend £10 on dry-cleaning. The problem is that our student is forgetful. There is a ten per cent chance that, having taken the umbrella to college, he will lose it there. The cost of replacing it is £20. Before you look at panel 2, try preparing your own decision tree to recommend what the student should do. (A hint: if he goes by public transport, there’s no point in taking the umbrella.)

Did you successfully identify that the best solution is to walk to college with the umbrella? We already knew from the first example that walking without the umbrella was preferable to going by public transport, but the decision tree now tells us that taking the umbrella as well as walking is an even better decision.

Decision trees can be applied to a variety of business decision-making scenarios. Examples might include:

- Whether or not to launch a new product and, if so, whether this launch should be local, national or international. If the launch is national or international, should this launch then be extended to national or international level?
- In the light of forecast demand increases, whether extra production requirements should be met by extending the factory or by subcontracting to an external supplier.

Because decision trees rely upon EVs, there is some concern about using them for big one-off decisions. They are really more suited to repeated decisions. Take our earlier example: we recommended that the student should walk to college with his umbrella. This was because the £2 cost was the lowest. But on any one journey he will not incur a cost of £2. He will incur either £20 if he loses his umbrella or no cost if he doesn’t lose it. Because decision trees rely on EVs, managers may make decisions without taking full account of the range of possible outcomes.

If our student has only £10 available to him, he might prefer to walk without the umbrella, since he would be certain of being able to afford the dry-cleaning but couldn’t afford to replace his umbrella. But, if the student travels to college regularly, the decision tree’s recommendation may be more reliable. If he walks and takes his umbrella, then his long-run average daily cost should be £2 (or thereabouts), which should be cheaper than the "no umbrella" and "public transport" alternatives.

Here’s another decision tree problem for you. A company has recently spent £1.7m on developing a new product and must now decide whether it should be launched. If the product is launched, this may be either to the local market or to the national market. If the initial launch is local, this could be upgraded to go national after the first year. After two years, the product will be obsolete and have no residual value. If the product is launched, then the level of demand will be either high (probability 70 per cent) or low and different annual cash profits will arise depending upon this level of demand (see panel 3). Once the demand is established, it will remain static for both years. If the product is not launched, the intellectual property rights can be sold immediately for £1m. You are required to advise the company on the best thing to do with the new product.

The solution to this problem will appear in FM’s next issue. FM

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### 3 FINANCIAL DATA FOR LAUNCH PROBLEM

The following monetary amounts have been expressed in present value terms, so there is no need to discount them.

<table>
<thead>
<tr>
<th></th>
<th>Local launch</th>
<th>National launch</th>
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</thead>
<tbody>
<tr>
<td>Cost of initial launch</td>
<td>£1m</td>
<td>£2m</td>
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<tr>
<td>Annual cash profit if high demand</td>
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<td>£4m</td>
</tr>
<tr>
<td>Annual cash profit (loss) if low demand</td>
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<td>(£1m)</td>
</tr>
<tr>
<td>Cost of going national after first year</td>
<td>£1m</td>
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</table>