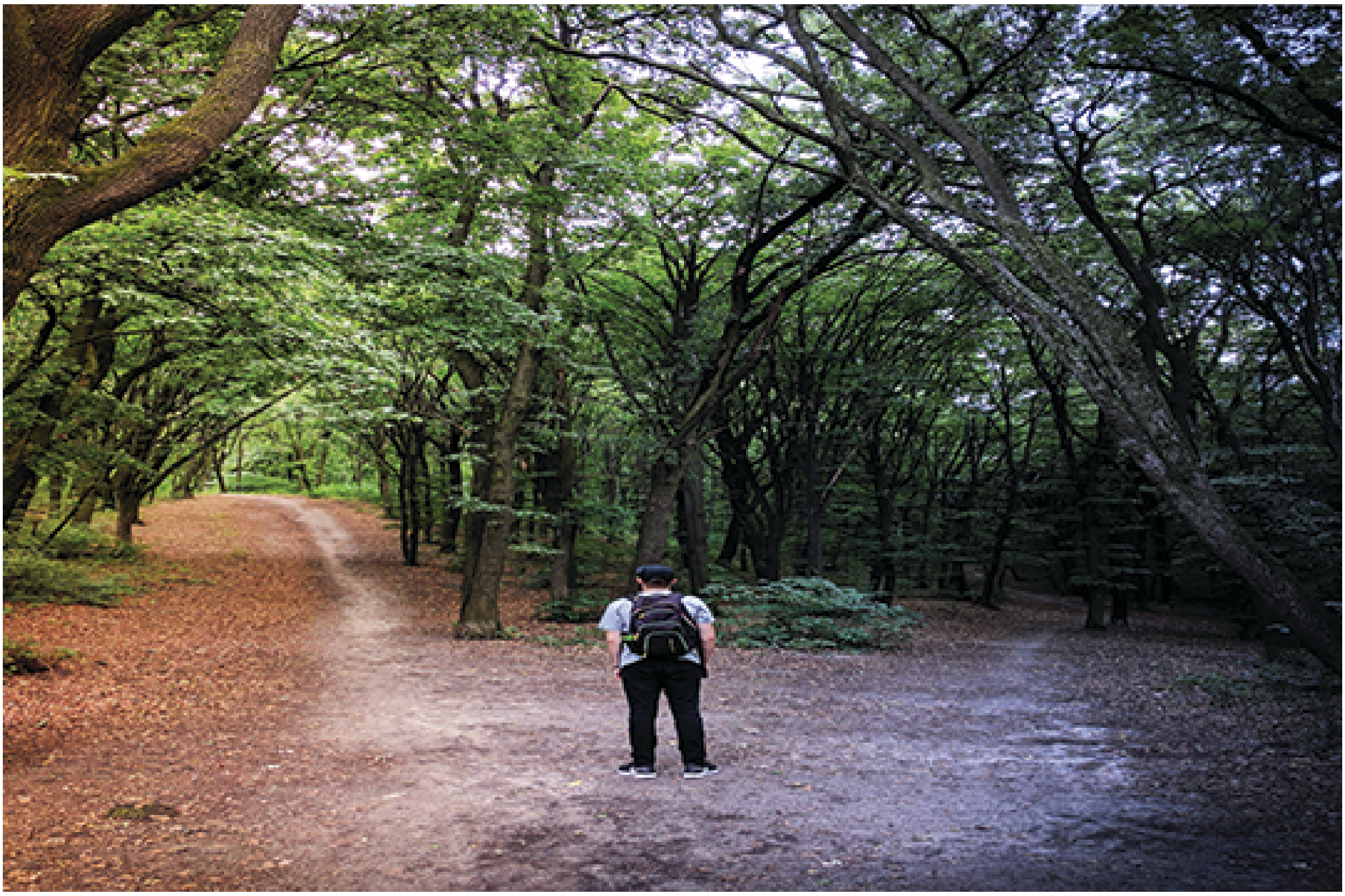
Decision trees and dealing with uncertainty



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About this free course

This free course is an adapted extract from the Open University course B874 *Finance for strategic decision-making* - www.open.ac.uk/postgraduate/modules/b874.

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Decision trees and dealing with uncertainty

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Contents

Introduction

This course is concerned with using decision trees to simplify and formulate business decisions, typically using financial information. As decisions affect the future well-being of an organisation, they almost always rely on some form of forecast information. In this course, you will consider the subject of uncertainty in a financial context and meet a few ways of dealing with it, including a basic introduction to probability. This will help you to understand a common approach to dealing with financial information known as an 'expected value'.

Once you have a basic understanding of probability, you will then use that knowledge in the context of a powerful and sophisticated technique referred to as a 'decision tree'. This technique allows you to consider, simultaneously, a variety of possible outcomes and to find the optimal decision for the organisation.

This OpenLearn course is an adapted extract from the Open University course B874 *Finance for strategic decision-making*.

Learning Outcomes

After studying this course, you should be able to:

- deal with basic uncertainty in a decision-making context
- understand the basic ideas of probability
- calculate expected values
- produce and analyse a decision tree.

1 Dealing with uncertainty: an introduction to probability

Allow approximately 1 hour 30 minutes to complete this section.

Decision-making is often undertaken in an uncertain world. That is, you might have some doubts about the reliability of the data you have been provided with, as well as the future environment in which you will be operating. In business, uncertainty regarding the future can cover a very wide range of scenarios, including:

- political – who will be running the country in five years' time? What will be their view on, for example, tax, regulation, etc.?
- economic – will the country be in recession, or booming? What will interest rates be?
- market – how will your product market develop? Will there be new entrants, leavers or substitutes?

As decision-makers, you need to find strategies to deal with uncertainty and so, in this section, you will be introduced to the topic of probability.

A knowledge of probability enables you to assess the likelihood of something happening. For example, what is the chance that a 55-year-old person will buy a new car in the next 12 months?

You might subdivide the data – what is the probability that a 55-year-old *man* will buy a car within the next 12 months?

You can then go further by attaching conditions. For example, what is the probability that a 55-year-old man, *who bought his last car three years ago*, will buy a new car within the next 12 months?

Or even, *if a 55-year-old man has purchased a new car within the last three years, how long will it be before he buys a new car?*

Unfortunately, probability theory is quite a complex subject and so in this course you will only consider the most basic ideas. These ought to suffice for the kinds of decisions that managers need to make most of the time. In the next activity you will be introduced to those basic ideas.

Activity 1 What is probability?

Allow approximately 20 minutes to complete this activity

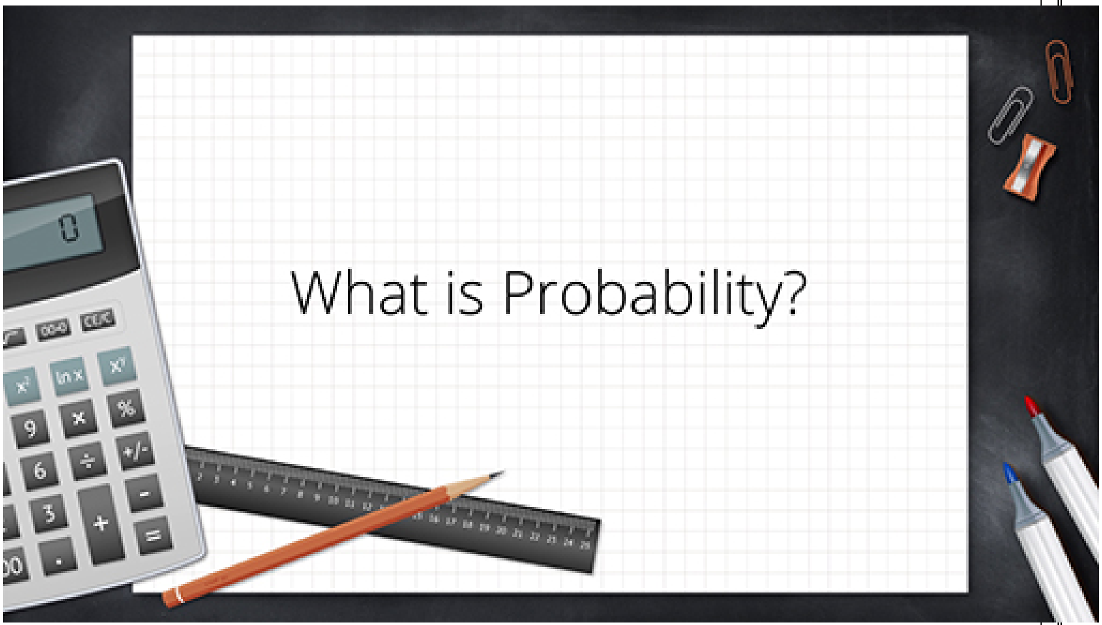
In Videos 1 and 2, you will be introduced to the basic ideas of probability. An understanding of probability allows you to quantify uncertainty.

You will build on your understanding of probability, especially later on in this course when you learn about decision trees. So you may need to watch Videos 1 and 2 a few times until you feel comfortable with how probability starts to address the question of how to deal with uncertainty in decision-making.

Part 1

Watch Video 1. You may like to make notes in the text box below.

Video content is not available in this format.
Video 1 An introduction to probability: part 1



Provide your answer...

Part 2

Watch Video 2. You may like to make notes in the text box below.

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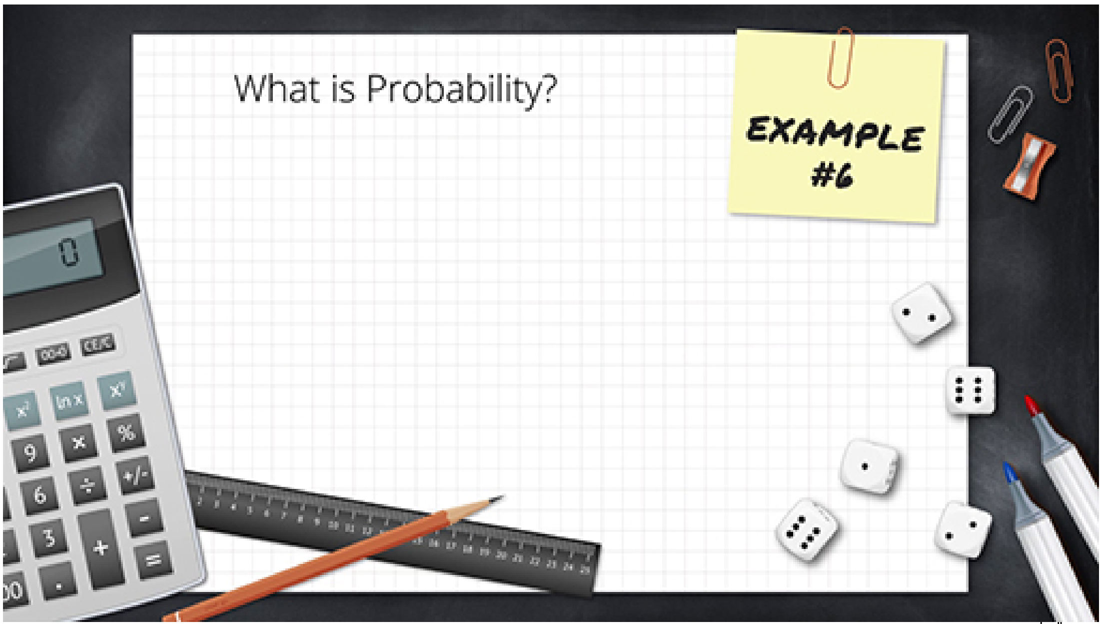
Video 2 An introduction to probability: part 2



Provide your answer...

Discussion

From Video 2 you learnt that probability is a way of measuring uncertainty. The probability of an event may be taken as the proportion of times that an event can occur out of the total possible events. The video provided some simple examples of how you might estimate a probability.

Most people will have an instinctive feel for what probability is. **Probability** is a measure of how likely it is that something will occur. How might you assess that likelihood?

Probability: first principles

To begin, you might be able to derive a number from first principles.

For example, it is hopefully obvious that if someone throws a 'normal' six-sided die, the number '3' is likely to land face up 1 in 6 times. You might say that the probability of throwing a '3' is , or one sixth.

Of course, if someone throws a die six times then they might get '3' more than once or even no '3's. It is only if the die is thrown thousands of times that the person will notice that roughly one sixth of the throws result in a '3' landing face up.

Probability: considering past behaviour

Another way of arriving at a probability might be to observe past behaviour. For example, the Eurovision song contest has, as of April 2019, had 66 winners (some years there have been joint winners). The Republic of Ireland has won it seven times. So you might conclude that the Republic of Ireland has a probability of winning the next contest. Coming to such a conclusion is, of course, rather simplistic. You would need to consider how much past success indicates the chance of future success, given that the performers are usually different.

Probability: subjective opinion

One last way you might assign a probability is through simply expressing a subjective opinion. For example, if you watch the Eurovision performers prior to voting, you might arrive at a view of which act is most likely to appeal to the voters (nowadays, a combination of the public and appointed judges). Of course, this probability might be very different to that assigned by another watcher.

The concept of probability could also be used to consider how the gambling industry functions and the interplay between odds and subjective probabilities, but this will not be covered in this course.

> In business scenarios, it is not often that you can rely on the first approach of deriving a number from first principles of probability only. More often, you have to arrive at a probability based on a combination of some data (via a market survey, for example) and experience.

Before proceeding, the definition and mathematical rules for probability need to be explained. From the die example earlier, a reasonable definition of a probability can be concluded as follows:

-
- Probability is expressed as a ratio whose value is positive. You cannot have negative probabilities.
- A probability is less than or equal to 1. This means that a probability cannot exceed 1.
- The total of all probability outcomes must equal 1.

  For example, if the probability of something happening is 0.45, the probability of it not happening must be .

In the next section you will have the opportunity to check your understanding of probability.

2 Check your understanding of probability

Allow approximately 30 minutes to complete this section.

In this section, you will attempt some questions and work through examples to test and embed your understanding of basic probability, as used in decision-making. First, try some simple questions on probability in Activity 2.

Activity 2 Probability quiz

Allow approximately 5 minutes to complete this activity

Select the response that best answers each question.

1. What does a probability of 1 mean?

- ○ This means that the event is certain to occur.
- ○ There is a 1 in 100 chance of the event occurring.
- ○ The event can only occur once.
- ○ There is a 1 in 10 chance of the event occurring.

2. What must all the probabilities of all outcomes total to?

- ○ They must total to 1.
- ○ The total value of all outcomes.
- ○ 0.50.
- ○ It depends on the event.

Now study the following worked example in Box 1.

Box 1 Worked example on probability

What is the probability of throwing three heads and one tail, when throwing four coins at the same time?

To answer this, you need to explore the total number of possible outcomes. Here are two approaches to this problem.

Approach 1

Each coin will fall independently. The possible combinations are as follows. (Note that the scenarios of ‘three heads and one tail’ are in bold and italics below.)

HHHH

HHHT

HHTH

HHTT

HTHH

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TTTH

TTTT

From the list of possible combinations, you can conclude that there are 16 combinations, four of which (in italics) are three heads and one tail. This can be shown as:

Approach 2

The number of combinations could also have been found as follows:

- each coin has two possible outcomes

  If the first coin has two possible outcomes and the second also has two, then between them there are four combinations (i.e. $2 \times 2 = 2^2 = 4$)
- adding a third coin (which has two outcomes) doubles the combinations (i.e. $2 \times 2 \times 2 = 2^3 = 8$)
- finally, the last coin makes it 16 (i.e. 2^4) as there are 4 coins, each of which may be heads or tails, then there are 4 combinations with 3 heads and one tail, so, the probability is: .

In Activity 3, you will apply your understanding of probabilities in considering a different scenario.

Activity 3 Probability of ribbons in a box

Allow approximately 10 minutes to complete this activity

You place five ribbons in a box. They are coloured, black, blue, red, yellow and green. If you pull out two ribbons and the first is black, what is the probability that the second you select is blue?

Provide your answer...

Answer

The probability of the second ribbon selection being blue is then:

You have now covered the basic ideas of probability and for the rest of this course you will learn how to apply these ideas in the context of making business decisions.

3 Expected values

Allow approximately 1 hour to complete this section.

You can use probability to arrive at a weighted average of the value of an outcome, reflecting the various levels of likelihood. This weighted average can be called the **expected value**. Work through the following example to see how this idea is used in financial forecasting.

Box 2 Worked example on forecasting interest rates

Economic forecasters are unsure what interest rates will be next year. However, combining the various contributing economic scenarios, they believe the outcomes shown in Table 1 are possible.

Table 1 Probability of different possible interest rates

Possible interest rate %	Probability
1.50	0.29
2.75	0.54
3.90	0.17

Note that there are only three possible outcomes.

Their probabilities must total one.

So, .

The ‘expected value’ of interest rates can be calculated as follows:

As a common sense test, note that the expected value is close to the overwhelmingly most probable (2.75%, with a probability of 0.54).

Also, the expected value, being an average, must lie within the range of possible outcomes (that is, between 1.5% and 3.9%).

In the next activity you will use the idea of expected value to estimate stock returns. Although this approach may seem simplistic, it lies at the heart of modern-day corporate finance.

Activity 4 Calculating the expected value of stock returns

Allow approximately 15 minutes to complete this activity

In this activity, you will calculate the expected value of stock returns. You will assume that the rates of return on the stock market over the last 120 years are as summarised in Table 2. The frequency tells you how many of those years a particular return was made.

Table 2 Frequency of stock returns

Return %	Frequency
3.00	4
3.25	12
4.00	19
4.50	23
5.12	28
6.00	18
6.50	12
7.00	4
	120

Part 1 Calculating the probability of stock returns

Before you calculate the expected value of stock returns, you will first need to find the probabilities and record them in Table 3.

Hint: if something occurs 4 times out of 120, what is its probability?

Table 3 Calculating the probability of stock returns

Return %	Frequency	Probability
3.00	4	*Provide your answer...*
3.25	12	*Provide your answer...*
4.00	19	*Provide your answer...*
4.50	23	*Provide your answer...*
5.12	28	*Provide your answer...*
6.00	18	*Provide your answer...*

6.50	12	*Provide your answer...*
7.00	4	*Provide your answer...*
	120	*Provide your answer...*

Tip: do not forget to check that all of the probabilities add up to a total of one.

Answer

So, taking 3.00% as an example from Table 2, you can see that it has occurred four out of a possible total 120 times. This gives it a probability as follows: .

If you then calculate the probability for all of the stock returns, you should get the results shown in Table 4.

Table 4 The probability of stock returns

Return %	Frequency	Probability
3.00	4	0.0333
3.25	12	0.1000
4.00	19	0.1583
4.50	23	0.1917
5.12	28	0.2333
6.00	18	0.1500
6.50	12	0.1000
7.00	4	0.0333
	120	1.0000

Part 2 Calculating the expected value of stock returns

You can now calculate the expected value of stock returns and complete Table 5.

Table 5 Calculating the expected value of stock returns

Return %	Frequency	Probability	Expected value
3.00	4	0.0333	*Provide your answer...*
3.25	12	0.1000	*Provide your answer...*
4.00	19	0.1583	*Provide your answer...*
4.50	23	0.1917	*Provide your answer...*

5.12	28	0.2333	Provide your answer...
6.00	18	0.1500	Provide your answer...
6.50	12	0.1000	Provide your answer...
7.00	4	0.0333	Provide your answer...
	120	1.000	Provide your answer...

Answer

To get the expected value of stock returns, you multiply each stock return by its probability and then sum the result, as shown in Table 6 below.

Table 6 Expected value of stock returns

Return %	Frequency	Probability	Expected value
3.00	4	0.0333	0.100
3.25	12	0.1000	0.325
4.00	19	0.1583	0.633
4.50	23	0.1917	0.863
5.12	28	0.2333	1.195
6.00	18	0.1500	0.900
6.50	12	0.1000	0.650
7.00	4	0.0333	0.233
	120	1.000	4.899

So the expected value of stock returns is 4.899%, which you could round up to 4.9%.

You will use expected value in the next section on decision trees.

4 Decision trees

Allow approximately 2 hours to complete this section.

Sometimes decisions can be complex and require a number of stages to arrive at a final outcome. Such a final outcome may be dependent on earlier, intermediate decisions. Alternatively, the final decision may be dependent on a series of uncertain, intermediate outcomes. Dealing with these types of decisions may appear, on the face of it, quite difficult. However, the technique of **decision trees** that you are going to explore in this section will help to simplify this process.

The best way to illustrate the technique is by a worked example in Activity 5. Before doing so, it is important to point out the meaning of two symbols that will be used in the decision trees.

Where a branch appears on your tree, this point will be called a **node**. A node may appear for one of two reasons. The first is that a decision is required. In other words, the node represents a series of choices. This type of node will be called a **decision node** and a square will be used to denote it. The second type of node is a **chance node**. Here, there is a range of possible events or outcomes of varying probabilities. Such nodes are denoted with a circle.

Activity 5 Introduction to decision trees

Allow approximately 30 minutes to complete this activity

In Videos 3 and 4, you will be introduced to the powerful technique of decision trees. This technique allows you to incorporate probabilities into a range of potential outcomes, which may themselves be conditional on other outcomes.

You may wish to watch the videos a few times and make notes in the text boxes to ensure that you understand the concept of decision trees, as well as to answer the questions.

Part 1

A company (MKOU) is assessing two outsourcing bids, A and B. Company A is more expensive but is reckoned to have a higher probability of delivering a high quality good than B. This is important as the higher the quality the more MKOU can charge and the less it will need to refund to dissatisfied customers. The data may be summarised as shown in Table 7.

Table 7 Possible financial benefits of using companies A and B

Company	Probability of acceptable service level	Net financial benefit if acceptable £M	Net financial cost if not acceptable £M
A	80%	120	-30
B	55%	160	-10

Video content is not available in this format.

Video 3 A worked example on decision trees

Provide your answer...

Part 2

A company is considering launching a new product. It can either launch immediately or in one year's time. If it launches immediately there is a 0.75 chance of the launch being successful. If it is unsuccessful then the launch will be halted at a cost of £1M and relaunched in a year's time. If the company launches immediately it may opt to also have a promotion, which has a 0.6 chance of success. If the promotion is successful the financial benefit is £10M, if not £2M. If the company does not do the promotion the benefit is £5M. If the company launches in a year's time the benefit is £6M. What should the company do?

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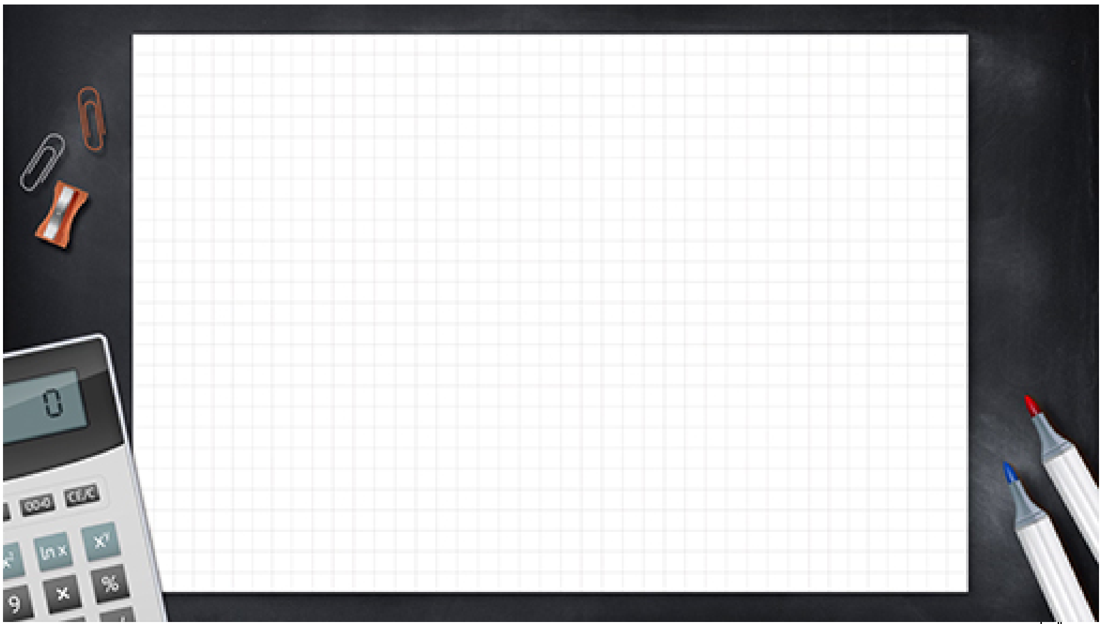
Video 4 A second worked example on decision trees



Provide your answer...

Discussion

To summarise, you can use decision trees to break down a decision into a series of events that involve the decision-maker making a sub-decision ('decision node') or there being a chance event outside of the decision-maker's control ('chance node'). (Note that 'sub-decision' means a decision taken after the first, main, decision.)

By allocating probabilities to the chance nodes you can evaluate the expected value from the various combinations of sub-decisions and chance events.

This then informs which initial decision and then subsequent sub-decisions should be taken.

Now that you have watched the videos on decision trees, you will consider potential decisions faced by businesses. In the next section you will see some more applied examples of how decision trees are used in making business decisions.

4.1 Decision trees and expected value

You are now at a stage to see how an understanding of expected values and probability can be combined to simplify complex business problems.

Example: decision tree for a business considering a new office location

You are considering opening a new office somewhere in the UK and you have shortlisted two town councils: A and B. However, a key factor is the impact of local taxes, also called business rates.

Local elections are coming up with two main parties in the running: J and K. Each party has a different view on how business should be treated; however, there is uncertainty as to whether they will increase or decrease business rates.

Table 8 shows the probabilities of each party winning, their possible views towards business and the impact of each.

Table 8 Probabilities of each party

Council	Party	Probability of winning	Probability of being business friendly	Estimated impact of being business friendly/ £M	Estimated impact of being business unfriendly/ £M
A	J	0.55	0.7	3.0	-0.50
	K	0.45	0.4	0.5	-2.00
B	J	0.30	0.6	2.5	-0.25
	K	0.70	0.35	1.0	-1.00

The probabilities of winning might be based, for example, on the odds currently being offered by a betting website, predicting the chances of that party winning.

The probabilities of being business friendly would be based on past experience and any announcements being made by the parties.

The final two columns show the estimated monetary impact, positive or negative, in £ millions.

In the fifth column, 'Estimated impact of being business friendly/£M', if, for example, in the first row, in council A, party J has a 0.7 probability of being business friendly, then it must have a probability of 0.3 of being unfriendly towards business. This is because the total probabilities must total to 1.

Table 8 includes estimates of the financial impact. So, for example, in the first row, it has been estimated that in council A, if party J were business friendly, the company would benefit financially by £3M. On the other hand, if the party were not business friendly, the company would suffer financially by £0.5M.

The data shown in Table 8 can be mapped in a decision tree as follows.

Creating a decision tree

1. Put in the main decision and choice nodes (Figure 1).

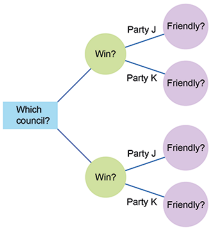


Figure 1 Decision tree for which council

2. Add the final column (Figure 2). This column leads to the final value for each particular path. In other words, you will add the top branch of the decision tree – the impact if council A wins and it is business friendly.

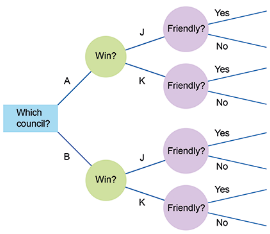


Figure 2 Decision tree for which council, with 'yes'/'no' chance nodes

3. Put in the impact values (Figure 3).

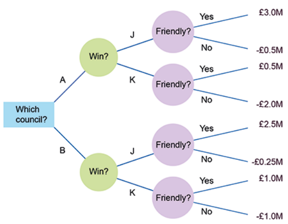


Figure 3 Decision tree for which council, with terminal values added

4. Then add their probabilities. Note that if party J in council A has a 0.7 probability of being business friendly, then it must have a 0.3 (1 – 0.7) probability of being business unfriendly.

   As the only possibilities are being friendly or unfriendly, the probabilities of these must equal 1 – it is definitely either friendly or unfriendly (Figure 4).

   This example only has one decision node: which town to move to. There are then two sets of chance nodes. The 'chances' being those actions outside of the decision-maker's control. They are: Which party will win? (So you can create a branch for each of the two possibilities) and, is that winning party business-friendly or not?

   Again, you create a branch for each answer. If there were more decisions, at each decision node you would insert a branch for each option open to the decision-maker.

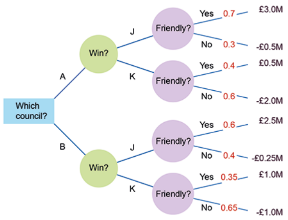


Figure 4 Decision tree for which council, with probabilities added

Calculating the expected value

Now you can find the expected value of the financial impact for each party in each council.

- What is the expected value of the financial impact if party J won in council A?
- There is a 0.7 probability of it being business friendly and 0.3 of it being unfriendly. If party J won council A, the expected financial impact would be:

  (0.7 × £3M) + (0.3 × -£0.5M) = £1.95M.

  The expected values can be added to the decision tree (Figure 5).

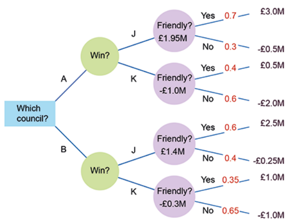


Figure 5 Decision tree for which council, with expected values added to ‘Friendly’ nodes

- What is the financial impact if the company moved to council B?
- There is a 0.3 probability of J winning (with an expected financial impact of £1.4M) and 0.7 of K winning (with an expected impact of -£0.3M). So the expected financial impact of moving to B is:

  (0.3 × £1.4M) + (0.7 × -£0.3M) = £0.21M.

  The probabilities can be added to the decision tree (Figure 6).

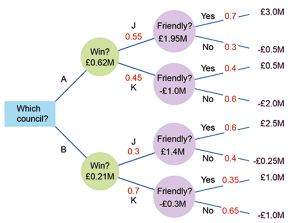


Figure 6 Decision tree for which council, with win probabilities and win node expected values added

For example, for council A, the expected value is:

(0.55 × £1.95M) + (0.45 × -£1M) = £0.62M

So now you can step back and see that council A has the higher expected value (£0.62M compared with £0.21M in B) and so, on the grounds of economic impact (there may be other factors), you would select to relocate to A.

This general approach to solving the problem, by analysing from the last stage back to the first, is a process called **dynamic programming**. The content of this course will not go beyond decision trees.

In the next subsection you will consider an example of a complex decision tree related to the launch of a product.

4.2 A complex decision tree – deciding whether or not to launch a product early

From the last worked example, you should now have a good understanding of the basics of how decision trees work. In this next example in Activity 6 you will meet a more complex decision tree with more than just the initial decision node. In other words, more than one decision will be needed. Thus, as well as providing an initial decision (what to do now), the decision tree will also provide a strategy for future decisions depending on the outcomes of various chance events.

Activity 6 Example of a complex decision tree: considering early launch of a product

Allow approximately 45 minutes to complete this activity

A company is planning on launching a new product. It was thinking of launching in June of next year but it believes that a rival is also considering launching a similar product around that time. The company is considering bringing the launch forward to the end of this year. This will cost an extra €3M to carry out and the company believes it will have a 0.8 probability of beating the rival to the market. If, however, they wait until June, the probability of beating the rival falls to 0.2.

To make the decision easier, the company assumes that sales will be either high, medium or low. If the company launches before its rival, the probability of high sales is 0.6 and the probability of medium sales is 0.25. If it launches after its rival, the probability of high sales falls to 0.35 and medium sales rises to 0.45. If the rival launches first, the company could undertake a sales promotion, costing €1.5M, but would change the probabilities of high sales to 0.5 and medium to 0.4.

The financial impacts are that high sales would be worth €9M, medium would be worth €5M and low, €1M.

Using a decision tree analysis, calculate what the company’s investment strategy should be. You can use pen and paper, an Excel spreadsheet, or record your calculations in the text box below.

Once you have arrived at a solution, watch Video 5 for the feedback of this activity.

Provide your answer...

Discussion

Now watch Video 5.

Video content is not available in this format.

Video 5 Solution for considering the early launch of a product

You may find it useful to work through the written solution below too. In this more complex decision tree you had to make some subsequent decisions based on the final outcomes of each branch. Thus you not only arrived at an initial decision (what action to take now) but also what actions to take at future points based on future chance events.

Written solution

You can also read the solution below.

The decision tree is shown in Figure 7.

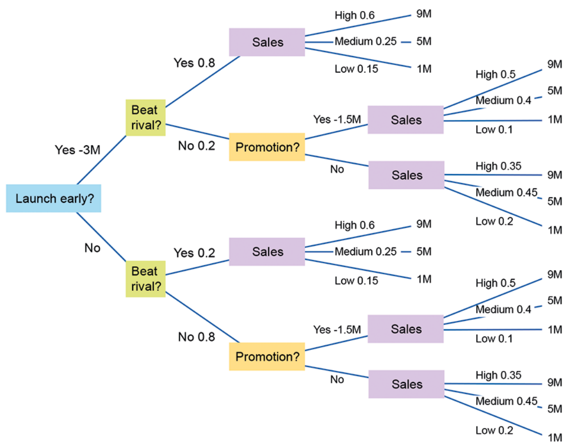


Figure 7 Decision tree: a company deciding on when to launch a new product

The calculations for each node are as shown in Table 9 (remember that you will need to work from right to left).

Expected sales

Table 9 Expected sales

Sales’ node number (from top to bottom of decision tree)	Expected sales – calculation €M	Expected sales – value €M
1	(0.6 × 9) + (0.25 × 5) + (0.15 × 1)	6.8
2	(0.5 × 9) + (0.4 × 5) + (0.1 × 1)	6.6
3	(0.35 × 9) + (0.45 × 5) + (0.2 × 1)	5.6
4	(0.6 × 9) + (0.25 × 5) + (0.15 × 1)	6.8
5	(0.5 × 9) + (0.4 × 5) + (0.1 × 1)	6.6
6	(0.35 × 9) + (0.45 × 5) + (0.2 × 1)	5.6

Expected sales after promotion

There are two promotion decision nodes, as summarised in Table 10.

Table 10 Expected sales after promotion

Promotion node number (from top to bottom of decision tree)	Expected sales after promotion – calculation €M	Expected sales after promotion – value €M
1 – Yes	6.6 – 1.5	5.1
1 – No	5.6	5.6
2 – Yes	6.6 – 1.5	5.1
2 – No	5.6	5.6

At both decision nodes, the expected value of sales is higher without the promotion than with it. The company will, therefore, never promote if launching after its rival. The higher figure of expected sales (€5.6m) is now carried forward.

Table 11 Expected sales at 'Beat rival?' chance node

‘Beat rival’ node number (from top to bottom of decision tree)	Expected sales – calculation €M	Expected sales – value €M
1	[(0.8 × 6.8) + (0.2 × 5.6)] − 3	3.56
2	(0.2 × 6.8) + (0.8 × 5.6)	5.84

You can see from Table 11 that the value of launching early is €3.56M, whereas the value of not launching early is €5.84M.

Thus, the decision is two-fold: the company should not launch early. If it then finds that it has not beaten its rival, it should not undertake a promotion.

In the next subsection you will consider another example of a complex decision tree, this time related to the launch of a new pharmaceutical drug.

4.3 A complex decision tree – developing a new pharmaceutical drug

Now that you have watched Video 5 that presents a more complex example of using decision trees, the next activity will give you an opportunity to practise the skill of building and evaluating a decision tree.

Activity 7 Example of a complex decision tree: considering the development of a new pharmaceutical drug

Allow approximately 30 minutes to complete this activity

A pharmaceutical company is considering developing a new drug. The key decision criteria is the development time, which the company would like to minimise. There are two approaches to developing the drug. The first is to base it on stem cell research ('stem'). There is a 0.4 probability that this approach would lead to a drug within 5 years, otherwise it will take up to 7 years (0.6 probability). Note, these times are from the start of the use of this approach.

An alternative approach is based on a method called targeted delivery ('TD'). This has a 0.3 probability of delivering a drug within 3 years. However, if at the end of 3 years there is no drug, the company would have to choose between switching to stem or carrying on with TD. At that point, the TD will have a 0.8 probability of delivering the drug within a further 2 years.

Although, if the drug has still not been delivered after a further 2 years, the company can still switch to the stem approach. Alternatively, persevering at this stage with TD will definitely yield a drug after a further 7 years.

Given the objective is to minimise development time, use a decision tree to determine what the company's strategy should be.

You can use pen and paper, an Excel spreadsheet, or record your calculations in the text box below.

Provide your answer...

Discussion

First, you should draw the decision tree. Your decision tree should look something like Figure 8 below.

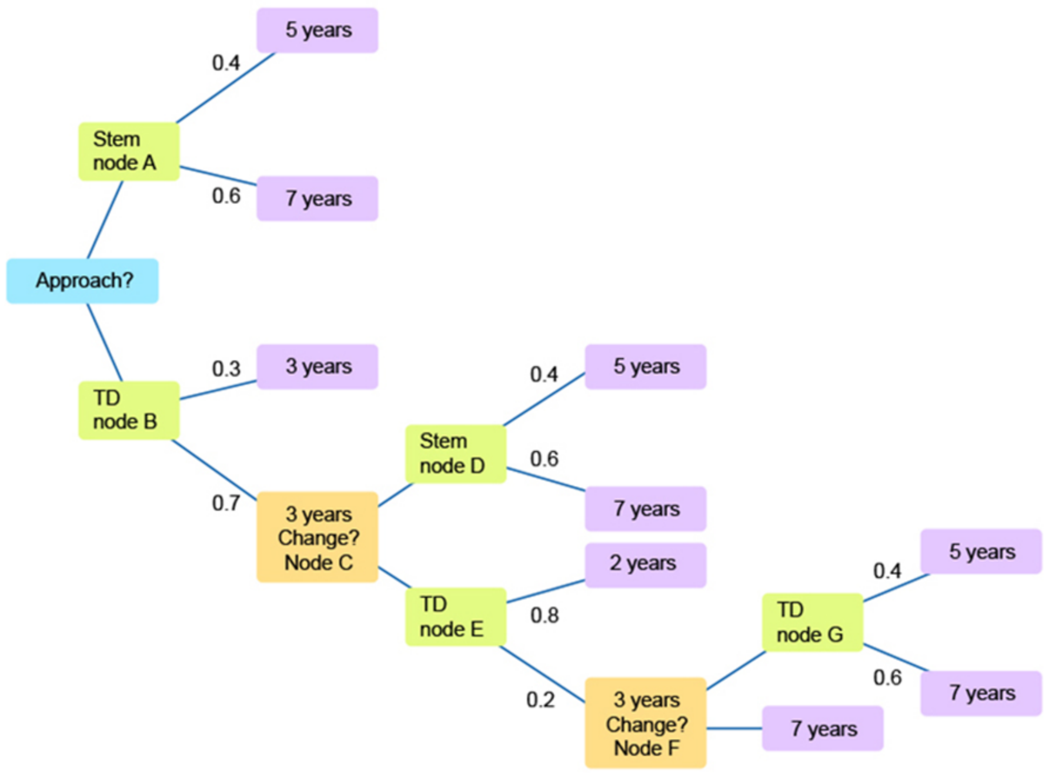


Figure 8 Decision tree: a company deciding on the development of a new pharmaceutical drug

As before, you start from the right-hand side and work back towards the start.

At node G, the expected development time from that point is (0.4 × 5) + (0.6 × 7) = 6.2 years. Note that this is the development time for stem, so you can use this calculation again.

As this is shorter than the alternative (7 years), at decision node F you would choose to start the stem approach, taking 6.2 years from that point. However, you have already waited 2 years before making that choice. From node E, there are 8.2 years (6.2 + 2) if you follow the lower branch (leading to node F).

So from node E you have an expected development time of
(0.8 × 2) + (0.2 × 8.2) = 3.24 years.

You know that node D has an expected development time of 6.2 years (the stem time). At node C you would choose to carry on with TD as the expected time is lower (3.24 years). However, it has taken you 3 years to arrive at node C, so the development time is 6.24 years.

At node B, then, the expected development time is (0.3 × 3) + (0.7 × 6.24) = 5.27 years.

Now you have the strategy. As the first decision stem has an expected development time of 6.2 years, whereas the first decision TD has an expected development time of 5.27 years.

Thus, you would start on TD. If after three years you had not developed the drug (now at node C), you would choose to carry on with TD as the expected time at that point of 3.24 years is less than stem (6.2 years).

If after a further two years you still had not developed the drug (at node F), you would switch and start the stem approach, as 6.2 expected years for the stem approach is less than the definite 7 years it would take to complete the TD approach.

Conclusion

In this course, you learned how to use probability to quantify uncertainty. Probability enables the decision-maker to calculate a quantity called the expected value, which gives you a quantity that takes account of the differing probabilities of the potential outcomes of an event.

Finally, you learned how to use these ideas in situations where there is a range of possible outcomes, some of which may be dependent on earlier outcomes. The technique used was that of a decision tree.

This OpenLearn course is an adapted extract from the Open University course B874 *Finance for strategic decision-making*.

References

The Yale Tribune (2020) *Mergers are on the Rise: Is it Good for the Economy?*. Available at: https://campuspress.yale.edu/tribune/mergers-are-on-the-rise-is-it-a-good-thing-for-the-economy/ (Accessed: 2 September 2020).

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Images/Tables

Course/ Introduction image: Making decision: Photo by Vladislav Babienko on Unsplash.

Audio/Video