

Stochastic Models and Decision Analysis

Activity 1: Using spreadsheets to build and analyze decision trees

The objective of this activity is to familiarize you with two Excel add-ins (TreePlan & SensIt) to build and analyze decision trees.

Part 0: Get ready

Download the Excel practice template and two add-ins (TreePlan and SensIt).

Open Excel practice template,

- If you are using Microsoft Office 2010 or 2013, click **File** button on the upper right corner and choose **Options -> Add-Ins**, then click **Go** at the bottom of the window. In the pop up window, click **Browse** and find TreePlan and SensIt where you have saved them, then click **OK**. Make sure the boxes before TreePlan and SensIt in the Add-Ins window are both checked. Then click **OK**. Verify that the add-ins are installed by checking if “Add-Ins” tab contains “Decision Tree” and “Sensitivity Analysis”.
- If you are using Mac Excel 2011, choose **Tools -> Add-Ins**, then click **Select**, find TreePlan and SensIt add-in files, click **OPEN** then click **OK** to close the pop up window. You should be able to use the add-in by choosing **Tools** in the menu bar and choose Sensitivity Analysis (SensIt), or Decision Tree (TreePlan).

Part 1: Create a decision tree using TreePlan

Consider the first Goferbroke Co. problem in the text book (no seismic survey)

Step 1: In the first worksheet “first practice”, select decision tree from the Add-Ins tab (from **Tools** in the menu bar if you are using Excel 2011 on mac) and click on New Tree.

This creates the default decision tree as shown in Figure 1.1 with a single (square) decision node with two branches.

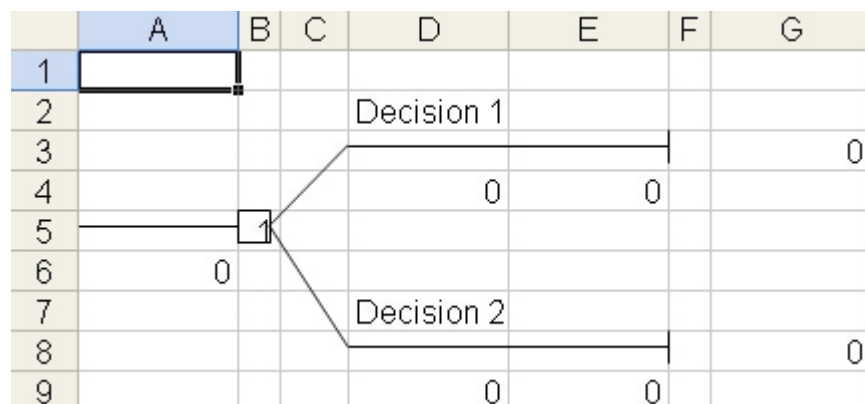


Figure 1.1

Note: To change the type of any node in TreePlan, select the cell containing the node (B5 in Figure 1.1) and choose Decision Tree from the Tools menu. This brings up a dialogue box that allows you to change the types of node.

Step 2: Click on the cells to change the labels. Change labels for “Decision 1” and “Decision 2” (cells D2 & D7 in Figure 2) to “Drill” and “Sell” respectively.

Step 3: Click on the cell containing the terminal node at the end of the drill branch (F3 in Figure 1.1), and choose Decision Tree from the Tools menu. This brings up the TreePlan dialog as shown in Figure 1.2

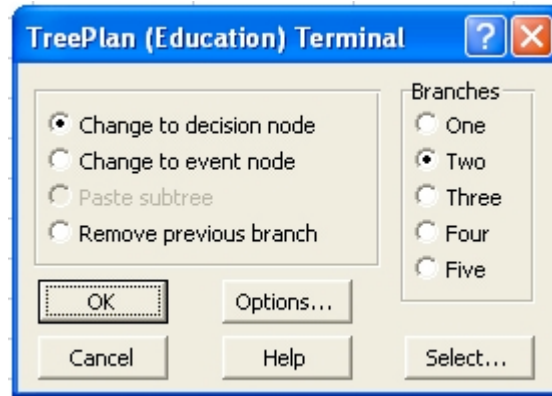


Figure 1.2

Choose the “change to event node” option on the left and select two branches on the right then click OK. This results in the decision tree with the nodes and branches shown in Figure 1.3 (after replacing the default labels “Event 1” and “Event 2” with “Oil” and “Dry”, respectively)

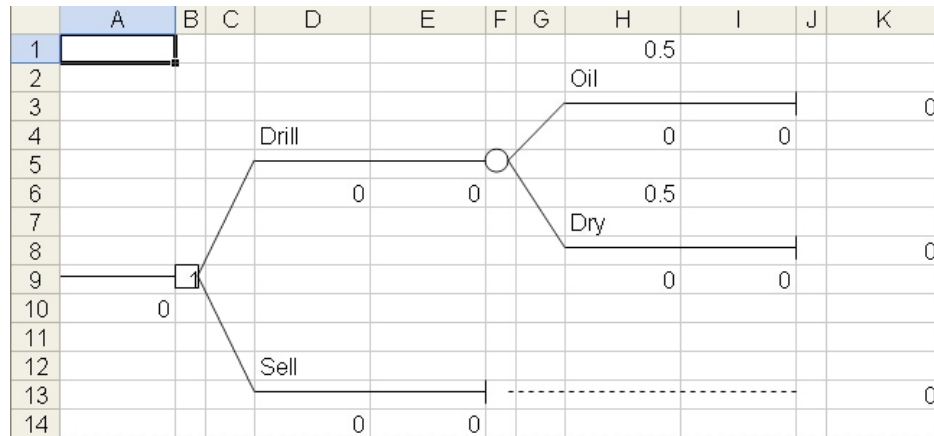


Figure 1.3

Step 4: Change the net cash flows and prior probabilities of each branch by clicking on the default values and replace them with correct numbers.

Initially, each branch would show a default value of 0 for the net cash flow being generated. Each of the two branches leading from event node would display default values of 0.5 for their prior probabilities. They should be changed as follows:

D6 = -100, D14 = 90, H1 = 0.25, H4 = 800, H6 = 0.75, H9 = 0

At each stage in constructing a decision tree, TreePlan automatically solves for the optimal policy with the current tree when using *Bayes' Decision rule*. See Figure 1.4. The number inside each decision node indicates which branch should be chosen (assuming the branches emanating from that node are numbered consecutively from top to bottom).

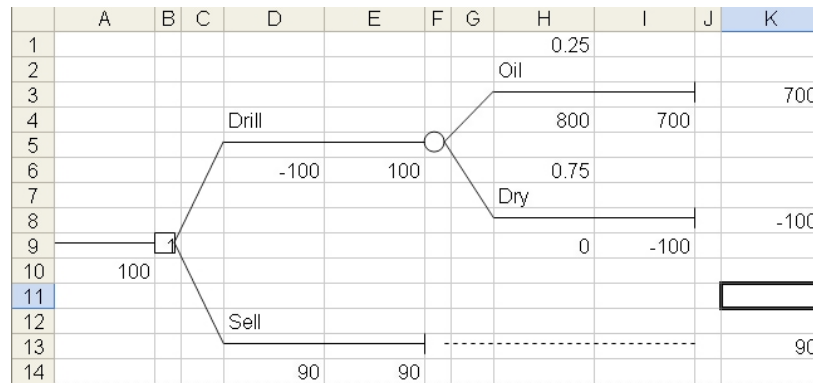


Figure 1.4

Part 2: Calculate posterior probabilities using Excel

Use the given template in the worksheet "bayes theorem" to practice calculating posterior probabilities using Bayes' theorem. We were given $P(\text{FSS}|\text{oil})$ and $P(\text{USS}|\text{dry})$ and the prior probability, but wanted the posterior probabilities. This can be done in Excel using the following formulas shown here.

	A	B	C	D
1	Prior Probability of oil	0.25		
2	$P(\text{FSS} \text{oil})$	0.6		
3	$P(\text{USS} \text{dry})$	0.8		
4				
5	given $P(\text{finding} \text{state})$			finding
6	state	$P(\text{state})$	FSS	USS
7	oil	=B1	=+B2	=1-C7
8	dry	=1-B7	=1-D8	=+B3
9				
10	find $P(\text{state} \text{finding})$			state
11	finding	$P(\text{finding})$	oil	dry
12	FSS	=+SUMPRODUCT(B7:B8,C7:C8)	=+C7*B7/B12	=+C8*B8/B12
13	USS	=+SUMPRODUCT(B7:B8,D7:D8)	=+D7*B7/B13	=+D8*B8/B13

Figure 2.1

The result should look similar to Figure 2.2.

	A	B	C	D
1	Prior Probability of oil	0.25		
2	$P(\text{FSS} \text{oil})$	0.6		
3	$P(\text{USS} \text{dry})$	0.8		
4				
5	given $P(\text{finding} \text{state})$		finding	
6	state	$P(\text{state})$	FSS	USS
7	oil	0.25	0.6	0.4
8	dry	0.75	0.2	0.8
9				
10	find $P(\text{state} \text{finding})$		state	
11	finding	$P(\text{finding})$	oil	dry
12	FSS	0.3	0.5	0.5
13	USS	0.7	0.142857	0.857143
14				
15				

Figure 2.2

Part 3: Expand decision tree to include seismic survey experimentation

The expanded decision tree is in the work sheet “decision tree”. Fill in the yellow boxes with the results from “bayes theorem” worksheet. The result should look like Figure 3.1.

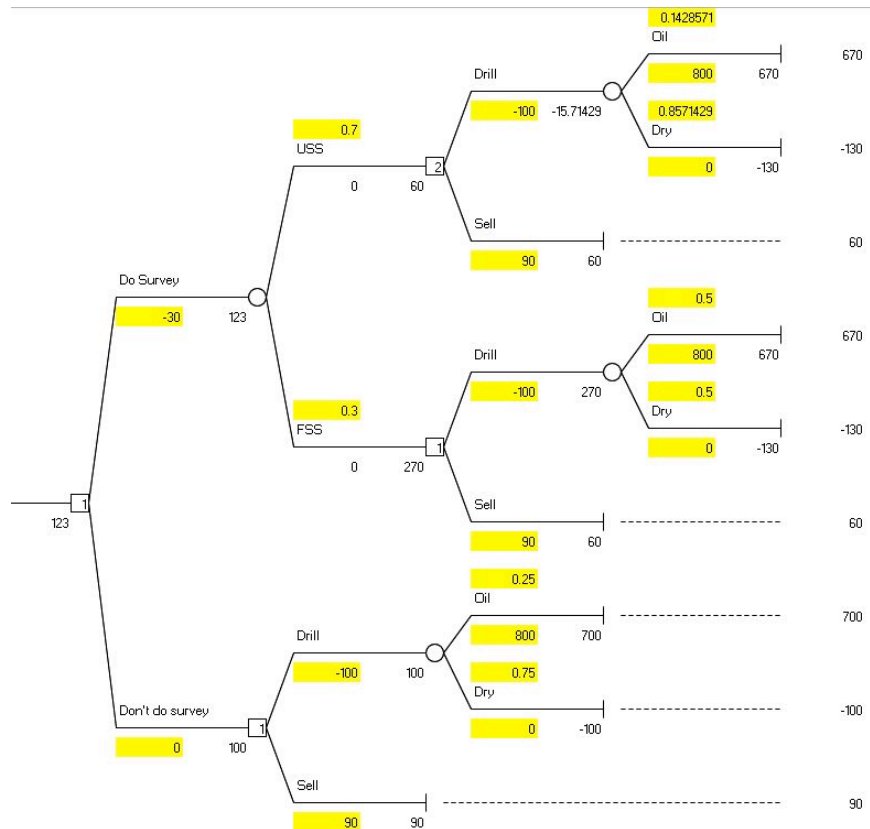


Figure 3.1

Part 4: Consolidate decision tree and perform sensitivity analysis for the full Goferbroke Co. problem (With the seismic survey)

The template of the decision tree and the probability tables for the full Goferbroke Co. problem are given in the worksheet “decision tree consolidated”.

To perform the sensitivity analysis, we need to ‘consolidate’ the problem data. That is, we want to collect all problem parameters to one place (the tables on the right side of the decision tree as in the worksheet) and refer to them in the decision tree. So, we want the data in the decision tree taken from the values from the tables, such that they are updated any time a change is made in the ‘consolidated’ data. Note that the posterior probabilities are functions of the prior probabilities (constructed as in Part 2) and will be updated once a change is made in any of the prior probabilities.

You should now have all cells shaded in the decision tree as a function of your consolidated data. The result should look like Figure 4.1. Note, in Figure 4.1, the Expected Payoff (result of your decision tree) and the optimal decision policy are summarized at the bottom of the consolidated data using a set of formulas.

	U	V	W	X	Y
1					
2					
3	Prior Probability of oil	0.25			
4	P(FSS oil)	0.6			
5	P(USS dry)	0.8			
6					
7	given P(finding state)		finding		
8	state	P(state)	FSS	USS	
9	oil	0.25	0.6	0.4	
10	dry	0.75	0.2	0.8	
11					
12	find P(state finding)		state		
13	finding	P(finding)	oil	dry	
14	FSS	0.3	0.5	0.5	
15	USS	0.7	0.142857	0.857143	
16					
17	Cost of survey	30			
18	Cost of drill	100			
19	Revenue if oil	800			
20	Revenue if sell	90			
21	Revenue if dry	0			
22					
23	Expected Payoff	123			
24					
25	Decision:	Do Survey			
26	if FSS, then	Drill			
27	if USS, then	Sell			
28					

Figure 4.1

Now it should be very easy for you to try different values for the costs, probabilities and other parameters and see how these affect your decision!

Let's try some what-ifs!

- a. if the prior probability of finding oil
 - i. increased to 0.5?
 - ii. decreased to 0.1?
- b. if the cost of drilling increased to \$ 250,000?
- c. if the probability of a favorable seismic sounding given there is oil is 0.5?

Part 5: Use Sensit to create sensitivity analysis graphs

Plot is used to generate a graph that shows how an output cell varies for different values of a single data cell.

Select Sensitivity Analysis → One Input, One Output from the Add-ins tab, brings up the dialogue box shown in Figure 5.1. The left side of the Plot dialogue box is used to specify the data cell that will be varied (the prior probability of oil in V3) and the right side is used to specify the output cell of interest (the expected payoff in V23). Then, the range of values to be considered for the single data cell (the prior probability of oil) is specified. Clicking OK generates the graph shown in Figure 5.2.

The screenshot shows a dialog box titled "Sensit 1.40 Academic - One Input, One Output". It is divided into two main sections: "Cells for Input Variable" and "Cells for Output Variable".

Cells for Input Variable:

- Label: "tree consolidated!\$U\$3"
- Value: "tree consolidated!\$V\$3"

Cells for Output Variable:

- Label: "ee consolidated!\$U\$23"
- Value: "ee consolidated!\$V\$23"

Input Values:

- Start: 0
- Step: 0.05
- Stop: 1

At the bottom right, there are four buttons: "Reset All", "OK", "Cancel", and "Help".

Figure 5.1

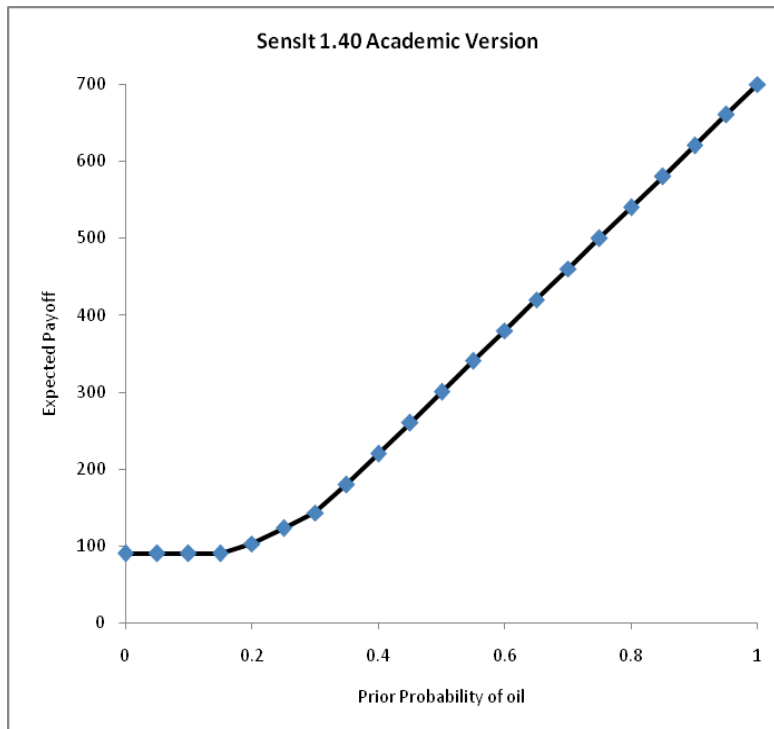


Figure 5.2

Spider Graph can be used to investigate how a cell value changes (e.g. the expected payoff) under percentage changes of a certain set of cells (e.g. costs or revenues in cells V17:V21).

Select Sensitivity Analysis -> Many Inputs, One Output from the Add-ins tab. In the dialog box shown in Figure 5.3, we select cost and revenue cells for input variables and assign ranges for output variables as given in Figure 5.4. The resulting spider graph is given in Figure 5.5.

Then we select the Single-Factor Spider Chart option.

SensIt 1.40 Academic - Many Inputs, One Output

Ranges for Input Variables

Labels:

Values:

Cells for Output Variable

Label:

Value:

Ranges for Input Values

One Extreme:

Base Case:

Other Extreme:

☐ Single-Factor Tornado Chart

☒ Single-Factor Spider Chart

Step Percent:

☐ Two-Factor Tornado Chart

Buttons: Reset All, Cancel, Help, OK

Figure 5.3

	low	base	high
Cost of survey	15	30	45
Cost of drill	50	100	150
Revenue if oil	400	800	1200
Revenue if sell	45	90	135
Revenue if dry			

Figure 5.4

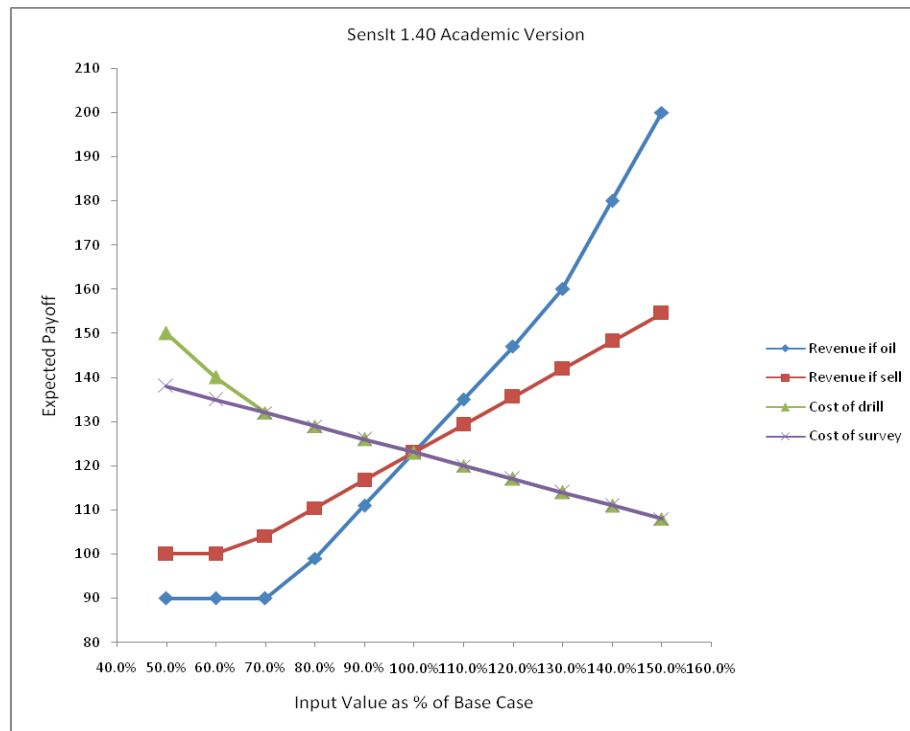


Figure 5.5

Tornado graph: Similarly, we fill the input variables and ranges and then select the Single-Factor Tornado-Chart option as shown in Figure 5.5. The resulting tornado graph is shown in Figure 5.6.

SensIt 1.40 Academic - Many Inputs, One Output

Ranges for Input Variables

Labels:

Values:

Cells for Output Variable

Label:

Value:

Ranges for Input Values

One Extreme:

Base Case:

Other Extreme:

☒ Single-Factor Tornado Chart

☐ Single-Factor Spider Chart

Step Percent:

☐ Two-Factor Tornado Chart

Reset All Cancel Help OK

Figure 5.5

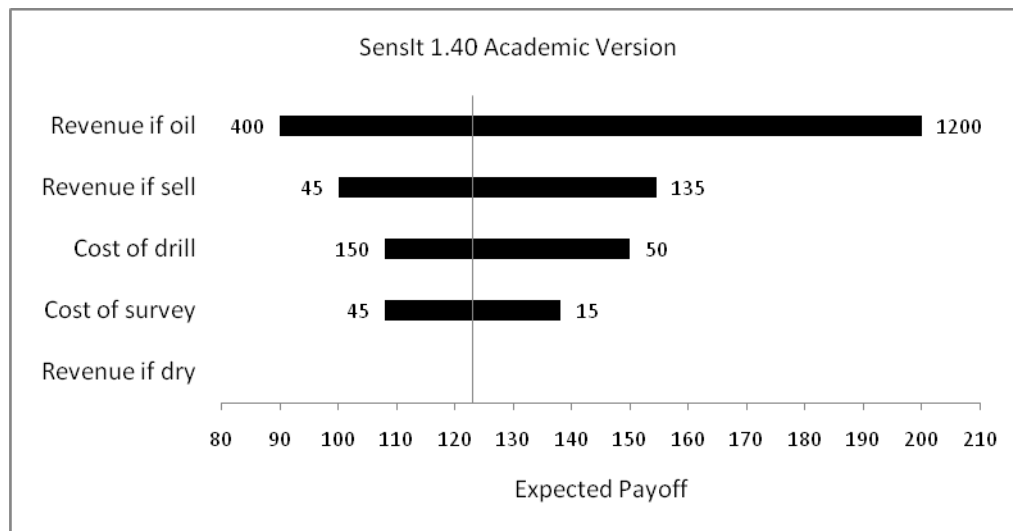


Figure 5.6