

DECISION SUPPORT MODELS 2020/2021

Precision Tree handout – Part 1

Constructing a decision tree for the research-and-development decision

1. Step 1:

- 1.1. Start by opening both the Excel and the PrecisionTree programs and enabling the macros if prompted¹. Figure 1 shows the two toolbars that appear at the top of your screen after opening Precision Tree.

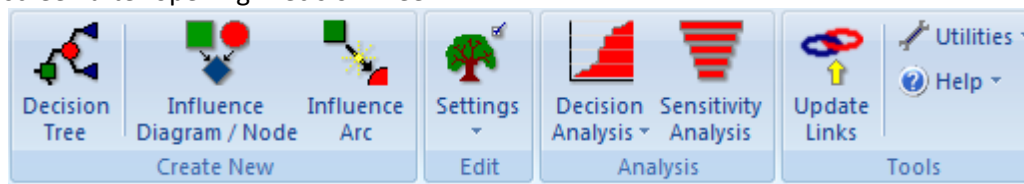


Figure 1: PrecisionTree and DecisionTools toolbars that are added to Excel's toolbar

- 1.2. To access the on-line help. Pull down the PrecisionTree menu and choose **H**elp in the **C**ontents. Use the on-line help when you have a question concerning the operation of PrecisionTree or any of the other DecisionTools programs.
 - 1.3. To create your decision tree, return to Excel and click on the **D**ecision Tree button, the first button from the left on the PrecisionTree toolbar. No changes occur until the next step, when you indicate the cell to start the tree.
 - 1.4. Click on the spreadsheet at the location where the tree will start. For this example, choose cell **A1**. The tree's root appears in A1 along with a single end node (blue triangle).
 - 1.5. Give a name to the tree, in the box where you have the *tree settings* dialog box.
 - 1.6. Fill **R&D Decision** in the tree name. Click ok.
2. **Step 2:** the next step is to add the "Development?" decision node.
- 2.1. To create this node, click on the **e**nd node (blue triangle). The *Node Settings* dialog box pops up.
 - 2.2. Click on the **d**ecision node button (green square, second from the left) and change the name from *Decision* to **Development?** Your node settings dialog box should now look like Figure 2.

¹ To run an add-in within Excel it is necessary to have the "ignore other applications" options turned off. Choose *T*ools on the menu bar, then *O*ptions, and click on the *G*eneral tab in the resulting *O*ptions dialog box. Be sure that the box by *I*gnore other applications is not checked.

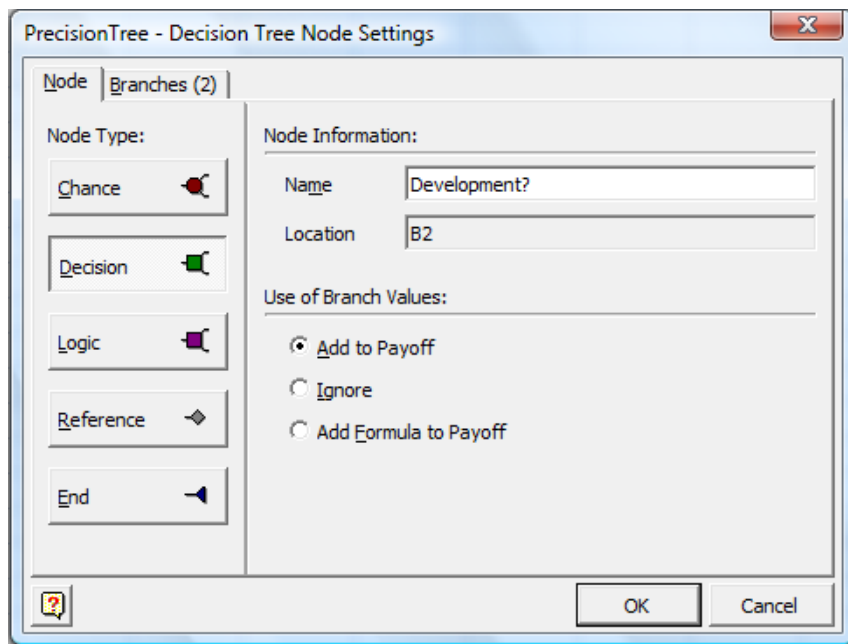


Figure 2: Node Settings dialog box for decision trees

- 2.3. Leave the number of branches at 2 because there are two alternatives: to continue or suspend developing the research project. Click **OK**.
 - 2.4. Rename the branches by clicking on their labels and replacing the word *branch* with **Continue Development** on one and **Stop Development** on the other.
 - 2.5. Enter -2 in the spreadsheet cell below the *Continue Development* branch because it costs \$2 million to continue developing the research project.
 - 2.6. Enter 0 in the cell below the *Stop Developing* branch because there is no cost in discontinuing the project.
3. **Step 3:** If you decide to stop development, no further modelling is necessary and the tree ends for this alternative. On the other hand, if the decision is to continue development, the future uncertainty regarding the patent requires further modelling. The uncertainty is model as the “Patent” chance node shown in Figure 3.

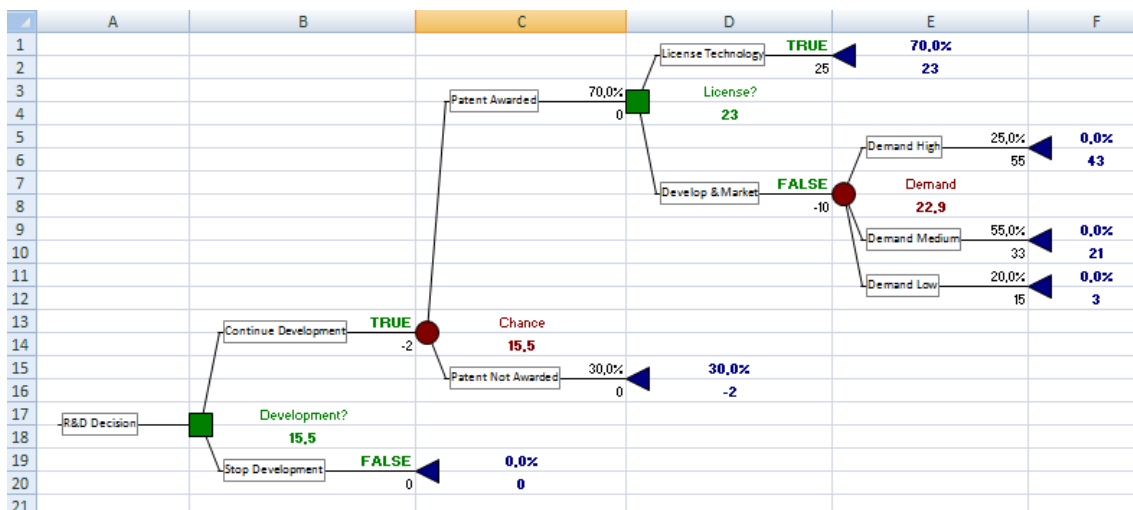


Figure 3: Decision tree for the research-and-development problem created in PrecisionTree

- 3.1. To add this chance node, click on the **end node** that follows the *Continue Development* branch.
- 3.2. In the *Node Settings* box that appears, choose the **chance node** button (red circle, first from the left) and change the name from *Chance* to **Patent**.

- 3.3. As before, there are two branches, this time because our concern is whether the patent will or will not be awarded. Click **OK**.
 - 3.4. Change the names of the branches to **Patent Awarded** and **Patent Not Awarded** by clicking on the labels and typing in the new names.
 - 3.5. Click in the spreadsheet cell above *Patent Awarded* and type **0.70** to indicate that there is a 70% chance of the patent being awarded.
 - 3.6. Select the cell above *Patent Not Awarded* and enter either **0.30** or **=1-C1**, where C1 is the cell that contains 0.70. In general, it is better to use cell references than numbers when constructing a model so that any changes will automatically be propagated throughout the model. In this case, using the cell reference **=1-C1** will guarantee that the probabilities add to one even if the patent-award probability changes.
 - 3.7. The values remain at zero because there are no direct gains or losses that occur at the time of either outcome.
4. **Step 4:** Once you know the patent outcome, you must decide whether to licence the technology or develop and market the product directly. Model this by adding a decision node following the “Patent Awarded” branch (see Figure 3).
 - 4.1. Click the **end node** (blue triangle) of the *Patent Awarded* branch.
 - 4.2. Choose decision node (green square) in the *node settings* dialog box.
 - 4.3. Name the decision **Licence?**
 - 4.4. Confirm that the node will have two branches.
 - 4.5. Click **OK**.
 - 4.6. Rename the two new branches **License Technology** and **Develop & Market**.
 - 4.7. PrecisionTree defaults to a value of zero for each branch. To change the values, highlight the cell below the *Licence Technology* given that the patent has been awarded is \$25 million.
 - 4.8. Similarly, place **-10** in the cell below the *Develop & Market* branch, because a \$10 million investment in production and marketing is needed, again assuming we have the patent.
5. **Step 5:** Developing the product in-house requires us to model market demand, the final step in the structuring process.
 - 5.1. Click on the **end node** of the *Development & Market* branch.
 - 5.2. Select chance as the node type.
 - 5.3. Enter the name **demand**.
 - 5.4. **Add** one more branch, because we have three outcomes for this uncertainty.
 - 5.5. Click **OK**.
 - 5.6. Retitle the branches **Demand High**, **Demand Medium** and **Demand Low**.
 - 5.7. Enter the probabilities **0.25**, **0.55**, **0.20** above and the values **55**, **33**, **15** below the respective branches *Demand High*, *Demand Medium* and *Demand Low*.

Constructing an Influence Diagram for the basic risky decision, generating the corresponding tree and calculate the EVPI

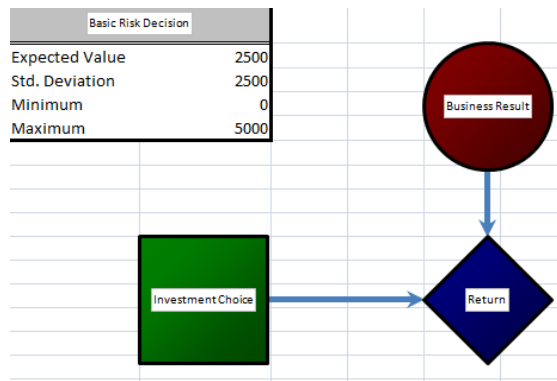


Figure 4: Influence diagram for the basic risky decision created in PrecisionTree

6. Step 6:

- 6.1. Select a new sheet.
- 6.2. Start by clicking on the **Influence Diagram/Node** icon (Figure 1, PrecisionTree toolbar, second button from the left).
- 6.3. Move the cursor, which has changed into crosshairs, to the spreadsheet. Although an influence diagram may be started by clicking inside any cell, for this example start the diagram by clicking on cell **B10**.
- 6.4. Name the Influence Diagram as Basic Risk Decision.
- 6.5. Click on the Payoff node and choose the decision node. Enter the name Investment Choice as the node name.

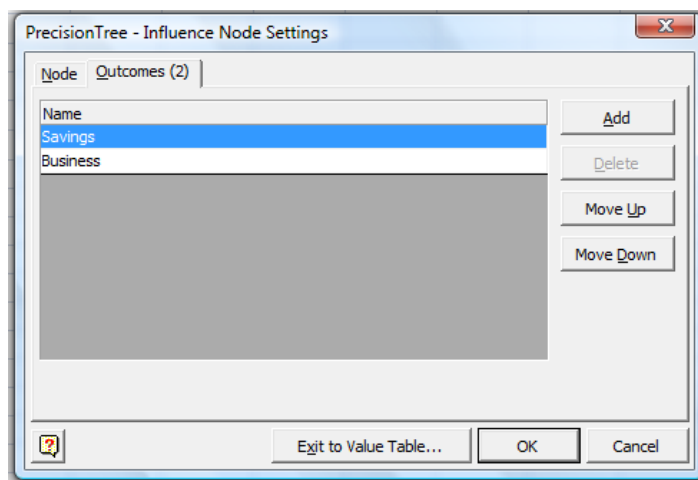
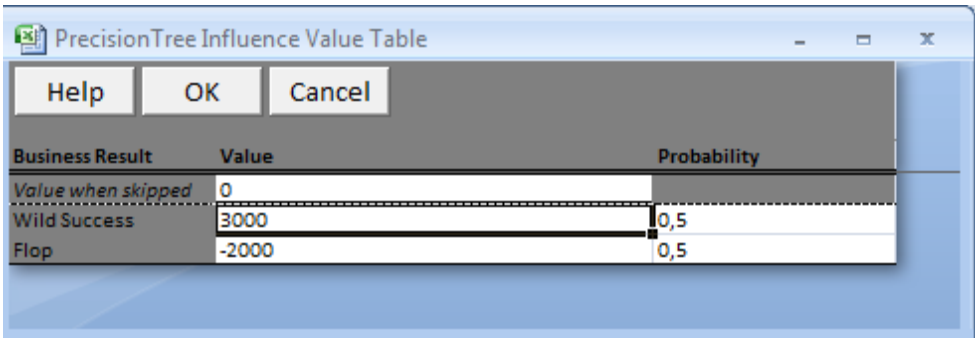


Figure 5: Influence Node settings dialog box for influence diagrams

- 6.6. Click on the heading *Outcomes* at the top of the box, and you will see the list of possible outcomes. Naming the outcomes is analogous to naming the branches of a decision tree. To enter outcomes names, first click on **Outcome #1**.
- 6.7. Move the cursor down to where the text can be edited.
- 6.8. Delete *Outcome #1* from this line by backspacing, and type in the new outcome name **Savings**.
- 6.9. Change the name of *Outcome #2* by moving the cursor back up to the *Outcomes* List and clicking on **Outcome #2**.
- 6.10. Return to the editing box, delete *Outcome #2* by backspacing, and replace it with the new outcome name **Business**.

- 6.11. When you are finished, your *Influence Node Settings* dialog box should look like Figure 5. Click **OK**.
7. **Step 7:** Now let's add the "Business Result" chance node
- 7.1. Click on the **New Influence Diagram/Node** button on the PrecisionTree toolbar.
 - 7.2. Click in cell E2.
 - 7.3. To make this a chance node, click on the **chance node** icon (red circle, first from the left) in the *Influence Node Settings* dialog box.
 - 7.4. Following the same procedure as before, name the node **Business Result** and the two outcomes **Wild success** and **Flop**.
 - 7.5. Click **OK**.
8. **Step 8:** The last node to be added to our diagram is the payoff node. PrecisionTree allows only one payoff node in an influence diagram. Creating a payoff node is similar to creating the other types of nodes except that naming the node is the only available option.
- 8.1. Start by clicking the **New Influence Diagram/Node** button.
 - 8.2. Click on cell E10.
 - 8.3. Click on the pay off node icon (blue diamond, fourth from the left) in the *Influence Node Settings* dialog box, enter the name **Return**, and click **OK**.
9. **Step 9:**
- 9.1. Click on the Influence Arc button on the PrecisionTree toolbar (Figure 1, third button from the left).
 - 9.2. Place the cursor in the source node *Investment Choice*, and Destination node in the Return. Click **OK**.
 - 9.3. To add the second arc, again click on the **Influence Arc** button and create an arc from the chance node *Business Result* to *Return* as described above.
10. **Step 10:** Now that our decisions have been structured, we can add the probabilities and values. We begin by adding the values and probabilities to the chance node.
- 10.1. Click on the option **Exit to Value Table** on the node name **Business Result** to bring up the *Influence Node Settings* dialog box.
 - 10.2. Click on the **Exit to Value Table** button in the lower right-hand corner to bring up the *Influence Value Editor* box (Figure 6). This box is configured with the names of the two outcomes or branches on the left, a column for entering values in the middle, and a column for entering probabilities on the right.



Business Result	Value	Probability
Value when skipped	0	
Wild Success	3000	0,5
Flop	-2000	0,5

Figure 6: Influence Value Editor for the "Business Result" chance node

- 10.3. Enter the values and probabilities shown in Figure 6 hitting the tab key after entering each number, including the last entry. (Be sure to enter a zero if an outcome has no value associated with it, as in the *Value When Skipped* cell)
- 10.4. When all numbers are entered, click **OK**.

11. Step 11:
 - 11.1. To add the values to a decision node, click on the **Investment Choice** and choose the **Exit to Value Table** button.
 - 11.2. Enter **0** for the values to the *Value when Skipped*, **2000** for the *Savings*, and **2000** for the *Business* alternatives. Be sure to hit the tab or enter key to confirm each entry, including the last entry.
 - 11.3. When finished, click **OK**.

12. Step 12: Here are the steps for the
 - 12.1. Open the *Influence Value Editor* box by clicking on the payoff node name **Return** and clicking the **Exit to Value Table...** button.
 - 12.2. Type an equal sign (=) into the first value cell.
 - 12.3. Move the cursor to the word Savings to the right of the value cell and below the *Investment Choice* Heading, and click. "E4" appears in the value cell next to equal sign. E4 references the \$2000 value we assigned to savings in step 11. PrecisionTree will substitute this value into the formula.
 - 12.4. To complete this cell, after = E4, type **+200**, the amount of interest earned with the savings account.
 - 12.5. In the next row down, type another = into the value cell.
 - 12.6. Click on **Savings** to the cell's right and two rows below the heading *Investment Choice*. "E5" appears in the cell. Finish by typing **+200**.
 - 12.7. In the third value cell, Type =, click on **Business** (to access the \$2000 investment), type +, and click on **Wild Success** (to access the \$3000 earnings) to the cell's Right and three rows below the heading *Business Result*.
 - 12.8. Using Figure 7 as a guide, enter the final set of values, and click **OK**. Note that you use the cells to the right and in the same row as the value cell you are defining.

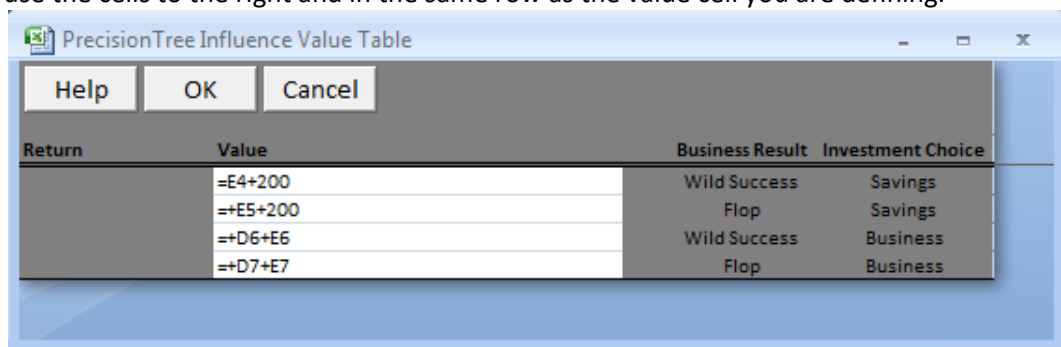


Figure 7: Influence Value Editor for the payoff node. This mini-spreadsheet specifies how PrecisionTree calculates the values for the payoff node

13. Step 13: Here are the steps for:
 - 13.1. Generating the decision tree from the influence diagram. This can be done with, "right click" over any node and choose the option "**Convert to Decision Tree**", as presented on Figure 8

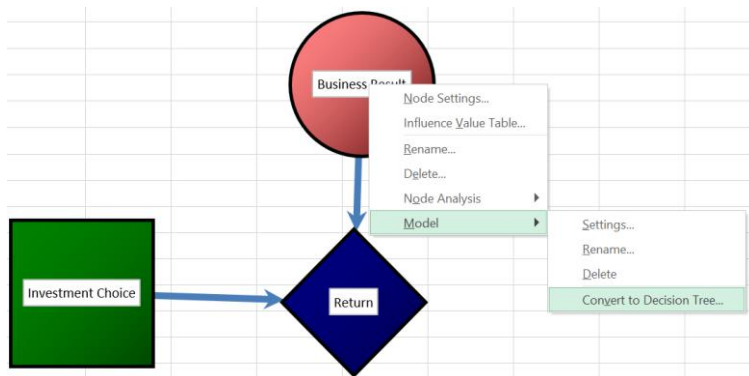


Figure 8: Generating a decision tree from an influence diagram

13.2. You should obtain the following tree in Figure 9:

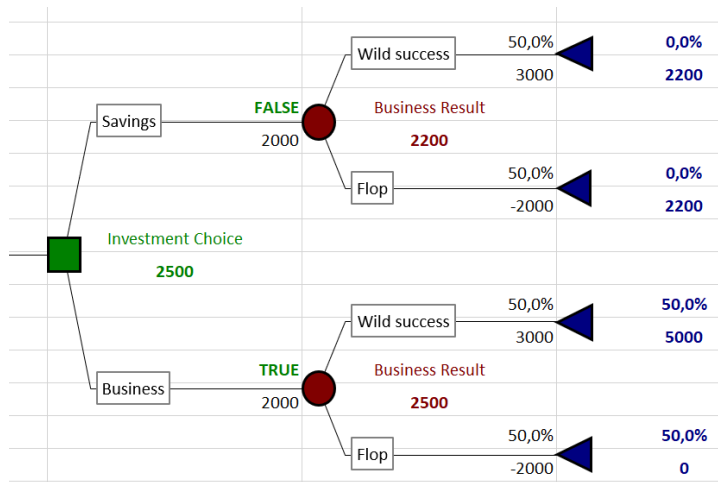


Figure 9: Decision tree for the initial problem

14. To achieve the **Expected Value of the Perfect Information (EVPI)**, insert an arc in the influence diagram, from “**Business Result**” node to “**Investment Choice**” node as shown in Figure 10:

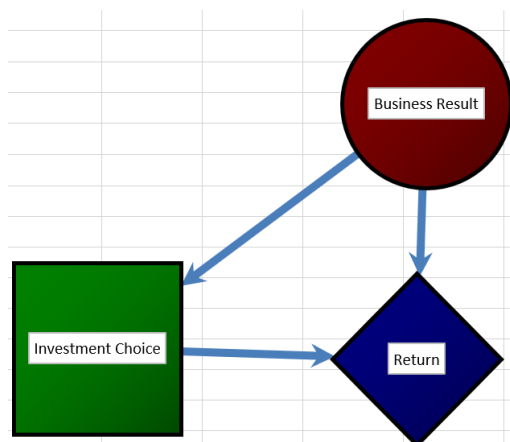


Figure 10: Deciding only after having access to the perfect information

14.1. "Right click" over any node and choose "Convert to Decision Tree". You should obtain the following tree as presented in Figure 11:

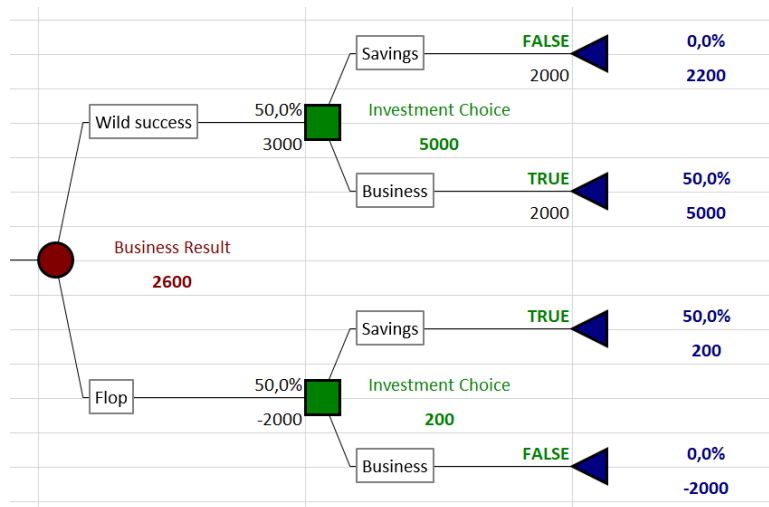


Figure 11: Tree with the perfect information

14.2. The **Expected value of the Perfect Information (EVPI)** is achieved subtracting the expected value from the initial tree (Figure 9) from the expected value achieved with the maximum amount of information (Figure 11): $2600 - 2500 = 100 = \text{EVPI}$

15 Suppose you have now an opinion from an Expert in market research about the probability of success to Business. So, create a new chance node (**Expert opinion**) with the information from the Expert, as shown in Figure 12:

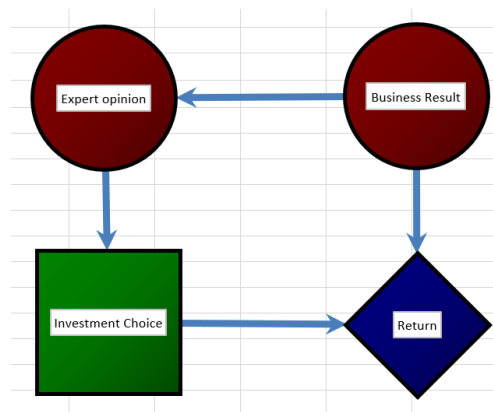


Figure 12: Influence diagram with a new node "Expert opinion"

15.1 Create the two possible outcomes from the Expert decisions as presented in figure 13:

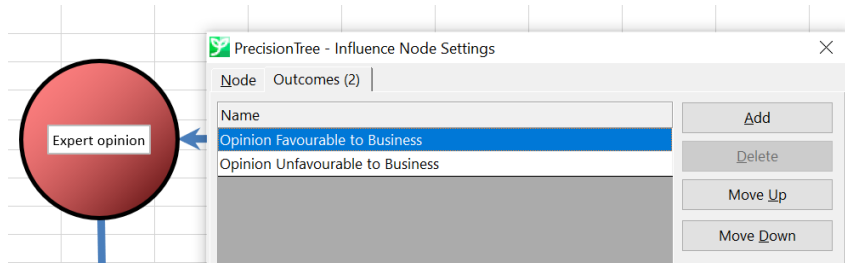


Figure 13: Chance node “Expert opinion” with two outcomes

15.2 The accuracy of the Expert opinion is quite good in historical terms, but it is not perfect, as shown in the next table., You need to these values in the node “Expert opinion”, as shown in figure 14:

Expert opinion	Value	Probability	Business Result
Value when skipped	0		
Opinion Favourable to Business		0,97	Wild success
Opinion Unfavourable to Business		0,03	Wild success
Opinion Favourable to Business		0,15	Flop
Opinion Unfavourable to Business		0,85	Flop

Figure 14: “Expert opinion” conditional probabilities reflecting the accuracy of their opinion: $P(\text{Opinion favorable or Unfavorable} \mid \text{Success or Flop})$

15.3 Right click over any node and convert the influence diagram to a decision tree as shown in figure 15:

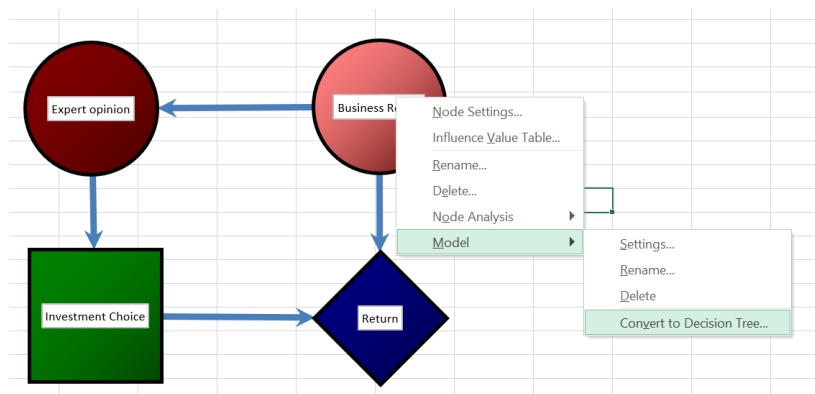


Figure 15: convert the influence diagram to a decision tree

15.4 The generated tree is presented in figure 16 and the difference between the expected Monetary value for this new tree (EMV=2513) and the original tree (2500), is the value of the imperfect information (EVII). So, $EVII=2513-2500=13$

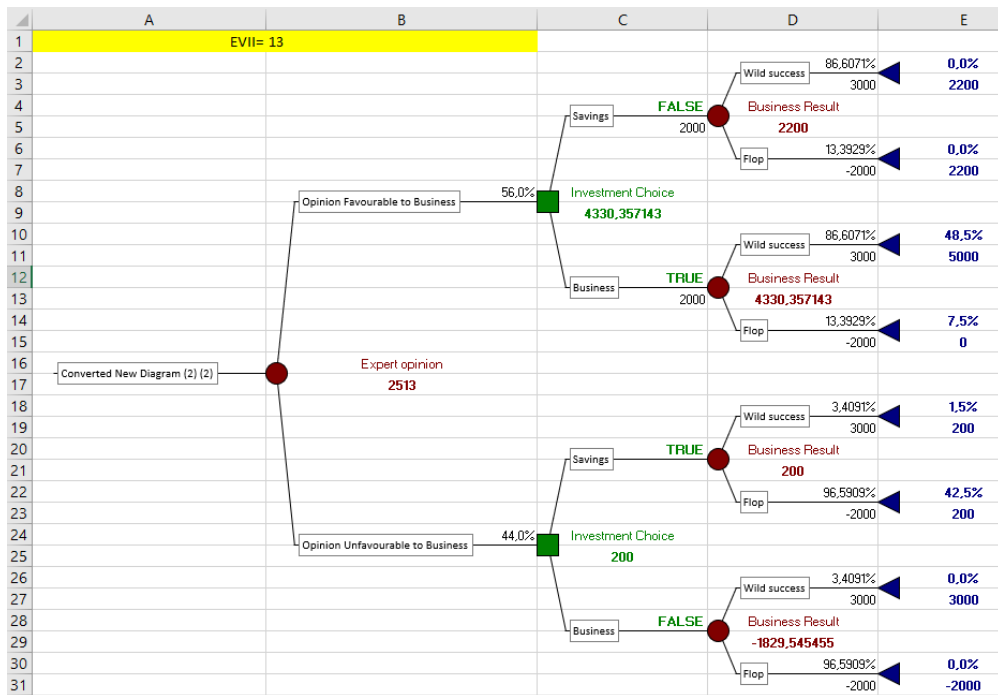


Figure 16: Decision tree with Bayesian calculated probabilities and the inherent EVII

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