A tutorial

introduction to

TreePlan

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1. INTRODUCTION

This document provides an introduction to the use of TreePlan, an Excel add-in for building decision tree models. For updates or further information about TreePlan, go to www.TreePlan.com. The following example problem is used for illustration in this tutorial.

Example problem

A pharmaceutical company is facing a go-to-market decision for a new product in China. The market is very large and expected to grow. The drug, being a combination of two active ingredients, is expected to offer an attractive treatment alternative. Yet, the market share that can be captured is highly uncertain due to the presence of increasing competition and evolving reforms likely to alter the pharmaceutical market landscape. Three market entry strategies are under consideration: a traditional "base-case" approach, in which the drug is marketed via hospitals, relying on existing sales representative to promote the new product alongside with the existing product portfolio of the company. This approach piggybacks on existing marketing activities and involves only marginal marketing efforts. The second option involves entering the market also via hospitals but as a single brand, by deploying a dedicated sales force. This requires adding sales representatives. The third option involves a dedicated focus on retail sales, which may reach a potentially much larger market for this product, in addition to pursuing hospital sales. Focusing on retail is a much more ambitious entry strategy that requires a significant increase in sales force and marketing efforts in unchartered waters.

For each marketing strategy, projections of sales revenues have been elaborated using discounted cash flow analysis, under a high market share scenario and a low market share scenario. Investment costs (including development and prelaunch activities) have also been estimated. The figures are summarized in the table below (all figures are Present Values in millions of RMB).

Financial estimates for new drug marketing strategy

		Net Sales Revenue	
Marketing Option	***Cost***	High Mkt Share	Low Mkt Share
Hospital-Base-case	**20**	**270**	**30**
Hospital-Enhanced	**40**	**300**	**45**
Retail + Hospital	**120**	**580**	**50**

(Note: all values are in million RMB, discounted to the present year)

2. DECISION TREES

Decision problems can be represented in a graphical form known as a **decision tree**. Figure 1 shows the decision problem for the pharmaceutical company represented in this format.

As shown in Figure 1, a decision tree is composed of a collection of nodes (represented by squares and circles) interconnected by branches (represented by lines). A square node is called a **decision node** because it represents a decision. Branches emanating from a decision node represent the different alternatives for a particular decision. In Figure 1, a single decision node represents the decision the company faces about how to market the new drug. The four branches coming out of this decision node represent the three marketing alternatives under consideration and the option of simply abandoning the project. The cash flow (i.e. development cost) associated with each alternative is also listed. For example, the value −20 below the alternative labeled "Hospital-Base-case" indicates that if the company pursues that strategy, it must incur a cost of 20.

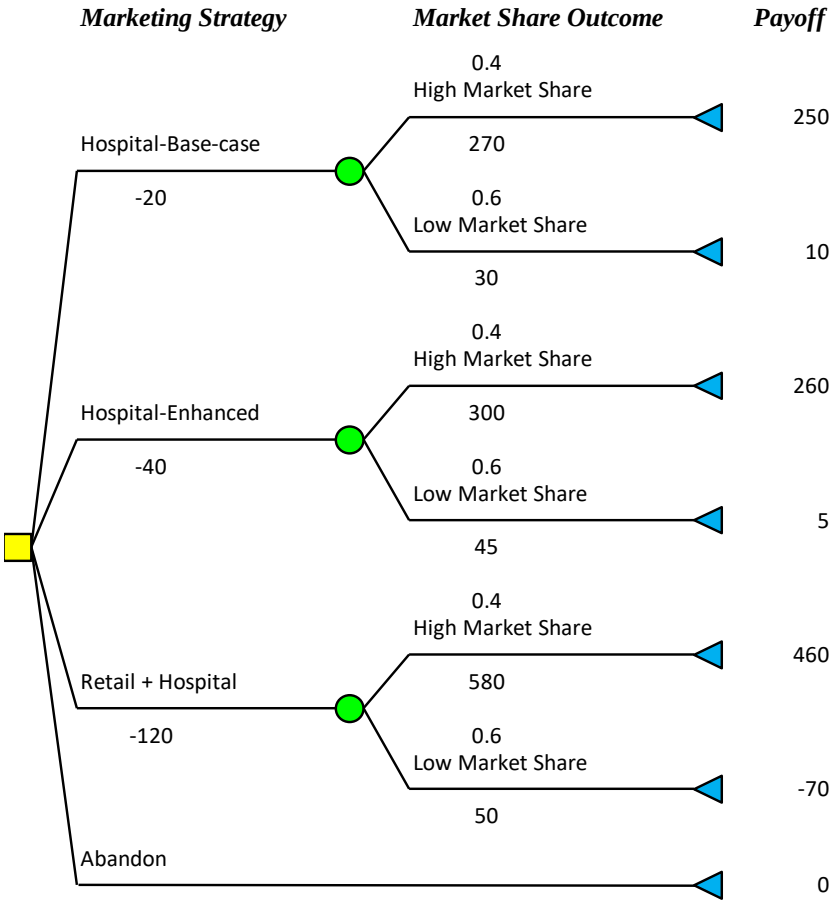


Figure 1 A decision tree representation of the example problem.

The circular nodes in a decision tree represent uncertain events and are so-called **event nodes**. The branches emanating from event nodes correspond to the possible states of nature or the possible outcomes of an uncertain event. Figure 1 shows that the first three decision alternatives are followed by an uncertain event. The branches from each event node represent possible market share outcomes for the new product. In each case, the new product can reach either a high or a low market share. The value attached to each branch from an event node indicates the cash flow that will occur for that decision/event combination. For example, at the top event node the value 270 below the first event branch indicates that if the company pursues a base-case marketing strategy and the product reaches a high market share, a cash flow of 270 will occur. Probabilities are also attached to event branches, reflecting their chance of occurrence. The value 0.4 on the top event branch indicates that the probability of obtaining a high market share has been assessed at 40%.

The various paths in a decision tree end at the small triangles called **terminal nodes**. The payoff occurring at each terminal node corresponds to one way in which the decision problem can terminate: it is computed by summing the cash flows along the set of branches leading to each terminal node. For example, following the uppermost branches through the tree, a payoff of 250 results if the decision to use the base-case marketing is followed by a high market share for the product
(−20 + 270 = 250). You should verify the cash-flow values on each branch and at each terminal node before continuing. The Abandon branch leads to a 0 payoff, because no costs or benefits are accrued by selecting this alternative.

Decision trees are particularly suited to modeling situations that involve cascades of decisions and events, that is, multiple phases where future decisions may be interdependent with previous decisions and chance events.

2.1 Calculating Best Decisions

After computing the payoffs at each terminal node, we can apply any of several decision rules. For example, we could identify the maximum possible payoff for each decision and apply the so-called **maximax** decision rule. This consists of selecting the alternative that leads to the best possible payoff. Another rule, called **maximin**, consists of maximizing the minimum payoff obtainable. Maximin works by identifying the worst payoff for each alternative, and selecting the alternative leading to the maximum worst case payoff. Although it has been found that decision makers do sometimes pay attention to the best and, particularly, worst payoffs in dealing with risks, the maximax and maximin rules are limited because the best and worst payoffs may be very unlikely. These rules focus exclusively on the extreme payoffs, and thus ignore probabilities and information about the whole distribution of possible outcomes. A compelling rule for evaluating risky decisions is the **Expected Value** (EV) rule –that is, to identify the decision with the best expected value. The expected value of a risk prospect is obtained by multiplying each payoff by its probability and summing the whole.

We can apply a process known as **rolling back** to a decision tree to determine the decision with the largest EV. To roll back the decision tree, we start with the terminal payoffs and work our way from right to left, back through the decision tree, computing the expected values for each node. For example, the third event node has a 0.4 probability of resulting in a payoff of 460, and a 0.6 probability of resulting in a loss of 70. Thus, the EV at that node is calculated as:

EV at third event node = $0.4 \times 460 + 0.6 \times -70 = 142$

The expected value calculations for the other event nodes are:

EV at first event node = $0.4 \times 250 + 0.6 \times 10 = 106$
EV at second event node = $0.4 \times 260 + 0.6 \times 5 = 107$

The EV for a decision node is obtained in a different way. For example, at the decision node we face a decision among four alternatives that lead to events with expected values of 106, 107, 142, and 0, respectively. At a decision node we always select the alternative that leads to the best EV. Thus, the EV at the decision node is 142, which corresponds to the EV resulting from the decision to pursue the retail marketing strategy.

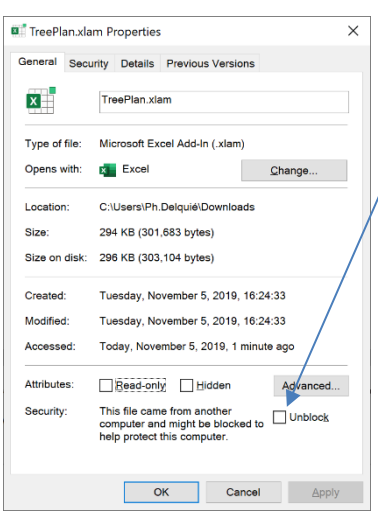
3. USING TREEPLAN

The spreadsheet add-in called **TreePlan** can help us create and analyze decision trees in Excel. We will use TreePlan to implement the decision tree presented above in Excel. TreePlan is an Excel macro, that is, a set of commands, contained in the file TreePlan.xlam. It does not require installation; however, you must follow specific steps to load the TreePlan macro in Excel.

To use TreePlan, follow these instructions:

1. Save your own copy of the file TreePlan.xlam to a location that you can remember on your computer (do not attempt to open TreePlan.xlam from a download server, save it first).
2. *Windows* users only, you may have to do the following before using TreePlan for the first time: Right-click on TreePlan.xlam, select Properties, General tab, and check Unblock (if you see such a box) and click OK.

   Notes: (i) You need to unblock the downloaded TreePlan.xlam file only once. (ii) This does not apply to Mac Excel users.



3. Start Excel with a blank worksheet, go to File > Open, then browse to open TreePlan.xlam. If you see a Security Notice pop up, click "Enable Macros". This will add a tab called **Add-Ins** to your Excel menu, which contains a **Decision Tree** command (as seen in Figure 2 below). In Mac Excel, the Decision Tree command may appear in the **Tools** menu. **Important**: Do *not* double-click on TreePlan.xlam to start it, as you normally do to open Excel workbooks (.xlsx files), because this may not load the macro properly. Instead, first start Excel, then open TreePlan.xlam as instructed here.

To create a new decision tree in an empty worksheet, click the Decision Tree command. Another way of calling the Decision Tree command is to use the Windows Excel short-cut by pressing the [Ctrl][Shift][T] keys simultaneously. In Mac Excel, a Decision Tree command will not appear in any menu, you must use the short-cut [option][command][T] to use TreePlan. In response, TreePlan displays the dialog box shown in Figure 2.

The remainder of this document provides step-by-step instructions for building the decision tree of Figure 1, showing screen-prints at every step. You can replicate the entire process on your computer to learn how to use TreePlan. All screen shots appearing in this document were generated on a Windows PC. Minor variations on your computer screen may occur due to different software versions.

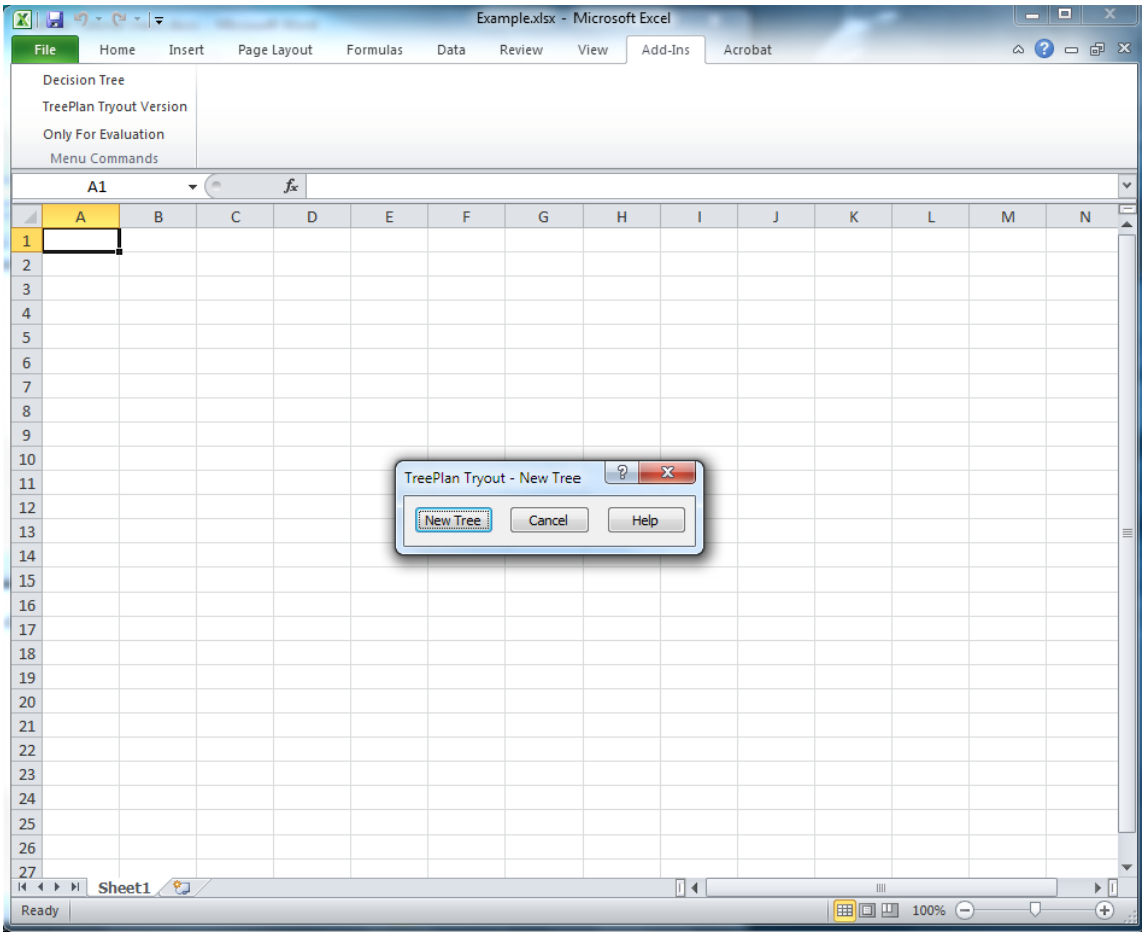


Figure 2 Initial TreePlan dialog box.

If you click the New Tree button, TreePlan creates a tree diagram with one initial decision node and two decision branches. As shown in Figure 3, this initial tree diagram is inserted in the spreadsheet near the cell that is selected when TreePlan is invoked.

TreePlan automatically labels the branches in the tree as Alternative 1 and Alternative 2. Later, we will edit these labels to describe more accurately the alternatives in our example problem. First, we will add two more decision branches to the initial tree shown in Figure 3.

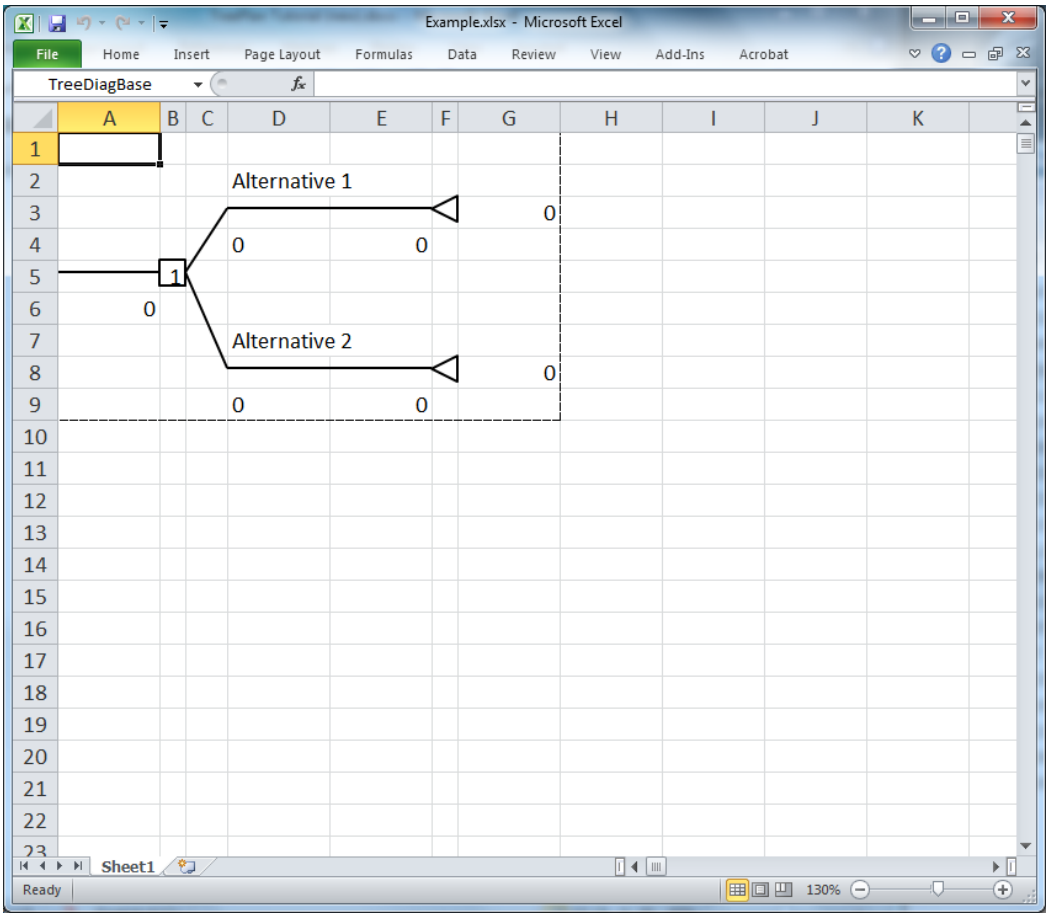


Figure 3 Initial decision tree created by TreePlan

3.1 Adding Branches

To add a new decision branch to our tree:

1. Select the decision node (cell B5).
2. Press [Ctrl][Shift][T] to invoke TreePlan ([option][command][T] on a Mac).

The dialog box shown in Figure 4 appears. Because we selected a decision node before invoking TreePlan, this dialog box displays the options for working on the selected decision node. Different dialog boxes appear if we select an event node or terminal node and then invoke TreePlan. It is important to understand that TreePlan is context-sensitive: that is, the dialog box that appears depends on what cell is selected when you invoke TreePlan.

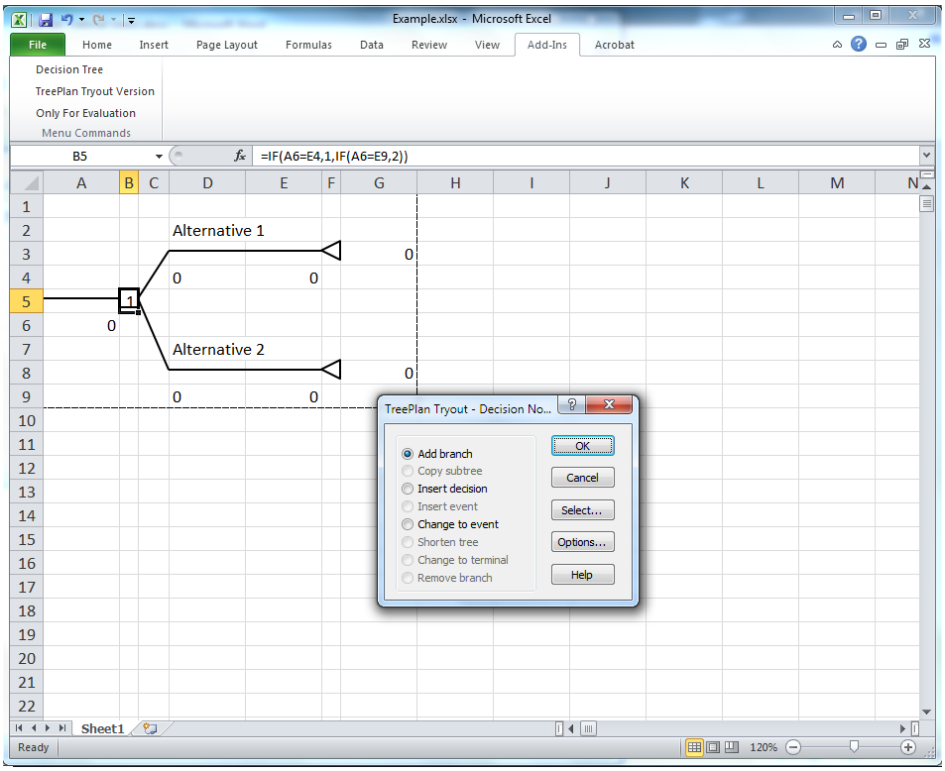


Figure 4 TreePlan Decision Node dialog box.

To add a branch to the currently selected decision node, click the Add branch button, then click OK. A third branch is added to the tree, as shown in Figure 5.

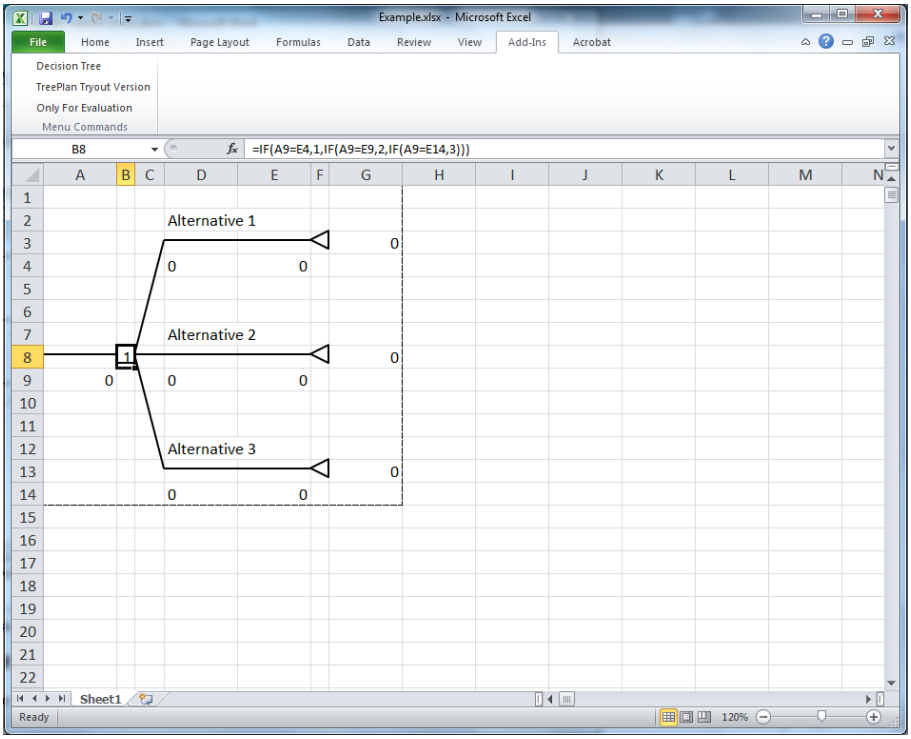


Figure 5 Modified tree with three decision branches.

We repeat the process to add a fourth decision branch, and we type text in the label cell on each branch to describe the decision alternatives. This is visible in Figure 6.

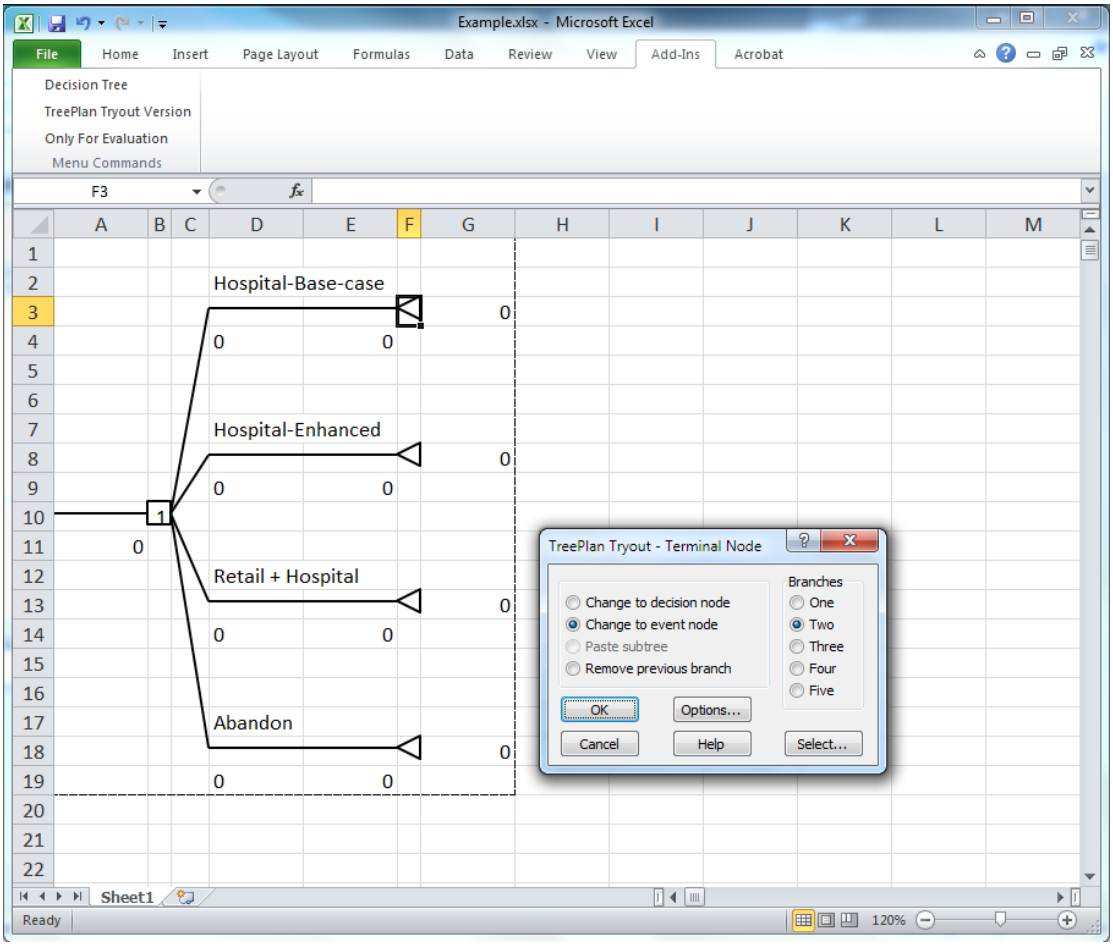


Figure 6 Modified tree with four decision branches and TreePlan Terminal Node dialog box.

3.2 Adding Event Nodes

Three of the decision branches in Figure 1 lead to an event node with two event branches. Thus, we need to add event nodes to the decision tree shown in Figure 6. To add an event node at the end of a decision branch:

1. Select the cell containing the terminal node of the first decision branch (cell F3).
2. Press [Ctrl][Shift][T] to invoke TreePlan ([option][command][T] on a Mac).

Because we selected a terminal node before invoking TreePlan, the TreePlan Terminal Node dialog box appears as shown in Figure 6. (**Note**: depending on the version of TreePlan, it may be necessary to select the *cell* containing the terminal node, *not* the triangle shape itself.)

This dialog box displays the options for working on a terminal node. In this case, we want to change the selected terminal node to an event node with two branches.

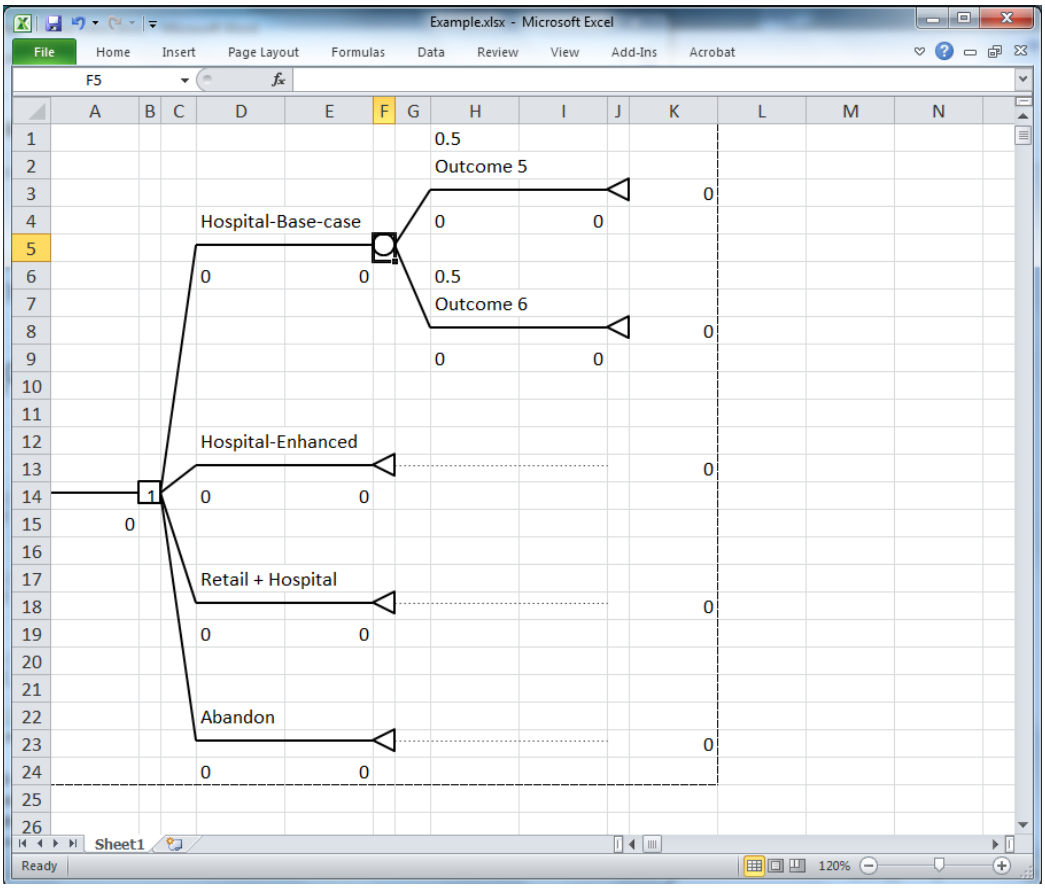


Figure 7 Modified tree with an event node.

The resulting spreadsheet is shown in Figure 7. TreePlan automatically labels the event branches as Outcome 5 and Outcome 6, but we can change the labels to whatever we want. The cells immediately above each event branch label (cells H1 and H6) are reserved to hold the probability of each event brnach. By default, TreePlan assigns equal probabilities to the events (that is, 0.5 in the case of two branches), but we can change these values to whatever is appropriate for our particular problem.

In Figure 8, we changed the labels and probabilities of the event branches to correspond to the events occurring in the example problem. For the probability of low market share in cell H6, we entered the Excel formula =1−H1, because the probabilities of all branches out of an event node must add up to 1. This way, if we later change the probability of High Market share, the other probability will be automatically adjusted. The procedure used to create the event node for the Base-case marketing decision could be repeated to create event nodes for the decision branches corresponding to Hospital-Enhanced and Retail+Hospital strategies. However, because all of the event nodes are identical (except for the associated partial cash flows), we can simply copy the existing event node.

You might be tempted to copy and paste the existing event node using the standard Excel commands – but if you use the standard Excel commands, TreePlan cannot update the tree settings properly. As shown in Figure 8, TreePlan provides a built-in option that allows you to copy a **subtree** of a decision tree to another part of the tree. It is important to copy subtrees using this

command so that TreePlan can update the appropriate formulas in the spreadsheet. To create a copy of the event node:

1. Select the event node you want to copy (cell F5).
2. Press [Ctrl][Shift][T] to invoke TreePlan ([option][command][T] on a Mac).
3. Click Copy subtree.
4. Click OK.

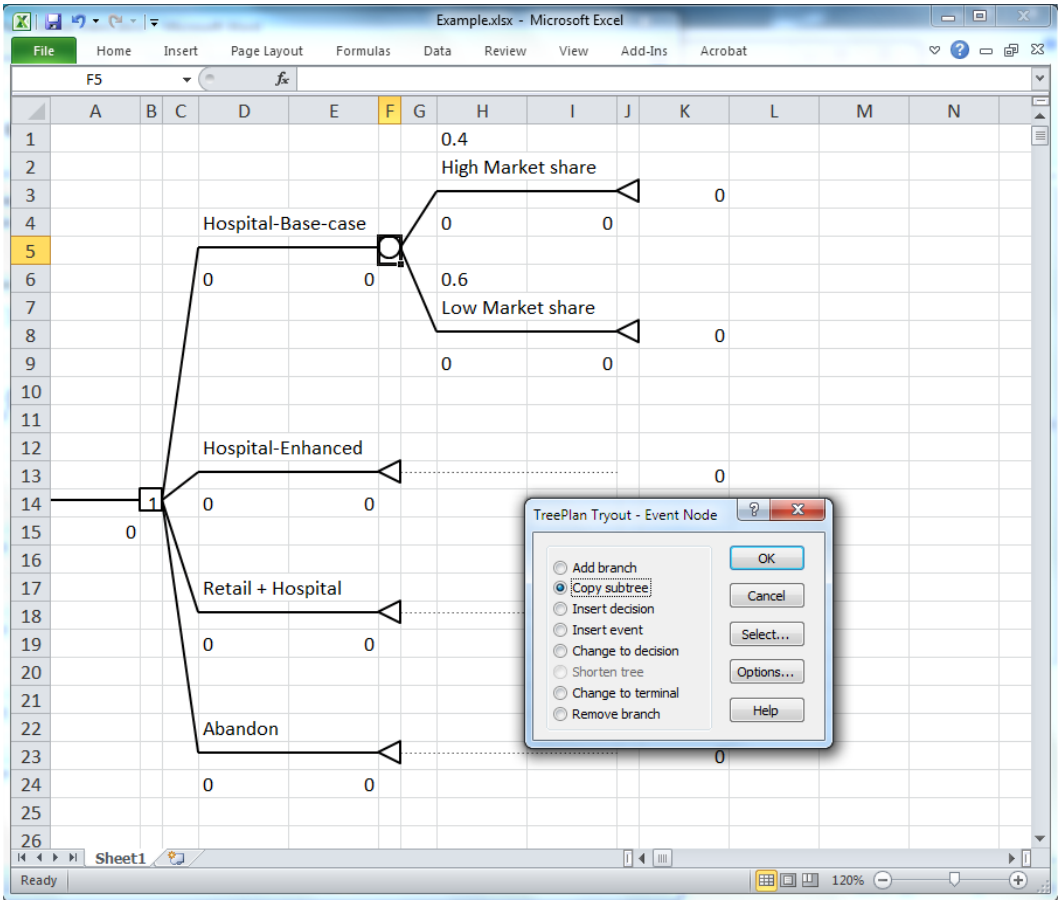


Figure 8 Using TreePlan to copy a subtree.

This creates a copy of the selected event node on the clipboard. As shown in Figure 9, to paste a copy of this subtree into the decision tree:

1. Select the target cell location (cell F13).
2. Press [Ctrl][Shift][T] to invoke TreePlan ([option][command][T] on a Mac).
3. Click Paste subtree.
4. Click OK.

We can repeat this copy-and-paste procedure to create the third event node needed for the decision to pursue the Retail+Hospital marketing strategy. Figure 10 shows the resulting spreadsheet.

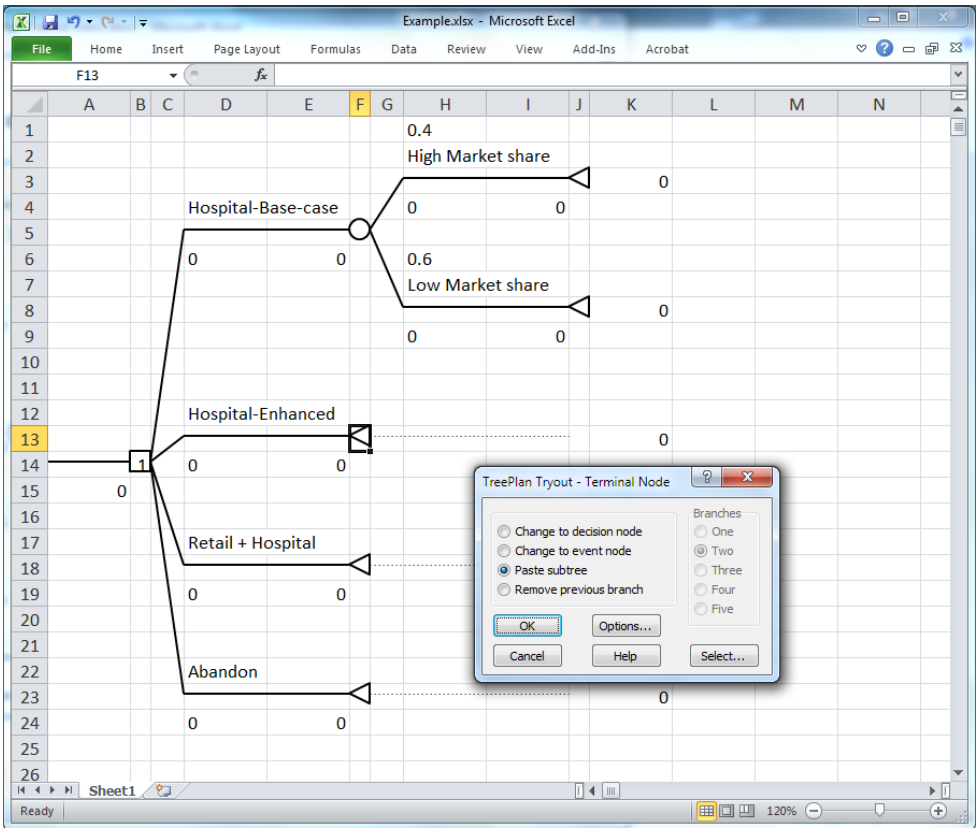


Figure 9 Using TreePlan to paste the copied subtree.

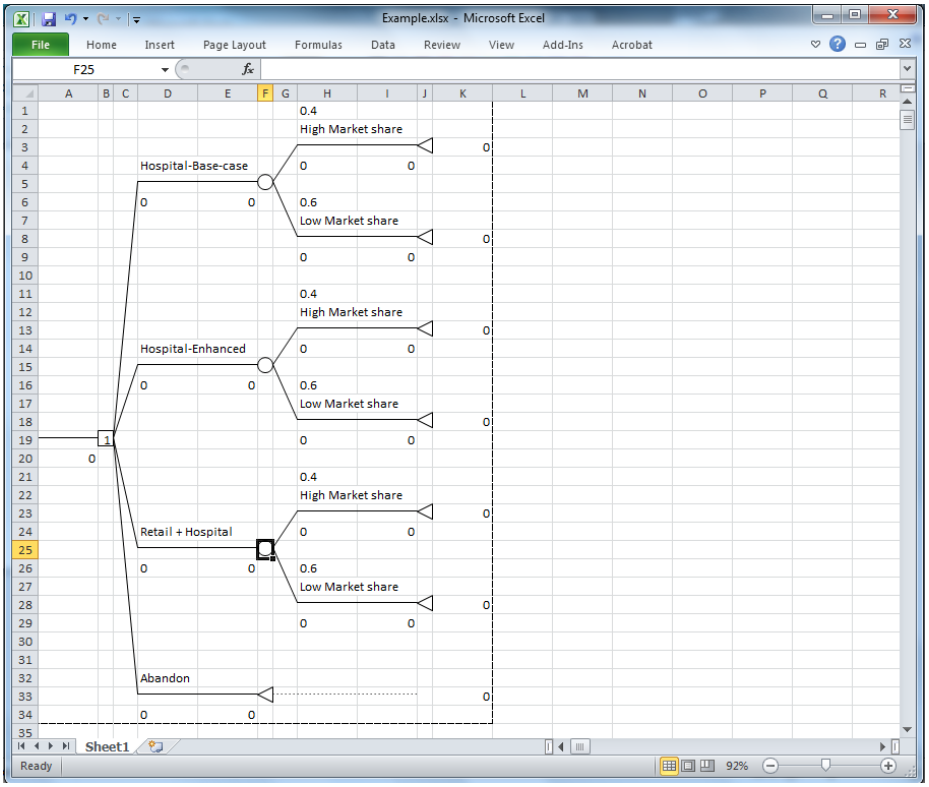


Figure 10 Decision tree with three event nodes.

3.3 Adding the Cash Flows

To complete the decision tree, we need to add the cash flows that are associated with each decision and event. TreePlan reserves the first cell below each branch to represent the partial cash flow associated with that branch. For example, in Figure 11 cell D6 represents the partial cash flow that occurs if the company selects the Base-case strategy, and cell H4 represents the partial cash flow that occurs if the company selects the Base-case strategy and a High market share is attained. The remaining partial cash flows for each decision are entered in the appropriate cells in Figure 11 in a similar manner.

3.4 Determining the Payoffs and EVs

Next to each terminal node, TreePlan automatically created a formula that sums the payoffs along the branches leading to that node. For example, cell K3 in Figure 11 contains the formula =SUM(H4,D6). Thus, when we enter or change the partial cash flows for the branches in the decision tree, the payoffs are updated automatically.

Immediately below and to the left of each node, TreePlan created formulas that compute the EV at each node in the same way as described earlier in our discussion of rolling back a decision tree. Thus, cell A20 in Figure 11 indicates that the largest EV at the decision node is 142. The value 3 in the decision node (cell B19) indicates that this maximum EV is obtained by selecting the third decision branch (that is, the Retail+Hospital alternative).

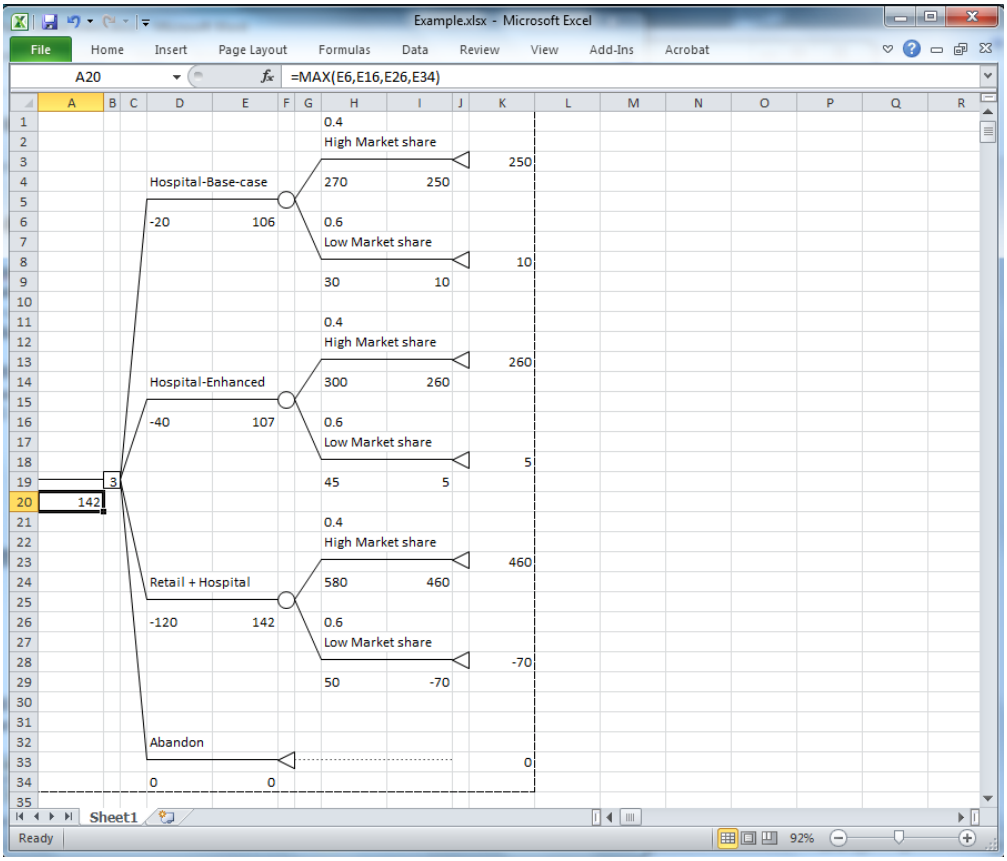


Figure 11 Completed decision tree for the example decision problem.

3.5 Further Analysis

A TreePlan model such as the one in Figure 11 is made up entirely of standard Excel formulas and has all the features of a "regular" Excel model. For example, we can do what-if analysis on the probability of reaching a High Market Share, by changing that probability to different values to see how it influences the choice of marketing strategy. For this, we link the probability of High Market Share of the three event nodes together so that we can change the value in one cell and the change is propagated to all relevant places. In cells H11 and H21, we entered the formula =H1. If we input low and high values in H1, we find that the Hospital-Base-case strategy is optimal for a probability of High market share below about 0.28; above 0.28, the Retail strategy is optimal. The Hospital-Enhanced strategy never becomes optimal as the value in H1 changes.

3.6 Other Features

The preceding discussion gives you an overview of how TreePlan operates, its capabilities, and some of its options. Most of the other TreePlan options are self-explanatory, and you can obtain descriptions of them by clicking the Help button available in all the TreePlan dialog boxes. The Select and Options buttons available in all the TreePlan dialog boxes are briefly described here.

At times we want to select all the instances of a certain type of element in a decision tree. For example, we may want to select all the partial cash flows and display them in a currency format, or we may want to format the probability values in a different color. The TreePlan Select dialog box shown in Figure 12 is designed to simplify this process. By selecting an option in this dialog box, all the elements of the type chosen will be selected automatically in the spreadsheet, enabling us to format them all at the same time.

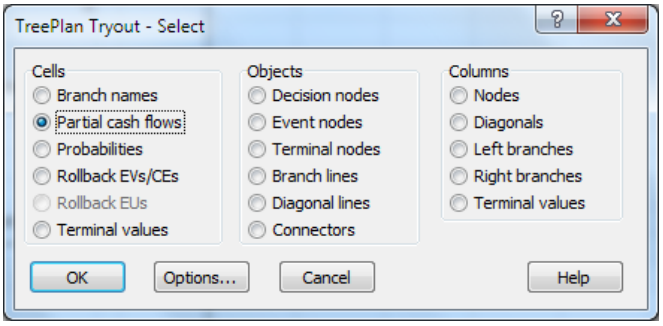


Figure 12 TreePlan Select dialog box.

The TreePlan Options dialog box shown in Figure 13 serves two purposes. By default, TreePlan assumes that we want to analyze the decision tree using expected values. However, another technique (described elsewhere) uses exponential utility functions to incorporate risk aversion in calculating best decisions. The Options dialog box provides options for selecting whether TreePlan should use expected values or exponential utility functions. Also, by default TreePlan assumes that the terminal payoffs represent profit and that we want to identify the decision with the largest EV. However, in some decision trees the payoffs could represent costs that we want to minimize. Thus, this dialog box provides options for maximizing or minimizing EVs.

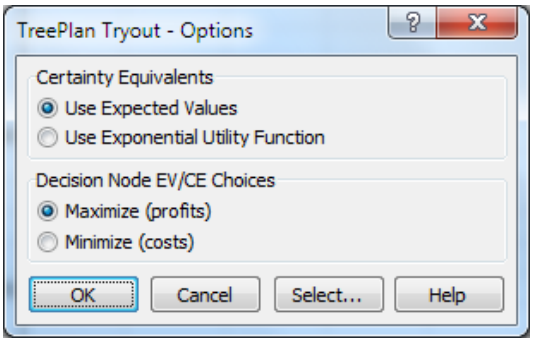


Figure 13 TreePlan Options dialog box.

About TreePlan

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