15.10 Using TreePlan

A spreadsheet add-in called **TreePlan** can help us create and analyze decision trees in Excel. We will use TreePlan to implement the decision tree shown in Figure 15.13 in Excel.

To attach the TreePlan add-in, use Excel's Open command to open the file named treeplan.xla provided on your data disk. To create a decision tree using TreePlan, open a new workbook, then invoke TreePlan by choosing the DecisionTree command from the Add-Ins menu (or by pressing [Ctrl][t]). In response, TreePlan displays the dialog box shown in Figure 15.14.

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 15.15, this initial tree diagram is inserted in the spreadsheet near the cell that is active when TreePlan is invoked. Also note that TreePlan uses the vertical lines shown in cells F3 and F8 to denote the leaves (or terminal nodes) in a decision problem.

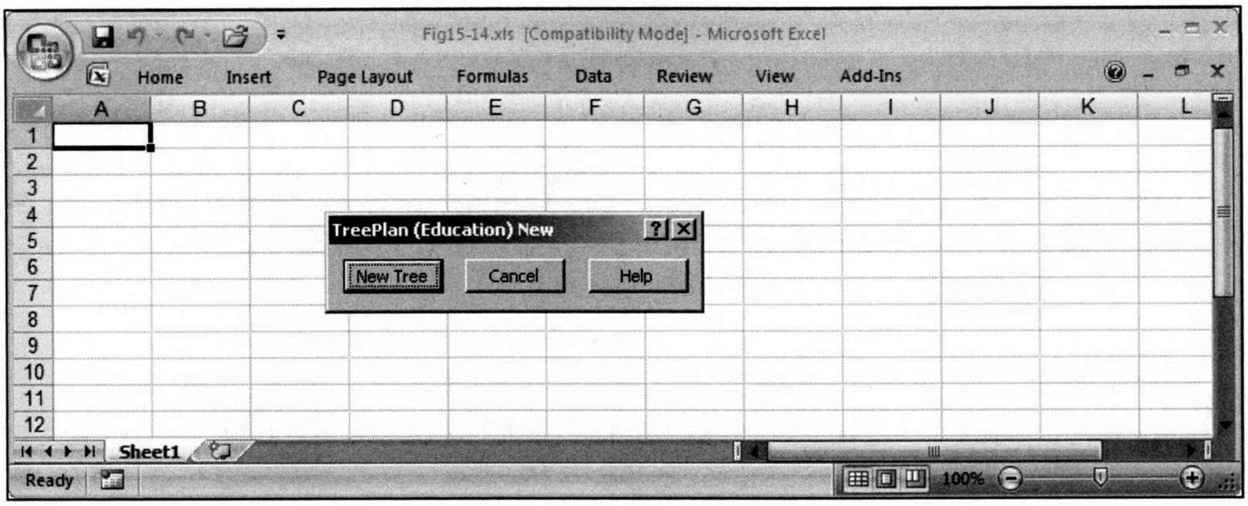


FIGURE 15.14

Initial TreePlan dialog box

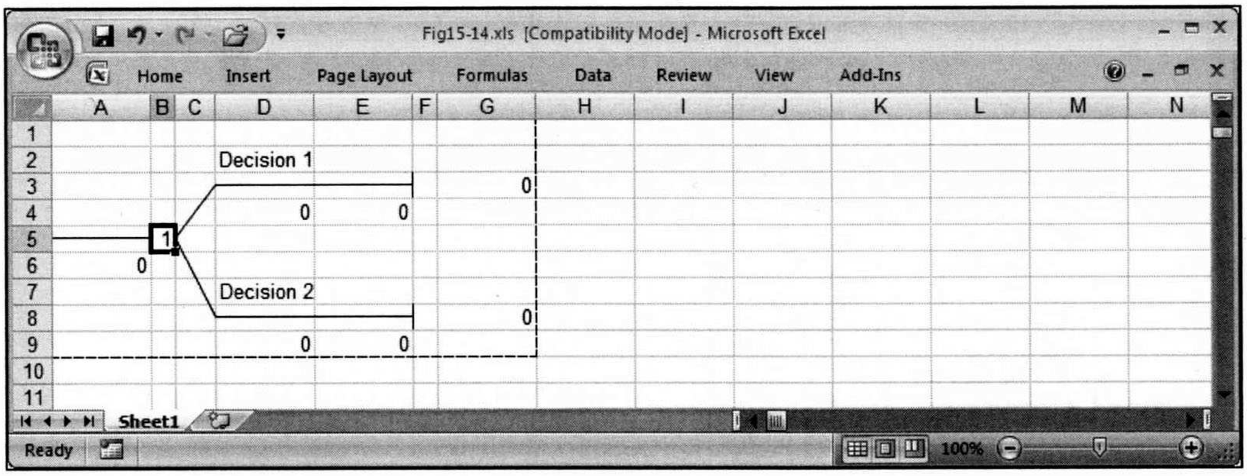


FIGURE 15.15

Initial decision tree created by TreePlan

TreePlan automatically labels the branches in the tree as Decision 1 and Decision 2. Later, we will change these labels to describe more accurately the decisions in our example problem. First, we will add two more decision branches to the initial tree shown in Figure 15.14.

15.10.1 ADDING BRANCHES

To add a new decision branch to our tree:

1. Click the decision node (cell B5).
2. Press [Ctrl][t] to invoke TreePlan.

The dialog box shown in Figure 15.16 appears. Because we selected a decision node before invoking TreePlan, this dialog box displays the options for working on a 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 when you invoke TreePlan depends on which cell is selected when TreePlan is invoked.

To add a branch to the currently selected decision node, click the Add branch option, and then click OK. A third branch is added to the tree, as shown in Figure 15.17.

FIGURE 15.16

TreePlan Decision dialog box

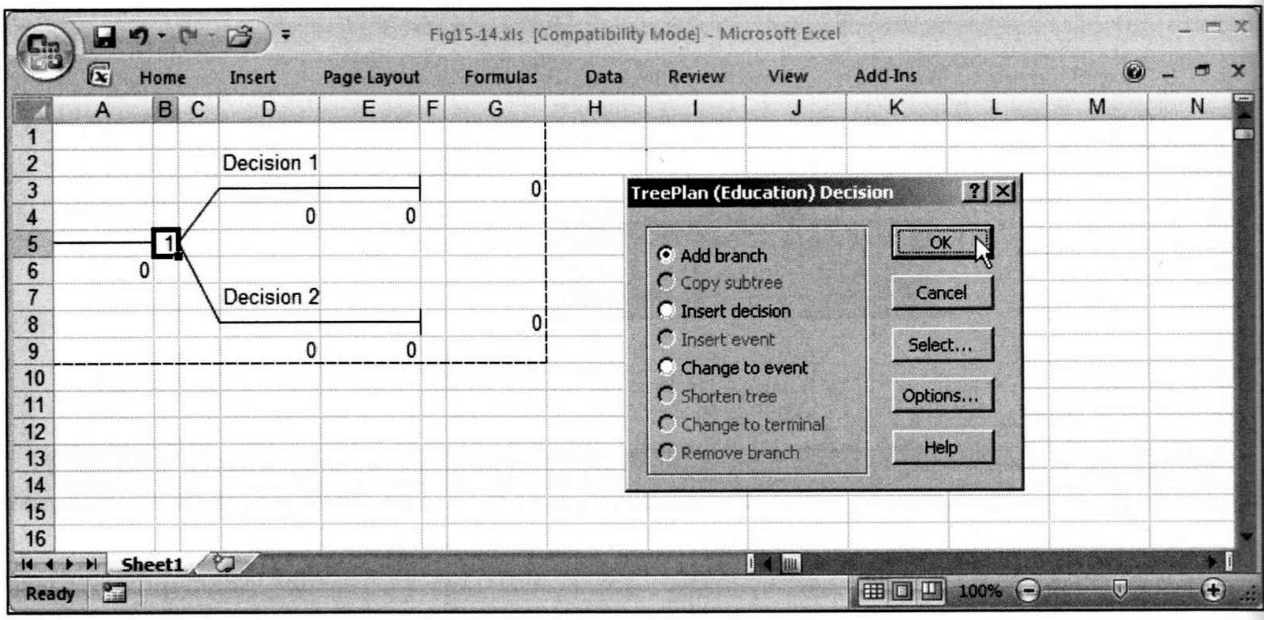
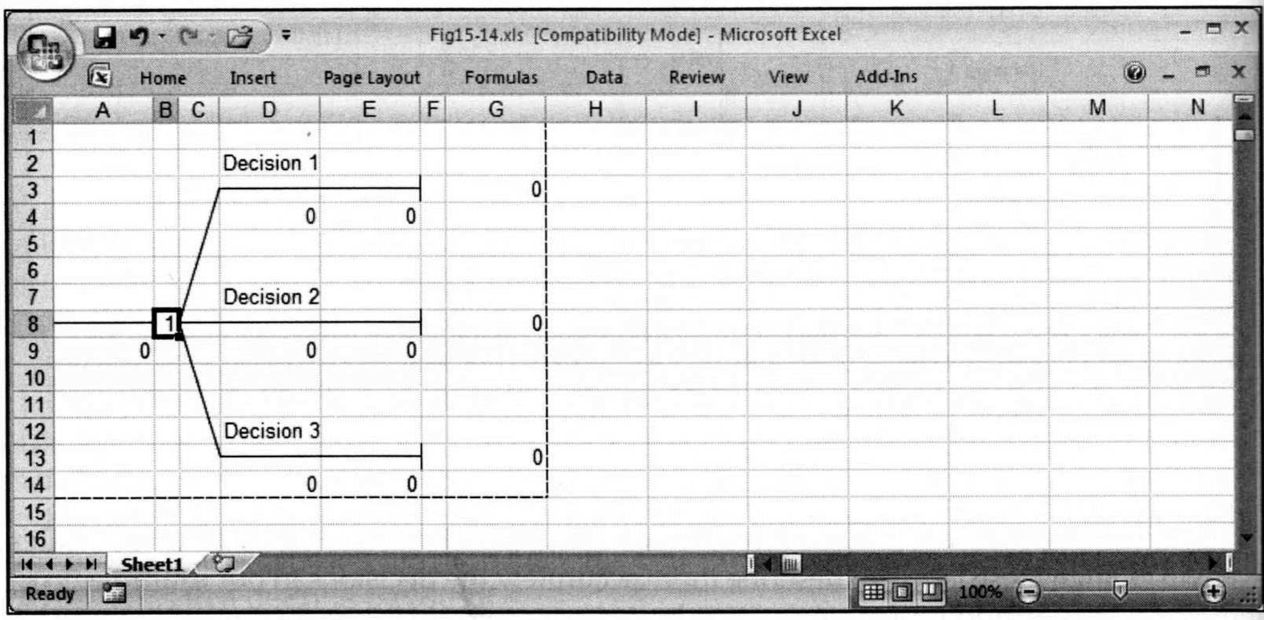


FIGURE 15.17

Modified tree with three decision branches



To add the fourth decision branch to the tree, we can follow the same procedure:

1. Click the decision node (cell B8).
2. Press [Ctrl][t] to invoke TreePlan.
3. Click Add branch.
4. Click OK.

The four decision branches for this problem appear as shown in Figure 15.18. Notice that we changed the label on each branch to reflect the decision alternatives for Magnolia Inns.

15.10.2 ADDING EVENT NODES

Each of the first three decision branches in Figure 15.13 leads to an event node with two event branches. Thus, we need to add similar event nodes to the decision tree shown in Figure 15.18. To add an event node:

1. Select the terminal node for the branch labeled Buy A (cell F3).
2. Press [Ctrl][t] to invoke TreePlan.

Because we selected a terminal node before invoking TreePlan, the TreePlan Terminal dialog box appears as shown in Figure 15.19.

This dialog box displays the options for working on a terminal node. In this case, we want to change the selected terminal node into an event node with two branches, as shown in Figure 15.19. The resulting spreadsheet is shown in Figure 15.20.

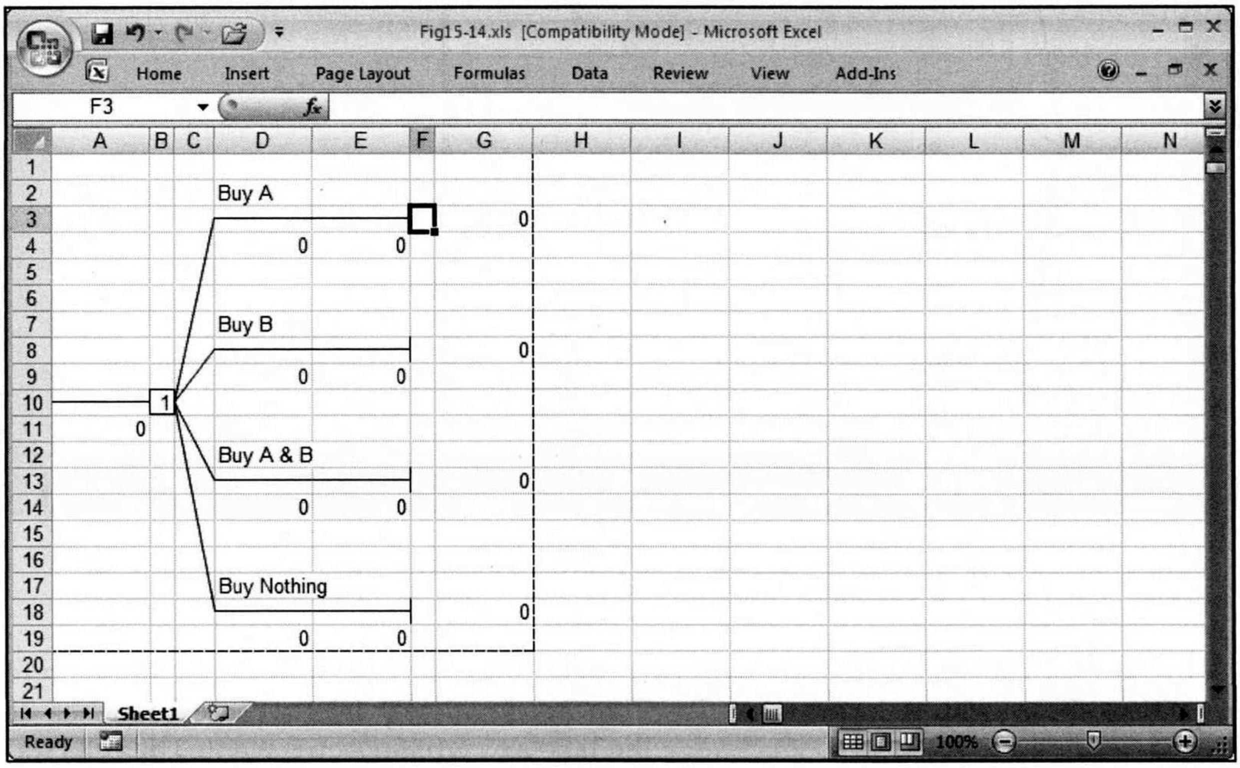


FIGURE 15.18

Modified tree with four decision branches labeled for the Magnolia Inns decision problem

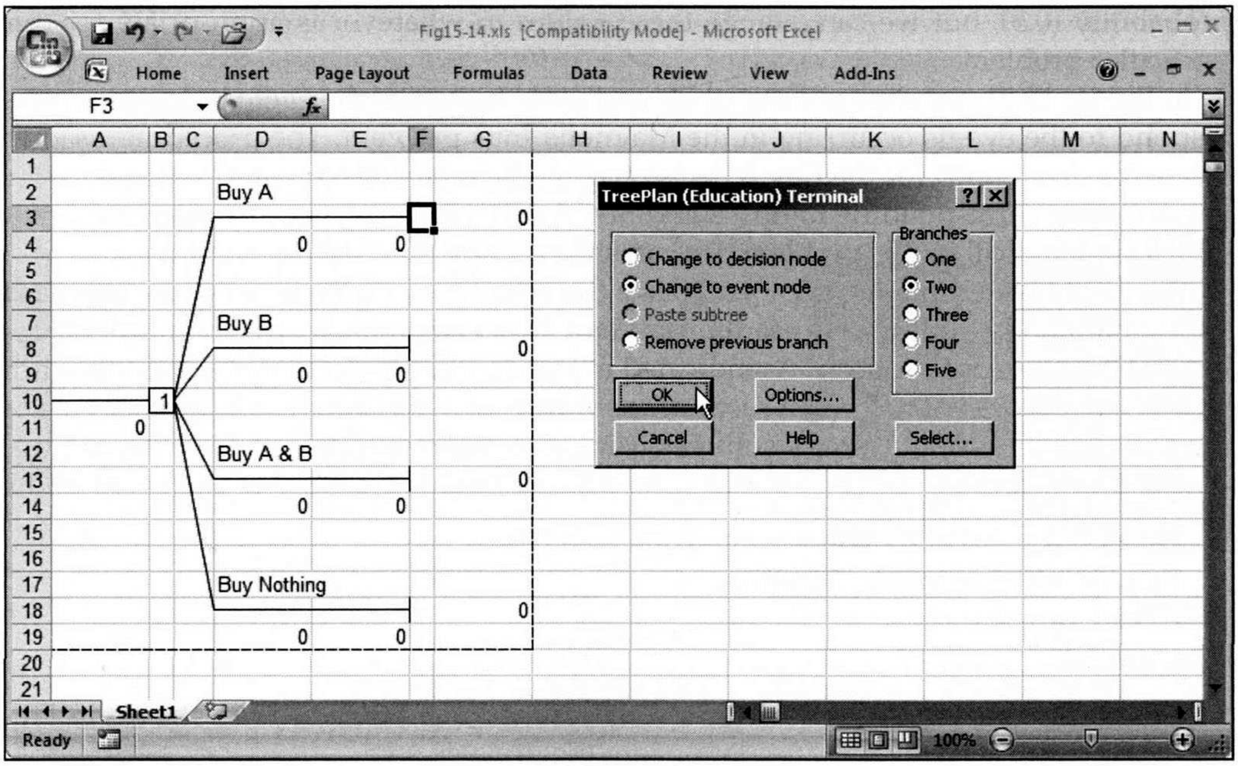


FIGURE 15.19

TreePlan Terminal dialog box

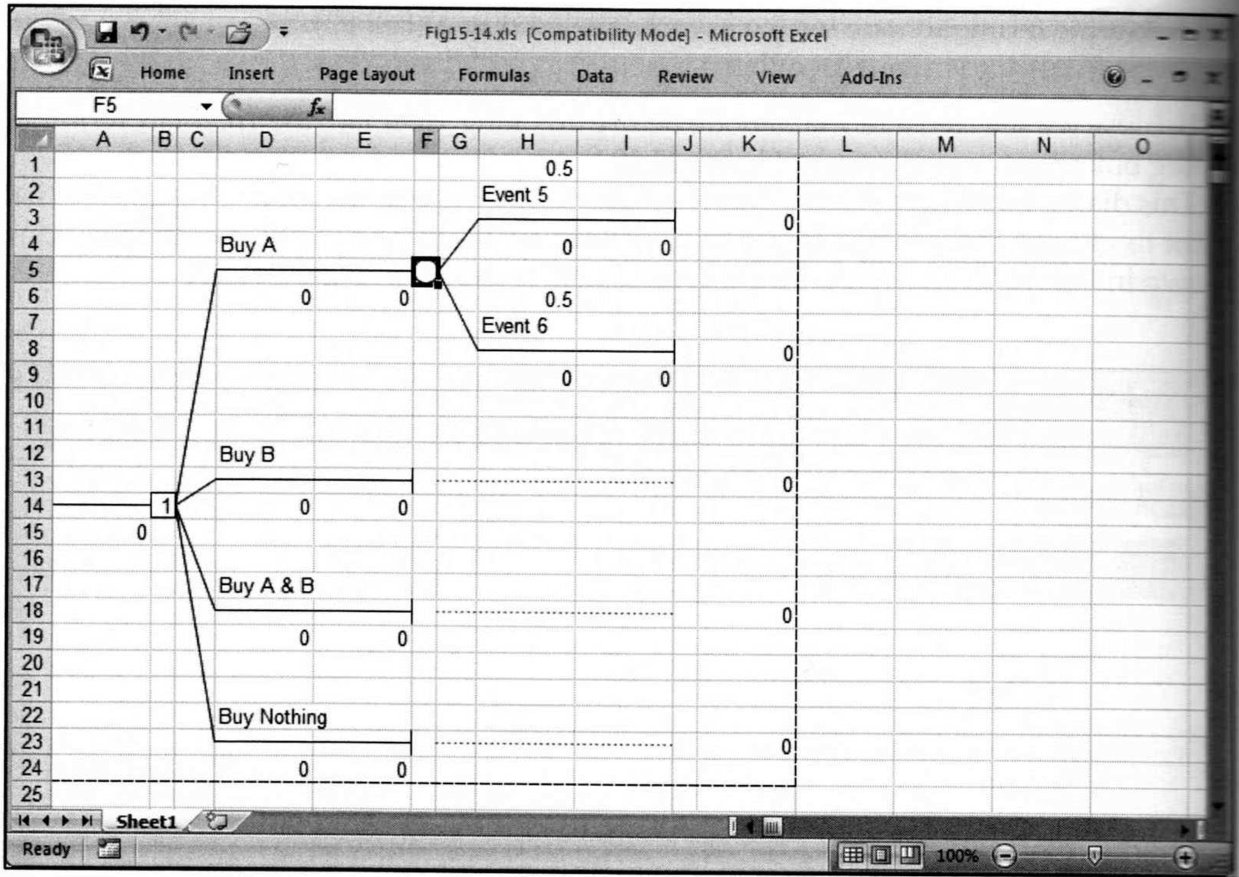


FIGURE 15.20

Modified tree with an event node

In Figure 15.20, an event node with two event branches now follows the decision to purchase the parcel at location A. TreePlan automatically labels these branches as Event 5 and Event 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 represent the probability of each event. By default, TreePlan assumes that the events have equal probability (0.5), but we can change these values to whatever is appropriate for our particular problem.

In Figure 15.21, we changed the labels and probabilities of the event branches to correspond to the events occurring in the Magnolia Inns problem. The procedure used to create the event node for the Buy A decision could be repeated to create event nodes for the decisions corresponding to Buy B and Buy A & B. However, because all of the event nodes are identical in this problem, 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 indicated in Figure 15.21, TreePlan provides a built-in option that allows you to copy a section, or **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][t] to invoke TreePlan.
3. Click Copy subtree.
4. Click OK.

This creates a copy of the selected event node on the Clipboard. As shown in Figure 15.22, to paste a copy of this subtree into the decision tree:

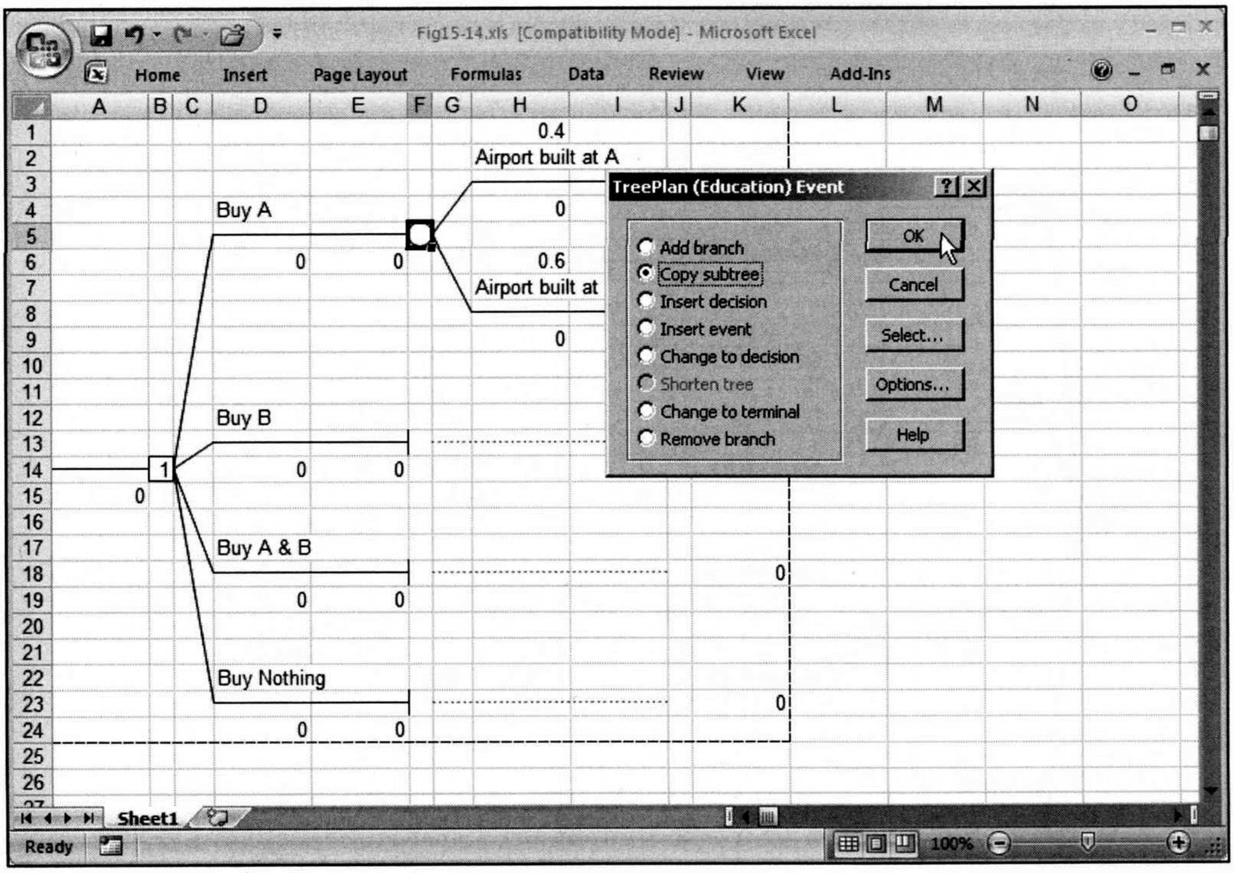


FIGURE 15.21

Using TreePlan to copy a subtree

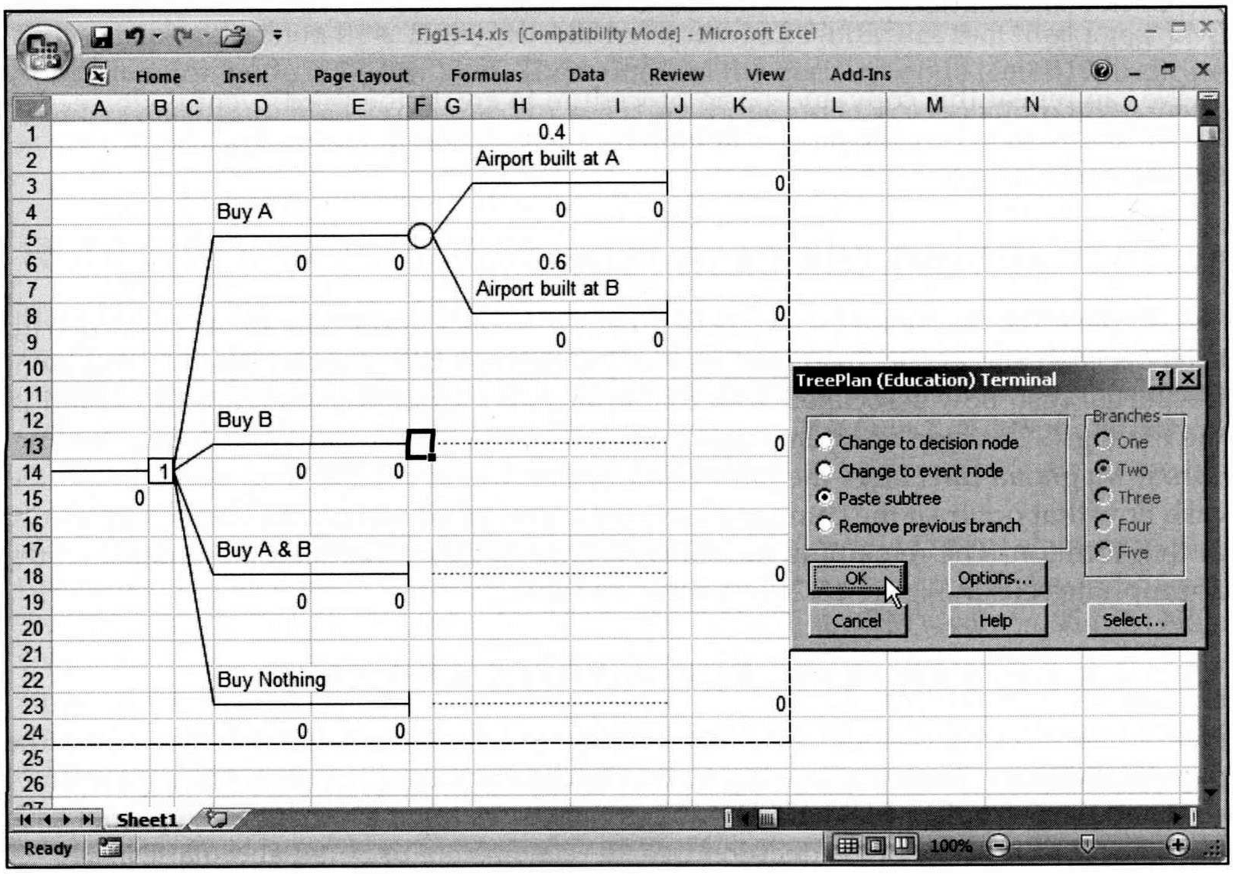
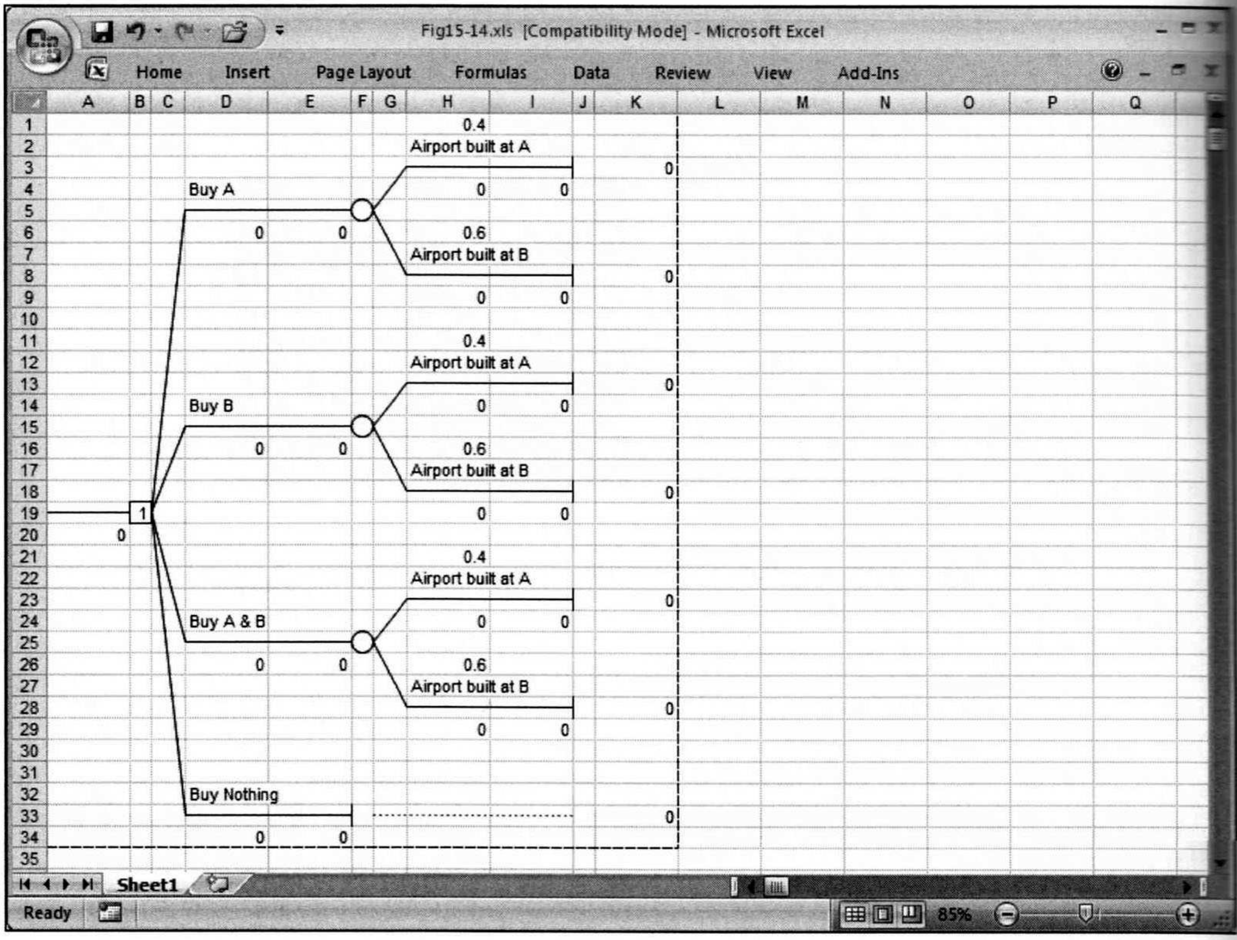


FIGURE 15.22

Using TreePlan to paste the copied subtree

FIGURE 15.23

Decision tree with three event nodes



1. Select the target cell location (cell F13).
2. Press [Ctrl][t] to invoke TreePlan.
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 buy the parcels at both locations A and B. Figure 15.23 shows the resulting spreadsheet.

15.10.3 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 15.24 (and in the file Fig15-24.xls on your data disk), cell D6 represents the partial cash flow that occurs if Magnolia Inns buys the parcel at location A, and cell H4 represents the partial cash flow that occurs if the company buys the parcel at location A *and* the airport is built at that location. The remaining partial cash flows for each decision are entered in the appropriate cells in Figure 15.24 in a similar manner.

15.10.4 DETERMINING THE PAYOFFS AND EMVs

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 15.24 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.

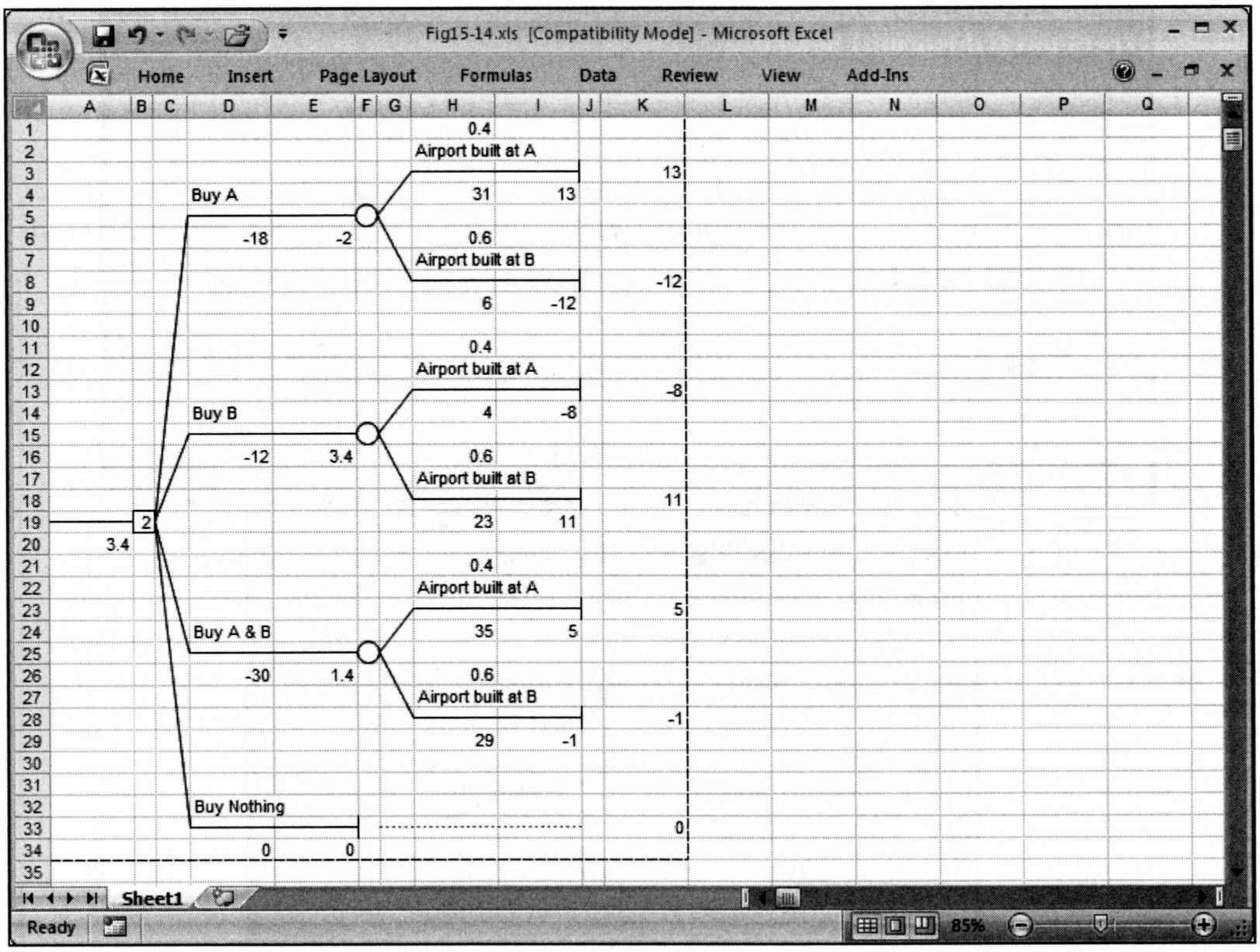


FIGURE 15.24

Completed decision tree for the Magnolia Inns decision problem

Immediately below and to the left of each node, TreePlan created formulas that compute the EMV at each node in the same way as described earlier in our discussion of rolling back a decision tree. Thus, cell A20 in Figure 15.24 indicates that the largest EMV at the decision node is $3.4 million. The value 2 in the decision node (cell B19) indicates that this maximum EMV is obtained by selecting the second decision alternative (that is, by purchasing the parcel at location B).

15.10.5 OTHER FEATURES

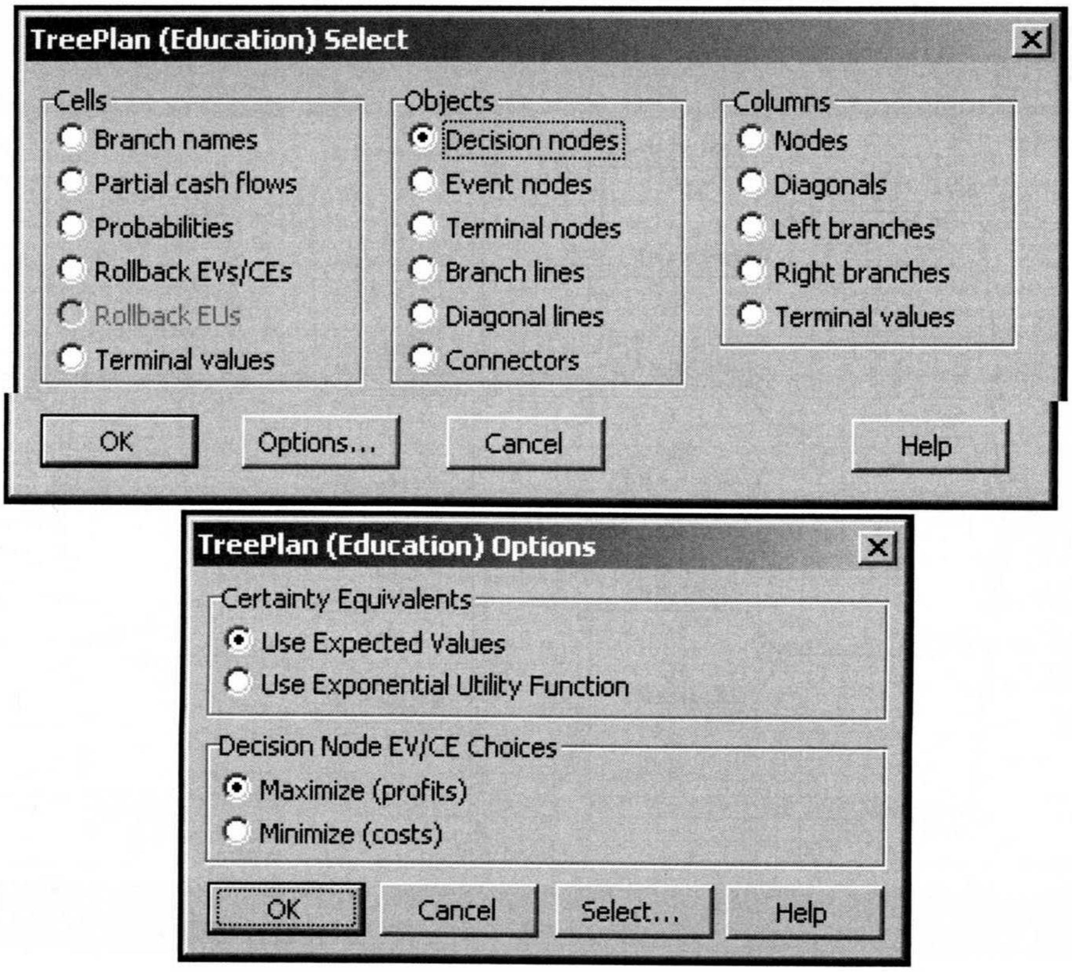
The preceding discussion of TreePlan was intended to give you an overview of how TreePlan operates, its capabilities, and some of its options. Most of the other TreePlan options are self-explanatory, and you can obtain descriptions of them by clicking the Help button available in all the TreePlan dialog boxes. The Select and Options buttons available in all the TreePlan dialog boxes presented earlier lead, respectively, to the two dialog boxes shown in Figure 15.25.

At times, we might want to select all the instances of a certain type of element in a decision tree. For example, we might want to select all the partial cash flows and display them in a currency format, or we might want to hide all the EMV values. The TreePlan Select dialog box shown in Figure 15.25 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.

The TreePlan Options dialog box serves two purposes. By default, TreePlan assumes that we want to analyze the decision tree using expected values. However, another technique (described later) uses exponential utility functions in place of expected values.

FIGURE 15.25

TreePlan Select and TreePlan Options dialog boxes



Thus, this dialog box provides options for selecting whether TreePlan should use expected values or exponential utility functions. Also by default, TreePlan assumes that the EMVs that it calculates represent profit values, and that we want to identify the decision with the largest EMV. However, in some decision trees, the expected values could represent costs that we want to minimize. Thus, this dialog box provides options for maximizing profits or minimizing costs.

About TreePlan

TreePlan is a *shareware* product. The developer of this package, Dr. Michael Middleton, graciously allows it to be distributed with this textbook at no charge to you. If you like this software package and plan to use it for more than 30 days, you are expected to pay a nominal registration fee. Details on registration are available near the end of the TreePlan help file, which you can access by clicking the Help button in any TreePlan dialog box or on the Web at http://www.treeplan.com.

15.11 Multistage Decision Problems

To this point, our discussion of decision analysis has considered only **single-stage** decision problems—that is, problems in which a single decision must be made. However, most decisions that we face lead to other decisions. As a simple example, consider the decision of whether to go out to dinner. If you decide to go out to dinner, you must then decide how much to spend, where to go, and how to get there. Thus, before you actually decide to go out to dinner, you'll probably consider the other issues and decisions that must be made if you choose that alternative. These types of problems are called **multistage** decision problems. The following example illustrates how a multistage decision problem can be modeled and analyzed using a decision tree.

The Occupational Safety and Health Administration (OSHA) has recently announced that it will award an $85,000 research grant to the person or company submitting the best proposal for using wireless communications technology to enhance safety in the coal-mining industry. Steve Hinton, the owner of COM-TECH, a small communications research firm located just outside of Raleigh, North Carolina, is considering whether or not to apply for this grant. Steve estimates that he would spend approximately $5,000 preparing his grant proposal and that he has about a 50-50 chance of actually receiving the grant. If he is awarded the grant, he then would need to decide whether to use microwave, cellular, or infrared communications technology. He has some experience in all three areas, but would need to acquire some new equipment depending on which technology is used. The cost of the equipment needed for each technology is summarized as:

Technology	Equipment Cost
Microwave	$4,000
Cellular	$5,000
Infrared	$4,000

In addition to the equipment costs, Steve knows that he will spend money in research and development (R&D) to carry out the research proposal, but he does not know exactly what the R&D costs will be. For simplicity, Steve estimates the following best-case and worst-case R&D costs associated with using each technology, and he assigns probabilities to each outcome based on his degree of expertise in each area.

	Possible R&D Costs			
	Best Case		Worst Case	
	Cost	Prob.	Cost	Prob.
Microwave	$30,000	0.4	$60,000	0.6
Cellular	$40,000	0.8	$70,000	0.2
Infrared	$40,000	0.9	$80,000	0.1

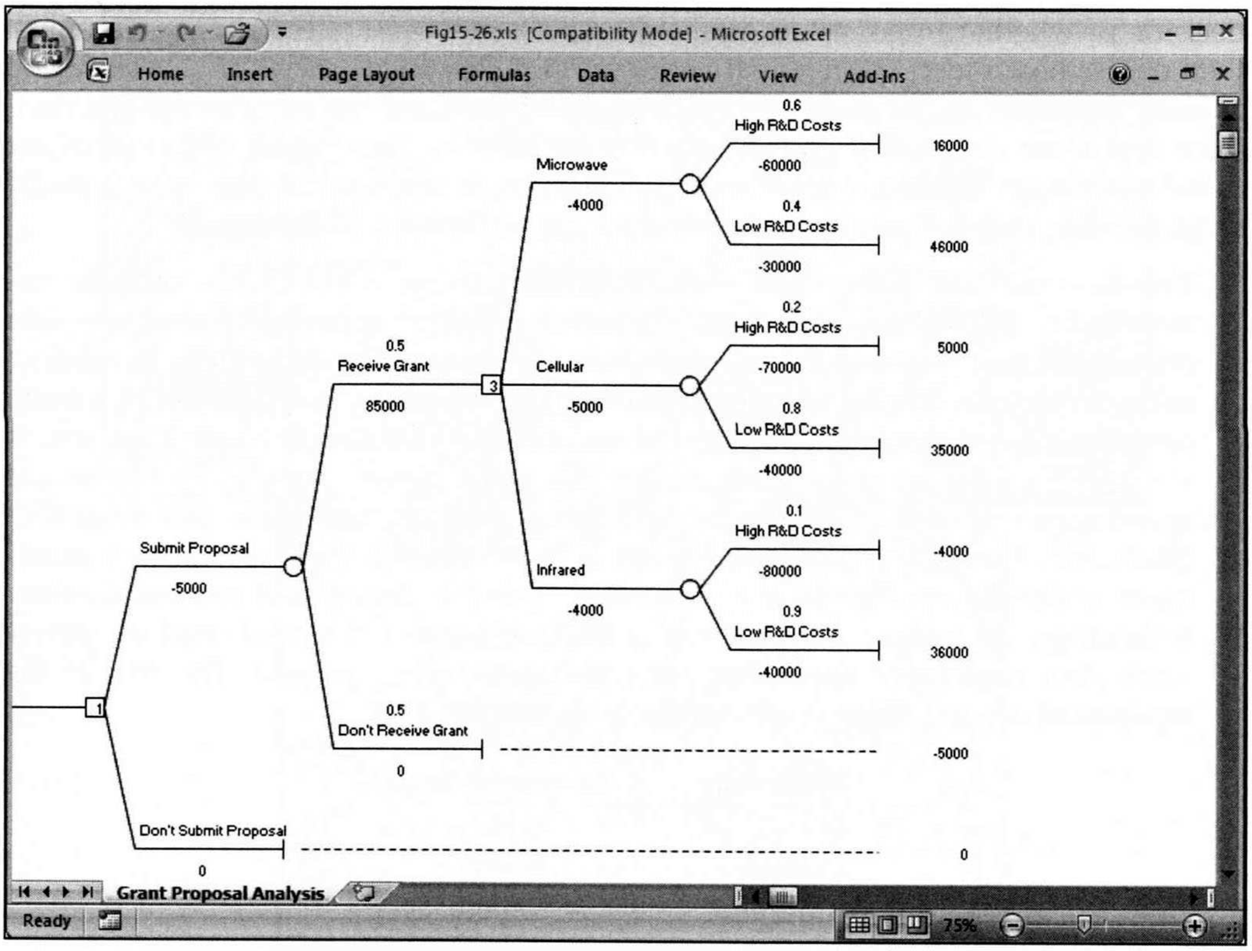
Steve needs to synthesize all the factors in this problem to decide whether or not to submit a grant proposal to OSHA.

15.11.1 A MULTISTAGE DECISION TREE

The immediate decision in this example problem is whether or not to submit a grant proposal. To make this decision, Steve also must consider the technology selection decision that he will face if he receives the grant. So, this is a multistage decision problem. Figure 15.26 (and the file Fig15-26.xls on your data disk) shows the decision tree representation of this problem where, for clarity, we have temporarily hidden the rollback EMVs at each event and decision node in the tree.

FIGURE 15.26

Multistage decision tree for COM-TECH's grant proposal problem



This decision tree clearly shows that the first decision Steve faces is whether or not to submit a proposal, and that submitting the proposal will cost $5,000. If a proposal is submitted, we then encounter an event node showing a 0.5 probability of receiving the grant (and a payoff of $85,000), and a 0.5 probability of not receiving the grant (leading to a net loss of $5,000). If the grant is received, we then encounter a decision about which technology to pursue. Each of the three technology options has an event node representing the best-case (lowest) and worst-case (highest) R&D costs that might be incurred. The final (terminal) payoffs associated with each set of decisions and outcomes are listed next to each terminal node. For example, if Steve submits a proposal, receives the grant, employs cellular technology, and encounters low R&D costs, he will receive a net payoff of $35,000.

In Figure 15.26, note that the probabilities on the branches at any event node always must sum to 1 because these branches represent all the events that could occur. The R&D costs that actually would occur using a given technology could assume an infinite number of values. Some might argue that these costs could be modeled more accurately by some continuous random variable. However, our aim is to estimate the expected value of this random variable. Most decision makers probably would find it easier to assign subjective probabilities to a small, discrete set of representative outcomes for a variable such as R&D costs rather than try to identify an appropriate probability distribution for this variable.

Figure 15.27 (and the file Fig15-27.xls on your data disk) shows the completed decision tree for our example problem, including the EMV at each node. According to this decision tree, Steve should submit a proposal because the expected value of this decision is $13,500 and the expected value of not submitting a proposal is $0. The decision tree also indicates that if Steve receives the grant, he should pursue the infrared

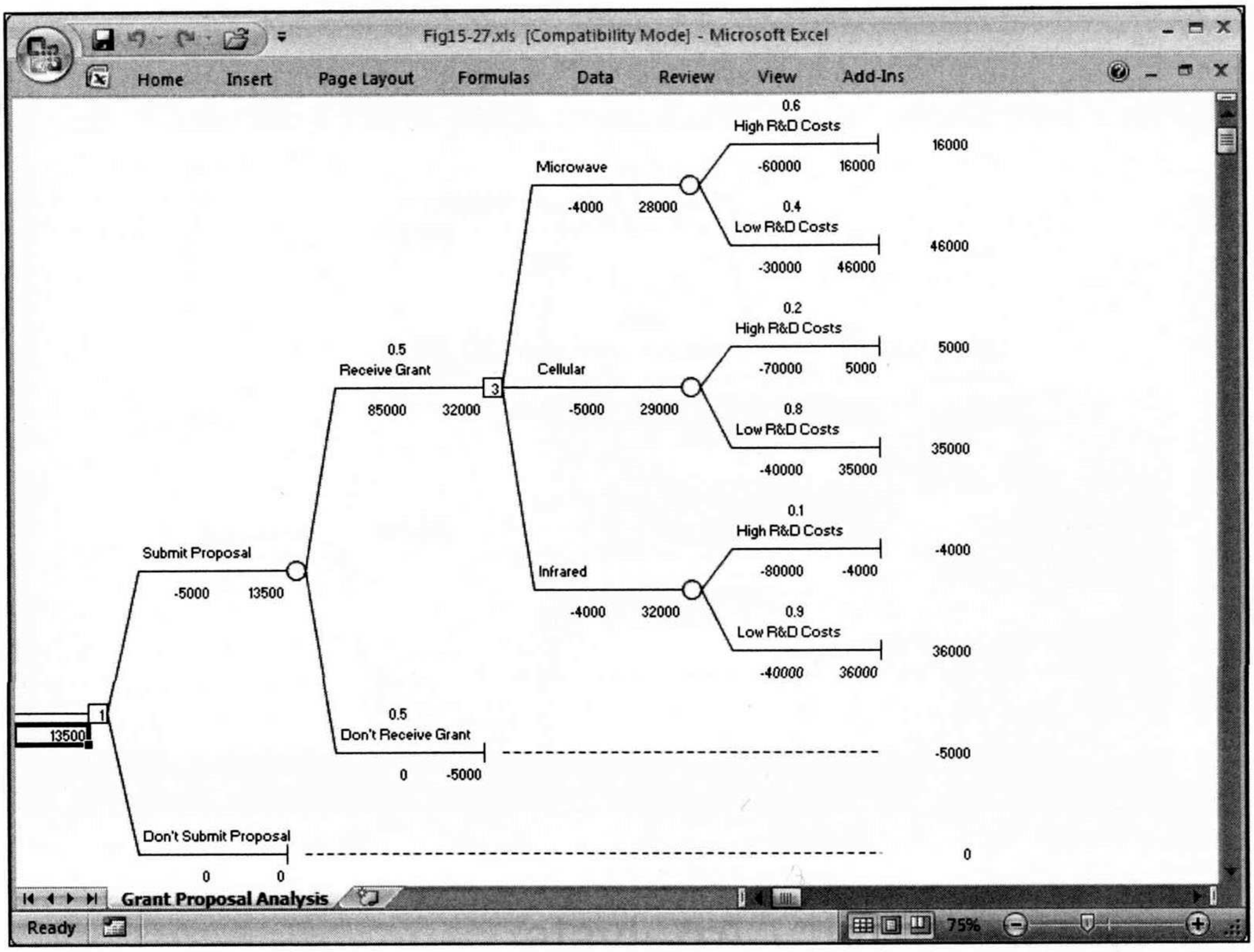


FIGURE 15.27
Multistage decision tree with EMVs for COM-TECH's grant proposal problem

communications technology because the expected value of this decision ($32,000) is larger than the expected values for the other technologies.

15.11.2 DEVELOPING A RISK PROFILE

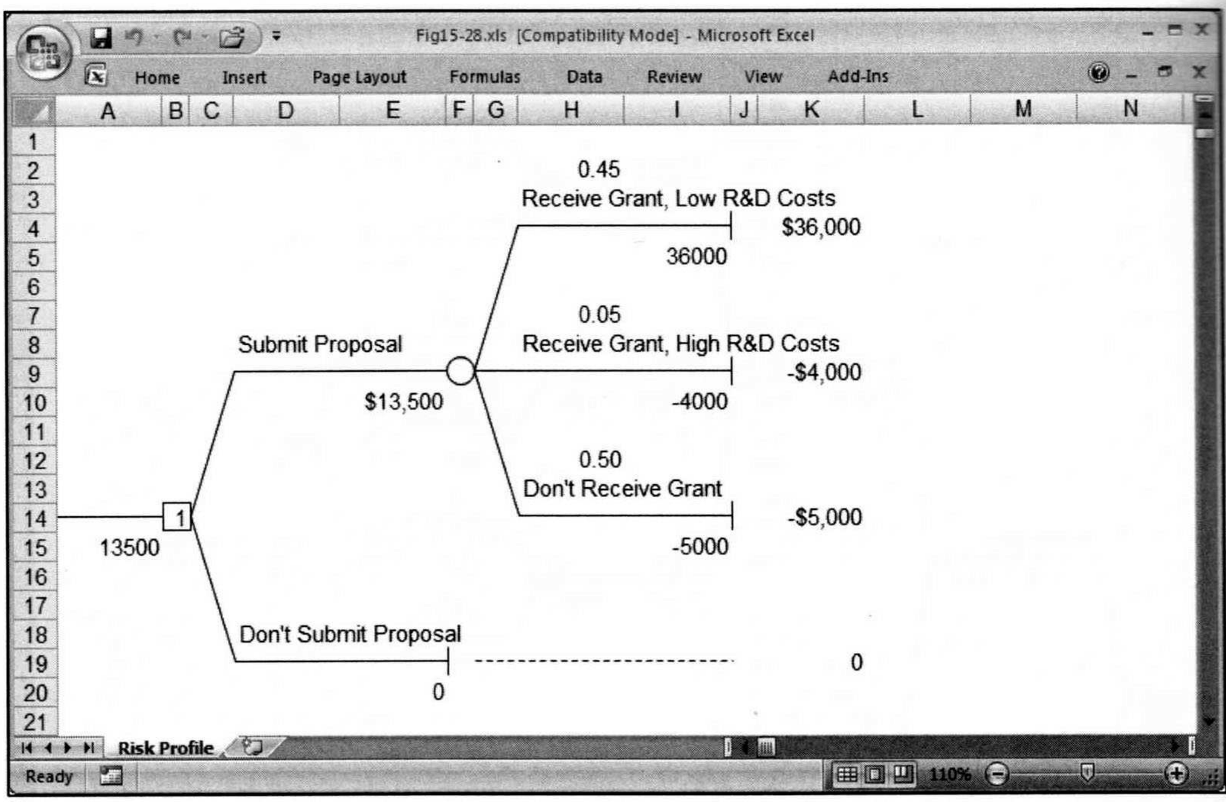
When using decision trees to analyze one-time decision problems, it is particularly helpful to develop a risk profile to make the sure that the decision maker understands all the possible outcomes that might occur. A ***risk profile*** is a graph or tree that shows the chances associated with possible outcomes. Figure 15.28 shows the risk profile associated with not submitting the proposal, and that of the optimal EMV decision-making strategy (submitting the proposal and using infrared technology) identified from Figure 15.27.

From Figure 15.28, it is clear that if the proposal is not submitted, the payoff will be $0. If the proposal is submitted, there is a 0.50 chance of not receiving the grant and incurring a loss of $5,000. If the proposal is submitted, there is a 0.05 chance ($0.5 \times 0.1 = 0.05$) of receiving the grant but incurring high R&D costs with the infrared technology and suffering a $4,000 loss. Finally, if the proposal is submitted, there is a 0.45 chance ($0.5 \times 0.9 = 0.45$) of enjoying small R&D costs with the infrared technology and making a $36,000 profit.

A risk profile is an effective tool for breaking an EMV into its component parts and communicating information about the actual outcomes that can occur as the result of various decisions. By looking at Figure 15.28, a decision maker could reasonably decide that the risks (or chances) of losing money if a proposal is submitted are not worth the potential benefit to be gained if the proposal is accepted and low R&D costs occur. These risks would not be apparent if the decision maker was provided only with information about the EMV of each decision.

FIGURE 15.28

A risk profile for the alternatives of submitting or not submitting the proposal



15.15 Utility Theory

Although the EMV decision rule is widely used, sometimes the decision alternative with the highest EMV is not the most desirable or most preferred alternative by the decision maker. For example, suppose that we could buy either of the two companies listed in the following payoff table for exactly the same price:

	State of Nature			
Company	**1**	**2**	**EMV**	
A	150,000	−30,000	60,000	← maximum
B	70,000	40,000	55,000	
Probability	0.5	0.5		

The payoff values listed in this table represent the annual profits expected from this business. Thus, in any year, a 50% chance exists that company A will generate a profit of \$150,000 and a 50% chance that it will generate a loss of \$30,000. On the other hand, in each year, a 50% chance exists that company B will generate a profit of \$70,000 and a 50% chance that it will generate a profit of \$40,000.

According to the EMV decision rule, we should buy company A because it has the highest EMV. However, company A represents a far more risky investment than company B. Although company A would generate the highest EMV over the long run, we might not have the financial resources to withstand the potential losses of \$30,000 per year that could occur in the short run with this alternative. With company B, we can be sure of making at least \$40,000 each year. Although company B's EMV over the long run might not be as great as that of company A, for many decision makers, this is more than offset by the increased peace of mind associated with company B's relatively stable profit level. However, other decision makers might be willing to accept the greater risk associated with company A in hopes of achieving the higher potential payoffs this alternative provides.

As this example illustrates, the EMVs of different decision alternatives do not necessarily reflect the relative attractiveness of the alternatives to a particular decision maker. **Utility theory** provides a way to incorporate the decision maker's attitudes and preferences toward risk and return in the decision-analysis process so that the most desirable decision alternative is identified.

15.15.1 UTILITY FUNCTIONS

Utility theory assumes that every decision maker uses a **utility function** that translates each of the possible payoffs in a decision problem into a nonmonetary measure known as a utility. The **utility** of a payoff represents the total worth, value, or desirability of the outcome of a decision alternative to the decision maker. For convenience, we will begin by representing utilities on a scale from 0 to 1, where 0 represents the least value and 1 represents the most.

Different decision makers have different attitudes and preferences toward risk and return. Those who are "risk neutral" tend to make decisions using the maximum EMV decision rule. However, some decision makers are risk avoiders (or "risk averse"), and others look for risk (or are "risk seekers"). The utility functions typically associated with these three types of decision makers are shown in Figure 15.37.

Figure 15.37 illustrates how the same monetary payoff might produce different levels of utility for three different decision makers. A "risk averse" decision maker assigns the largest relative utility to any payoff but has a diminishing marginal utility for increased

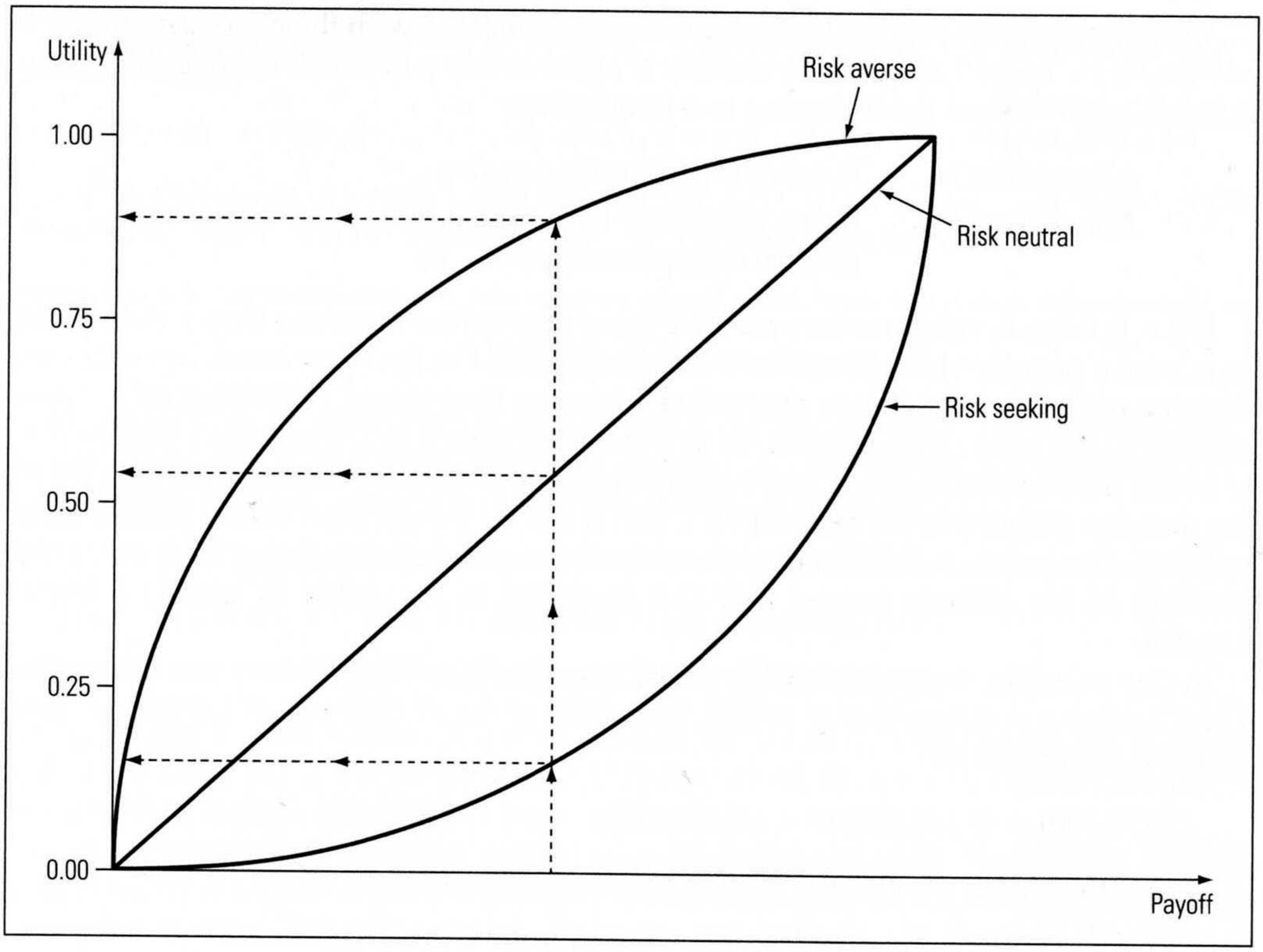


FIGURE 15.37

Three common types of utility functions

payoffs (that is, every additional dollar in payoff results in smaller increases in utility). The "risk seeking" decision maker assigns the smallest utility to any payoff but has an increasing marginal utility for increased payoffs (that is, every additional dollar in payoff results in larger increases in utility). The "risk neutral" decision maker (who follows the EMV decision rule) falls in between these two extremes and has a constant marginal utility for increased payoffs (that is, every additional dollar in payoff results in the same amount of increase in utility). The utility curves in Figure 15.37 are not the only ones that can occur. In general, utility curves can assume virtually any form depending on the preferences of the decision maker.

15.15.2 CONSTRUCTING UTILITY FUNCTIONS

Assuming that decision makers use utility functions (perhaps at a subconscious level) to make decisions, how can we determine what a given decision maker's utility function looks like? One approach involves assigning a utility value of 0 to the worst outcome in a decision problem and a utility value of 1 to the best outcome. All other payoffs are assigned utility values between 0 and 1. (Although it is convenient to use endpoint values of 0 and 1, we can use any values provided that the utility value assigned to the worst payoff is less than the utility value assigned to the best payoff.)

We will let $U(x)$ represent the utility associated with a payoff of $\$x$. Thus, for the decision about whether to buy company A or B, described earlier, we have:

$$U(-30{,}000) = 0$$
$$U(150{,}000) = 1$$

Now suppose that we want to find the utility associated with the payoff of $70,000 in our example. To do this, we must identify the probability p at which the decision maker is indifferent between the following two alternatives:

Alternative 1. Receive $70,000 with certainty.

Alternative 2. Receive $150,000 with probability p and lose $30,000 with probability $(1 - p)$

If $p = 0$, most decision makers would choose alternative 1 because they would prefer to receive a payoff of $70,000 rather than lose $30,000. On the other hand, if $p = 1$, most decision makers would choose alternative 2 because they would prefer to receive a payoff of $150,000 rather than $70,000. So as p increases from 0 to 1, it reaches a point—p^*—at which the decision maker is indifferent between the two alternatives. That is, if $p < p^*$, the decision maker prefers alternative 1, and if $p > p^*$, the decision maker prefers alternative 2. The point of indifference, p^*, varies from one decision maker to another, depending on his attitude toward risk and according to his ability to sustain a loss of $30,000.

In our example, suppose that the decision maker is indifferent between alternative 1 and 2 when $p = 0.8$ (so that $p^* = 0.8$). The utility of the $70,000 payoff for this decision maker is computed as:

$$U(70{,}000) = U(150{,}000)\, p^* + U(-30{,}000)(1 - p^*) = 1\, p^* + 0(1 - p^*) = p^* = 0.8$$

Notice that when $p = 0.8$, the expected value of alternative 2 is:

$$\$150{,}000 \times 0.8 - \$30{,}000 \times 0.2 = \$114{,}000$$

Because the decision maker is indifferent between a risky decision (alternative 2) that has an EMV of $114,000 and a nonrisky decision (alternative 1) that has a certain payoff of $70,000, this decision maker is "risk averse." That is, the decision maker is willing to accept only $70,000 to avoid the risk associated with a decision that has an EMV of $114,000.

The term **certainty equivalent** refers to the amount of money that is equivalent in a decision maker's mind to a situation that involves uncertainty. For example, $70,000 is the decision maker's certainty equivalent for the uncertain situation represented by alternative 2 when $p = 0.8$. A closely related term, **risk premium**, refers to the EMV that a decision maker is willing to give up (or pay) to avoid a risky decision. In our example, the risk premium is $114,000 − $70,000 = $44,000; that is:

$$\text{Risk premium} = \begin{pmatrix}\text{EMV of an}\\ \text{uncertain situation}\end{pmatrix} - \begin{pmatrix}\text{certainty equivalent of}\\ \text{the same uncertain situation}\end{pmatrix}$$

To find the utility associated with the $40,000 payoff in our example, we must identify the probability p at which the decision maker is indifferent between the following two alternatives:

Alternative 1. Receive $40,000 with certainty.

Alternative 2. Receive $150,000 with probability p and lose $30,000 with probability $(1 - p)$.

Because we reduced the payoff amount listed in alternative 1 from its earlier value of $70,000, we expect that the value of p at which the decision maker is indifferent also would be reduced. In this case, suppose that the decision maker is indifferent between the two alternatives when $p = 0.65$ (so that $p^* = 0.65$). The utility associated with a payoff of $40,000 is:

$$U(40{,}000) = U(150{,}000)\,p^* + U(-30{,}000)(1 - p^*) = 1\,p^* + 0(1 - p^*) = p^* = 0.65$$

Again, the utility associated with the amount given in alternative 1 is equivalent to the decision maker's indifference point p^*. This is not a coincidence.

Key Point

When utilities are expressed on a scale from 0 to 1, the probability p^* at which the decision maker is indifferent between alternatives 1 and 2 always corresponds to the decision maker's utility for the amount listed in alternative 1.

Notice that when $p = 0.65$, the expected value of alternative 2 is:

$$\$150{,}000 \times 0.65 - \$30{,}000 \times 0.35 = \$87{,}000$$

Again, this is "risk averse" behavior because the decision maker is willing to accept only $40,000 (or pay a risk premium of $47,000) to avoid the risk associated with a decision that has an EMV of $87,000.

For our example, the utilities associated with payoffs of –$30,000, $40,000, $70,000, and $150,000 are 0.0, 0.65, 0.80, and 1.0, respectively. If we plot these values on a graph and connect the points with straight lines, we can estimate the shape of the decision maker's utility function for this decision problem, as shown in Figure 15.38. Note that the shape of this utility function is consistent with the general shape of the utility function for a "risk averse" decision maker given in Figure 15.37.

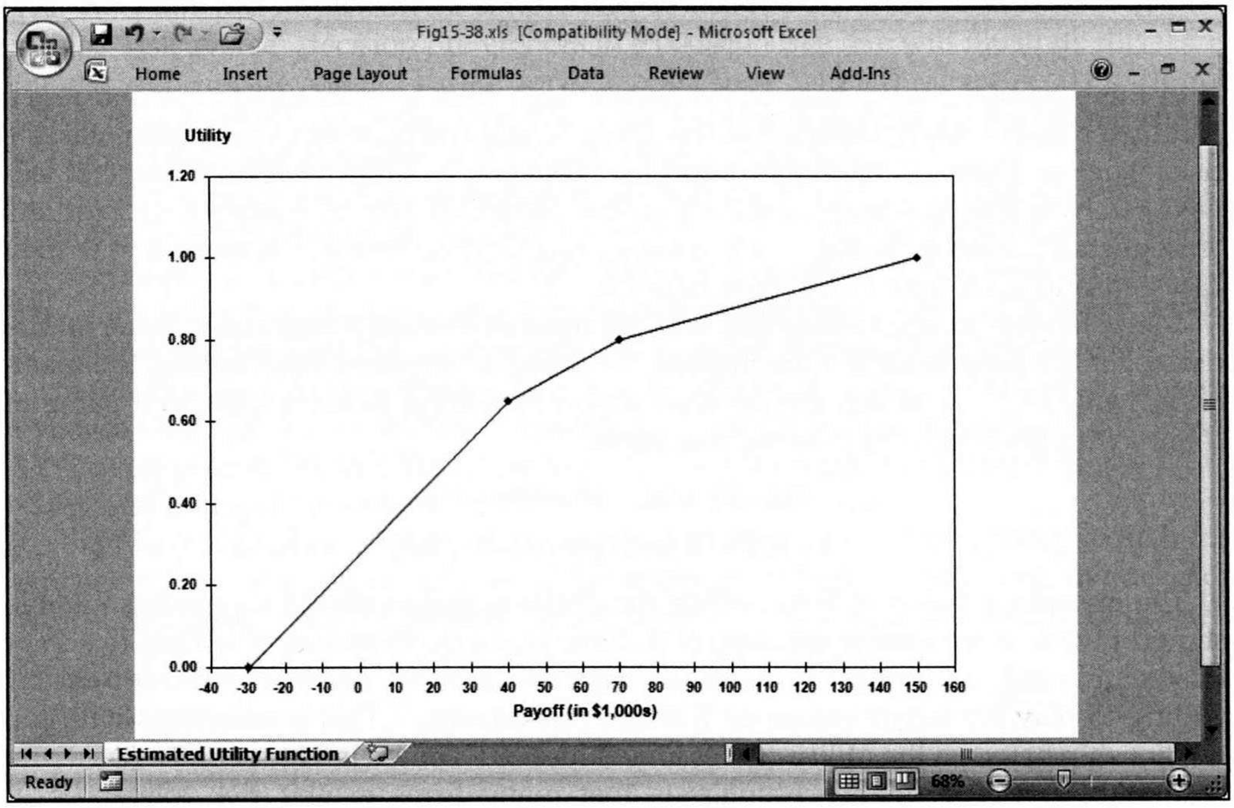


FIGURE 15.38

An estimated utility function for the example problem

15.15.3 USING UTILITIES TO MAKE DECISIONS

After determining the utility value of each possible monetary payoff, we can apply the standard tools of decision analysis to determine the alternative that provides the highest expected utility. We do so using utility values in place of monetary values in payoff tables or decision trees. For our current example, we substitute the appropriate utilities in the payoff table and compute the expected utility for each decision alternative as:

	State of Nature			
Company	**1**	**2**	**Expected Utility**	
A	1.00	0.00	0.500	
B	0.80	0.65	0.725	← maximum
Probability	0.5	0.5		

In this case, the decision to purchase company B provides the greatest expected level of utility to this decision maker—even though our earlier analysis indicated that its EMV of \$55,000 is less than company A's EMV of \$60,000. Thus, by using utilities, decision makers can identify the alternative that is most attractive given their personal attitudes about risk and return.

15.15.4 THE EXPONENTIAL UTILITY FUNCTION

In a complicated decision problem with numerous possible payoff values, it might be difficult and time-consuming for a decision maker to determine the different values for p^* that are required to determine the utility for each payoff. However, if the decision maker is "risk averse," the **exponential utility function** can be used as an approximation of the decision maker's actual utility function. The general form of the exponential utility function is:

$$\mathrm{U}(x) = 1 - e^{-x/R}$$

In this formula, e is the base of the natural logarithm ($e = 2.718281\ldots$) and R is a parameter that controls the shape of the utility function according to a decision maker's risk tolerance. Figure 15.39 shows examples of the graph of this function for several values of R. Note that as R increases, the shape of the utility curve becomes flatter (or less "risk averse"). Also note that as x becomes large, $\mathrm{U}(x)$ approaches 1; when $x = 0$, then $\mathrm{U}(x) = 0$; and if x is less than 0, then $\mathrm{U}(x) < 0$.

To use the exponential utility function, we must determine a reasonable value for the risk tolerance parameter R. One method for doing so involves determining the maximum value of Y for which the decision maker is willing to participate in a game of chance with the following possible outcomes:

Win \$Y with probability 0.5

Lose \$Y/2 with probability 0.5

The maximum value of Y for which the decision maker would accept this gamble should give us a reasonable estimate of R. Note that a decision maker willing to accept this gamble only at very small values of Y is "risk averse," whereas a decision maker willing to play for larger values of Y is less "risk averse." This corresponds with the relationship between the utility curves and values of R shown in Figure 15.39. (As a rule of thumb, anecdotal evidence suggests that many firms exhibit risk tolerances of approximately one-sixth of equity or 125% of net yearly income.)

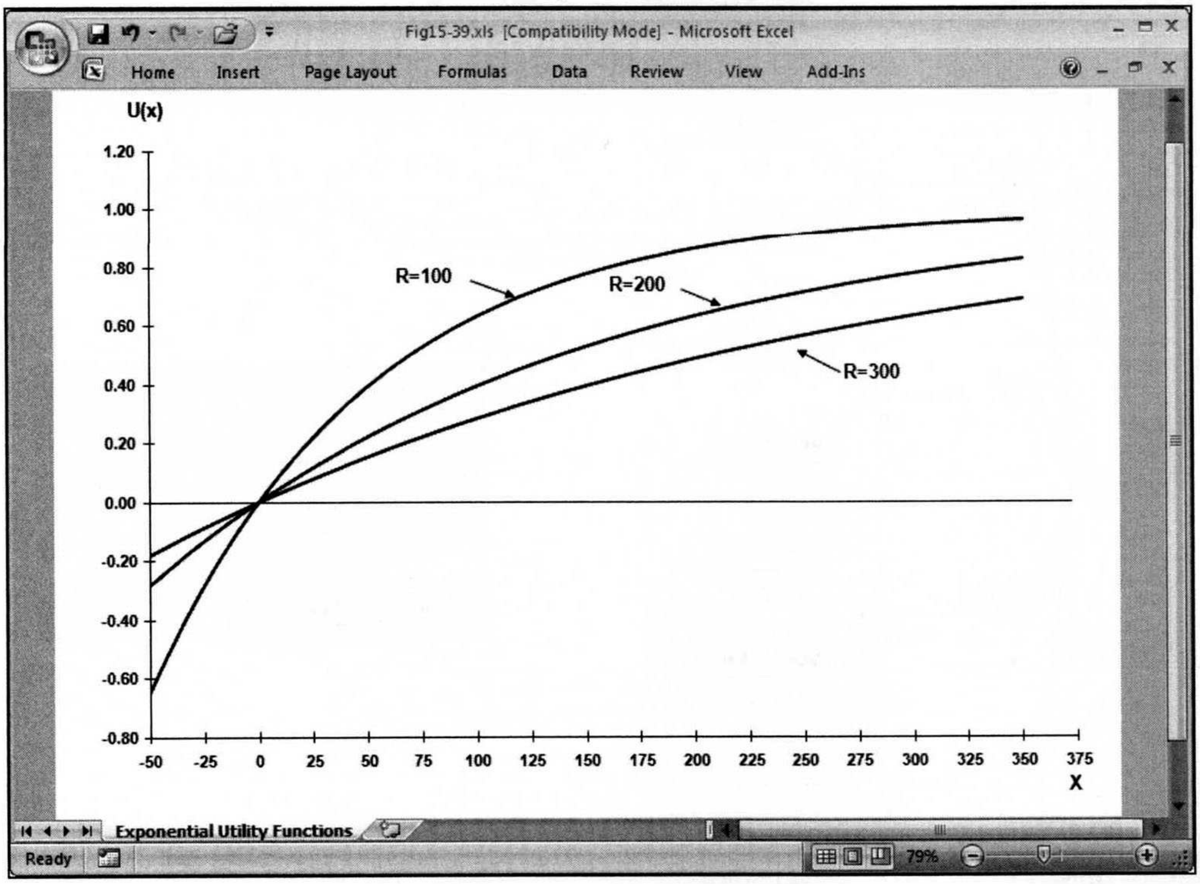


FIGURE 15.39

Examples of the exponential utility function

15.15.5 INCORPORATING UTILITIES IN TREEPLAN

The TreePlan add-in provides a simple way to use the exponential utility function to model "risk averse" decision preferences in a decision tree. We will illustrate this using the decision tree developed earlier for Magnolia Inns, where Barbara needs to decide which parcel of land to purchase. The decision tree developed for this problem is shown in Figure 15.40 (and in the file Fig15-40.xls on your data disk).

To use the exponential utility function, we first construct a decision tree in the usual way. We then determine the risk tolerance value of R for the decision maker using the technique described earlier. Because Barbara is making this decision on behalf of Magnolia Inns, it is important that she provide an estimated value of R based on the acceptable risk levels of the corporation—not her own personal risk tolerance level.

In this case, let's assume that $4 million is the maximum value of Y for which Barbara believes Magnolia Inns is willing to gamble winning $Y with probability 0.5 and losing $Y/2 with probability 0.5. Therefore, $R = Y = 4$. (Note that the value of R should be expressed in the same units as the payoffs in the decision tree.)

TreePlan requires that we enter the value of R in a cell named "RT" (short for Risk Tolerance). (This cell must be outside of the rectangular region containing the decision tree.) Cell D36 in Figure 15.36 serves this purpose. To assign the name "RT" to this cell:

1. Click cell D36.
2. Click Formulas.
3. Click Define Name.
4. Type RT.
5. Click OK.

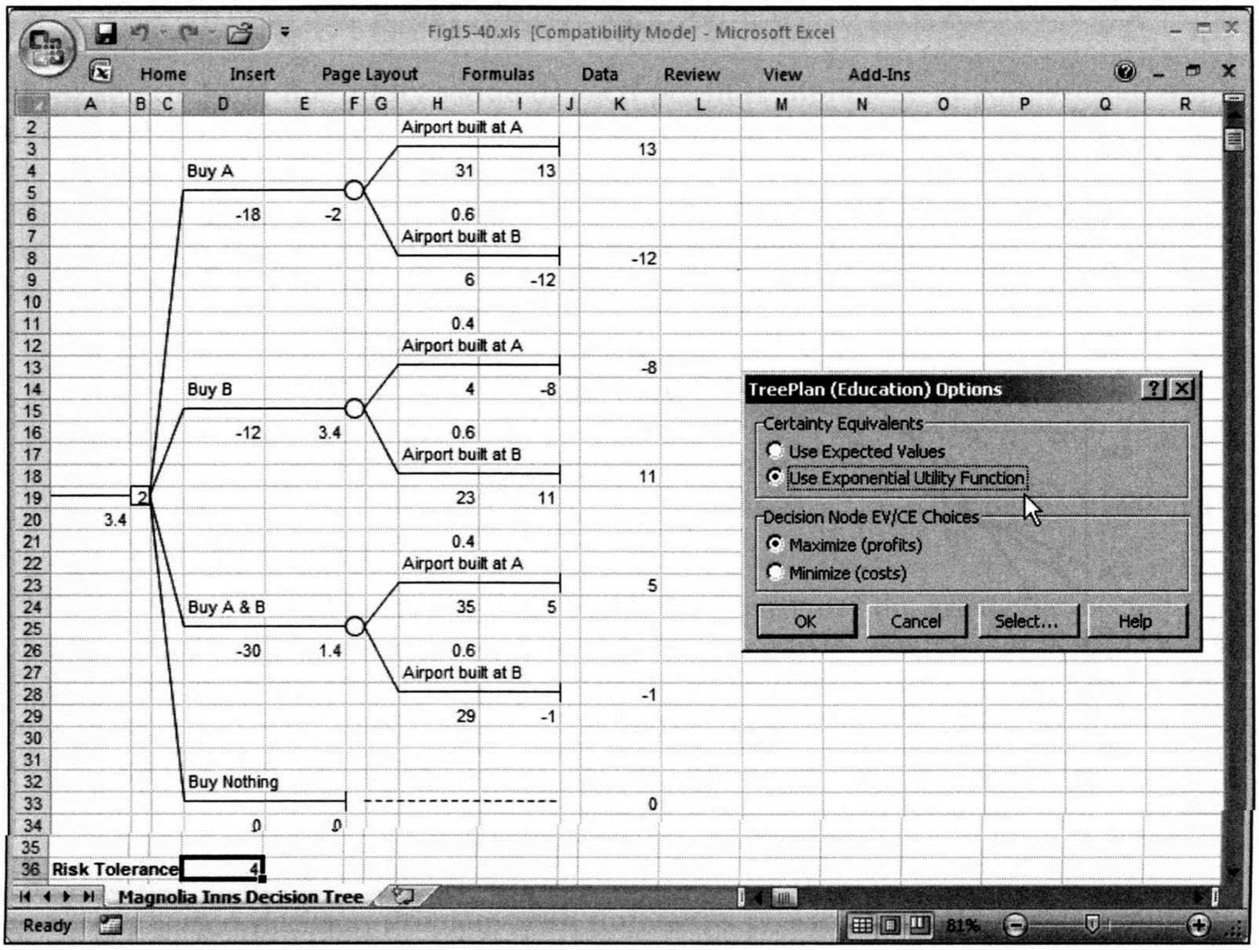


FIGURE 15.40

Decision tree for the Magnolia Inns land purchase problem

We can now instruct TreePlan to use an exponential utility function to determine the optimal decision. To do this:

1. Click cell D3.
2. Press [Ctrl][t] to invoke TreePlan.
3. Click the Options button.
4. Click Use Exponential Utility Function.
5. Click OK.

TreePlan automatically converts the decision tree so that the rollback operation is performed using expected utilities rather than EMVs. The resulting tree is shown in Figure 15.41. The certainty equivalent at each node appears in the cell directly below and to the left of each node (previously the location of the EMVs). The expected utility at each node appears immediately below the certainty equivalents. According to this tree, the decision to buy the parcels at locations A and B provides the highest expected utility for Magnolia Inns.

Here again, it might be useful to create a strategy table to show how the recommended decision might change if we had used a different risk tolerance value and/or different probabilities. Figure 15.42 (and file Fig15-42.xls on your data disk) shows a completed strategy table for the problem.