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Problems

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Level A

1. Several decision criteria besides EMV are suggested in the section. For each of the following criteria, rank all three decisions in Figure 6.1 from best to worst.
 - a. Look only at the worst possible outcome for each decision.
 - b. Look only at the best possible outcome for each decision.
 - c. Look at the variance of the distribution of outcomes for each decision, which you want to be small. (The variance of a probability distribution is the weighted sum of squared differences from the mean, weighted by the probabilities.)
2. For the decision problem in Figure 6.1, use data tables to perform the following sensitivity analyses. The goal in each is to see whether decision 1 continues to have the largest EMV. In each part, provide a brief explanation of the results.
 - a. Let the payoff from the best outcome, the value in cell A3, vary from \$30,000 to \$50,000 in increments of \$2500.

- b. Let the probability of the worst outcome for the first decision, the value in cell B5, vary from 0.7 to 0.9 in increments of 0.025, and use *formulas* in cells B3 and B4 to ensure that they remain in the ratio 1 to 2 and the three probabilities for decision 1 continue to sum to 1.
- c. Use a two-way data table to let the inputs in parts a and b vary simultaneously over the indicated ranges.

Level B

3. Some decision makers prefer decisions with low risk, but this depends on how risk is measured. As we mentioned in this section, variance (see the definition in problem 1) is one measure of risk, but it includes both upside and downside risk. That is, an outcome with a large positive payoff contributes to variance, but this type of “risk” is good. Consider a decision with some possible payoffs and some possible costs, with given probabilities. How might you develop a measure of *downside* risk for such a decision? With your downside measure of risk, which decision in Figure 6.1 do you prefer, decision 1 or decision 2? (There is no single correct answer.)

6-4 One-Stage Decision Problems

Many decision problems are similar to the simple decision problem discussed in the previous section. You make a decision, then you wait to see an uncertain outcome, and a payoff is received or a cost is incurred. We refer to these as **single-stage decision problems** because you make only one decision, the one right now. They all unfold in essentially the same way, as indicated by the spreadsheet model in Figure 6.1 or the decision tree in Figure 6.3. The following example is typical of one-stage decision problems. This example is used as a starting point for more complex examples in later sections.

EXAMPLE

NEW PRODUCT DECISIONS AT ACME

The Acme Company must decide whether to market a new product. As in many new-product situations, there is considerable uncertainty about the eventual success of the product. The product is currently part way through the development process, and some fixed development costs have already been incurred. If the company decides to continue development and then market the product, there will be additional fixed costs, and they are estimated to be \$6 million. If the product is marketed, its unit margin (selling price minus variable cost) will be \$18. Acme classifies the possible market results as “great,” “fair,” and “awful,” and it estimates the probabilities of these outcomes to be 0.45, 0.35, and 0.20, respectively. Finally, the company

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The Acme problem is a prototype for all single stage decision problems. When all the elements of the decision problem have been specified, it is easy to calculate the required EMVs for the possible decisions and hence determine the EMV maximizing decision in a spreadsheet model. The problem and the calculations can also be shown in a decision tree, although this doesn't really provide any new information except possibly to give everyone involved a better "picture" of the decision problem. In the next section, we examine a multistage version of the Acme problem, and then the real advantage of decision trees will become evident.

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Level A

4. The fixed cost of \$6 million in the Acme problem is evidently not large enough to make Acme abandon the product at the current time. How large would the fixed cost need to be to make the abandon option the best option? Explain how the decision tree, especially the version in Figure 6.5, answers this question easily.
5. Perform a sensitivity analysis on the probability of a great market. To do this, enter *formulas* in cells B9 and B10 (see Figure 6.4) to ensure that the probabilities of "fair" and "awful" remain in the same ratio, 35 to 20, and that all three probabilities continue to sum to 1. Then let the probability of "great" vary from 0.25 to 0.50 in increments of 0.05. Is it ever best to abandon the product in this range?
6. Sometimes it is possible for a company to influence the uncertain outcomes in a favorable direction. Suppose Acme could, by an early marketing blitz, change the probabilities of "great," "fair," and "awful" from their current values to 0.75, 0.15, and 0.10. In terms of EMV, how much would the company be willing to pay for such a blitz?

Level B

7. Sometimes a "single-stage" decision can be broken down into a sequence of decisions, with no uncertainty between these decisions. Similarly, uncertainty can sometimes be broken down into a sequence of uncertain outcomes. Here is a typical example. A company has a chance to bid on a government project. The company first decides whether to place a bid, and then if it decides to place a bid, it decides how much to bid. Once these decisions have been made, the uncertainty is resolved. First, the company observes whether there are any competing bids. Second, if there is at least one competing bid, the company observes the *lowest* competing bid. The lowest of all bids wins the contract. Draw a decision tree that reflects this sequence. There should be two "stages" of decision nodes, followed by two "stages" of probability nodes. Then label the tree with some reasonable monetary values and probabilities, and perform the folding back process to find the company's best strategy. Note that if the company wins the contract, its payoff is its bid amount minus its cost of completing the project minus its cost of preparing the bid, where these costs are assumed to be known.

6-5 The PrecisionTree Add-In

Decision trees present a challenge for Excel. The challenge is to take advantage of Excel's calculation capabilities (to calculate EMVs, for example) and its graphical capabilities (to draw the decision tree). Using only Excel's built-in tools, this is virtually impossible (or at least very painful) to do. Fortunately, Palisade has developed an Excel add-in called **PrecisionTree** that makes the process relatively straightforward. This add-in not only enables you to draw and label a decision tree, but it also performs the folding-back procedure automatically and then allows you to perform sensitivity analysis on key input parameters.

The first thing you must do to use PrecisionTree is to "add it in." We assume you have already installed the Palisade DecisionTools Suite. Then to run PrecisionTree, you have two options:

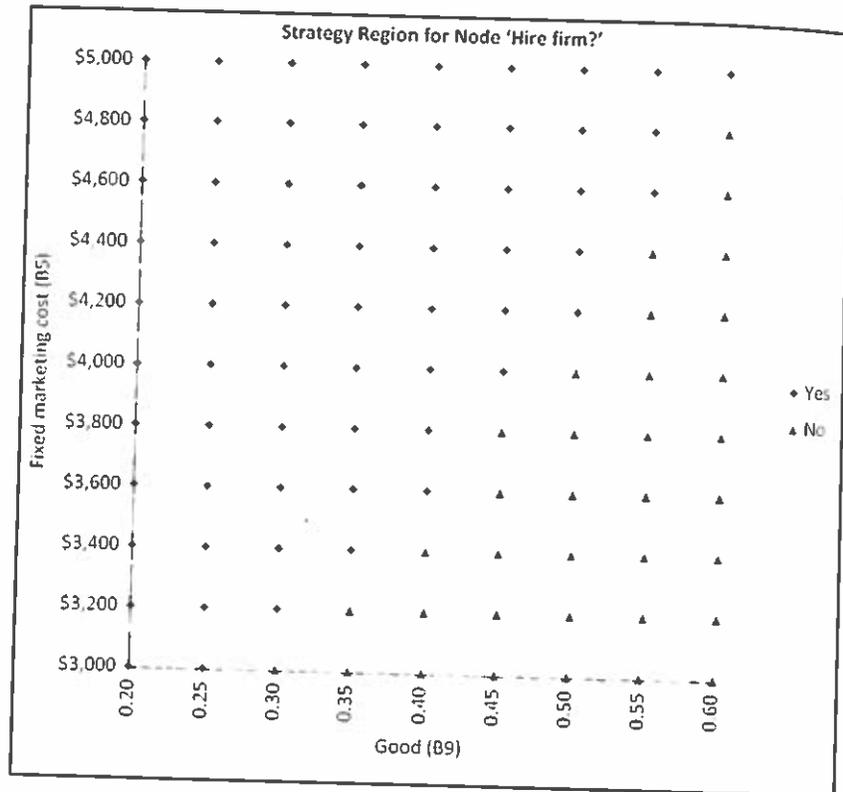
- If Excel is not currently running, you can open Excel *and* PrecisionTree by selecting PrecisionTree from the Palisade group in the list of programs on your computer.
- If Excel is currently running, the first option will open PrecisionTree on top of Excel.

In either case, you will see the Welcome screen in Figure 6.8. Note the Quick Start link. We will come back to this shortly.

Once you click OK to dismiss the Welcome screen, you will know that PrecisionTree is loaded because of the new PrecisionTree tab and associated ribbon shown in Figure 6.9.

As you can see, Acme should *not* market the product after a bad prediction unless the prior probability of a good market is approximately 0.55 or higher. This makes intuitive sense. In one final sensitivity analysis, a two-way analysis, we let the prior probability of a good market vary as before, and we let the fixed marketing cost vary from 25% below to 25% above its current value of \$4 million. Also, we choose "Entire Model" as the starting node. The results are shown in Figure 6.25. The diamonds correspond to input values where Acme should hire the firm, and the triangles correspond to input values where Acme shouldn't hire the firm. The pattern indicates that hiring is best only when the fixed marketing cost is high and/or the prior probability of a good market is low. For example, if the prior probability of a good market is 0.5, the Acme should hire the firm only if its fixed marketing cost is \$4.2 million or above. As another example, if Acme's fixed marketing cost is \$3.8 million, it should hire the firm only if the prior probability of a good market is 0.4 or below.

Figure 6.25 Two Way Sensitivity Analysis



One of the most important benefits of using PrecisionTree (or Excel data tables) is that once you have built the decision tree, you can quickly run any number of sensitivity analyses such as the ones shown. They often provide important insights that help you better understand the decision problem. You are asked to perform other sensitivity analyses on this example (and Example 6.2) in the problems.

Problems

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Level A

11. In Example 6.2, Acme's probability of technological success, 0.8, is evidently large enough to make "continue development" the best decision. How low would this probability have to be to make the opposite decision best?

12. In Example 6.2, the fixed costs are split \$4 million for development and \$2 million for marketing. Perform a sensitivity analysis where the sum of these two fixed costs remains at \$6 million but the split changes. Specifically, let the fixed cost of development vary from \$1 million to \$5 million in increments of \$0.5 million. Does Acme's best strategy change in this range? Use either a data table or PrecisionTree's Sensitivity Analysis tools to answer this question.

state of the economy, are given in the file **P06_33.xlsx**. The probabilities of a strong, fair, or weak economy in the coming year are assessed to be 0.30, 0.50, and 0.20, respectively.

- a. Identify the strategy that maximizes Techware's expected net revenue.
 - b. Perform a sensitivity analysis on the optimal decision, letting each of the inputs vary one at a time plus or minus 25% from its base value, and summarize your findings. Which of the inputs appears to have the largest effect on the best solution?
34. An investor with \$10,000 available to invest has the following options: (1) he can invest in a risk-free savings account with a guaranteed 3% annual rate of return; (2) he can invest in a fairly safe stock, where the possible annual rates of return are 6%, 8%, or 10%; or (3) he can invest in a more risky stock, where the possible annual rates of return are 1%, 9%, or 17%. The investor can place all of his available funds in any one of these options, or he can split his \$10,000 into two \$5000 investments in any two of these options. The joint probability distribution of the possible return rates for the two stocks is given in the file **P06_34.xlsx**.
- a. Identify the strategy that maximizes the investor's expected one-year earnings.
 - b. Perform a sensitivity analysis on the optimal decision, letting the amount available to invest and the risk-free return both vary, one at a time, plus or minus 100% from their base values, and summarize your findings.
35. A buyer for a large department store chain must place orders with an athletic shoe manufacturer six months prior to the time the shoes will be sold in the department stores. The buyer must decide on November 1 how many pairs of the manufacturer's newest model of tennis shoes to order for sale during the coming summer season. Assume that each pair of this new brand of tennis shoes costs the department store chain \$45 per pair. Furthermore, assume that each pair of these shoes can then be sold to the chain's customers for \$70 per pair. Any pairs of these shoes remaining unsold at the end of the summer season will be sold in a closeout sale next fall for \$35 each. The probability distribution of consumer demand for these tennis shoes during the coming summer season has been assessed by market research specialists and is provided in the file **P06_35.xlsx**. Finally, assume that the department store chain must purchase these tennis shoes from the manufacturer in lots of 100 pairs.
- a. Identify the strategy that maximizes the department store chain's expected profit earned by purchasing and subsequently selling pairs of the new tennis shoes. Is a decision tree really necessary? If so, what does it add to the analysis? If not, why not?
 - b. Perform a sensitivity analysis on the optimal decision, letting the three monetary inputs vary one at a time over reasonable ranges, and summarize your findings.

Which of the inputs appears to have the largest effect on the best solution?

36. Two construction companies are bidding against one another for the right to construct a new community center building. The first construction company, Fine Line Homes, believes that its competitor, Buffalo Valley Construction, will place a bid for this project according to the distribution shown in the file **P06_36.xlsx**. Furthermore, Fine Line Homes estimates that it will cost \$160,000 for its own company to construct this building. Given its fine reputation and long-standing service within the local community, Fine Line Homes believes that it will likely be awarded the project in the event that it and Buffalo Valley Construction submit exactly the same bids. Find the bid that maximizes Fine Line's expected profit. Is a decision tree really necessary? If so, what does it add to the analysis? If not, why not?
37. You have sued your employer for damages suffered when you recently slipped and fell on an icy surface that should have been treated by your company's physical plant department. Your injury was sufficiently serious that you, in consultation with your attorney, decided to sue your company for \$500,000. Your company's insurance provider has offered to settle this suit with you out of court. If you decide to reject the settlement and go to court, your attorney is confident that you will win the case but is uncertain about the amount the court will award you in damages. He has provided his assessment of the probability distribution of the court's award to you in the file **P06_37.xlsx**. In addition, there are extra legal fees of \$10,000 you will have to pay if you go to court. Let S be the insurance provider's proposed out-of-court settlement (in dollars). For which values of S will you decide to accept the settlement? For which values of S will you choose to take your chances in court? Assume that your goal is to maximize the expected net payoff from this litigation.
38. Consider a population of 2000 people, 800 of whom are women. Assume that 300 of the women in this population earn at least \$60,000 per year, and 200 of the men earn at least \$60,000 per year.
- a. What is the probability that a randomly selected person from this population earns less than \$60,000 per year?
 - b. If a randomly selected person is observed to earn less than \$60,000 per year, what is the probability that this person is a man?
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39. Yearly automobile inspections are required for residents of the state of Pennsylvania. Suppose that 18% of all inspected cars in Pennsylvania have problems that need to be corrected. Unfortunately, Pennsylvania state inspections fail to detect these problems 12% of the time. On the other hand, assume that an inspection never

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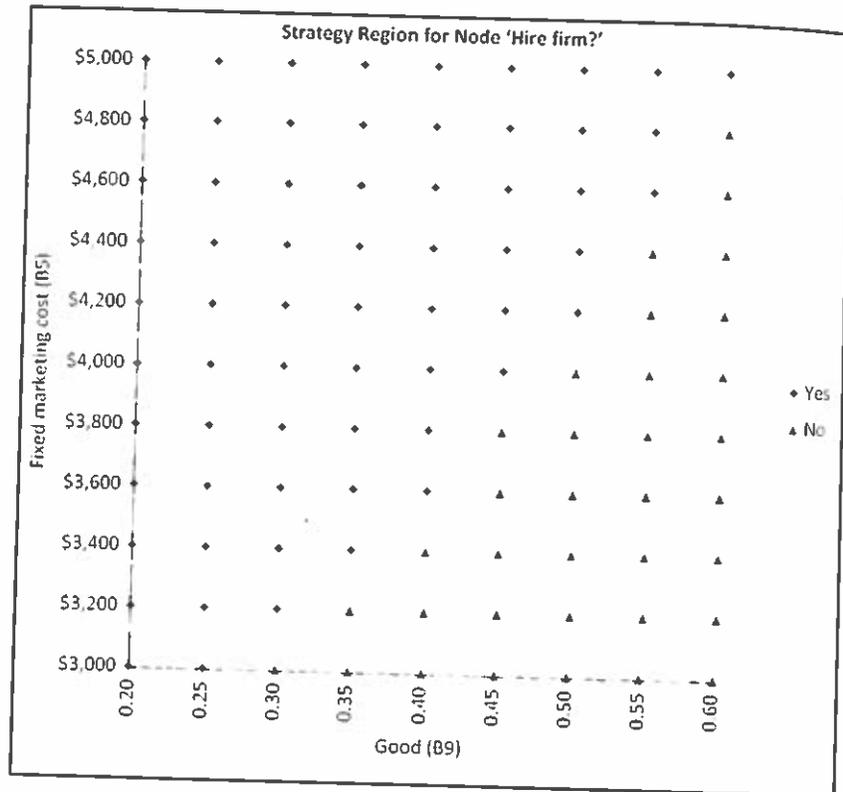
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