IN ACTION Ford Uses Decision Theory to Choose Parts Suppliers

Ford Motor Company manufactures about 5 million cars and rucks annually and employs more than 200,000 people at about 00 facilities around the globe. Such a large company often needs o make large supplier decisions under tight deadlines.

This was the situation when researchers at MIT teamed up vith Ford management and developed a data-driven supplier se-ection tool. This computer program aids in decision making by ipplying some of the decision-making criteria presented in this chapter. Decision makers at Ford are asked to input data about their suppliers (part costs, distances, lead times, supplier reliability, etc.) as well as the type of decision criterion they want to use. Once these are entered, the model outputs the best set of suppliers to meet the specified needs. The result is a system that is now saving Ford Motor Company over $40 million annually.

Source: Based on E. Klampfl, Y. Fradkin, C. McDaniel, and M. Wolcott. "Ford Uses OR to Make Urgent Sourcing Decisions in a Distressed Supplier Environment," *Interfaces* 39, 5 (2009): 428–442.

BLE 3.8
mpson's Minimax ision Using portunity Loss

	STATE OF NATURE		
ALTERNATIVE	FAVORABLE MARKET ($)	UNFAVORABLE MARKET ($)	MAXIMUM IN A ROW ($)
Construct a large plant	0	180,000	180,000
Construct a small plant	100,000	20,000	(100,000) ← Minimax
Do nothing	200,000	0	200,000

Using the opportunity loss (regret) table, the **minimax regret** criterion first consider the maximum (worst) opportunity loss for each alternative. Next, looking at these maximum values, pick that alternative with the minimum (or best) number. By doing this, the opportunity loss actually realized is guaranteed to be no more than this minimax value. In Table 3.8, we can see that the minimax regret choice is the second alternative, "construct a small plant." When this alternative is selected, we know the maximum opportunity loss cannot be more than 100,000 (the *mini*mum of the *max*imum regrets).

In calculating the opportunity loss for minimization problems such as those involving costs, the best (lowest) payoff or cost in a column is subtracted from each payoff in that column. Once the opportunity loss table has been constructed, the minimax regret criterion is applied in exactly the same way as just described. The maximum opportunity loss for each alternative is found, and the alternative with the minimum of these maximums is selected. As with maximization problems, the opportunity loss can never be negative.

We have considered several decision-making criteria to be used when probabilities of the states of nature are not known and cannot be estimated. Now we will see what to do if the probabilities are available.

5 Decision Making Under Risk

Decision making under risk is a decision situation in which several possible states of nature may occur, and the probabilities of these states of nature are known. In this section, we consider one of the most popular methods of making decisions under risk: selecting the alternative with the highest expected monetary value (or simply expected value). We also use the probabilities with the opportunity loss table to minimize the expected opportunity loss.

Expected Monetary Value

IV is the weighted sum possible payoffs for each ernative.

Given a decision table with conditional values (payoffs) that are monetary values, and probability assessments for all states of nature, it is possible to determine the **expected monetary value (EMV)** for each alternative. The *expected value*, or the *mean value*, is the long-run average value of that decision. The EMV for an alternative is just the sum of possible payoffs of the alternative, each weighted by the probability of that payoff occurring.

This could also be expressed simply as the expected value of X, or $E(X)$, which was discussed in Section 2.6 of Chapter 2.

$$\text{EMV(alternative)} = \sum X_i P(X_i) \quad (3\text{-}1)$$

TABLE 3.9
Decision Table with Probabilities and EMVs for Thompson Lumber

ALTERNATIVE	STATE OF NATURE: FAVORABLE MARKET ($)	UNFAVORABLE MARKET ($)	EMV ($)
Construct a large plant	200,000	−180,000	10,000
Construct a small plant	100,000	−20,000	40,000 ← Best EMV
Do nothing	0	0	0
Probabilities	0.50	0.50	

where

$$X_i = \text{payoff for the alternative in state of nature } i$$
$$P(X_i) = \text{probability of achieving payoff } X_i \text{ (i.e., probability of state of nature } i)$$
$$\Sigma = \text{summation symbol}$$

If this were expanded, it would become

$$\begin{aligned}&\text{EMV (alternative)}\\ &= (\text{payoff in first state of nature}) \times (\text{probability of first state of nature})\\ &\quad + (\text{payoff in second state of nature}) \times (\text{probability of second state of nature})\\ &\quad + \cdots + (\text{payoff in last state of nature}) \times (\text{probability of last state of nature})\end{aligned}$$

The alternative with the maximum EMV is then chosen.

Suppose that John Thompson now believes that the probability of a favorable market is exactly the same as the probability of an unfavorable market; that is, each state of nature has a 0.50 probability. Which alternative would give the greatest EMV? To determine this, John has expanded the decision table, as shown in Table 3.9. His calculations follow:

$$\begin{aligned}\text{EMV (large plant)} &= (\$200{,}000)(0.50) + (-\$180{,}000)(0.50) = \$10{,}000\\ \text{EMV (small plant)} &= (\$100{,}000)(0.50) + (-\$20{,}000)(0.50) = \$40{,}000\\ \text{EMV (do nothing)} &= (\$0)(0.50) + (\$0)(0.50) = \$0\end{aligned}$$

The largest expected value ($40,000) results from the second alternative, "construct a small plant." Thus, Thompson should proceed with the project and put up a small plant to manufacture storage sheds. The EMVs for the large plant and for doing nothing are $10,000 and $0, respectively.

When using the EMV criterion with minimization problems, the calculations are the same, but the alternative with the smallest EMV is selected.

Expected Value of Perfect Information

John Thompson has been approached by Scientific Marketing, Inc., a firm that proposes to help John make the decision about whether to build the plant to produce storage sheds. Scientific Marketing claims that its technical analysis will tell John with certainty whether the market is favorable for his proposed product. In other words, it will change his environment from one of decision making under risk to one of decision making under certainty. This information could prevent John from making a very expensive mistake. Scientific Marketing would charge Thompson $65,000 for the information. What would you recommend to John? Should he hire the firm to make the marketing study? Even if the information from the study is perfectly accurate, is it worth $65,000? What would it be worth? Although some of these questions are difficult to answer, determining the value of such *perfect information* can be very useful. It places an upper bound on what you should be willing to spend on information such as that being sold by Scientific Marketing. In this section, two related terms are investigated: the **expected value of perfect information (EVPI)** and the **expected value with perfect information (EVwPI)**. These techniques can help John make his decision about hiring the marketing firm.

EVPI places an upper bound on what to pay for information.

The expected value *with* perfect information is the expected or average return, in the long run, if we have perfect information before a decision has to be made. To calculate this value, we