Decision-Making Tools

MODULE A

Outline

- The Decision Process in Operations
- Fundamentals of Decision Making
- Decision Tables
- Types of Decision-Making Environments
- Decision Trees

Learning Objectives

When you complete this chapter you should be able to:

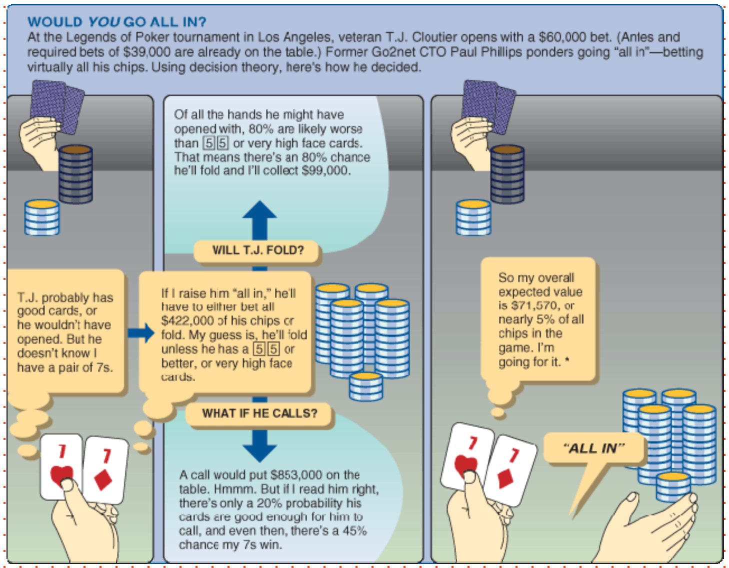
1. **Create** a simple decision tree
2. **Build** a decision table
3. **Explain** when to use each of the three types of decision-making environments
4. **Calculate** an expected monetary value (EMV)

Learning Objectives

When you complete this chapter you should be able to:

5. **Compute** the expected value of perfect information (EVPI)
6. **Evaluate** the nodes in a decision tree
7. **Create** a decision tree with sequential decisions

Decision to Go All In



The Decision Process in Operations

1. Clearly define the problem and the factors that influence it
2. Develop specific and measurable objectives
3. Develop a model
4. Evaluate each alternative solution
5. Select the best alternative
6. Implement the decision and set a timetable for completion

Fundamentals of Decision Making

1. Terms:
    a. *Alternative* – a course of action or strategy that may be chosen by the decision maker
    b. *State of nature* – an occurrence or a situation over which the decision maker has little or no control

Fundamentals of Decision Making

2. Symbols used in a decision tree:
    a. ■ – Decision node from which one of several alternatives may be selected
    b. ● – A state-of-nature node out of which one state of nature will occur

Decision Tree Example

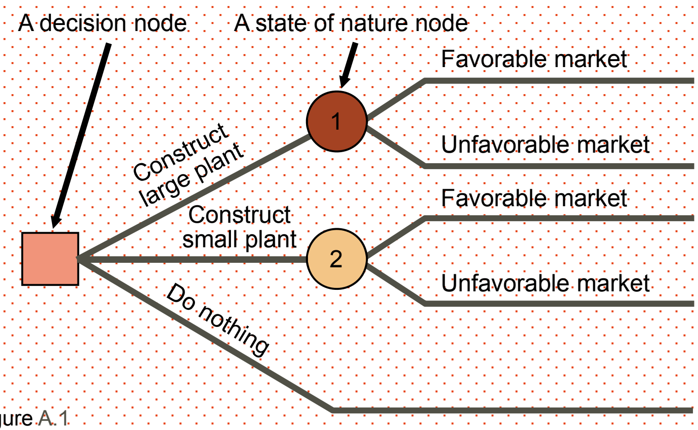


Figure A.1

Decision Table Example

TABLE A.1 Decision Table with Conditional Values for Getz Products

	STATES OF NATURE	
ALTERNATIVES	**FAVORABLE MARKET**	**UNFAVORABLE MARKET**
Construct large plant	$200,000	–$180,000
Construct small plant	$100,000	–$ 20,000
Do nothing	$ 0	$ 0

Decision-Making Environments

- Decision making under uncertainty
  - Complete uncertainty as to which state of nature may occur
- Decision making under risk
  - Several states of nature may occur
  - Each has a probability of occurring
- Decision making under certainty
  - State of nature is known

Uncertainty

1. **Maximax**
   - Find the alternative that *max*imizes the *max*imum outcome for every alternative
   - Pick the outcome with the maximum number
   - *Highest* possible *gain*
   - This is viewed as an optimistic decision criteria

Uncertainty

2. Maximin

- Find the alternative that *max*imizes the *min*imum outcome for every alternative
- Pick the outcome with the minimum number
- *Least* possible *loss*
- This is viewed as a pessimistic decision criteria

Uncertainty

3. Equally likely

- Find the alternative with the highest average outcome
- Pick the outcome with the maximum number
- Assumes each state of nature is equally likely to occur

Uncertainty Example

TABLE A.2 Decision Table for Decision Making Under Uncertainty

	STATES OF NATURE				
ALTERNATIVES	FAVORABLE MARKET	UNFAVORABLE MARKET	MAXIMUM IN ROW	MINIMUM IN ROW	ROW AVERAGE
Construct large plant	$200,000	–$180,000	$200,000	–$180,000	$10,000
Construct small plant	$100,000	–$ 20,000	$100,000	–$ 20,000	$40,000
Do nothing	$ 0	$ 0	$ 0	$ 0	$ 0
			Maximax	Maximin	Equally likely

1. Maximax choice is to construct a large plant
2. Maximin choice is to do nothing
3. Equally likely choice is to construct a small plant

Decision Making Under Risk

- Each possible state of nature has an assumed probability
- States of nature are mutually exclusive
- Probabilities must sum to 1
- Determine the **expected monetary value** (**EMV**) for each alternative

Expected Monetary Value

EMV (Alternative *i*) = (Payoff of 1st state of nature) x (Probability of 1st state of nature)

+ (Payoff of 2nd state of nature) x (Probability of 2nd state of nature)

+ … + (Payoff of last state of nature) x (Probability of last state of nature)

EMV Example

TABLE A.3 Decision Table for Getz Products

	STATES OF NATURE	
ALTERNATIVES	FAVORABLE MARKET	UNFAVORABLE MARKET
Construct large plant (A_1)	\$200,000	–\$180,000
Construct small plant (A_2)	\$100,000	–\$ 20,000
Do nothing (A_3)	\$ 0	\$ 0
Probabilities	0.6	0.4

1. EMV(A_1) = (.6)(\$200,000) + (.4)(–\$180,000) = \$48,000
2. EMV(A_2) = (.6)(\$100,000) + (.4)(–\$20,000) = \$52,000
3. EMV(A_3) = (.6)(\$0) + (.4)(\$0) = \$0

Best Option

Decision Making Under Certainty

- Is the cost of perfect information worth it?
- Determine the expected value of perfect information (EVPI)

Expected Value of Perfect Information

EVPI is the difference between the payoff under certainty and the payoff under risk

$$\text{EVPI} = \begin{array}{c}\text{Expected value}\\ \text{with perfect}\\ \text{information}\end{array} - \begin{array}{c}\text{Maximum}\\ \text{EMV}\end{array}$$

Expected value *with* perfect information (EVwPI) = (Best outcome or consequence for 1st state of nature) x (Probability of 1st state of nature)
+ Best outcome for 2nd state of nature)
x (Probability of 2nd state of nature)
+ … + Best outcome for last state of nature)
x (Probability of last state of nature)

EVPI Example

1. The best outcome for the state of nature "favorable market" is "build a large facility" with a payoff of $200,000. The best outcome for "unfavorable" is "do nothing" with a payoff of $0.

Expected value with perfect information = ($200,000)(.6) + ($0)(.4) = $120,000

EVPI Example

2. The maximum EMV is $52,000, which is the expected outcome without perfect information. Thus:

EVPI = EVwPI – Maximum EMV

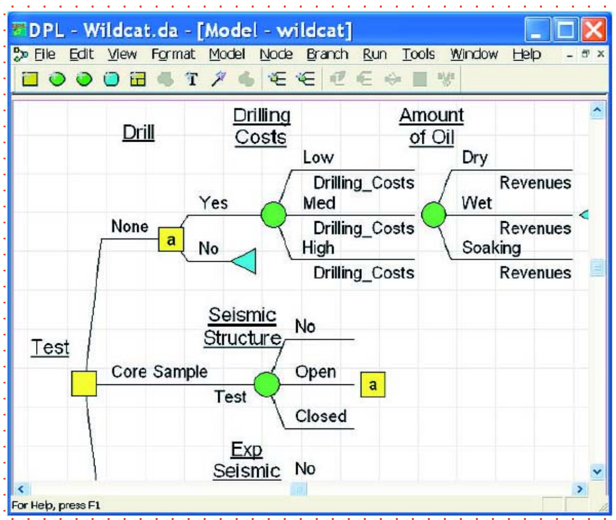
= $120,000 – $52,000 = $68,000

The most the company should pay for perfect information is $68,000

Decision Trees

- Information in decision tables can be displayed as decision trees
- A decision tree is a graphic display of the decision process that indicates decision alternatives, states of nature and their respective probabilities, and payoffs for each combination of decision alternative and state of nature
- Appropriate for showing sequential decisions

Decision Trees

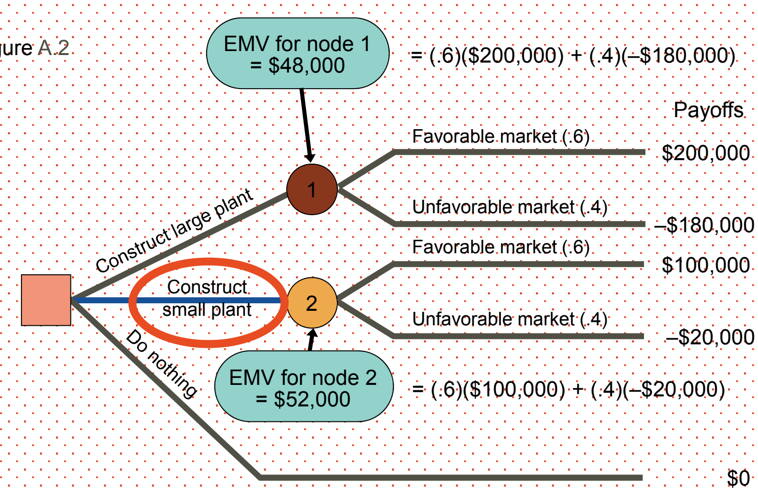


Decision Trees

1. Define the problem
2. Structure or draw the decision tree
3. Assign probabilities to the states of nature
4. Estimate payoffs for each possible combination of decision alternatives and states of nature
5. Solve the problem by working backward through the tree computing the EMV for each state-of-nature node

Decision Tree Example

Figure A.2



Complex Decision Tree Example

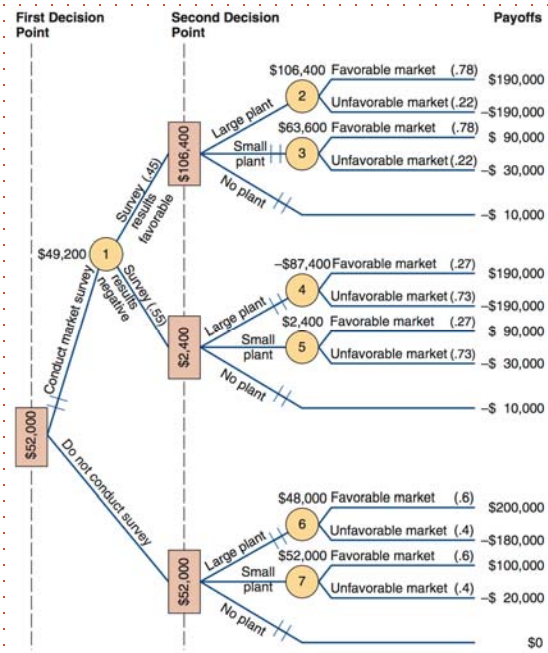


Figure A.3

Complex Example

1. Given favorable survey results

EMV(2) = (.78)($190,000) + (.22)(–$190,000) = $106,400

EMV(3) = (.78)($90,000) + (.22)(–$30,000) = $63,600

The EMV for no plant = –$10,000 so, if the survey results are favorable, build the large plant

Complex Example

2. Given negative survey results

EMV(4) = (.27)($190,000) + (.73)(–$190,000) = –$87,400

EMV(5) = (.27)($90,000) + (.73)(–$30,000) = $2,400

The EMV for no plant = –$10,000 so, if the survey results are negative, build the small plant

Complex Example

3. Compute the expected value of the market survey

EMV(1) = (.45)($106,400) + (.55)($2,400) = $49,200

4. If the market survey is not conducted

EMV(6) = (.6)($200,000) + (.4)(–$180,000) = $10,000

EMV(7) = (.6)($100,000) + (.4)(–$20,000) = $40,000

The EMV for no plant = $0 so, given no survey, build the small plant

Complex Example

5. The expected monetary value of not conducting the survey is $52,000 and the EMV for conducting the study is $49,200

   The best choice is to not seek marketing information and build the small plant

The Poker Design Process

If T. J. folds, — The money already in the pot

EMV = (.80)($99,000)
= $79,200

If T. J. calls, — The chance T.J. will call

EMV = .20[(.45)($853,000) – Phillips's bet of $422,000]
= .20[$383,850 – $422,000]
= .20[–$38,150] = –$7,630

Overall EMV = $79,200 – $7,630 = $71,750

The Poker Design Process

If T. J. folds

The overall EMV of $71,570 indicates that if this decision were to be made many times, the average payoff would be large. Even though Phillips's decision in this instance did not work out, his analysis and procedure was the correct one.

Phillips's bet of $422,000]

.20[$383,850 – $422,000]

= .20[–$38,150] = –$7,630

Overall EMV = $79,200 – $7,630 = $71,750