Unit 4
DECISION ANALYSIS

Lesson 34

Learning Objective:
• **To enable students to make business and management decisions when there is uncertainty.**

Hello class.
Lets discuss through this lesson about the construction of a decision matrix and apply a number of decision criteria and calculate the best decision.

In this lecture you will study about the different criterion used for taking **DECISION UNDER UNCERTAINITY.**

INTRODUCTION

In decision under uncertainity you (the decision maker) are unwilling or unable to specify the probabilities with which the various states of nature will occur.

There is a long standing debate as to whether such a situation should exist; i.e., should you always be willing to specify the probabilities even when you do not know anything or much about what state of nature is apt to occur?

Although, this is hard to imagine on actual business decision being made under such a cloud, we'll leave this debate to the philosophers and let us turn to the various approaches suggested for this class of models.

So,

Let us follow the different criterion on the following example:

ACME Road Runner Traps

- ACME International is considering building an overseas manufacturing facility to produce a new, high-tech version of their famous Road Runner Trap.
- Forecasted demand for road runner traps is highly uncertain, depending on two interrelated parameters that are difficult to assess: road runner population and coyote population.
- ACME's CEO, Wolfgang E. Cactus, believes demand in the next five years could be high, medium or low.
- If demand was to be high and ACME builds a large plant, they expect to make $15 million in (net present value) profits. If demand were medium, ACME would clear only $3 million with a large plant. But if demand were low, ACME would incur a $6 million loss.
- Were ACME to build a small plant, Cactus is confident they would avoid losses altogether but stand to make much less profit: $3 million, $2 million and $1 million for high, medium and low demands, respectively.
- ACME's VP for strategic analysis, Goldie Lockes, has proposed building a mid-size plant she calls "just right." With this plant, she estimates profits would be $9 million on a high-demand scenario and $4 million under medium demand. Low demand would produce an estimated loss of $2 million.
- Cactus and Lockes are in agreement about these estimates as well as a planning horizon of five years.

In this example, we have no knowledge about the probabilities of occurrence of different states of nature i.e. demand (high, medium, low).

Let's follow the approach I recommended you previously to formulate the model with a payoff table for this decision problem.

- Given that Cactus and Lockes are in agreement in order to maximize net present value profits for the five year period.
- They identify the alternatives (courses of action) as to build either a large plant, small plant, or "just right" plant, or build no plant at all!
- Demand for road runner traps turns out to be high, medium or low.
- The profit figures will serve as the corresponding payoffs.
- It is assumed in this example that no probability information about the states of nature is available to ACME's managers.

STATES OF NATURE	ALTERNATIVES			
	Large plant	Just Right plant	Small plant	No plant
High demand	15	9	3	0
Medium demand	3	4	2	0
Low demand	-6	-2	1	0

Now, I describe about the different criterion for Decision under uncertainity......

THE OPTIMIST CRITERION (MAXIMAX CRITERION)

The optimist criterion attempts to describe the decision-making behavior of people who are overly optimistic in their expectations.

If you are optimistic decision maker then you are likely to be attracted by large rewards and you are willing to risk high losses in order to obtain them.

You'll evaluate each decision by the "best thing that can happen" if you make that decision.

It is possible to model the optimist profile with the MAXIMAX decision rule when the payoffs are positive-flow rewards, such as profits or income. When payoffs are given as negative-flow rewards, such as costs or losses, the optimist decision rule is MINIMIN.
Note that negative-flow rewards are expressed with positive numbers.

Let's assume that ACME's managers are thoroughly optimistic. We would suppose they would therefore go for a large manufacturing facility in hopes of attaining the maximum profit.
Thus the psychological processes leading to such behavior can be captured by the two-step logic of the Maximax rule.

Maximax decision rule

1. Determine the maximum possible payoff for each alternative (course of action).
2. From these maxima, select the maximum payoff. The alternative that corresponds to this maximum payoff is the chosen decision.

Use ACME's payoff table defined previously:

STATES OF NATURE	ALTERNATIVES			
	Large plant	Just Right plant	Small plant	No plant
High demand	15	9	3	0
Medium demand	3	4	2	0
Low demand	-6	-2	1	0
Maximum payoff	15 Maximax	9	3	0

Decision : **To build a large plant**

The Minimin decision rule is applicable when the payoff matrix consists of negative-flow rewards, such as costs or losses. An optimistic decision maker amongst you would be attracted by lower costs.

Now Let's see what are the drawbacks of this criterion:

Critique of Maximax (Minimin)
Maximax (Minimin) is not a rationally acceptable decision rule because it excludes most of the information available in the payoff matrix. Notice that the Maximax payoff row in Road runner trap problem shows only four numbers (15, 9, 3, 0) from which to select the course of action. Nine payoffs were excluded from consideration in the choice.

This means that ~75% of the data for the problem were neglected.

Neglecting available information in a decision problem! Is it rational?

Decide for yourself
Consider the following situation:

STATES OF NATURE	ALTERNATIVES	
	A1	A2
S1	0	99
S2	100	99
Maximum payoff	100 Maximax	99

Would you risk getting nothing to go after an extra $1over a sure $99?

Let's see If you are not optimistic and rather you are pessimistic then what happens……

THE PESSIMIST CRITERION

The pessimist criterion attempts to describe the decision-making behavior of people who are overly pessimistic in their expectations. If you are a pessimistic decision maker, you are averse to large losses and are willing to forgo attractive gains in order to avoid a large risk.

If you are pessimistic, you evaluate each decision by the worst thing that can happen, if you make that decision. You evaluate each decision by the minimum possible return associated with the decision.

It is possible to model the pessimist profile with the MAXIMIN decision rule when the payoffs are positive-flow rewards, such as profits or income. When payoffs are given as negative-flow rewards, such as costs or losses, the pessimist decision rule is MINIMAX.

Let's assume that ACME's managers are diehard pessimists. We would suppose they would therefore opt for a small manufacturing facility in hopes of securing a profit, even though it may be small. The psychological processes leading to such behavior can be captured by the two-step logic of the Maximin rule.

Wald's Maximin decision rule

1. For each action alternative determine the minimum payoff possible. This represents the worst possible outcome if that decision alternative were chosen.
2. From these minima, select the maximum payoff. The person may be pessimistic but is not a dunderhead: from among the bad outcomes, choose the least bad. The action alternative leading to this payoff is the chosen decision.

Use ACME's decision matrix defined previously:

STATES OF NATURE	ALTERNATIVES			
	Large plant	Just Right plant	Small plant	No plant
High demand	15	9	3	0
Medium demand	3	4	2	0

Low demand	-6	-2	1	0
Minimum payoff	-6	-2	1 Maximin	0

Decision : To build a small plant

The Minimax decision rule applies when the payoff matrix measures negative-flow rewards, such as costs. A pessimistic decision maker would tend to avoid higher costs. The minimax rule guarantees the lesser of possible worst evils. It portrays a very conservative approach to risk.

Now Let's see what are the drawbacks of this criterion:

Critique of Maximin (Minimax)
Maximin (Minimax) is not a rationally acceptable decision rule because it excludes most of the information available in the payoff matrix. In this example, nine payoffs were excluded from consideration in making the choice. Since ~75% of the data for the problem were neglected, the decision process was not rational.

Decide for yourself
Consider the following situation:

STATES OF NATURE	ALTERNATIVES	
	A1	A2
S1	100	1
S2	0	1
Minimum payoff	0	1 Maximin

Would you pass up the chance of getting $100 to avoid losing $1?

.........................Surely, No?

Let us move on to the next criterion.

THE HURWICZ CRITERION

The Hurwicz criterion attempts to find a middle ground between the extremes posed by the optimist and pessimist criteria. Instead of assuming total optimism or pessimism, Hurwicz incorporates a measure of both by assigning a certain percentage weight to optimism and the balance to pessimism.

> A weighted average can be computed for every action alternative with an alpha-weight α, called the *coefficient of realism*. "Realism" here means that the unbridled optimism of maximax is replaced by an attenuated optimism as denoted by the α. Note that $0 \leq \alpha \leq 1$. Thus, a better name for the coefficient of realism is *coefficient of optimism*. An $\alpha = 1$ implies absolute optimism (maximax) while an $\alpha = 0$ implies absolute pessimism (maximin).

Selecting a value for α simultaneously produces a *coefficient of pessimism* $1 - \alpha$, which reflects the decision maker's aversion to risk. A Hurwicz weighted average H can now be computed for every action alternative A_i in A as follows:

> H (A_i) = α (column maximum) + (1 - α) (column minimum)
> for positive-flow payoffs (profits, income)

> H (A_i) = α (column minimum) + (1 - α) (column maximum)
> for negative-flow payoffs (costs, losses)

Hurwicz decision rule

1. Select a coefficient of optimism value α.

2. For every action alternative compute its Hurwicz weighted average.

3. Choose the action alternative with the best Hurwicz weighted average as the chosen decision. ("Best" means the maximum H for positive-flow payoffs, and the minimum H for negative-flow payoffs.)

Let's assume that ACME's managers have agreed to assess their level of optimism at 60%. Thus $\alpha = 0.6$. Using the decision matrix defined previously:

STATES OF NATURE	ALTERNATIVES			
	Large plant	Just Right plant	Small plant	No plant
High demand	15	9	3	0
Medium demand	3	4	2	0
Low demand	-6	-2	1	0

H (L) = 0.6 (15) + 0.4 (-6) = 6.6

H (JR) = 0.6 (9) + 0.4 (-2) = 4.6

H (S) = 0.6 (3) + 0.4 (1) = 2.2

H (N) = 0.6 (0) + 0.4 (0) = 0

Here, consider that Hurwicz weighted average is maximum for alternative 'to build a large plant'.

So, you decide to build a large plant.

You might wish to redo the computations for α = 0.3 to see the effect a greater degree of pessimism on the decision.

Now Let's see what are the drawbacks of this criterion:

Critique of Hurwicz Criterion

Although Hurwicz is an improvement of sorts over Maximax and Maximin (more of the available data are taken into consideration), it still falls short of being a rationally sound approach because part of the information is neglected. In this particular case ~33% of the data was excluded. But if there had been, say, ten states of nature, then 80% of the data would have been ignored. Ignoring intermediate payoffs can lead to questionable decisions.

Now, Try some problems yourself:

1. A food product company is contemplating the introduction of a revolutionary new product with new packing to replace the existing product at much higher price (S_1) or a moderate change in the composition of the existing product with a new packaging at a small increase in price (S_2) or a small change in the composition of the existing expect the word 'New' with a negligible increase in price (S_3). The three possible states of nature of events are
(i)   High increase in sales (N_1)
(ii)   No change in sales (N_2) and
(iii)   Decrease in sales (N_3).

The marketing department of the company worked out the payoffs in term of yearly net profits for each of the strategies for these events (expected sales). This is represented in following table:

State of nature	Payoffs (in Rs.)		
Strategies	S_1	S_2	S_3
A_1	7,00,000	3,00,000	1,50,000
A_2	5,00,000	4,50,000	0
A_3	3,00,000	3,00,000	3,00,000

Which strategy should the executive concerned choose on the basis of :
(i)   Maximin criterion,
(ii)   Maximax criterion,
(iii)   Hurwicz criterion (with $\alpha = 0.7$)

2. Dr. Mohan Lal has been thinking about starting his own independent nursing home. The problem is to decide how large nursing home should be? The annual returns will depend on both the size of nursing home and a number of marketing factors. After a careful analysis, Dr. Mohan Lal developed the following table:

Size of Nursing home	Good market (Rs.)	Fair market (Rs.)	Poor market (Rs.)
Small	50,000	20,000	− 10,000
Medium	80,000	30,000	− 20,000
Large	1,00,000	30,000	− 40,000
Very large	3,00,000	25,000	− 1,60,000

(i)   Develop a decision table for this decision.

(ii)   What is the maximax decision?

(iii)   What is the maximin decision?

(iv)   What is the criterion of realism decision? Use α value of 0.8.

3. The proprietor of a food stall has invented a new food-delicacy, which he calls Whim. He has calculated that the cost of manufacture is Re. 1 per piece and because of its novelty it can be sold for Rs. 3 per piece. It is, however, perishable, and good unsold at the end of the day are a dead loss. He expected the demand to very between 10 and 15.

How many pieces should be manufactured so that his net profit is maximum? Use Maximin and Minimax criteria.

So, now let us summarize today's discussion:

Summary
We have discussed in details about **Decision making under uncertainity**.

- The Optimist Criterion.
- The Pessimist Criterion
- The Hurwicz Criterion.

Slide 1

_____

_____

_____

_____

_____

_____

_____

_____

Slide 2

DECISION MAKING UNDER UNCERTAINITY

- THE OPTIMIST CRITERION (MAXIMAX CRITERION)

- THE PESSIMIST CRITERION (MAXIMIN CRITERION)

- THE HURWICZ CRITERION

Slide 3

DECISION MAKING UNDER UNCERTAINITY

- **THE SAVAGE MINIMAX REGRET CRITERION**

- **THE LAPLACE INSUFFICIENT REASON CRITERION**

- **THE MAXIMUM LIKELIHOOD (MODAL) CRITERION**

Slide 4

THE OPTIMIST CRITERION
(MAXIMAX CRITERION)

Maximax decision rule

1. Determine the maximum possible payoff for each alternative (course of action).
2. From these maxima, select the maximum payoff.
3. The alternative that corresponds to this maximum payoff is the chosen decision.

Slide 5

THE PESSIMIST CRITERION
(MAXIMIN CRITERION)

Maximin decision rule

1. For each action alternative determine the minimum payoff possible.
2. From these minima, select the maximum payoff.
3. The action alternative leading to this payoff is the chosen decision.

Slide 6

THE HURWICZ CRITERION

Hurwicz decision rule

1. Select a coefficient of optimism value α .
2. For every action alternative compute its Hurwicz weighted average.
3. Choose the action alternative with the best Hurwicz weighted average as the chosen decision