DECISION MAKING TECHNIQUES IN MANAGEMENT INFORMATION SYSTEMS (MIS)

LECTURE -2-

(Decision making under uncertainty and risk)

COMPONENTS OF DECISION ANALYSIS

- A *state of nature* is an actual event that may occur in the future.
- A *payoff matrix (decision table)* is a means of organizing a decision situation, presenting the payoffs from different decisions/alternatives given the various states of nature.

BASIC STEPS IN DECISION ANALYSIS

1) Clearly define the problem at hand
2) List the possible alternatives
3) Identify the possible state of natures
4) List the payoff (profit/cost) of alternatives with respect to state of natures
5) Select one of the mathematical decision analysis methods (models)
6) Apply the method and make your decision

TYPES OF DECISION-MAKING ENVIRONMENTS

- Type 1: Decision-making under certainty
  - DM *knows with certainty* the payoffs of every alternative .
- Type 2: Decision-making under uncertainty
  - DM *does not know* the probabilities of the various states of nature.
- Type 3: Decision-making under risk
  - DM *does know* the probabilities of the various states of nature.

DECISION MAKING UNDER CERTAINTY

- Instead of state of natures, a true state is known to the decision maker before s/he has to make decision
- The optimal choice is to pick an alternative with the highest payoff

DECISION MAKING UNDER UNCERTAINTY

- Maximax
- Maximin
- Criterion of Realism
- Equally likelihood
- Minimax

DECISION TABLE / PAYOFF MATRIX

	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

MAXIMAX (RISK SEEKING BEHAVIOR)

Choose the alternative with the maximum optimistic level

$$o_k = \max_{i=1}^{m} \{o_i\} = \max_{i=1}^{m} \{\max_{j=1}^{m} \{v_{ij}\}\}$$

	STATES OF NATURE		
ALTERNATIVES	Favorable market	Unfavorable market	Maximum in row (o_k)
Construct large plant	$200,000	($180,000)	$200,000
Construct small plant	$100,000	($20,000)	$100,000
Do nothing	$0	$0	$0

MAXIMIN (RISK AVERSE BEHAVIOR)

Choose the alternative with the maximum security level

$$s_k = \max_{i=1}^{m} \{s_i\} = \max_{i=1}^{m} \{ \min_{j=1}^{m} \{v_{ij}\}\}$$

	STATES OF NATURE		
ALTERNATIVES	Favorable market	Unfavorable market	Minimum in row (s_k)
Construct large plant	$200,000	($180,000)	($180,000)
Construct small plant	$100,000	($20,000)	($20,000)
Do nothing	$0	$0	$0

CRITERION OF REALISM

*Hurwicz suggested to use the optimism-pessimism index (*a)

Choose the alternative with the maximum weighted average of optimistic and security levels

$$\max_{i=1}^{m} \{a\, o_i + (1 - a)\, s_i\} \quad \text{where } 0 \le a \le 1$$

	STATES OF NATURE			
ALTERNATIVES	Favorable market	Unfavorable market	Weighted average	α=0.7
Construct large plant	$200.000	($180.000)	380α-180	**86**
Construct small plant	$100.000	($20.000)	120α-20	64
Do nothing	$0	$0	$0	0

CRITERION OF REALISM

$120\alpha - 20 = 0 \Rightarrow \alpha = 0.1667$

$380\alpha - 180 = 120\alpha - 20 \Rightarrow \alpha = 0.6154$

$0 \leq \alpha \leq 0.1667 \Rightarrow$ "Do nothing"

$0.1667 \leq \alpha \leq 0.6154 \Rightarrow$ "Construct small plant"

$0.6154 \leq \alpha \leq 1 \Rightarrow$ "Construct large plant"

EQUALLY LIKELIHOOD

Laplace argued that "knowing nothing at all about the true state of nature" is equivalent to "all states having equal probability"

Choose the alternative with the maximum row average (expected value)

	STATES OF NATURE		
ALTERNATIVES	Favorable market	Unfavorable market	Row average
Construct large plant	$200,000	($180,000)	$10,000
Construct small plant	$100,000	($20,000)	$40,000
Do nothing	$0	$0	$0

MINIMAX REGRET (LOST OPPORTUNITY)

Savage defined the regret (opportunity loss) as the difference between

- *the value resulting from the best action given that state of nature j is the true state and*
- *the value resulting from alternative i with respect to state of nature j*

Choose the alternative with the minimum worst (maximum) regret

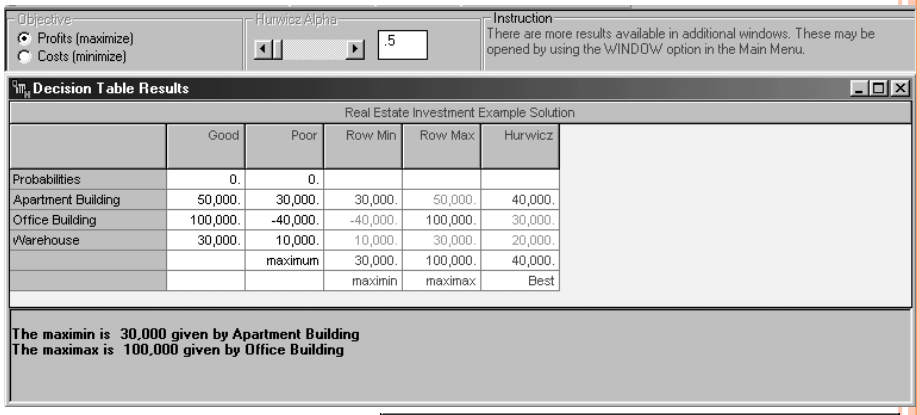
Regret Values	STATES OF NATURE		
ALTERNATIVES	Favorable market	Unfavorable market	Maximum in row
Construct large plant	$0	$180,000	$180,000
Construct small plant	$100,000	$20,000	$100,000
Do nothing	$200,000	$0	$200,000

SUMMARY OF EXAMPLE RESULTS

METHOD	DECISION
Maximax	"Construct large plant"
Maximin	"Do nothing"
Criterion of Realism	*depends on* α
Equally likelihood	"Construct small plant"
Minimax	"Construct small plant"

The appropriate method is dependent on the personality and philosophy of the DM.

SOLUTIONS WITH QM FOR WINDOWS



Objective
Profits (maximize)
Costs (minimize)

Hurwicz Alpha .5

Instruction
There are more results available in additional windows. These may be opened by using the WINDOW option in the Main Menu.

Decision Table Results

Real Estate Investment Example Solution

	Good	Poor	Row Min	Row Max	Hurwicz
Probabilities	0.	0.			
Apartment Building	50,000.	30,000.	30,000.	50,000.	40,000.
Office Building	100,000.	-40,000.	-40,000.	100,000.	30,000.
Warehouse	30,000.	10,000.	10,000.	30,000.	20,000.
		maximum	30,000.	100,000.	40,000.
			maximin	maximax	Best

The maximin is 30,000 given by Apartment Building
The maximax is 100,000 given by Office Building

	Good Regret	Poor Regret	Maximum Regret	Expected Regret
Probabilities	0.	0.		
Apartment Building	50,000.	0.	50,000.	0.
Office Building	0.	70,000.	70,000.	0.
Warehouse	70,000.	20,000.	70,000.	0.
Minimax regret			50,000.	

DECISION MAKING UNDER RISK

Probability
- Objective
- Subjective

- Expected (Monetary) Value

  Expected Value of Perfect Information
- Expected Opportunity Loss

PROBABILITY

- A *probability* is a numerical statement about the likelihood that an event will occur
- The probability, *P*, of any event occurring is greater than or equal to 0 and less than or equal to 1:

$$0 \leq P(event) \leq 1$$

- The sum of the simple probabilities for all possible outcomes of an activity must equal 1

OBJECTIVE PROBABILITY

Determined by experiment or observation:

- *Probability of heads on coin flip*
- *Probability of spades on drawing card from deck*

$$P(A) = \lim_{n \to \infty} n(A) / n$$

P(A): probability of occurrence of event A

n(A): number of times that event A occurs

n: number of independent and identical repetitions of the experiments or observations

SUBJECTIVE PROBABILITY

- Determined by an estimate based on the expert's
  - personal belief,
  - judgment,
  - experience,

  and
  - existing knowledge of a situation

PAYOFF MATRIX WITH PROBABILITIES

	STATES OF NATURE	
ALTERNATIVES	Favorable market	Unfavorable market
Probabilites	60%	40%
Construct large plant	$200,000	($180,000)
Construct small plant	$100,000	($20,000)
Do nothing	$0	$0

EXPECTED (MONETARY) VALUE

Choose the alternative with the maximum weighted row average

$$EV(a_i) = \sum_j v_{ij} P(\theta_j)$$

	STATES OF NATURE		
ALTERNATIVES	Favorable market	Unfavorable market	Expected Value
Construct large plant	$200,000	($180,000)	$48,000
Construct small plant	$100,000	($20,000)	$52,000
Do nothing	$0	$0	$0
PROBABILITIES	0.6	0.4	

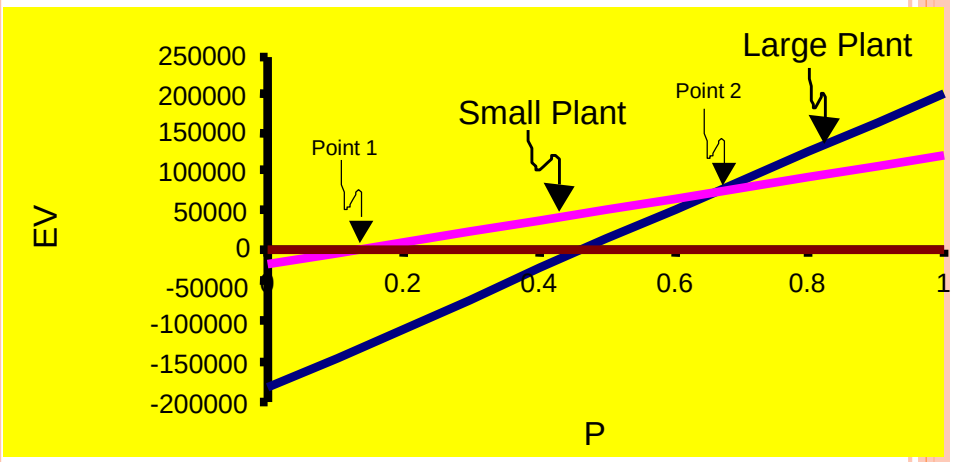
SENSITIVITY ANALYSIS

EV (Large plant) = $\$200{,}000P - \$180{,}000\ (1 - P)$

EV (Small plant) = $\$100{,}000P - \$20{,}000(1 - P)$

EV (Do nothing) = $\$0P + \$0(1 - P)$

SENSITIVITY ANALYSIS



EXPECTED VALUE OF PERFECT INFORMATION

- A consultant or a further analysis can aid the decision maker by giving exact (perfect) information about the true state: the decision problem is no longer under risk; it will be under certainty.
- Is it worthwhile for obtaining perfectly reliable information: is EVPI greater than the fee of the consultant (the cost of the analysis)?
- EVPI is the maximum amount a decision maker would pay for additional information

EXPECTED VALUE OF PERFECT INFORMATION

EVPI = EV with perfect information
– Maximum EV under risk

	STATES OF NATURE		
ALTERNATIVES	Favorable market	Unfavorable market	Expected Value
Construct large plant	$200,000	($180,000)	$48,000
Construct small plant	$100,000	($20,000)	$52,000
Do nothing	$0	$0	$0
PROBABILITIES	0.6	0.4	

EV with perfect information: 200*.6+0*.4=120
Maximum EV under risk: 52
EVPI = 120 – 52 = 68

EXPECTED OPPORTUNITY LOSS

Choose the alternative with the minimum weighted row average of the regret matrix

$$EOL(a_i) = \sum_j r_{ij} P(q_j)$$

Regret Values	STATES OF NATURE		Expected Opportunity
ALTERNATIVES	Favorable market	Unfavorable market	Loss
Construct large plant	$0	$180,000	$72,000
Construct small plant	$100,000	$20,000	$68,000
Do nothing	$200,000	$0	$120,000
PROBABILITIES	0.6	0.4	

DECISION ANALYSIS APPLICATION I

- Suppose that a construction company is trying to make a decision on the number of condos (apartments) to build in the next year. The situation of economy is very effective during this decision making process and the related data is determined as follows. Determine the best alternative by using:
  - Maximax
  - Maximin
  - Criterion of realism (a=0.6)
  - Equally likelihood
  - Minimax

	States of Nature		
Alternatives	**S1 (Good)**	**S2 (Fair)**	**S3 (Bad)**
A1 (1000 units)	10.000.000	4.000.000	-5.000.000
A2 (750 units)	7.000.000	3.000.000	-3.000.000
A3 (500 units)	4.000.000	2.000.000	-2.000.000
A4 (250 units)	2.500.000	1.000.000	-1.000.000

ANSWER TO DECISION ANALYSIS APPLICATION I

- Maximax = Alternative 1 (10.000.000)
- Maximin = Alternative 4 (- 1.000.000)
- Criterion of realism (a=0.6) = Alternative 1 (4.000.000)
- Equally likelihood = Alternative 1 (3.000.000)
- Minimax = Alternative 2 (3.000.000)

DECISION ANALYSIS APPLICATION II

- Suppose that a construction company is trying to make a decision on the number of condos (apartments) to build in the next year. The situation of economy is very effective during this decision making process and the related data is determined as follows. Moreover, the probabilities for each state of nature are given. Obtain the values of the following parameters regarding the case:
- Expected (monetary) value
- Epected value of perfect information
- Expected opportunity loss

	States of Nature		
Alternatives	**S1 (Good)**	**S2 (Fair)**	**S3 (Bad)**
Probabilities	**30%**	**50%**	**20%**
A1 (1000 units)	10.000.000	4.000.000	-5.000.000
A2 (750 units)	7.000.000	3.000.000	-3.000.000
A3 (500 units)	4.000.000	2.000.000	-2.000.000
A4 (250 units)	2.500.000	1.000.000	-1.000.000

ANSWER TO DECISION ANALYSIS APPLICATION II

- Expected (monetary) value = Alternative 1 (4.000.000)
- Expected value of perfect information = 800.000
- Expected opportunity loss = Alternative 1 (800.000)

REFERENCES

- Lecture notes of "Prof. Dr. Y. İlker Topçu", http://web.itu.edu.tr/topcuil/