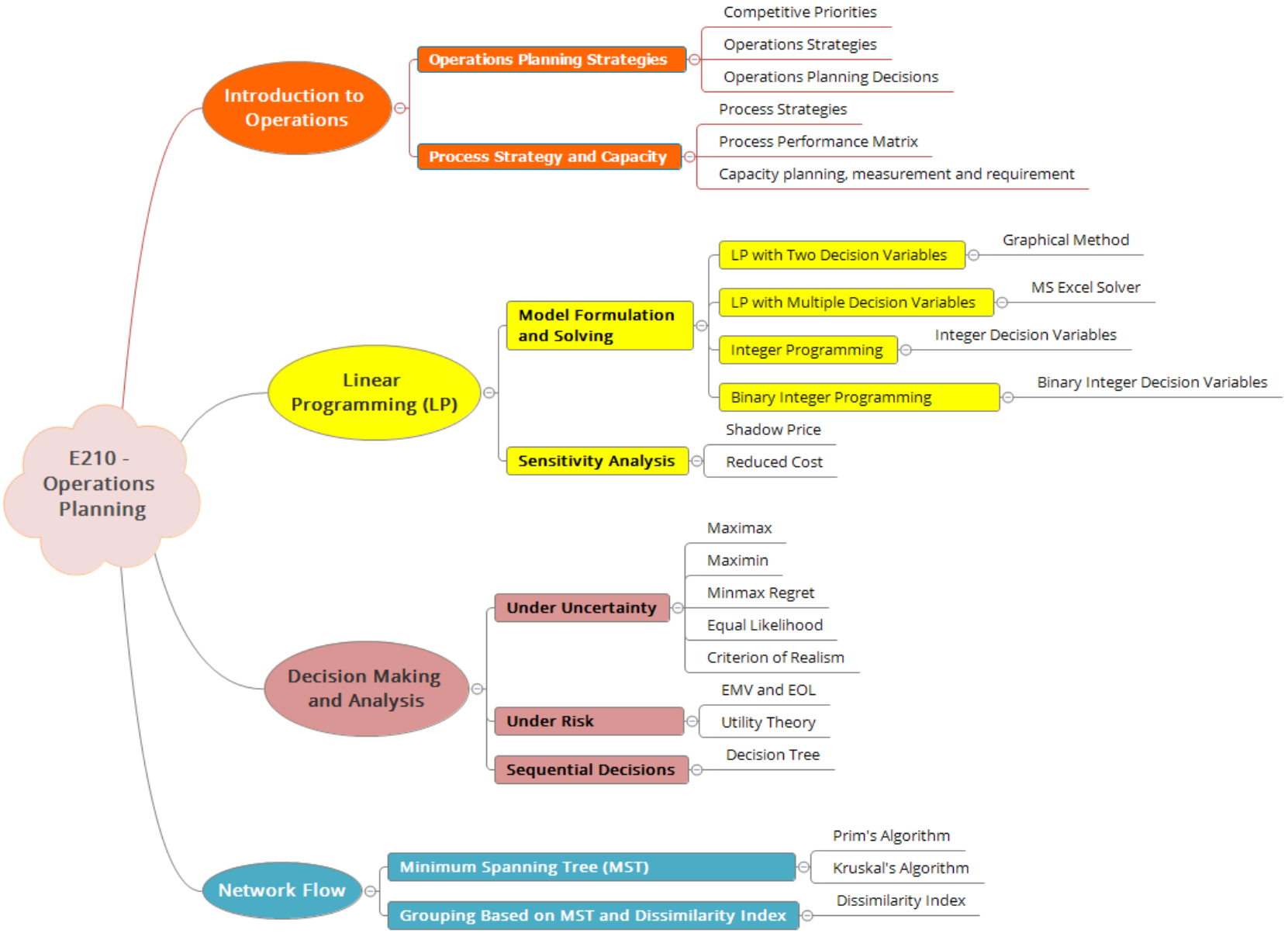
Problem 08

The Beautiful Roses

E210 – Operations Planning

SCHOOL OF ENGINEERING

E210 Operations Planning Topic Tree



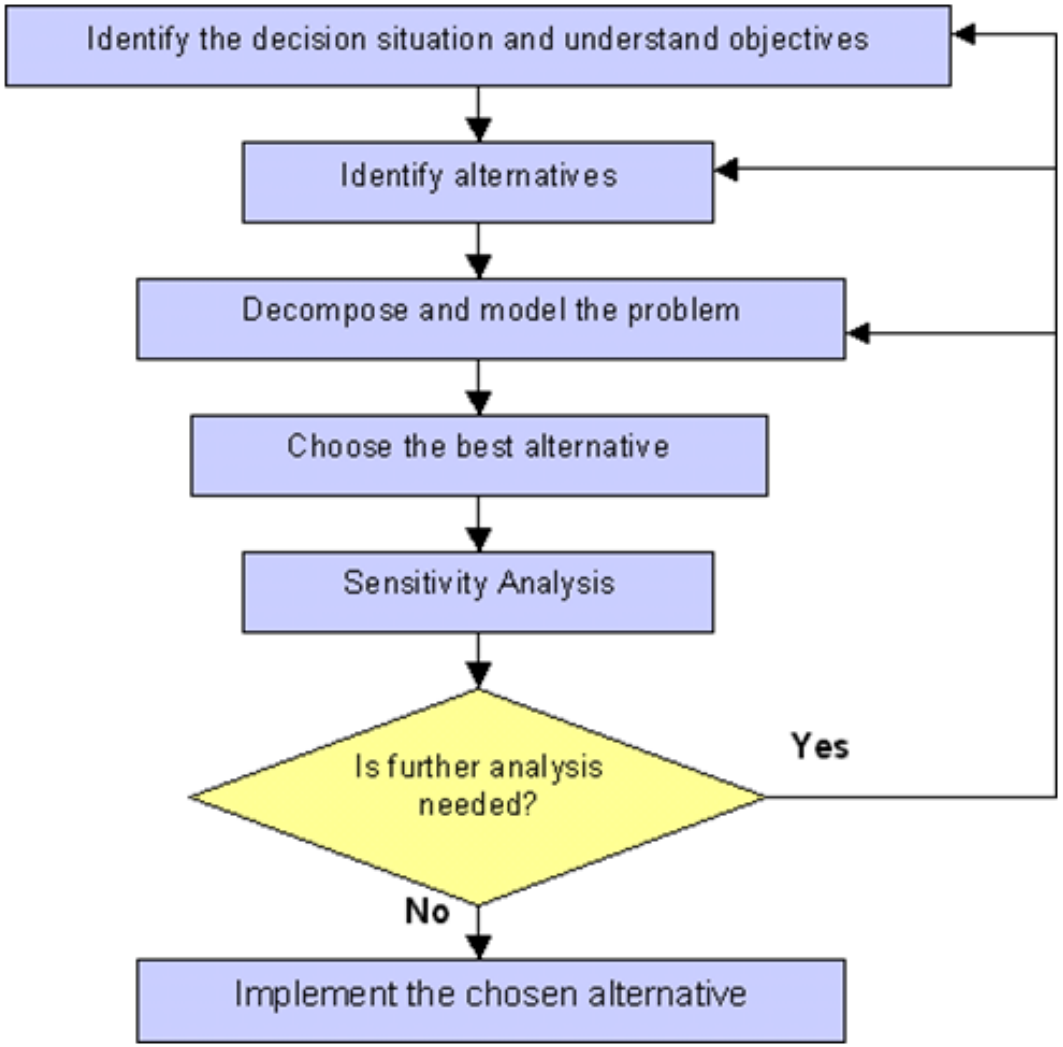
Decision Analysis (DA)

- DA is the discipline of evaluating complex **alternatives** in terms of **values** and **uncertainty.**
- Values are generally expressed monetarily because this is a major concern for Management & in Business context.
- DA provides insight into how the defined alternatives differ from one another and then generates suggestions for new and improved alternatives.
- Using numbers to quantify subjective values and uncertainties, DA enables us to understand the decision situation. (e.g. Buying a laptop based on brand etc.)
- These numerical results then must be translated back into words in order to generate qualitative insight.

Decision Analysis (DA) (cont..)

- DA is a process that allows the decision maker to select at least and at most one option from a set of possible decision alternatives.
- There must be uncertainty regarding the future along with the objective of optimizing the resulting payoff (return) in terms of some numerical decision criteria.

Decision Analysis Framework



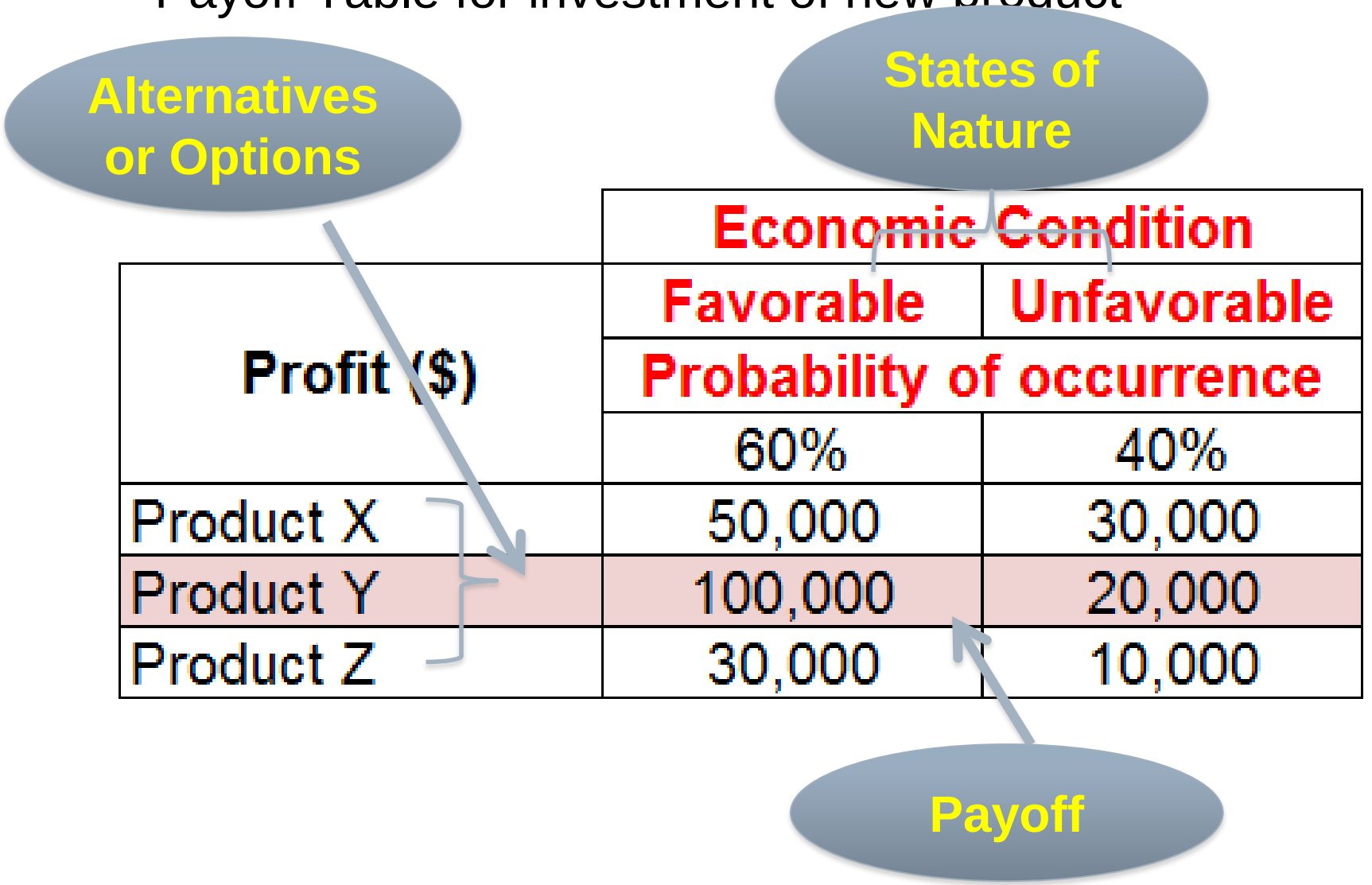
Resource: http://home.ubalt.edu/ntsbarsh/opre640a/partix.htm#rwida

Elements of a Decision

- **These are components to any decision:**
  - Decision Maker
  - The available choices (**alternatives** or **acts**)
  - The **criteria** that represent various factors that are important in the decision making.
  - The **states of nature**, which are actual events that are likely to occur and over which the decision maker has no control – uncontrollable future events.
  - The **payoff**, is the return of a decision. Different combinations of decisions and states of nature (uncertainty) generate different payoffs.
  - Payoffs are usually shown in tables. Usually **positive (+)** value for net revenue, income, or profit and **negative (-)** value for expense, cost or net loss.
  - Rows and columns are assigned possible decision alternatives and possible states of nature, respectively.

Payoff Table Example

- Payoff Table for investment of new product



Profit ($)	Economic Condition	
	Favorable	Unfavorable
	Probability of occurrence	
	60%	40%
Product X	50,000	30,000
Product Y	100,000	20,000
Product Z	30,000	10,000

Payoff Table and Expected Payoff

- A Payoff Table is a table that summarizes the final outcome (or payoff) of each decision alternative and each possible state of nature.

- The Expected Payoff or the Expected Monetary Value (EMV) is the expected value of a decision made under certain risks.

Decision Making Environments

Different Decision Making Conditions

- Decision making under **uncertainty**
  - E.g. John is deciding whether to build or lease his new warehouse for his business. However, he is not certain about the outcomes and cannot make reasonable probability estimates.

- Decision making under **risk**
  - E.g. A contestant in a game show can either choose to open 1 out of 3 boxes to win $1000 or nothing, or accept $100 and leave the game.

- Decision making under **certainty**
  - E.g. John is deciding in which bank he should deposit his excess cash. He knows exactly how much interest is being offered by each bank and the interest he will earn.

Risk Management

- Risk management is about making strategic decision under uncertainties and risk.
- It is NOT about making decision using your gut feeling!
- And it DOES NOT guarantee that the decision that you make on any occasion is the right one!
- Given enough data, decision analysis allows you to make optimal decision.
- Over a medium to long term, you will be better off than if you just simply decide by guessing.

Decision making under Uncertainty

- Carry out decision making under **uncertainty** when a decision maker is not certain about the outcomes and cannot even make reasonable probability estimates:

  - Maximax
  - Maximin
  - Equal likelihood
  - Criterion of realism (Hurwicz)
  - Minimax regret

Decision making under Risk

- Carry out decision making under **Risk** when a decision maker is able to estimate the likelihood of certain alternatives or outcomes.

  - Understand the following concepts in decision making
    - ✓ Expected Monetary Value (EMV)
    - ✓ Expected Opportunity Loss (EOL)
    - ✓ Expected Value of Perfect Information (EVPI)

  - Calculate **EMV** and **EOL**; and make decisions based on EMV, EOL

  - Calculate **EVPI**: the maximum value of additional information available, to limit what decision maker should be spending.

Problem 08
Suggested Solution

13

Problem Definition

- Decision Maker : The Management of LoveFlora (the flower shop)
- Alternatives: The types of rose
  - The ‘Magic’
  - The ‘Stripe’
  - The ‘Blue’
  - The ‘Delight’
- Criteria considered in the Decision Making: Monthly Profit
- States of nature: Market Responses
  (Good, Satisfactory and Poor)

Problem Definition – Under Uncertainty

- Payoffs

Rose Type (Profit/loss in $1000 per month)	Market Response		
	Good	Satisfactory	Poor
The ‘Magic’	27	10	-8
The ‘Stripe’	18	12	-5
The ‘Blue’	22	16	2
The ‘Delight’	19	15	3

Consider

- Uncertain outcome of the market responses.
- Different opinions of the decision makers

What will be the respective decision?

Problem Definition – Under Risk

- Payoffs

Rose Type (Profit/loss in $1000)	Market Response		
	Good (0.45)	Satisfactory (0.35)	Poor (0.20)
The ‘Magic’	27	10	-8
The ‘Stripe’	18	12	-5
The ‘Blue’	22	16	2
The ‘Delight’	19	15	3

- Given the probabilities of the various market responses, how will Elsa’s decision be affected?
- Should LoveFlora hire the consultant at a cost of $2,000 to be more certain in making the decision?

Decision Making – Under Uncertainty

- **Maximax -** Select the decision that results in the maximum of the maximum payoffs

Rose Type (Profit/loss in $1000)	**Market Response**			**Maximum in Row**
	Good	**Satisfactory**	**Poor**	
The 'Magic'	27	10	-8	27
The 'Stripe'	18	12	-5	18
The 'Blue'	22	16	2	22
The 'Delight'	19	15	3	19

- For those who are going for "Go for the Gold" are generally **optimistic**. They will assume that maximum profit for each decision alternative will occur.
- Hence, they will decide to select *The 'Magic'.*

Decision Making – Under Uncertainty

- **Maximin -** Select the decision that results in the maximum of the minimum payoffs

Rose Type (Profit/loss in $1000)	**Market Response**			**Minimum in Row**
	Good	**Satisfactory**	**Poor**	
The 'Magic'	27	10	-8	-8
The 'Stripe'	18	12	-5	-5
The 'Blue'	22	16	2	2
The 'Delight'	19	15	3	3

- For those who are going for "Best of the Worst" are generally **pessimistic** and will assume that worst case for each decision alternative will occur.
- They will select the maximum of the minimum payoffs. In this case, they will decide to select *The 'Delight'.*

Decision Making – Under Uncertainty

- **Equal likelihood -** Select the decision that results in the highest average payoffs.

Rose Type (Profit/loss in $1000)	**Market Response**			**Average**
	Good	**Satisfactory**	**Poor**	
The 'Magic'	27	10	-8	9.67
The 'Stripe'	18	12	-5	8.33
The 'Blue'	22	16	2	13.33
The 'Delight'	19	15	3	12.33

- For those who believe that all 3 market conditions will have an **equal chance** to happen, they will calculate the average payoffs for each alternative and select the highest average payoffs.
- Hence, they will decide to select *The 'Blue'.*

Decision Making – Under Uncertainty

- **Criterion of Realism (Hurwicz criterion) -** decision rule is as follows:
  - Select a coefficient of realism value α .
  - For every action alternative, compute Hurwicz weighted average H.

    H (Ai) = α (row maximum) + (1 - α) (row minimum)
  - Choose the action alternative with the best H as the chosen decision ("Best" means Max {H} for positive-flow payoffs, and Min {H} for negative-flow payoffs).
- Using α = 0.7

Rose Type (Profit/loss in $1000)	Market Response			Weighted Average
	Good	Satisfactory	Poor	
The 'Magic'	27	10	-8	16.5
The 'Stripe'	18	12	-5	11.1
The 'Blue'	22	16	2	16.0
The 'Delight'	19	15	3	14.2

  - Pick the alternative with the maximum weighted average: The 'Magic'.

- What kind of value of α will an optimist and pessimist select?

Decision Making – Under Uncertainty

- **Minimax Regret -** Select the decision that minimizes the maximum regret associated with each alternative.

Rose Type (Profit/loss in $1000)	**Market Response**						**Max Regret**
	Good		**Satisfactory**		**Poor**		
The 'Magic'	27	0	10	6	-8	11	11
The 'Stripe'	18	9	12	4	-5	8	9
The 'Blue'	22	5	16	0	2	1	5
The 'Delight'	19	8	15	1	3	0	8

The regret

- Calculate the regret for each market condition.
  Poor Market Response, *The Delight* has the maximum profit of 3
  Regret for *The 'Stripe'* => 3 - (-5) = 8
- Determine the maximum regret for each alternative considering all market responses.
- Pick the alternative with the minimum number: *The 'Blue'.*

Decision Making – Under Uncertainty

- **Summary**

Criteria	Decision Outcome
Maximax	The ‘Magic’
Maximin	The ‘Delight’
Equal Likelihood	The ‘Blue’
Criteria of Realism (Hurwicz) $\alpha = 0.7$	The ‘Magic’
Minimax Regret	The ‘Blue’

Decision Making – Under Risk

- Given the probabilities of the respective Market Responses

States of Nature

Rose Type (Profit/loss in $1000)	Market Response		
	Good (0.45)	Satisfactory (0.35)	Poor (0.20)
The 'Magic'	27	10	-8
The 'Stripe'	18	12	-5
The 'Blue'	22	16	2
The 'Delight'	19	15	3

Available Choices

payoffs

Decision Making Under Risk

The selection criteria can be:

- Expected Monetary Value (EMV), and
- Expected Opportunity Loss (EOL)

Rose Type (Profit/loss in $1000)	Market Response		
	Good (0.45)	Satisfactory (0.35)	Poor (0.20)
The ‘Magic’	27	10	-8
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The ‘Blue’	22	16	2
The ‘Delight’	19	15	3

Expected Monetary Value (EMV) Criterion

- EMV(The 'Magic')

  = 0.45×27K + 0.35×10K + 0.2x(-8K) = $14.05K = $14,050

- EMV(The 'Stripe')

  = 0.45×18K + 0.35×12K + 0.2x(-5K) = $11.30K = $11,300

- EMV(The 'Blue')

  = 0.45×22K + 0.35×16K + 0.2x2K = **$15.90K = $15,900**

- EMV(The 'Delight')

  = 0.45×19K + 0.35×15K + 0.2x3K = $14.40K = $14,400

Based on the expected monetary value (EMV) criterion, the best option to choose is *The 'Blue'* (Expected profit of $15,900 to earn)

Question: Will LoveFlora actually make this amount of profit for this selection?

- This value only represents the expected value or mean return of the alternative if LoveFlora could repeat the decision a large number of times.

Expected Opportunity Loss (EOL)

- The opportunity loss or regret, represents the potential loss in monetary value when compared with the best alternative under each state of nature.

- The expected opportunity loss (EOL) is the expected value of the opportunity loss over all possible states of nature. The EOL criterion selects the alternative with the lowest EOL.

- *Will the EMV and EOL decision rules always result in the selection of the same decision alternative?*

Expected Opportunity Loss (EOL) Criterion

Calculate the opportunity loss or regret, *<similar to the regret in the minimax regret criterion>.* It represents the potential loss in monetary value when compared with the best alternative under each market response.

The opportunity loss or regret

Rose Type (Profit/loss in $1000)	Market Response					
	Good (0.45)		Satisfactory (0.35)		Poor (0.20)	
The 'Magic'	27	0	10	6	-8	11
The 'Stripe'	18	9	12	4	-5	8
The 'Blue'	22	5	16	0	2	1
The 'Delight'	19	8	15	1	3	0

<u>Eg. Computation</u>
Max payoff (Good Market Response) – payoff (The 'Blue')
=27K – (22K) = 5K

<u>Eg. Computation</u>
Max payoff (Poor Market Response) – payoff (The 'Delight')
=3K – 3K= 0K

Expected Opportunity Loss (EOL) Criterion

Rose Type (Profit/loss in $1000)	**Market Response**			**EOL**
	Good (0.45)	**Satisfactory (0.35)**	**Poor (0.20)**	
The 'Magic'	0	6	11	4.30
The 'Stripe'	9	4	8	7.05
The 'Blue'	5	0	1	2.45
The 'Delight'	8	1	0	3.95

- EOL(The 'Delight')

  = 8×0.45 + 1×0.35 + 0×0.2

  = $3.95K

- Based on the expected opportunity loss (EOL) criterion, the best option to choose is *The 'Blue'* (Lowest expected opportunity loss of $2.45K = $2,450).

Uncertainty Versus Risks

- Differences:
  - Decision making under Risk has some form of “certainty” involved, when making decision. Would say, it is a “surer” mode of decision making.
  - Decision making under uncertainty is making decisions under pure uncertainty, all depend on decision maker’s personality and risk outcome – no right or wrong decision in that sense.

- Similarities:
  - Both are decision making and in all decision making, risks and unexpected outcomes/events may occur. No definite winning decision for sure that can be made before hand.

Expected Value of Perfect Information (EVPI)

- Occasionally additional (perfect) information is available, or can be purchased, regarding future events, enabling the decision maker to make a better decision – e.g. hire economic forecaster, market analysis, etc.
- This value of information is known as “expected value of perfect information (EVPI)”.
- EVPI is the maximum amount that should be paid to gain information that would result in a better decision than those decisions made without perfect information.

EVPI Computation

- Steps:
  1) Look at decisions under each state of nature.
  2) Select best decision for each state & calculate Expected Value with Perfect Information (EVwithPI)
  3) EVPI = EVwithPI – Max Expected Monetary Value (expected payoff without perfect information)

EVPI

- Using the expected value (EMV) criterion, the optimal decision is *The 'Blue'.* However, the company cannot be 100% sure.
- Under the assumption that the outcome of state of nature is known in advance (from marketing research), then each time when a decision is to be made, it would be a decision under a close-to-100% certainty.
- For example, if LoveFlora knew that the market response is going to be Poor, it would choose The 'Delight' because it gives the highest payoff ($3K).

EVPI Computation

Rose Type (Profit/loss in $1000)	Market Response		
	Good (0.45)	Satisfactory (0.35)	Poor (0.20)
The ‘Magic’	27	10	-8
The ‘Stripe’	18	12	-5
The ‘Blue’	22	16	2
The ‘Delight’	19	15	3

- If the Market Response can be known in advance, the flower shop will surely want to achieve the maximum payoff for the respective market response:

Market Response	Optimal Decision	Payoff ($K)
Good	**The ‘Magic’**	**27**
Satisfactory	**The ‘Blue’**	**16**
Poor	**The ‘Delight’**	**3**

Is it Worth to Hire the External Consultant?

- Assuming that the information from the consultant is perfectly accurate, there is a 45% chance that a payoff will be $27K, a 35% chance that it will be $16K and a 20% chance that it will be $3K

  The **Expected Value with Perfect Information (EVwithPI)**:

0.45 x $27K + 0.35 x $16K + 0.2 x $3K = $18.35K

- Without engaging the consultant, The 'Blue' gives the maximum **Expected Monetary Value** (Max EMV) of:

0.45×22K + 0.35×16K + 0.2x2K = $15.9K

- **The Value of such perfect information (EVPI)**

  = **EVwithPI – Max EMV**

  = $18.35 - $15.90K = $2.45K = $2,450

EVPI and EOL

- **The Value of such perfect information (EVPI)**

  = **EVwithPI – Max EMV**

  = $18.35 - $15.90K = **$2.45K = $2,450**

  Since the consultant is charging **$2,000** which is lower than EVPI, it is worth to engage the consultant.

- The gain of $18.35 - $15.90K = **$2.45K** is the expected value of perfect information (EVPI) (which is also equal to EOL of The 'Blue')

Rose Type (Profit/loss in $1000)	**Market Response**			**EOL**
	Good (0.45)	**Satisfactory (0.35)**	**Poor (0.20)**	
The 'Magic'	0	6	11	4.30
The 'Stripe'	9	4	8	7.05
The 'Blue'	5	0	1	2.45
The 'Delight'	8	1	0	3.95

Conclusion

- Elsa must understand how decisions are made under different conditions and know which decision-making tools to use.
- What makes the difference between a good and bad decision depends on whether it is based on logic and considers all available data and possible alternatives.
- In the case of LoveFlora, based on the EMV criterion, Elsa should consider selecting The ‘Blue’ for a maximum EMV of $15,900.
- LoveFlora should at most hire the consultant at a cost of $2,450 for the perfect information.

Learning Objectives

- Carry out decision making under **uncertainty** when a decision maker is not certain about the outcomes and cannot even make reasonable probability estimates:
  - Maximax; Maximin ;Equal likelihood ;Criterion of realism (Hurwicz) ; Minimax regret
- Carry out decision making under **risk** when a decision maker is able to estimate the likelihood of certain alternatives or outcomes.
  - Understand the concepts of EMV, EOL and EVPI in decision making.
  - Calculate EMV and EOL; and make decisions based on EMV, EOL
  - Calculate EVPI: the maximum value of perfect information available, to limit what decision maker should be spending on perfect information .

Overview of E210 Operation Planning Module