

**IE 102**

**Decision Making Using Multiple Criteria**

# Decision Making

- This is an example for decision process for a smart person
- Suppose you want to consider more than one performance measure

# Decision Making

- Application: Consider you have
  - A set of alternatives;
  - Set of criteria;
  - An approach to score each alternative for each criteria;
  - An approach to combine different criteria to reflect decision maker's preferences;

# Step 0: What is your target?

Examples:

- Select a department for college education
- Buy an automobile
  - Make a one-time decision – non-repetitive
  - Usually, no chance to observe and re-plan

## General Approach:

- Observe your limitations (constraints)
  - Constraint (dictionary): restriction
  - Budget and time limitation—on information that can be collected

# Step 1 – Generate Criteria

- Generate a set of relevant criteria – (singular for criteria is criterion)
  - *Criterion (Dictionary): a standard, rule, or test by which something can be judged*
  - *Criterion (Functional): An aspect of the alternative that you wish to minimize or maximize*
- Set should represent decision maker's concerns
- Determine at least one performance measure to reflect the essence of each criterion
  - *Measure: quantification of one (try to make it the relevant and important one!) aspect of a criterion*

# Step 2 – Scale Criteria

- Values attained by each measure can be
  - Numeric/continuous (naturally)
  - numeric (assigned)
  - categorical (constructed)
  - categorical (universally defined)
- Define a range of attainable values for each measure

# Step 3 – Data Collection

- For each alternative and for each performance measure considered, assess a numerical or categorical value.
- Sources – public sources, tests, pilot studies, ..... :various
- Usually requires time and budget
- Statistical techniques (regression, data mining, .... : various

## Step 4 – Rescale to common units

General understanding – rules of thumb

- † Use of the range specified in Step 2

- † Put all the numbers in the  $(0,1)$  interval, where

**Q** is the most preferred value, and

**Q** is the least preferred

- † Obtain a score for each alternative for each criterion in  $[0,1]$  interval



# Step 5 – Weigh (or rank) the criteria

- Relative importance
  - One decision-maker: ask pair wise comparisons
  - Multiple decision-makers: interviews, etc
- A very hard part
- Come up with numbers in a range (easier to assign in a range)
- Convert those numbers to (0, 1) scale

# Step 6 – Final computation and interpretation

- For each alternative, and each performance measure
- Multiply the weight with the score
- Add the scores for each alternative
- Analyze more closely the ones that are the highest
- *Sensitivity analysis: analyze the effect of changing weights, measurement errors, ....*

# Issues to remember

criterion, measure, numeric (continuous)

measure, categorical measure

scaled score, rescaling to a common unit

weights, weighted scores, total scores

sensitivity

multiple criteria, multiple decision makers

cost/time for making a decision

# Summarize

Step 0: Set Target

Step 1: Generate Criteria

Step 2: Scale Criteria

Step 3: Data Collection

Step 4: Rescale to common units

Step 5: Weigh (rank) the criteria

Step 6: Final computation and interpretation



# Example: Networking Strategy

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- ✧ An engineering design company networking its computers
- ✧ Target: Redesigning the network

# Example: Networking Strategy

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## ✧ Criteria

- ✧ Productivity enhancement
- ✧ Cost increase
- ✧ Security

What kind of a scale would be appropriate for each one of these evaluation measures?

# Scales

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- ✧ Productivity enhancement
  - ✧ -1: significantly diminished
  - ✧ 0: no change
  - ✧ 1: improvement
  - ✧ 2: significant improvement
- ✧ Security:
  - ✧ -2: very bad
  - ✧ -1: bad
  - ✧ 0 : same
  - ✧ 1 : good
- ✧ Cost increase: \$ amount

## DATA : Alternatives & Scores/Levels wrt Each Criteria

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| Alternative | Criteria     |      |          |
|-------------|--------------|------|----------|
|             | Productivity | Cost | Security |
| Status Quo  | 0            | 0    | 0        |
| 1           | 2            | 125  | 0.5      |
| 2           | 1            | 95   | 0        |
| 3           | 0.5          | 65   | -1       |

How would you rank these alternatives?



# Rescale and/or weigh

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- ✧ Combine the three evaluation measures and obtain a single **rating/value** for each alternative.
- ✧ Obviously, a higher score is preferred in productivity and security but a lower score is better in cost...

# Averaging

| Alternative | Score                    |
|-------------|--------------------------|
| Status Quo  | 0                        |
| 1           | $(2-125+0.5)/3 = -40.83$ |
| 2           | -31.33                   |
| 3           | -21.83                   |

It seems that doing nothing is the best option... Is it really?

| Alternative | Criteria     |      |          |
|-------------|--------------|------|----------|
|             | Productivity | Cost | Security |
| Status Quo  | 0            | 0    | 0        |
| 1           | 2            | 125  | 0.5      |

Recall the  
data

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- ✧ Proportion of the way along the allowed range
  - ✧ If a higher score is more preferred

$$\text{Rating} = \frac{\text{Score} - \text{Lowest Level}}{\text{Highest Level} - \text{Lowest Level}}$$

- ✧ If a lower score is more preferred

$$\text{Rating} = \frac{\text{Highest Level} - \text{Score}}{\text{Highest Level} - \text{Lowest Level}}$$

# Ratings Now

|              |            |
|--------------|------------|
| productivity | -1, ..., 2 |
| Security     | -2, ..., 1 |
| Cost         | $\geq 0$   |

✧ Status Quo:

$$\frac{1}{3} \left\{ \frac{0 - (-1)}{2 - (-1)} + \frac{125 - 0}{125 - 0} + \frac{0 - (-2)}{1 - (-2)} \right\} = 0.67$$

✧ Alternative 1: 0.61

✧ Alternative 2: 0.52

✧ Alternative 3: 0.44

Now the units have no impact on the ratings and hence the ranking.  
Any other issues?



## Other issues

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- ✧ The ranges within which the evaluation measures can take on values have an impact on the ratings
- ✧ Each evaluation measure is given equal importance
- ✧ For example, security problems are equally as important as cost issues

# Using Weights

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- ✧ Account for both
  - ↳ The effects of the ranges and
  - ↳ The impacts of different ranges
- ✧ Example assign 0.5 to productivity, 0.3 to cost and 0.2 to security.

# New Ratings with the Assigned Weights

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✧ Status Quo:

$$0.5 \frac{0 - (-1)}{2 - (-1)} + 0.3 \frac{125 - 0}{125 - 0} + 0.2 \frac{0 - (-2)}{1 - (-2)} = 0.60$$

✧ Alternative 1: 0.70

✧ Alternative 2: ?

✧ Alternative 3: ?

KAHOOT