

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
 - **1 is the most preferred value**, and
 - **0 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

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



Example: Networking Strategy

- Criteria
 - Productivity enhancement
 - Cost increase
 - Security

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



Scales

- 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

Alternative	Criteria		
	Productivity	Cost	Security
Status Quo			
1			
2			
3			



DATA : Alternatives & Scores/Levels wrt Each Criteria

Alternative	Criteria		
	Productivity	Cost	Security
Status Quo	0	0	0
1			
2			
3			

DATA :

Alternatives & Scores/Levels wrt Each Criteria

Alternative	Criteria		
	Productivity	Cost	Security
Status Quo	0	0	0
1	2		
2	1		
3	0.5		

Range for productivity -1 ... 2

DATA :

Alternatives & Scores/Levels wrt Each Criteria

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

- 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

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

- 
-
- 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	≥ 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

- 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

- 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

- 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: ?

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