Problem 02
Best Location

SCHOOL OF ENGINEERING

Location Selection

- General objective when selecting location:

  To minimize

  - regional costs
  - outbound distribution costs
  - inbound distribution costs

- Types of Analysis

  Macro analysis

  - To evaluate alternative countries, regions, communities

  Micro analysis

  - To evaluate specific sites in the selected community

Factors Affecting Location Selection

- Regional factors
  - International Company = country
  - National Company = section of country or state
  - Local Company = country or city
- Market location
  - Important for service firms / manufacturers of fragile or perishable goods
  - Cost of shipping to customers
  - Firms that are suppliers for JIT process
  - Customer identification with firm due to proximity
  - Location of competitors
- Raw material and supplier proximity
  - For example, manufacturers that use perishable raw materials locate near source

Factors Affecting Location Selection

- Transportation facilities (currently less important, compared to before 1950s)
  - Airports, Seaports, Highways.
- Labour climate
  - Labour force is crucial to operation of the firm
  - Availability: large pool
  - Skills must match needs of firm
  - Cost: wage rate in that area; level of unionization
- Quality of life
  - Help keep quality workforce
- Government
  - Taxes & Incentives
- Currency exchange rates and risks involved

Factors Affecting Site Selection – Local

- Typical engineering considerations
  - Sufficient land to build and expand
  - Availability of utilities / infrastructure
  - Waste disposal
  - Transportation access
  - Legal and other impediments
  - Proximity to supporting industries
- Land Lease Cost
- Land Zoning

Factor Analysis Technique

- Popular, subjective- decision making tool, relatively easy to use
  - First assign an appropriate weight to the 5 factors (typically between 0 to 1) based on the relative importance of each.
  - Then assign a score (typically between 0 to 100) to each location with respect to each factor identified in (a)
  - A weighted score for each factor for each location can then be obtained by multiplying the weight with the score
  - Finally, the sum of the weighted scores can be obtained and selection done based on these scores.

FAT Example

Weight	Factor	Suntec City	RP	Jurong Point
0.30	**Lease Cost**	75	95	80
0.20	**Customer volume**	90	70	85
0.20	**Competition in area**	60	75	50
0.15	**Availability of site**	70	50	60
0.15	**Customer profile**	60	90	80
$\sum W = 1$				

Analytic Hierarchy Process (AHP)

- Alternative approach to FAT.

- The basic idea of AHP approach is to convert subjective assessments of relative importance to a set of overall scores or weights.

- The methodology of AHP is based on pairwise comparisons of the following type of question : “How important is criterion C_i relative to criterion C_j ?”.

- Compared to FAT, AHP involves a relatively complex mathematical procedure.
- Computer software, e.g. Expert Choice, has been developed to support this method.

Scale for Pairwise Comparison

- Example of Fundamental Scale for Pairwise Comparison

The Fundamental Scale for Pairwise Comparisons	
Intensity of Importance	Definition
1	Equally important
3	Moderately more important
5	Strongly more important
7	Very strongly more important
9	Extremely more important

Intensities of 2, 4, 6, and 8 can be use to express intermediate values.

Intensities 1.1, 1.2, 1.3, etc. can be used for elecments that are very close in importance.

1/2, 1/3, 1/4, etc. to be used for elements that are LESS in importance.

Disadvantages in AHP

- Measurement scale is chosen is just ordinal at best. A rating of 10 does not mean the preference, risk or whatever for an item is twice that of an item rated 5.

- When there are more than a few items on the assessment list, it gets hard to keep all the prioritization considerations in one’s mind at the same time.

Steps in AHP

- *Step 1: Set up the decision hierarchy. The difference from FAT is that the alternative courses of action also appear on the hierarchy.*

- *Step 2: Make pairwise comparisons of attributes and alternatives, to determine the relative importance of factors and how well the alternatives perform on the different factors.*

- *Step 3: Transform the comparisons into weights and check the consistency of the decision maker's comparisons.*

- *Step 4: Use the weights to obtain scores for the different options and make a provisional decision.*

An Example of Pairwise Comparison

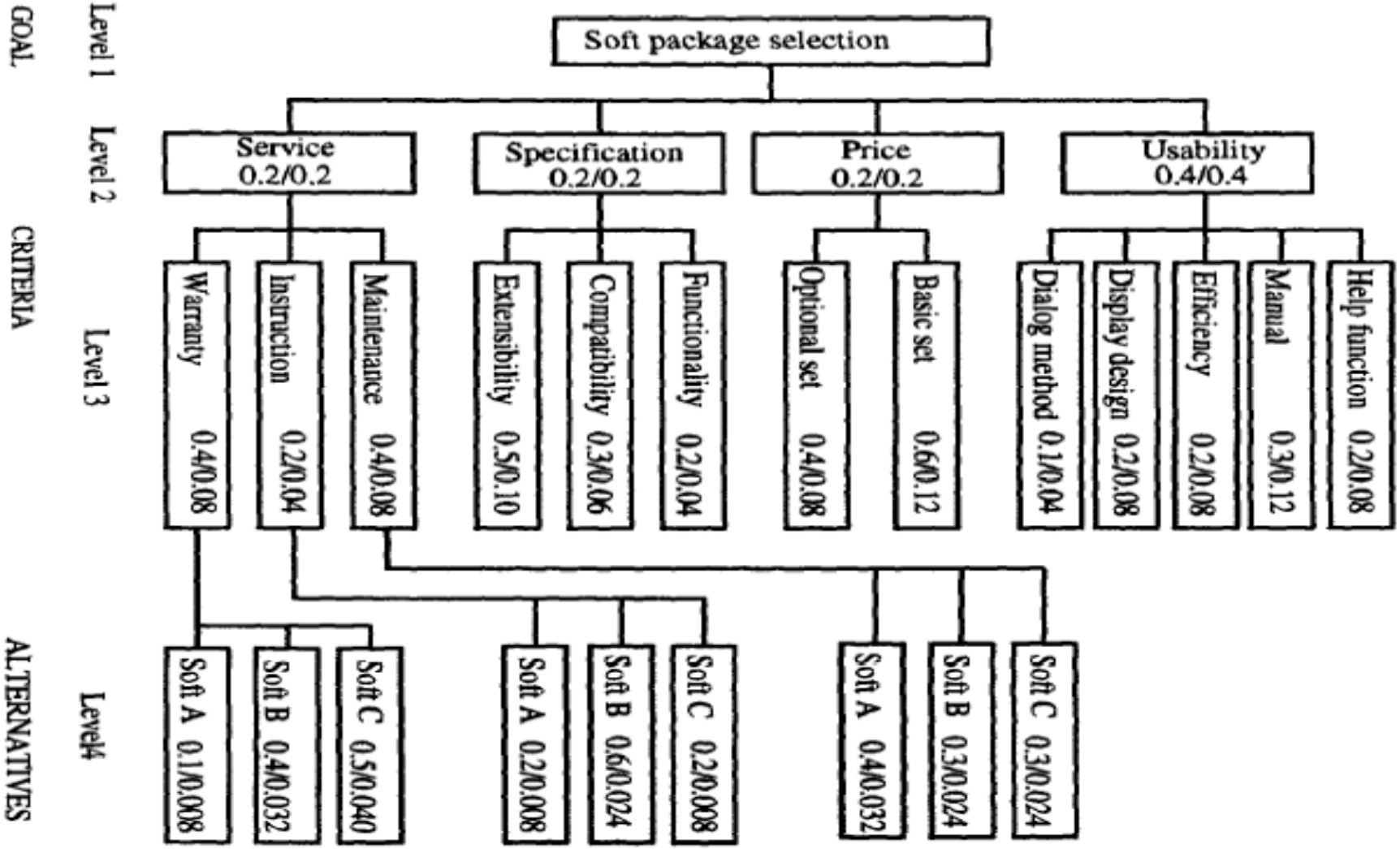
- Assuming that there are 3 factors: Cost, Availability and Human Traffic

e.g.

- Cost is **strongly more important** than Availability
- Cost is **moderately lesser important** than Human Traffic
- Human Traffic is **extremely more important** than availability

Cost	9 8 7 6 5 4 3 2 | 2 3 4 5 6 7 8 9	Availability
Cost	9 8 7 6 5 4 3 2 | 2 3 4 5 6 7 8 9	Human Traffic
Availability	9 8 7 6 5 4 3 2 | 2 3 4 5 6 7 8 9	Human Traffic

Example of a Hierarchy Structure



Consistency Index ***(CI)***

- Consistency index *(CI)* is designed to alert the decision maker to any inconsistencies in the comparisons which have been made.
- *CI* can be estimated by:

$$CI = \frac{\lambda_{\max} - n}{n-1}$$

where

n = number of factors under consideration in decision making

$\lambda_{\max}$, max eigenvalue = sum of each priority multiply by the respective total value of each column in pairwise comparison.

Consistency Ratio ***(CR)***

- After knowing the Consistency Index, this index will be compared with an 'appropriate' Consistency index, which is called Random Consistency Index ***(RI)***.
- Example reference for RI:

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

- ***CR*** can then be obtained by: $CR = \frac{CI}{RI}$

- Value of zero ***CR*** indicates perfect consistency (lower the value, higher the consistency).

Consistency Ratio ***(CR)***

- As a rule of thumb, inconsistency should only be a concern if **CR** exceeds 0.1, where comparisons of alternatives in the pairwise comparison table need to be checked through.

- However, *minimizing inconsistency should not be the main goal of the analysis. A set of erroneous judgments about importance and preference may be perfectly consistency, but they will not lead to the ‘best’ decision.

* Decision Analysis for Mangement Judgment, Goodwin & Wright,John Wiley & Sons, 3rd edition

FAT vs. AHP

- Similarities: they are both selection tools

- Differences in dealing with subcriteria:

  - Scoring model is a “one-level” process. Subcriteria are combined to the get the value for that factor.

  - AHP uses a hierarchy of criteria. It has weightings of criteria and subcriteria that compute a composite score for each candidate project as well as an overall score.

P02 Sample Solution

Problem Objectives

- Identify possible objectives of a facility
- Determine factors for selecting a site based on the objectives of the facility
- Select an appropriate site for a facility after considering the importance of each factors and how well each alternative site fare for each factor

Factors for sandwich Shop

- More emphasis placed more on the customers and competitors:
  1) Customers Volume
  2) Strategic Location (where the place is located)
  3) Operation/ Lease Cost
  4) Business Sustainability (Long-term survival)
  5) Availability of location (Tenure)
  6) Accessibility to complementary business / supplies
  7) Surrounding Business (Compete vs Complementary)
  8) Customers profile

  Though there are many factors, not all factors need to be used.

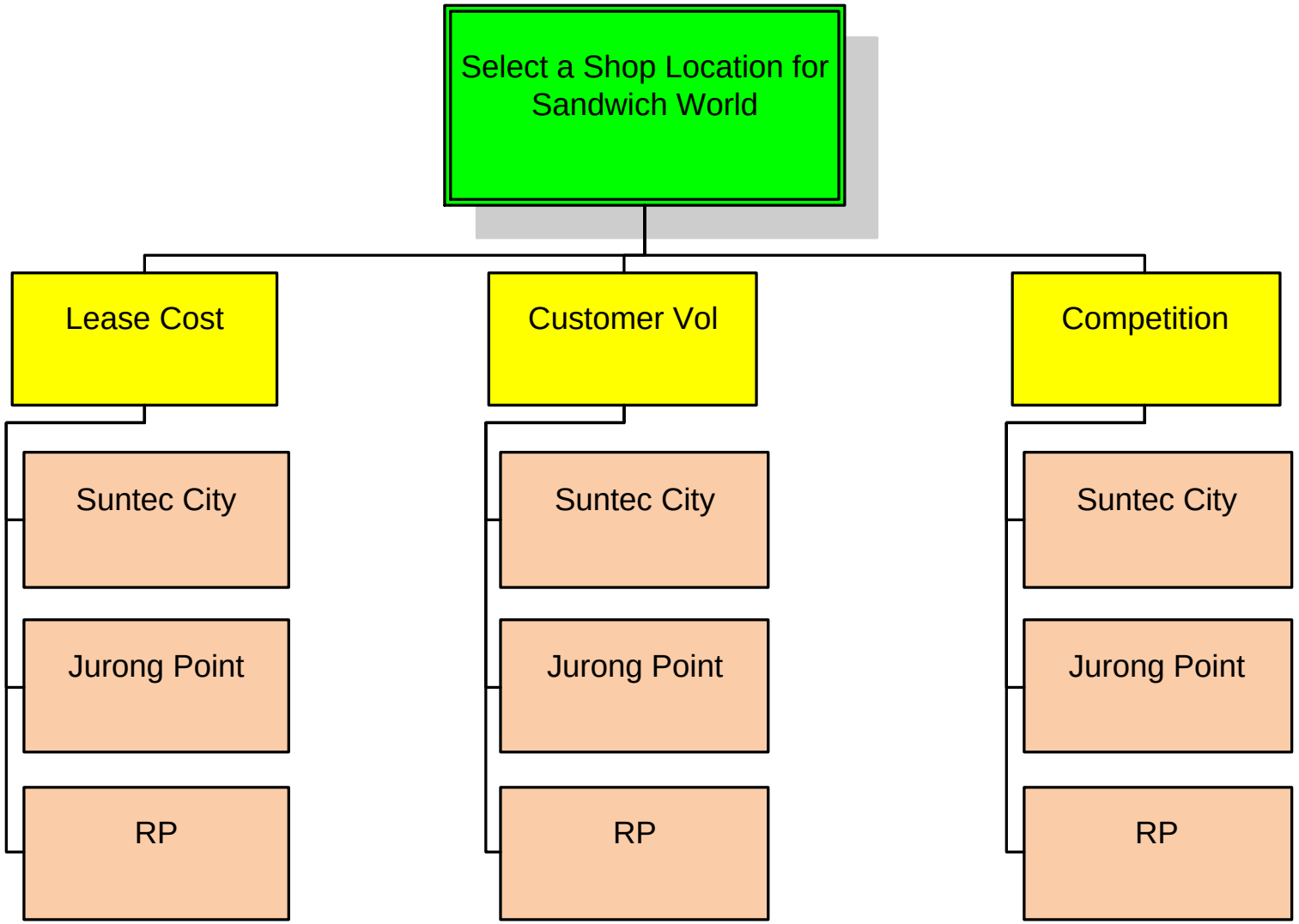
Using FAT

Weight	Factor	Suntec City	RP	Jurong Point
0.30	**Lease Cost**	75 x 0.30 =22.5	28.5	24
0.20	**Customer volume**	18	14	17
0.20	**Competition in area**	12	15	10
0.15	**Availability of site**	10.5	11.25	9
0.15	**Customer profile**	9	13.5	12
$\sum W = 1$	Sum of Weighted Score	72	**78.5**	72

Choose “RP”

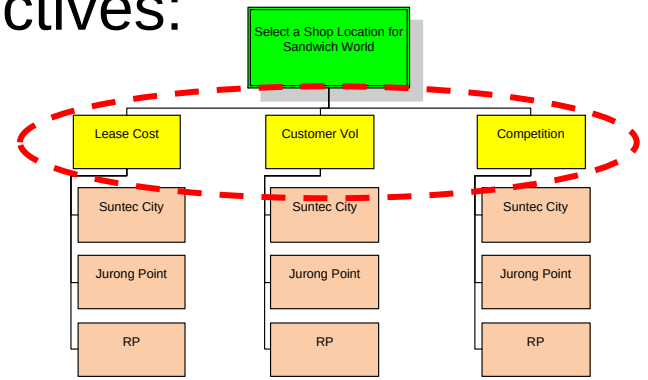
By AHP - Hierarchy

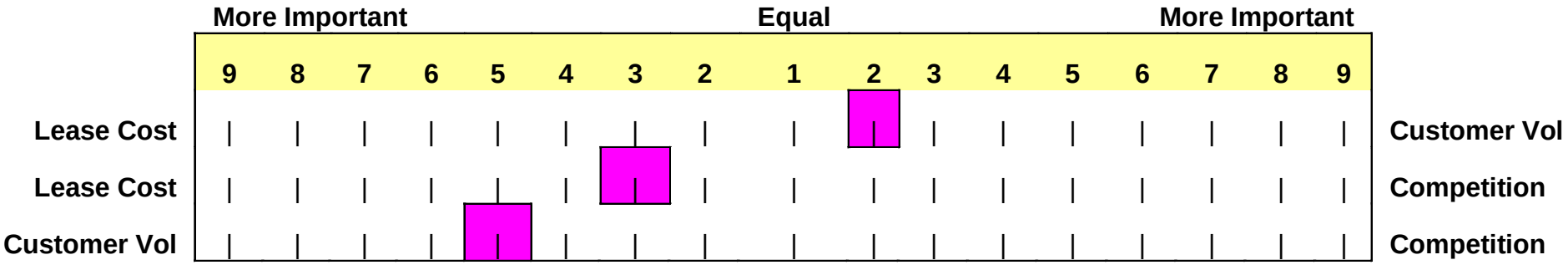
- Decisions in hierarchy



By AHP – Pairwise Comparison

- Pairwise comparison and intensity assignment
  - ➢ Between the factors/criteria/objectives:





Factors	Lease Cost	Customer Volume	Competition
Lease Cost	1	1/2	3
Customer Volume	2	1	5
Competition	1/3	1/5	1

By AHP – Pairwise Comparison

- Synthesization on comparison matrix
  - Sum values by column

Factor	Lease Cost	Customer Volume	Competition
Lease Cost	1	0.50	3
Customer Volume	2	1	5
Competition	0.33	0.20	1
sum	3.33	1.70	9

  - Normalize the matrix (divide each value by the column total)

Factor	Lease Cost	Customer Volume	Competition
Lease Cost	0.3000	0.2941	0.3333
Customer Volume	0.6000	0.5882	0.5556
Competition	0.1000	0.1176	0.1111

  - Prioritize the factors (average of each row)

Factor	Lease Cost	Customer Volume	Competition	Priority
Lease Cost	0.3000	0.2941	0.3333	0.3092
Customer Volume	0.6000	0.5882	0.5556	0.5813
Competition	0.1000	0.1176	0.1111	0.1096

Consistency Index, *CI*

Factor	Lease Cost	Customer Volume	Competition
Lease Cost	1	0.50	3
Customer Volume	2	1	5
Competition	0.33	0.20	1
sum	3.33	1.70	9

$$CI = \frac{\lambda_{\max} - n}{n-1}$$

Factor	Lease Cost	Customer Volume	Competition	Priority
Lease Cost	0.3000	0.2941	0.3333	0.3092
Customer Volume	0.6000	0.5882	0.5556	0.5813
Competition	0.1000	0.1176	0.1111	0.1096

Estimated $\lambda_{\max}$

= sum product of { (factor priority) and (factor sum) }

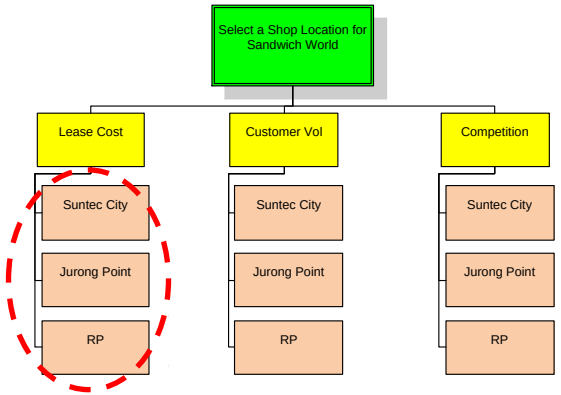
= (0.3092)(3.33) + (0.5813)(1.70) + (0.1096)(9)

= 3.0043

$$CI = \frac{3.0043 - 3}{3-1} = 0.0022$$

By AHP – Pairwise Comparison

- E.g. Pairwise comparison and intensity assignment
  - Between the alternatives on each factor/criteria/objective:



Lease Cost	Suntec City	Jurong Point	RP	Priority
Suntec City	1	1/2	1/8	0.08
Jurong Point	2	1	1/6	0.15
RP	8	6	1	0.77

C.I.=0.0170
C.R.=0.03

$$CR = \frac{0.017}{0.58} = 0.03$$

Customer Volume	Suntec City	Jurong Point	RP	Priority
Suntec City	1	2	4	0.56
Jurong Point	1/2	1	3	0.32
RP	1/4	1/3	1	0.12

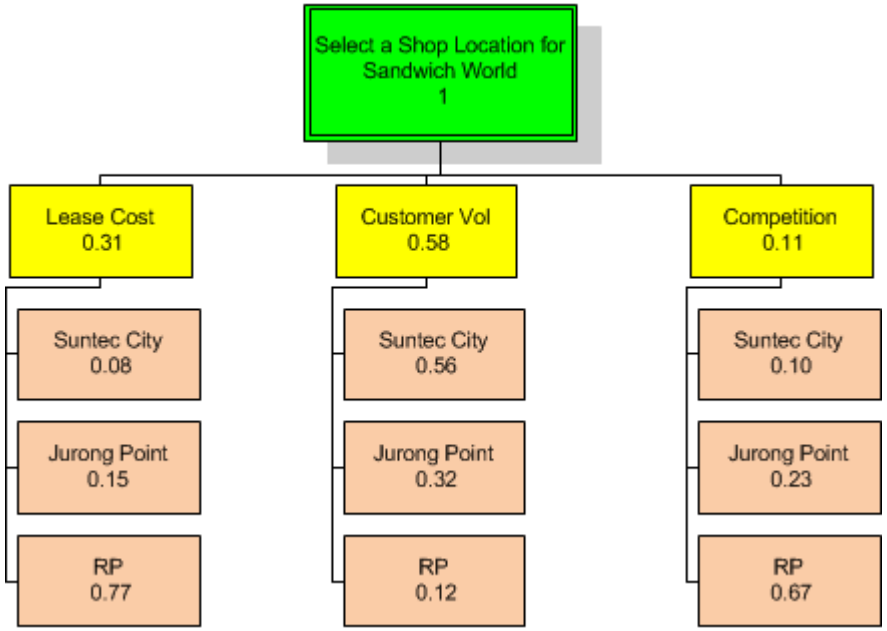
C.I.=0.0117
C.R.=0.02

⋮

Competition	Suntec City	Jurong Point	RP	Priority
Suntec City	1			
Jurong Point		1		
RP			1	

AHP - Decision

- Insert the priorities to the respective cell:



- Overall priority score for each alternative is developed:
  - Score for Suntec City: 0.31x0.08 + 0.58x0.56 + 0.11x0.10 = 0.36
  - Score for Jurong Point: 0.31x0.15 + 0.58x0.32 + 0.11x0.23 = 0.26
  - Score for RP: 0.31x0.77 + 0.58x0.12 + 0.11x0.67 = 0.38

- Decision based on AHP: Jenny should setup his sandwich shop at RP

Conclusions

- Factor Analysis Technique (FAT) or Analytical Hierarchy Process (AHP) can be used to help select suitable location/s for shops.

- Though FAT is relatively easier to use, AHP can capture both subjective and objective evaluation measures.

- In order to do location analysis, you need to decide on factors and alternatives. Data and information are also needed to help in your analysis.

Learning Objectives

- Analyze different locations for a facility based on a set of selection criteria

- Assign weights to different decision criteria based on their importance (according to management guidelines and decision)

- Facility location selection techniques:

  FAT (Factor Analysis Technique)

  vs

  AHP (Analytical Hierarchy Process)