1.AHP & TOPSIS Analysis

Introduction

A small manufacturing company is planning to expand its storage capacity and has come up with four alternatives with 5 key decision criteria based on which a decision should be made. The manufacturing company has provided us with the performance facts of each alternative in each decision criteria. The task is to convert these qualitative facts to quantitative data, assign weightage to each criterion by assessing the industry's priorities and perform AHP & TOPSIS analysis to suggest the client with the right alternative.

Conversion of qualitative facts to quantitative data.

To perform this process, a custom scale was derived which measures each qualitative fact as shown below:

Custom Scale	
No	0
Poor	1
Moderate	3
Good	5
Excellent	7

Table 1 – Custom Scale

The converted table is displayed in the excel sheet with the name '**Intro & Scaling'**.

Deciding on the weights of each criterion.

There are totally five criteria for which right weights should be allocated by understanding the priorities and the needs based on the assumptions below.

Assumption:

- *The industry is **small-scaled** and is **very cost sensitive**.*
- *The industry has expanded its production capacity recently but is facing **huge losses** due to **lack** of **storage infrastructure**.*
- *Client has decided to **improve** its **security** in the new facility.*
- *Client will **provide transportation facilities** to the employees*
- ***No requirement** for **parking facility** in the new facility.*

Analyzing the assumptions, it was inferred that the industry has expanded its production facilities and does not have enough space to store the produced goods. The industry is price sensitive and is exhibiting concerns on the security of the new facility. Considering this situation, the criteria can be ranked as shown:

Warehouse Space > Cost > Security > Public Transport > Parking

With the above conclusion made, the weightage table was derived, which is displayed in the 'Intro & Scaling' sheet of the attached excel file.

AHP Analysis

The first step in AHP analysis is to convert the qualitative facts to pairwise comparison scale which was converted measuring the difference in the weights and scores of each criterion and alternative respectively as shown below.

Weights to AHP scale.

Diff of weight in a pair	AHP Scale
0.05	3
0.1	5
0.15	7
0.2	9

Scores to AHP scale

Diff of Scores in a pair	AHP Scale
1	2
2 to 3	3
4 to 5	5
6 to 7	7
8 to 9	9

Table 3 – weights & Scores to AHP scale

Using the above tables, the AHP analysis was performed, which is perfectly illustrated in the attached excel sheet. (All the AHP related sheets are named after the text '***AHP'*** in the excel sheet.)

Results

Alternatives	Score	Rank	
Centre(A1)	0.10372441	4	***Worst option***
Suburb(A2)	**0.368694718**	**1**	***Best option***
Shared(A3)	0.244373127	3	
Extend(A4)	0.283207745	2	

Table 4 – AHP Results

Horizontal Bar Chart

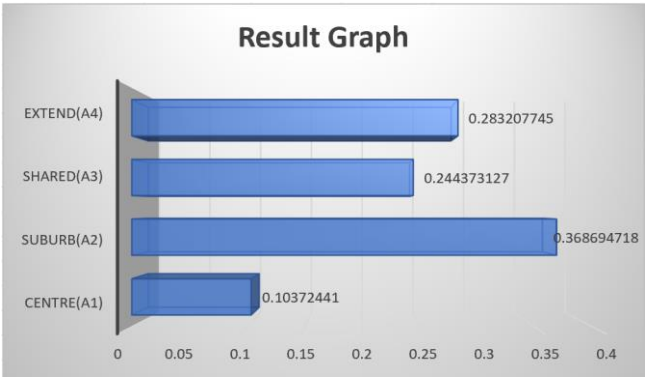

Fig 1 – AHP Graph

- According to AHP analysis, '**suburb'** is the best option, and this because of its extremely good performance in criteria such as ***Space and Security*** which accounts for **55%** of the weightage among the given criteria.
- **Extension of existing facility** is the second-best option, and this can be attributed to the fact that it performs extremely well in the ***Transportation and the Cost*** criteria.

- '**Shared'** option occupies the third position in this analysis with a very slight difference in score from the 'extend' option as its ***cost*** is very expensive than the 'extend' option.
- '**Centre'** option is the least performing option as it performs extremely low in two of the most important criteria ***Space & Cost***.

TOPSIS Analysis

The analysis is illustrated in the excel file attached, in the sheet named 'TOPSIS', kindly refer to the analysis. TOPSIS helps us decide the optimal solution by calculating the distances of each solution from the positive and the negative ideal solution.

Results

The results of the TOPSIS analysis were as follows:

Alternatives	Scores	Rank	
Centre(A1)	0.238893938	4	***Worst option***
Suburb(A2)	0.657501615	2	
Shared(A3)	**0.676891772**	**1**	***Best option***
Extend(A4)	0.624132075	3	

Table 5 – TOPSIS Results

Vertical Bar Chart

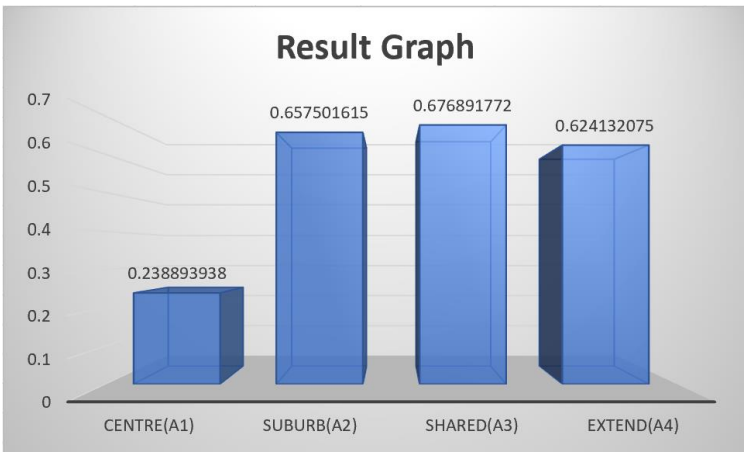

Fig 2 – TOPSIS Graph

- According to the obtained results, starting a new storage facility in **shared warehouses** is the best option. This is because the performance scores for this alternative is relatively good in the top three important criteria ***(space, cost, and security***) and has performed above the moderate level in the remaining two criteria.
- '**Suburb'** option occupying the second position can be attributed to the fact that it has performed extremely well in two of the most important criteria ***(Space & Security).***
- '**Extend'** option has occupied the third position due to fact that it performs extremely low in one of the important criteria ***Security*** despite having the lowest cost.
- '**Centre'** option is the least performing option as it is the home for three negative ideal solution in this analysis.

AHP vs TOPSIS

We can observe that the results of both the analysis is different from each other, it is because both the AHP and TOPSIS works differently from each other. AHP focuses on the part where a given alternative performs well and this focus shadows the part where the alternative performs poorly, whereas TOPSIS tries to fetch the solution that is close to the positive ideal solution and at the same time farthest from the negative ideal solution, providing us the optimal solution where there won't be any compromises.

This pattern is pretty evident when we observe the solutions suggested by both the procedures, TOPSIS suggests the 'shared' option which performs relatively good in the top three important criteria *(Space, Cost and Security)* and is the only alternative without any extreme low performances, whereas AHP suggests 'suburb' as it performs extremely well in two important criteria (*space & security*) and this is scaled up in AHP which overshadows this option's cost which is twice the 'shared' option's cost.

This pattern highlights one of the most important limitations of AHP → "**Scaling**", this can be observed on analyzing the steps of AHP calculation. Initially criteria 'Warehouse space' was given **30% weight**, on converting this weight to AHP scale and normalizing, the eigen value for this criterion was **51.28%** as shown in the table below

	Weights
Public Transport Links (C1)	0.063377
Parking(C2)	0.033335
Warehouse Space(C3)	0.512813 → **Scaled up weight**
Security(C4)	0.128976
Cost(C5)	0.261499

Table 6 – Scaling issue of AHP

Considering this limitation, it is better to follow the solution provided by TOPSIS model for this problem.

Recommended Solution

- On following the results of TOPSIS analysis it is optimal for the industry to start building the new storage space in the **shared warehouses** as this is the option with relatively good performance in all the important criteria with zero compromises to be made.
- On the other hand, it should be noted that the option '**suburb'** performs extremely well on two of the most important criteria *(space & security),* so if the industry is willing to spend on the alternative that will give them long term benefits, it is also recommended to go with 'suburb' option as this provides more utility than the 'shared' option that might be worth enough for the extra £300,000 to be spent.

Solution Explanation

As explained above, TOPSIS tries to fetch the solution which performs relatively good and at the same time has very less compromises as possible. The option '**shared'** has a score of 5 and 3 in the criteria *Space and Security* respectively both of which are the second highest score in their respective criteria and will cost £300,000 which is again the second lowest price, on observing closely it is evident that the option 'shared' is the only option with no negative ideal point and at the same time performs relatively good in every important criterion such as space, cost & security which accounts for **75% of criteria weightage**. **Thus, it is the only solution where the industry can gain the expected performance in every criterion without any compromises to be made in the future.**

But it should also be noted that the score of option '**suburb'** and '**extend'** is not significantly lesser than 'shared' option, this is because of the extreme performances of these alternatives. Option 'suburb' performs extremely well in two of the most important criteria *Space & Security* which accounts for **50%** of the criteria weightage and option 'extend' performs extremely well in the criteria *public transport and cost* which accounts for **40%** of the weightage. **Hence choosing either 'suburb' or 'extend' option will give the industry extreme performances but it comes with its own compromises**.

Depending on how the client values the compromises and the extreme performances from the three options 'shared', 'suburb' and 'extend' the client can choose anyone that they feel would be the best, as the utility obtained through these options are not significantly different from each other but acting as a **consultant I would recommend the option 'shared' as it is the only one with no compromises and relatively good performances in every criterion available.**