**Analysis using AHP and TOPSIS**

A manufacturing firm has planned to expand their company and as a result they want to acquire more space for their warehouse. They have already selected four different methods such as to either extend the existing warehouse or to lease space in the city centre, a suburb or shared warehouse. In addition to that the company has already analyzed and picked out five important criteria: connectivity to public transport, parking facility accessibility, warehouse layout, security and cost of acquisition. From the data collected they have prioritized the alternatives according to their standards in qualitative form as shown in Table 1 and want us to provide them the best solution with the help of MCDA methods like AHP (Analytical Hierarchy Process) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Alternatives**  **Criteria** | **A1(Centre)** | **A2(Suburb)** | **A3(Shared)** | **A4(Extend)** |
| **C1(Public Transport Links)** | Good bus and Rail links | Good bus links but no rail links | Poor bus links but good rail links | Excellent bus and rail links |
| **C2(Parking)** | Poor | Good | Excellent | Moderate’ |
| **C3(Warehouse Space)** | Poor | Excellent | Good | Good |
| **C4(Security)** | \*\*\* | \*\*\*\* | \*\* | \* |
| **C5(Cost)** | 900,000 | 600,000 | 300,000 | 200,000 |

Table 1 Alternatives and Criteria Multi Criteria Decision Analysis is categorized into three types.

1. Optimization – searching type decision.
2. Outranking - can be used while ranking the alternatives.
3. Multi-Attribute – this method provides a numerical value for all the alternatives.

This report describes Multi- Attribute MCDA methods – AHP, TOPSIS

# Prioritizing Criteria

**Warehouse Space >> Public Transport Links >> Parking >> Security >> Cost**

Fig 1

In this scenario I have chosen Warehouse Space as my main priority because space is the most crucial element while expanding. We need to acquire more space as the company can grow in future.

Next in order, public transport links as we would require more employees for work. It would be easily accessible for travel.

Next, we should consider parking since it would be easy to move goods from large trucks.

Then, security as we are not going to manufacture any valuable products. It is considered one of the least priorities.

Cost is considered least as a manufacturing firm can afford it. Also, they can gain investment by selling the product.

# AHP

Pairwise comparison method is based on one-to-one comparison. While comparing, external

criteria won’t be considered for comparing two criteria. It is always decided between the two which one is important. In Pairwise comparison, AHP is one of the best methods. Since it used a hierarchical structure.

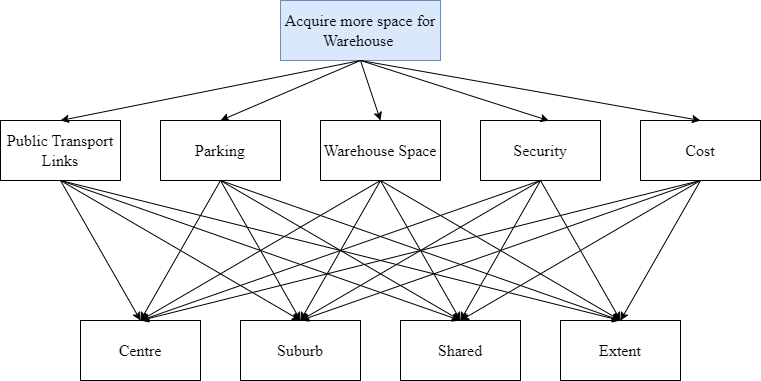


Fig 2 Flowchart (Mathew, 2018)

# Interpretation of Data

The given data in Table 1 is in terms of qualitative which can be converted in quantitative with the help of saaty scale (1972) as shown below.

|  |  |
| --- | --- |
| **Numerical Value** | **Definition** |
| 1 | Equivalent Importance |
| 3 | Reasonable Importance |
| 5 | Strong Importance |
| 7 | Veery Strong Importance |
| 9 | Utmost Importance |
| 2,4,6,8 | Intermediate Vales |

Table 2 Saaty Scale (Anon, n.d.)

# Criteria Based

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **C1** | **C2** | **C3** | **C4** | **C5** |
| **C1** | 1 | 2 | 0.33 | 3 | 5 |
| **C2** | 0.50 | 1 | 0.2 | 4 | 7 |
| **C3** | 3 | 5 | 1 | 7 | 9 |
| **C4** | 0.333333333 | 0.25 | 0.142857143 | 1 | 2 |
| **C5** | 0.2 | 0.142857143 | 0.111111111 | 0.5 | 1 |

Table 3 Pairwise matrix

The above table is one of the reciprocal matrices in which pairwise comparison is between the criteria. The hierarchy is based on figure 1.

The inference in this table as follows:

C1 is 2 times better than C2 C2 is 5 times worse than C3 C3 is 3 times better than C1 C5 is 2 times worse than C4

In order to check whether the matrix is correct we used consistency ratio which should always be less than 0.1. In this case it was 0.05. The ratio was lower than 0.1 for all the pairwise matrix.

|  |  |  |  |
| --- | --- | --- | --- |
| **Transport** | **Parking** | **Space** | **Security** |
| A4(Extent) | A3(Shared) | A2(Suburb) | A2(Suburb) |
| A1(Centre) | A2(Suburb) | A3(Shared) | A1(Centre) |
| A3(Shared) | A4(Extent) | A4(Extent) | A3(Shared) |
| A2(Suburb) | A1(Centre) | A1(Centre) | A4(Extent) |

Table 4 Hierarchy of alternative according to scale

Since Cost is a quantitative minimizing value, we need to inverse it and normalize.

# Methodology

Ahp consists of two methods - Eigenvector method, geometric mean

Select the hierarchy according to given data with the scale.

Do pairwise comparison and form a Reciprocal matrix. (Using Eigenvector method)

Sum the rows of these matrix and normalize them. Perform these steps until the normalized values are same.

Now, perform matrix multiplication

The weights of criteria and alternatives are multiplied for final output.

# TOPSIS

It is based on the ideal point methods as the positive solution is the best solution and negative is the worst solution. It uses distances to calculate.

There are two types of methods - TOPSIS and VIKOR

In Topsis we can calculate both positive (shortest distance) and negative solution (furthest distance).

# Interpretation of Data

In Topsis there is no scale hence we can follow our own scale. (Markovic, 2010)

|  |  |
| --- | --- |
| **Criteria** | **Weights** |
| C1(Public Transport Links) | 25% |
| C2(Parking) | 15% |
| C3(Warehouse Space) | 45% |
| C4(Security) | 10% |
| C5(Cost) | 5% |

Table 5 Criteria weights

|  |  |
| --- | --- |
| **Alternatives** | **Scale** |
| A1(Centre) | 5 |
| A2(Suburb) | 2 |
| A3(Shared) | 4 |
| A4(Extent) | 7 |

|  |  |
| --- | --- |
| **Alternatives** | **Scale** |
| A1(Centre) | 1 |
| A2(Suburb) | 5 |
| A3(Shared) | 7 |
| A4(Extent) | 3 |

|  |  |
| --- | --- |
| **Alternatives** | **Scale** |
| A1(Centre) | 1 |
| A2(Suburb) | 7 |
| A3(Shared) | 5 |
| A4(Extent) | 5 |

|  |  |
| --- | --- |
| **Alternatives** | **Scale** |
| A1(Centre) | 3 |
| A2(Suburb) | 4 |
| A3(Shared) | 3 |
| A4(Extent) | 1 |

Table 6 Alternatives scales

With the help of the above scales, we can form the table as shown below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **C1(MAX)** | **C2(MAX)** | **C3(MAX)** | **C4(MAX)** | **C5(MIN)** |
| **WEIGHT** | 0.25 | 0.15 | 0.45 | 0.1 | 0.05 |
| **A1** | 5 | 1 | 1 | 3 | 900000 |
| **A2** | 2 | 5 | 7 | 4 | 600000 |
| **A3** | 4 | 7 | 5 | 3 | 300000 |
| **A4** | 7 | 3 | 5 | 1 | 200000 |

Table 7 TOPSIS Analysis

# Methodology

Multiply the normalized value with the weights of criteria

Obtain the decision matrix using scale and normalize using vector normalization.

Determine the positive and negative ideal solution (Cost is minimizing so lower is better)

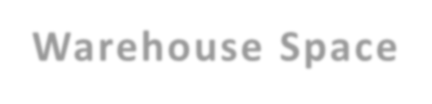
Now calculate the relative closeness to the ideal solution. (lowest/(lowest+highest)

Distance is calculated from each alternative to PIS and NIS.

The farthest alternative from the NIS is the solution

**Inference from AHP and TOPSIS**

# AHP Results



Warehouse Space

0.4

0.35

0.3

0.25

0.2

0.15

0.1

0.05

0

A1(Centre)

A2(Suburb)

A3(Shared)

A4(Extent)

|  |  |
| --- | --- |
| **A1(Centre)** | **0.112745** |
| **A2(Suburb)** | **0.363698** |
| **A3(Shared)** | **0.254395** |
| **A4(Extent)** | **0.269162** |

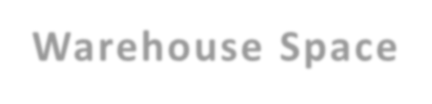
Table 8 AHP Results

Figure 3 graph for Ahp results

# TOPSIS Results

|  |  |
| --- | --- |
| **A1(Centre)** | **0.223093** |
| **A2(Suburb)** | **0.678165** |
| **A3(Shared)** | **0.642653** |
| **A4(Extent)** | **0.648778** |

Table 9 TOPSIS Results



Warehouse Space

0.8

0.7

0.6

0.5

0.4

0.3

0.2

0.1

0

A1

A2

A3

A4

Figure 4 graph for Topsis results

Since the criteria and alternatives are in the same order for both methods their way of imputing only differs but we get the same output in both methods.

>> >> >>

Suburb

Extent

Shared

Centre

Figure 5 Result comparison

After calculation, both the graphs suggest that suburb should be recommended to the manufacturing firm.

* The company can go with the suburb because the main priority set was to have more space which is available with suburb. But if the company feels it costly and there is no adequate rail transport for the employees to travel. Secondly, it has a good parking facility for the exchange of goods and raw materials. Additionally, security is also at its best.
* The firm can consider Extent as their second option since it has excellent links to travel. Most importantly the cost of extending the warehouse is very low. Also, Warehouse space which is an essential criterion for us is also not bad. As given in the question it is a small manufacturing company so good warehouse space would be sufficient for them. But the security provided is in bad condition.
* Next, in the worst case the company can consider shared as it has essential features like good warehouse space and parking, which are our top criteria. It also has decent transport links with good security and low cost.
* Lastly, the company should not consider the centre even though it has good transport and security. Since it has no space, which is our main criterion. Also, it is difficult to transport goods due to lack of parking area. Finally, the cost is also not so attractive, which is too high for these specifications.

Hence, I would suggest the firm go with Suburb even though it is slightly costly but other specifications are quite impressive