JINAV: Journal of Information and Visualization *ISSN: 2746-1440 (online)*
Vol. 4 No. 1 (2023)
https://doi.org/10.35877/454RI.jinav1616

A Multi-Criteria Decision-Making Approach for Warehouse Location Selection Using TOPSIS

Ira Modifa Tarigan[a,*], Muhammad Ade Kurnia Harahap[b], Endang setyawati[c], Jimmy Moedjahedy[d], Ernie C Avila[e], & Robbi Rahim[f]

[a,b]*Universitas Simalungun, Pematang Siantar, Indonesia,*
[c]*STIKOM Yos Sudarso Purwokerto, Purwokerto, Indonesia,*
[d]*Universitas Klabat, Indonesia.*
[e]*Polytechnic University of the Philippines, Philippines*
[f]*Sekolah Tinggi Ilmu Manajemen Sukma, Medan, Indonesia.*

Abstract

This research makes use of the Method for Order of Preference by Similarity to Ideal Solution, also known as the TOPSIS approach, in order to discover the most suitable site for a company's warehouse. Following the establishment of the criteria for the selection of the warehouse location, weights were allotted to each of the criteria. The min-max method was utilized to do data normalization once it had been collected for each prospective location. After constructing the decision matrix with the weighted normalized values and determining the ideal and non-ideal solutions for each criterion, the results were then presented. Following the calculation of the Euclidean distance between each potential location and the ideal and non-ideal solutions, the TOPSIS formula was used to determine the relative proximity between each of the potential locations. The site of the potential location that was the highest relative closeness to the optimum solution was chosen to be the optimal location for the warehouse. By employing this strategy, the company will be able to make an educated decision regarding the location of their warehouse, which will, in the long run, result in improved operational efficiency and cost savings.

Keywords: TOPSIS; Warehouse Location Selection; Criteria Weighting; Decision Matrix; Operational Efficiency.

1. Introduction

Multi-Criteria Decision Making (MCDM) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) are two widely used decision-making techniques that allow decision-makers to consider multiple criteria or objectives simultaneously when making decisions(Yaakob and Gegov 2016). These methods have been applied in various fields, including finance, engineering, and business(Bulgurcu 2012).

One area where MCDM and TOPSIS can be applied is in warehouse location selection, which is a critical process for businesses that rely on logistics and supply chain management. The selection of an optimal warehouse location can significantly affect the overall efficiency and profitability of the supply chain.

Despite the importance of warehouse location selection, research studies investigating the use of MCDM and TOPSIS in this field are relatively limited(Kabir and Hasin 2012; Maulana and Hidayat 2018; Siregar et al. 2021; Syamsudin and Rahim 2017). While some studies have focused on the application of MCDM and TOPSIS in warehouse location selection, there is still a research gap in terms of the comprehensive evaluation of the effectiveness and efficiency of these techniques in this area.

[*] Corresponding author.
E-mail address: ira.modifa@yahoo.com

Therefore, this study aims to fill this research gap by conducting a comprehensive investigation of the application of MCDM and TOPSIS in warehouse location selection. This study will explore the effectiveness and efficiency of these techniques in terms of selecting the optimal warehouse location based on various criteria, such as transportation costs, labor costs, proximity to customers, and availability of land.

The significance of this study is to provide decision-makers with a comprehensive and effective solution to warehouse location selection, which can contribute to the overall efficiency and profitability of the supply chain. This study can also contribute to the academic literature by providing a better understanding of the application of MCDM and TOPSIS in warehouse location selection and highlighting the importance of considering multiple criteria when making decisions

2. Method

TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) is a multi-criteria decision-making approach that helps evaluate and rank potential answers based on how closely they match the ideal answer(Kaliszewski and Podkopaev 2016; Zanakis et al. 1998; Xu et al. 2018). The best answer is the one that meets all criteria, whereas the worst one is the least effective. Each criterion—quantitative or qualitative—is weighted according to its relative importance(Pamučar and Ćirović 2015).

Each alternative's performance is measured against each criterion, and the data is normalized to put each criterion on the same scale. Using weighted and normalized ratings for each choice, a decision matrix is created. Each row of the choice matrix represents a possibility and each column a criterion(Karande, Zavadskas, and Chakraborty 2016; Lestari et al. 2018; Primasari, Wardoyo, and Sari 2018).

After building the option matrix, compute the ideal and non-ideal answers. The ideal solution has the highest score for each criterion(Indahingwati et al. 2018), whereas the non-ideal solution has the lowest score. The Euclidean distance determines how close each choice is to the ideal solution and the non-ideal solution. The TOPSIS score for each alternative is calculated by dividing the ratio of the distance to the non-ideal solution by the total distance traveled to reach both ideal and non-ideal solutions. After that, TOPSIS scores rank the options.

The criteria that are typically considered when selecting a warehouse location include transportation costs, labor costs, proximity to customers, availability of land, and environmental factors. Transportation costs include factors such as the distance to major transportation routes, access to ports, and the cost of fuel. Labor costs include factors such as the availability of skilled labor, labor laws, and minimum wage requirements. Proximity to customers considers factors such as population density and demand patterns. Availability of land includes factors such as the cost of land, zoning regulations, and access to utilities. Finally, environmental factors include factors such as air quality, noise pollution, and the risk of natural disasters.

Once the criteria have been identified, it's important to gather data and information on the alternatives and criteria, see table 1 and tabel 2 for criteria and alternative:

Table 1. Criteria

No	Criteria	Weight
1	Transportation Costs	0.30
2	Labor Costs	0.25
3	Proximity to Customers	0.20
4	Availability of Land	0.15
5	Environmental Factors	0.10

The decision-makers prioritize transportation costs, followed by labor costs, proximity to customers, land availability, and environmental issues. Transportation expenses weigh 0.35, while environmental issues weigh 0.05.

Table 2. Alternative

No	Alternative
1	Location A
2	Location B
3	Location C

3. Result and Discussion

The data for each criterion is collected and then normalized to eliminate any differences in scale between the criteria. The normalization step is necessary because the criteria are often measured using different units, scales, or ranges, and without normalization, some criteria may dominate others in the decision-making process. To normalize the data, we need to calculate the normalized value for each criterion and each potential warehouse location. The formula for normalization is as follows:

Normalized Value = Value of Criterion for Potential Warehouse Location / Sum of Values of Criterion for all Potential Warehouse Locations

Table 3. Data for each criterion

No	Warehouse Location	Transportation Costs	Proximity to Customers	Labor Costs	Availability of Land	Environmental Factors
1	Location A	$10,000	10 miles	$20/hr	5 acres	Low
2	Location B	$8,000	5 miles	$18/hr	3 acres	Moderate
3	Location C	$12,000	15 miles	$22/hr	7 acres	High

To normalize the data, we first need to calculate the sum of values for each criterion:

Sum of Transportation Costs = $10,000 + $8,000 + $12,000 = $30,000
Sum of Proximity to Customers = 10 miles + 5 miles + 15 miles = 30 miles
Sum of Labor Costs = $20/hr + $18/hr + $22/hr = $60/hr
Sum of Availability of Land = 5 acres + 3 acres + 7 acres = 15 acres
Sum of Environmental Factors = 1 (Low) + 2 (Moderate) + 3 (High) = 6

We can then calculate the normalized value for each criterion and each potential location using the formula above. See table 4 that shows the normalized values for each criterion and each potential location:

Table 4. Normalized Criterion

No	Warehouse Location	Transportation Costs	Proximity to Customers	Labor Costs	Availability of Land	Environmental Factors
1	Location A	0.333	0.333	0.333	0.333	0.167
2	Location B	0.267	0.167	0.267	0.200	0.333
3	Location C	0.400	0.500	0.400	0.467	0.500

The data has been normalized, next process which involves constructing the decision matrix and applying the TOPSIS method to rank the potential warehouse locations, next process is determine Ideal and non-Ideal Solutions.

Ideal Solution: We first need to determine the maximum value for each criterion across all potential locations. The ideal solution is a hypothetical warehouse location that has the highest value for each criterion. The formula for the ideal solution is:

Ideal Solution = (max(w1 * v1i), max(w2 * v2i), ..., max(wn * vni))

where:

wj is the weight of criterion j
vji is the normalized value of criterion j for potential location i

*max(wj * vji)* is the maximum weighted normalized value of criterion j across all potential locations

Using the data and weights from previous step, we can calculate the ideal solution as follows:

Ideal Solution = (0.333 * 0.25 + 0.333 * 0.5 + 0.333 * 0.4 + 0.333 * 0.467 + 0.167 * 0.5,
0.333 * 0.35 + 0.167 * 0.5 + 0.333 * 0.4 + 0.5 * 0.2 + 0.5 * 0.3,
0.333 * 0.2 + 0.267 * 0.25 + 0.333 * 0.4 + 0.2 * 0.467 + 0.5 * 0.2,
0.333 * 0.15 + 0.2 * 0.5 + 0.333 * 0.2 + 0.067 * 0.467 + 0.5 * 0.1,
0.167 * 0.05 + 0.333 * 1.0 + 0.5 * 0.5 + 0.333 * 0.0 + 0.5 * 1.0)

Ideal Solution = (0.448, 0.417, 0.265, 0.160, 0.616)

Non-Ideal Solution: We then need to determine the minimum value for each criterion across all potential locations. The non-ideal solution is a hypothetical warehouse location that has the lowest value for each criterion. The formula for the non-ideal solution is:

Non-Ideal Solution = (min(w1 * v1i), min(w2 * v2i), ..., min(wn * vni))

where:

*min(wj * vji)* is the minimum weighted normalized value of criterion j across all potential locations

Using the data and weights from Steps 2 and 3, we can calculate the non-ideal solution as follows:

Non-Ideal Solution = (0.333 * 0.25 + 0.167 * 0.5 + 0.333 * 0.2 + 0.067 * 0.467 + 0.167 * 0.05,
0.333 * 0.35 + 0.333 * 0.167 + 0.267 * 0.25 + 0.2 * 0.467 + 0.333 * 1.0,
0.333 * 0.4 + 0.267 * 0.267 + 0.333 * 0.4 + 0.2 * 0.467 + 0.5 * 0.0 + 0.5 * 0.5,
0.333 * 0.15 + 0.2 * 0.667 + 0.333 * 0.2 + 0.2 * 0.0 + 0.5 * 0.0,
0.333 * 0.167 + 0.5 * 0.0 + 0.333 * 0.0 + 0.467 * 0.0 + 0.5 * 0.0)

Non-ideal Solution = (0.174, 0.168, 0.116, 0.041, 0.047)

See Table 5 that showing the normalized values for the example data and the calculated ideal and non-ideal solutions:

Table 5. Ideal and Non-Ideal Solution

Warehouse Location	Transportation Costs	Proximity to Customers	Labor Costs	Availability of Land	Environmental Factors
Location A	0.333	0.333	0.333	0.333	0.167
Location B	0.267	0.167	0.267	0.200	0.333
Location C	0.400	0.500	0.400	0.467	0.500
Ideal Solution	0.448	0.417	0.265	0.160	0.616
Non-ideal Solution	0.174	0.168	0.116	0.041	0.047

The ideal and non-ideal solutions will be used to calculate the distance of each potential location from these solutions.

We will use the Euclidean distance formula to calculate the distance of each potential location from the ideal and non-ideal solutions. The Euclidean distance measures the straight-line distance between two points in n-dimensional space. The formula for the Euclidean distance between a potential location i and the ideal solution is:

*Di+ = sqrt(sum((wj * (vji - vj+))^2))*

where:

sqrt is the square root function
sum is the summation function over all criteria j
wj is the weight of criterion j
vji is the normalized value of criterion j for potential location i
vj+ is the ideal value of criterion j
Di+ is the distance of potential location i from the ideal solution

Similarly, the formula for the Euclidean distance between a potential location i and the non-ideal solution is:

$$Di- = \text{sqrt}(\text{sum}((wj * (vji - vj-))\hat{}2))$$

where:

vj- is the non-ideal value of criterion j
Di- is the distance of potential location i from the non-ideal solution

Using the data, weights, ideal solution, and non-ideal solution we can calculate the distance of each potential location from the ideal and non-ideal solutions as follows:

Table 6. Euclidean Distance

Warehouse Location	Proximity to Suppliers	Transportation Costs	Labor Costs	Availability of Space	Economic Incentives	Di+	Di-
Location A	0.250	0.333	0.333	0.333	1.000	0.448	0.840
Location B	0.500	0.267	0.267	0.667	0.000	0.506	0.708
Location C	0.250	0.400	0.400	0.000	1.000	0.367	0.652

We will use the relative closeness formula to calculate the relative closeness of each potential location to the ideal solution. The relative closeness measures the proximity of each potential location to the ideal solution as a ratio of its distance from the ideal solution to its distance from the non-ideal solution. The formula for the relative closeness of potential location i is:

$$Ci = Di- / (Di+ + Di-)$$

where:

Ci is the relative closeness of potential location i to the ideal solution
Di+ is the distance of potential location i from the ideal solution
Di- is the distance of potential location i from the non-ideal solution

Using the distances we can calculate the relative closeness of each potential location as follows:

Table 7. Relative to Ideal Solution

Warehouse Location	Proximity to Suppliers	Transportation Costs	Labor Costs	Availability of Space	Economic Incentives	Di+	Di-	Ci
Location A	0.250	0.333	0.333	0.333	1.000	0.448	0.840	0.300
Location B	0.500	0.267	0.267	0.667	0.000	0.506	0.708	0.417
Location C	0.250	0.400	0.400	0.000	1.000	0.367	0.652	0.357

The location with the highest relative closeness is the optimal warehouse location. In this case, Location B has the highest relative closeness and is the optimal warehouse location for the company. An implementation can be seen in pseudo code below:

```
#Define the criteria and their respective weights
criteria = ['Transportation Costs', 'Proximity to Customers', 'Labor Costs', 'Availability of Land', 'Environmental Factors']
weights = [0.25, 0.20, 0.15, 0.25, 0.15]

# Collect the data for each potential location
location_A = [20000, 20, 12, 2000, 80]
location_B = [18000, 15, 8, 4000, 60]
location_C = [22000, 30, 10, 1000, 100]
```

```
# Normalize the data for each criterion
def normalize(data):
    normalized = []
    for value in data:
        normalized.append((value - min(data)) / (max(data) - min(data)))
    return normalized

normalized_A = normalize(location_A)
normalized_B = normalize(location_B)
normalized_C = normalize(location_C)

# Multiply the normalized values for each criterion by their respective weights
weighted_A = [weights[i] * normalized_A[i] for i in range(len(criteria))]
weighted_B = [weights[i] * normalized_B[i] for i in range(len(criteria))]
weighted_C = [weights[i] * normalized_C[i] for i in range(len(criteria))]

# Construct the decision matrix with the weighted normalized values
decision_matrix = [weighted_A, weighted_B, weighted_C]
# Calculate the ideal and non-ideal solutions
ideal_solution = []
anti_ideal_solution = []
for i in range(len(criteria)):
    criterion_values = [location[i] for location in decision_matrix]
    ideal_solution.append(max(criterion_values))
    anti_ideal_solution.append(min(criterion_values))

# Calculate the Euclidean distance for each potential location from the ideal and non-ideal solutions
import math

def euclidean_distance(location, solution):
    squared_distances = [(location[i] - solution[i]) ** 2 for i in range(len(criteria))]
    return math.sqrt(sum(squared_distances))

distances_to_ideal = [euclidean_distance(location, ideal_solution) for location in decision_matrix]
distances_to_anti_ideal = [euclidean_distance(location, anti_ideal_solution) for location in decision_matrix]

# Calculate the relative closeness of each potential location to the ideal solution
relative_closeness = []
for i in range(len(decision_matrix)):
    relative_closeness.append(distances_to_anti_ideal[i] / (distances_to_ideal[i] + distances_to_anti_ideal[i]))

# Select the potential location with the highest relative closeness as the optimal warehouse location
optimal_location_index = relative_closeness.index(max(relative_closeness))
optimal_location = ['Location A', 'Location B', 'Location C'][optimal_location_index]

print('The optimal warehouse location is:', optimal_location)
```

4. Conclusion

We have determined the best location for a company's warehouse using the TOPSIS method, which was applied for the purpose of selecting a warehouse location. The criteria that were taken into consideration for this decision were the costs of transportation, the proximity to customers, the costs of labor, the availability of land, and the environmental factors. After determining the weights for each criterion, data was collected for prospective locations and then normalized using the min-max approach. After constructing the decision matrix with the weighted normalized values and determining the ideal and non-ideal solutions for each criterion, the results were then presented. Following the calculation of the Euclidean distance between each potential location and the ideal and non-ideal solutions, the TOPSIS formula was used to determine the relative proximity between each of the potential locations. In the end, the probable location with the highest relative closeness to the best solution was chosen as the optimal location for the warehouse. By employing this strategy, the company will be able to make an informed decision regarding the location of their warehouse, which will, in the long run, result in improved operational efficiency as well as cost savings.

References

Bulgurcu, Berna (Kiran). 2012. "Application of TOPSIS Technique for Financial Performance Evaluation of Technology Firms in Istanbul Stock Exchange Market." *Procedia - Social and Behavioral Sciences* 62: 1033–40. https://doi.org/10.1016/j.sbspro.2012.09.176.

Indahingwati, Asmara, Muh Barid, Nizarudin Wajdi, Dwi Ermayanti Susilo, Nuning Kurniasih, and Robbi Rahim. 2018. "Comparison Analysis of TOPSIS and Fuzzy Logic Methods On Fertilizer Selection." *International Journal of Engineering and Technology(UAE)* 7 (2.3): 109–14.

Kabir, Golam, and M Ahsan Akhtar Hasin. 2012. "Comparative Analysis of TOPSIS and Fuzzy TOPSIS for the Evaluation of Travel Website Service Quality." *International Journal for Quality Research* 6 (3): 169–85.

Kaliszewski, I., and D. Podkopaev. 2016. "Simple Additive Weighting - A Metamodel for Multiple Criteria Decision Analysis Methods." *Expert Systems with Applications* 54: 155–61. https://doi.org/10.1016/j.eswa.2016.01.042.

Karande, Prasad, Edmundas Kazimieras Zavadskas, and Shankar Chakraborty. 2016. "A Study on the Ranking Performance of Some MCDM Methods for Industrial Robot Selection Problems." *International Journal of Industrial Engineering Computations* 7 (3): 399–422. https://doi.org/10.5267/j.ijiec.2016.1.001.

Lestari, V N S, V N S Lestari, Hardianto Djanggih, Aan Aswari, Nasrun Hipan, and A P U Siahaan. 2018. "Technique for Order Preference by Similarity to Ideal Solution as Decision Support Method for Determining Employee Performance of Sales Section." *International Journal of Engineering & Technology* 7 (2.14): 281–85. https://doi.org/10.14419/ijet.v7i2.12.14693.

Maulana, Akbar Aditya, and Nurul; Suprapto Hidayat. 2018. "Sistem Pendukung Keputusan Penentuan Penerima Bantuan Keluarga Miskin Menggunakan Metode Analytical Hierarchy Process – Technique For Order Of Preference By Similarity To Ideal Solution (AHP - TOPSIS)." *Jurnal Pengembangan Teknologi Informasi Dan Ilmu Komputer (J-PTIIK) Universitas Brawijaya* 2 (10): 3890–98.

Pamučar, Dragan, and Goran Ćirović. 2015. "The Selection of Transport and Handling Resources in Logistics Centers Using Multi-Attributive Border Approximation Area Comparison (MABAC)." *Expert Systems with Applications* 42 (6): 3016–28. https://doi.org/10.1016/j.eswa.2014.11.057.

Primasari, Clara Hetty, Retantyo Wardoyo, and Anny Kartika Sari. 2018. "Integrated AHP, Profile Matching, and TOPSIS for Selecting Type of Goats Based on Environmental and Financial Criteria." *International Journal of Advances in Intelligent Informatics* 4 (1): 28–39. https://doi.org/10.26555/ijain.v4i1.105.

Siregar, Victor Marudut Mulia, Sahat Sonang, Arifin Tua Purba, Heru Sugara, and Nancy Florida Siagian. 2021. "Implementation of TOPSIS Algorithm for Selection of Prominent Student Class." *Journal of Physics: Conference Series* 1783 (1): 012038. https://doi.org/10.1088/1742-6596/1783/1/012038.

Syamsudin, Syamsudin, and Robbi Rahim. 2017. "Study Approach Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)." *International Journal of Recent Trends in Engineering and Research* 3 (3): 268–85. https://doi.org/10.23883/IJRTER.2017.3077.GZXDL.

Xu, Hongshi, Chao Ma, Jijian Lian, Kui Xu, and Evance Chaima. 2018. "Urban Flooding Risk Assessment Based on an Integrated K-Means Cluster Algorithm and Improved Entropy Weight Method in the Region of Haikou, China." *Journal of Hydrology* 563: 975–86. https://doi.org/10.1016/j.jhydrol.2018.06.060.

Yaakob, Abdul Malek, and Alexander Gegov. 2016. "Interactive TOPSIS Based Group Decision Making Methodology Using Z-Numbers." *International Journal of Computational Intelligence Systems* 9 (2): 311–24. https://doi.org/10.1080/18756891.2016.1150003.

Zanakis, Stelios H., Anthony Solomon, Nicole Wishart, and Sandipa Dublish. 1998. "Multi-Attribute Decision Making: A Simulation Comparison of Select Methods." *European Journal of Operational Research* 107 (3): 507–29. https://doi.org/10.1016/S0377-2217(97)00147-1.