THE APPLICATION OF CRITIC-TOPSIS METHOD TO SOLVE THE MATERIAL HANDLING EQUIPMENT (MHE) SELECTION PROBLEM

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Keywords: CRITIC, AHP, TOPSIS, MCDM

1. Introduction

Material handling equipment (MHE) is an essential component of any industry that requires materials to be stored or transported between places. Selecting the best MHE is a crucial aspect of every industry due to the large amount of capital involved in the process. This process mainly concentrated on selecting the best MHE while considering the multiple criteria that are often in conflict. This paper aims to propose the hybridization of Criteria Importance through Inter-criteria Correlation (CRITIC) method and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method known as CRITIC-TOPSIS method to solve the MHE selection problem. The TOPSIS method has a limitation since it does not account for the weights of the criteria (Tornyeviadzi et al., 2021). Thus, to overcome the shortcoming of this method, the CRITIC method is used to compute the weight of the criteria of MHE selection. Meanwhile, the TOPSIS method is used to find the best optimal solution for a problem while focusing on some notable uniqueness of it (Panda & Jagadev, 2018).

2. Methodology

Empirical data about the selection of material handling equipment (MHE) (Satoglu & Türkekul, 2021) was used to demonstrate the application of the CRITIC-TOPSIS method. The CRITIC method proposed by Diakoulaki et al. (1995) is used to determine objective weights for criteria. Correlation analysis is used to detect the contrast among criteria (Yilmaz & Harmancioglu, 2010). The steps listed below show the procedures in determining the objective weights of criteria (Diakoulaki et al., 1995):

Step 1: Develop the decision matrix and normalise the decision matrix using:

$$X^*_{ij} = \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})}, \qquad i = 1, 2, \ldots, m \text{ alternatives}, j = 1, 2, \ldots, n \text{ criteria} \qquad (1)$$

Step 2: The correlation between criteria must be calculated to get the symmetric linear correlation matrix. Then, the measure of the conflict is calculated using:

$$\sum_{k=1}^{n}(1-r_{jk}), \qquad j = 1, 2, ..., n \text{ criteria}, k = 1, 2, ..., n \text{ criteria} \tag{2}$$

Step 3: Calculate the standard deviation of the criterion, σ_j, the quantity of information, C_j and the objective weight W_j using:

$$C_j = \sigma_j \sum_{k=1}^{n}(1-r_{jk}), \qquad j = 1, 2, ..., n \text{ criteria}, k = 1, 2, ..., n \text{ criteria} \tag{3}$$

$$W_j = \frac{C_j}{\sum_{j=1}^{n} C_j}, \qquad j = 1, 2, ..., n \text{ criteria} \tag{4}$$

Then, the criteria weights were further used in the TOPSIS method. The TOPSIS method is one of the Multi Criteria Decision Making (MCDM) methods developed by Hwang and Yoon (1981). The concept of the TOPSIS method is the best alternative chosen should simultaneously have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution. The steps of TOPSIS are listed below (Abdel-Basset & Mohamed, 2020):

Step 1: Construct a decision matrix, D and normalise the decision matrix, D using:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij^2}}}, \qquad i = 1, 2, ..., m \text{ alternatives}, j = 1, 2, ..., n \text{ criteria} \tag{5}$$

Step 2: Compute the weighted normalized decision matrix.

Step 3: Determine the negative ideal solution, A^- and positive ideal solution, A^+.

Step 4: Calculate the separation for each alternative from the positive ideal solution, S_i^+ and the separation for each alternative from the negative ideal solution, S_i^- using:

$$S_i^+ = \sqrt{\left(\sum_{j=1}^{n}\left(V_{ij} - V_{ij}^+\right)^2\right)}, \qquad i = 1, 2, ..., m \text{ alternatives}, j = 1, 2, ..., n \text{ criteria} \tag{6}$$

$$S_i^- = \sqrt{\left(\sum_{j=1}^{n}\left(V_{ij} - V_{ij}^-\right)^2\right)}, \qquad i = 1, 2, ..., m \text{ alternatives}, j = 1, 2, ..., n \text{ criteria} \tag{7}$$

Step 5: Compute the relative closeness to the ideal solution, CC_i using the equation below and then rank the preference order.

$$CC_i = \frac{S_i^-}{\left(S_i^+ + S_i^-\right)}, 0 < CC_i^+ < 1, \qquad i = 1,2,...,m \text{ alternatives}, \ j = 1,2,...,n \text{ criteria} \tag{8}$$

$$CC_i = 1 \ \ if \ \ A_i = A^+ \ \text{ and } \ CC_i = 0 \ \ if \ \ A_i = A^-$$

3. Results and Discussions

The ranking order for criteria was Cost ≥ Risk > Power Required > Application > On-site Repair > Load-Carrying Capacity > Ease to Operate ≥ Availability of spare parts ≥ Area Constraints > Flexibility in Material > Distance to be Moved. Cost was chosen as the best criterion because the equipment maintenance procedure needs a lot of money, and the equipment is expensive. Meanwhile, Distance to be moved was chosen as the least preferred criterion because the company does not take the distance of the goods to be transferred into consideration (Satoglu & Türkekul, 2021). Meanwhile, the ranking order for alternatives was Electric Pallet Truck > Hydraulic Pallet Truck > Hand Pallet Truck > Semi Electric Pallet Truck > Hydraulic Hand Pallet Truck.

4. Conclusion

The sensitivity analysis was conducted to examine the impact of weight changes of each criterion on the ranking when the criteria were eliminated one by one. In conclusion, this hybrid method is important because it considers a high level of uncertainty and increases the consistency of the evaluation process (Abdel-Basset & Mohamed, 2020).

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