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Selection of Personnel Based on a Two-Stage Multi-Attribute Decision-Making Model

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Abstract: *The problem of personnel selection in the logistics process is one of the most important tasks of human resource management, and its relationship has a critical effect on achieving the organization's business goals. The considered problem can be stated as a two-stage multi-attribute decision problem that includes both quantitative and qualitative criteria. The attribute weights are determined by applying the modified CRiteria Importance Through Intercriteria Correlation (CRITIC) method. The proposed fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is applied to rank the personnel. The proposed model is illustrated by an example using literature data. It is shown that the proposed two-stage MADM model is highly suitable as a decision-making tool for making decisions about personnel selection in the logistics process.*

Keywords: *personnel selection, CRITIC, TOPSIS, logistics process*

1. INTRODUCTION

The development of new technologies, primarily information technologies, has led to the conclusion that it is not possible to base personnel selection on traditional decision-making methods. This issue is particularly prominent in the logistics process, where intuitive, analytical, and experienced workers are employed to ensure the achievement of goals. Therefore, it is inevitable to use scientific approaches in the process of selecting candidates who can meet job expectations in the best possible way.

The application of Multi-Attribute Decision-Making Methods (MADM) enables decision-makers (DMs) to evaluate potential candidates according to numerous attributes. These attributes can be qualitative and quantitative. It is common for DMs to assess the values of qualitative attributes using a measurement scale. The obtained results can help DMs make the right decision in a shorter period. It should be noted that DMs can use one or more MADM methods when solving problems.

Some authors [1] believe that the use of MADM methods increases the innovative and creative capacity of the organization. The selection of candidates based on an exact approach prevents employees from developing negative feelings toward the organization, which leads to increased effectiveness and efficiency of employees.

In the literature, many papers can be found where the considered problem is solved in an exact manner using multi-attribute decision-making methods [2, 3, 4, 5].

The aim of this research is to develop a method that can quickly and efficiently select the best candidate for the logistics process.

It is assumed that not all attributes have equal weights. Generally, the determination of attribute weights can be based on subjective MADM methods. The most commonly used MADM method in this group is the Analytic Hierarchical Process (AHP) [6]. The weights obtained in this way are to some extent influenced by the subjective views of DMs. By applying objective MADM methods such as CRiteria Importance Through Intercriteria Correlation (CRITIC) [7], subjectivity in determining attribute weights can be reduced. This method is widely used in the literature for determining the weight vector [8, 9, 10, 11, 12]. In all analyzed papers, the normalized decision matrix is constructed by applying Weitendorf's linear normalization procedure [13], as in this research. The main difference between the analyzed papers and our research is the domain of application of the CRITIC method.

In the second stage, the selection of candidates is based on the proposed Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [14]. The TOPSIS method is widely used in the literature for ranking various items [15].

Comparing papers that propose a model for ranking items by applying TOPSIS, some differences can be noted, which are further described below. The construction of the normalized decision matrix is based on using: (i) linear normalization procedures [16, 17, 18], and (ii) vector normalization procedures [1, 20, 21]. In our research, Weitendorf's linear normalization [13] was applied, which represents one of the main differences between our research and the papers found in the literature. In all analyzed papers, the positive ideal solution (PIS) and negative ideal solution (NIS) are determined according to the weighted normalized decision matrix. In our research, PIS and NIS are determined according to the veto concept, which represents another main difference between our research and the analyzed papers. The distance from both PIS and NIS is calculated with respect to expressions from traditional TOPSIS in the analyzed papers, as in our research.

The paper is organized as follows. The proposed methodological approach for selecting the best personnel in the logistics process is given in Section 2. Section 3 provides an example with real-life data.

2. MATERIAL AND METHODS

The problem of evaluating candidates for the logistics process is addressed by applying the proposed two-stage multi-attribute decision-making model. In the first part, the weights of the attributes are determined using the proposed CRITIC method. Secondly, the ranking of candidates is given using the TOPSIS method.

2.1. Defining the set of attributes

Attributes by which candidates are evaluated are taken from the literature [1]. These attributes are: Experience in logistics $(k = 1)$, Education/Training $(k = 2)$, Flexible work hours and overtime work $(k = 3)$, Proficiency in MS Office Programs $(k = 4)$, Package software used in the logistics field $(k = 5)$, and Recommendation letters $(k = 6)$. The attribute values are assessed on a scale ranging from 1 to 10. A value of 1 indicates the lowest attribute value, while a value of 9 indicates the highest attribute value.

2.2 The proposed CRITIC

The proposed CRITIC method is implemented through five steps, which are further formally presented:

Step 1. The decision matrix is constructed:

$$[x_{ik}]_{IxK}$$

Step 2. The normalized decision matrix is obtained through the application of Weitendorf's linear normalization [13]:

$$[r_{ik}]_{IxK}$$

where:

$$r_{ik} = \frac{x_{ik} - x_k^{min}}{x_k^{max} - x_k^{min}}$$

Step 3. The attribute weights have been determined:

$$W_k = \sigma_k \cdot \sum_{k=1,..,K} (1 - \rho_{kk'})$$

where:

σ_k, standard deviation of normalized attribute values for $k = 1,..,K$

$\rho_{kk'}, k, k' = 1,..,K$ coefficient of correlation for each pair of attributes.

Step 4. The normalized weights vector is determined.

$$[\omega_k]_{Kx1}$$

where:

$$\omega_k = \frac{W_k}{\sum_{k=1,..,K} W_k}$$

2.3 The proposed TOPSIS

Step 1. The decision matrix is constructed:

$$[x_{ik}]_{IxK}$$

Step 2. The normalized decision matrix is constructed:

$$[r_{ik}]_{IxK}$$

Step 3. The weighted normalized decision matrix is constructed:

$$[z_{ik}]_{IxK}$$

Step 4. Determine PIS, f_k^+ and NIS, f_k^- according to the veto concept.

Step 5. Determine the distances from PIS, d_i^+ and NIS, d_i^-:

$$d_i^+ = \sum_{k=1,..,K} |f_k^+ - z_{ik}|$$

$$d_i^- = \sum_{k=1,..,K} |f_k^- - z_{ik}|$$

Step 6. The closeness coefficient is determined:

$$c_i = \frac{d_i^-}{d_i^- + d_i^+}$$

Step 7. The values of the coefficient c_i in descending order. The best alternative is the one ranked first.

3. CASE STUDY

The attribute values by which potential candidates are evaluated are taken from the paper of [1]. The decision matrix is presented in Table 1.

Table 1. *Decision matrix*

	$k = 1$	$k = 2$	$k = 3$	$k = 4$	$k = 5$	$k = 6$
$i = 1$	4	8	5	6	7	1
$i = 2$	3	8	8	5	1	1
$i = 3$	3	6	8	7	1	1
$i = 4$	4	1	10	6	1	1
$i = 5$	9	5	3	6	5	1
$i = 6$	4	10	10	7	8	8
$i = 7$	3	10	6	7	1	1
$i = 8$	3	7	6	8	5	1
$i = 9$	3	10	8	8	6	5

3.1 Application of the proposed CRITIC

By applying the proposed algorithm (Step 2 to Step 3), the normalized decision matrix and standard deviation of criteria values are constructed and presented in Table 2.

Table 2. *The normalized decision matrix*

	$k=1$	$k=2$	$k=3$	$k=4$	$k=5$	$k=6$
$i=1$	0.167	0.778	0.286	0.333	0.857	0
$i=2$	0	0.778	0.714	0	0	0
$i=3$	0	0.556	0.714	0.667	0	0
$i=4$	0.167	0	1	0.333	0	0
$i=5$	1	0.444	0	0.333	0.571	0
$i=6$	0.167	1	1	0.667	1	1
$i=7$	0	1	0.429	0.667	0	0
$i=8$	0	0.667	0.429	1	0.571	0
$i=9$	0	1	0.714	1	0.714	0.571
σ_k	0.323	0.328	0.331	0.333	0.413	0.363

By applying the proposed procedure (Step 2 to Step 4), the weights of attributes have been determined as shown in Table 3.

Table 3. *Values of correlation coefficients and attribute weights*

	$k=1$	$k=2$	$k=3$	$k=4$	$k=5$	$k=6$	$\sum_{k=1,\ldots,K}(1-\rho_{kk'})$	W_k
k=1	1.000	-0.351	-0.585	-0.323	0.246	-0.101	6.114	1.975
k=2	-0.351	1.000	-0.059	0.368	0.414	0.510	4.118	1.351
k=3	-0.585	-0.059	1.000	0.073	-0.166	0.506	5.231	1.732
k=4	-0.323	0.368	0.073	1.000	0.331	0.378	4.174	1.389
k=5	0.246	0.414	-0.166	0.331	1.000	0.634	3.541	1.463
k=6	-0.101	0.510	0.506	0.378	0.634	1.000	3.074	1.116

The normalized weights vector of the considered attributes is obtained by applying the proposed algorithm (Step 5), as follows:

$$[0.219 \quad 0.150 \quad 0.192 \quad 0.154 \quad 0.162 \quad 0.124]$$

3.2 An application of the proposed TOPSIS

By applying the proposed procedure (Step 1 to Step 4), the weighted normalized decision matrix and reference point are determined and presented in Table 4.

Table 4. *The weighted normalized decision matrix, PIS and NIS*

	$k=1$	$k=2$	$k=3$	$k=4$	$k=5$	$k=6$
$i=1$	0,676	0,963	0,786	0,844	0,975	0
$i=2$	0	0,963	0,937	0	0	0
$i=3$	0	0,916	0,937	0,939	0	0
$i=4$	0,676	0	1	0,844	0	0
$i=5$	1	0,885	0	0,844	0,913	0
$i=6$	0,676	1	1	0,939	1	1
$i=7$	0	1	0,850	0,939	0	0
$i=8$	0	0,941	0,850	1	0,913	0
$i=9$	0	1	0,937	1	0,947	0,933
f_k^+	1	1	1	1	1	1
f_k^-	0	0	0	0	0	0

By applying the proposed algorithm (Step 5 to Step 7), the distances from PIS and NIS, closeness coefficient, and rank of candidates are calculated. The results are presented in Table 5.

Based on the obtained results, it can be concluded that candidate $i=6$ is the most suitable for the considered position in the logistics process.

Table 5. *The rank of candidates*

	d_i^+	d_i^-	c_i	rank
$i=1$	1.756	4.244	0.707	3
$i=2$	4.100	1.900	0.317	8
$i=3$	3.208	2.792	0.465	5-6
$i=4$	3.480	2.520	0.420	7
$i=5$	2.358	3.642	0.607	4
$i=6$	0.385	5.615	0.936	1
$i=7$	3.211	2.789	0.465	5-6
$i=8$	2.296	0.913	0.152	9
$i=9$	1.183	4.817	0.803	2

4. CONCLUSION

Based on the conducted research, the proposed two-stage multi-attribute decision-making model, which combines the CRITIC method for attribute weighting and the TOPSIS method for ranking candidates, proves to be an effective tool for personnel selection in the logistics process.

The CRITIC method is objective as it minimizes subjectivity in determining attribute weights, making it suitable for this problem. The TOPSIS method is beneficial because it provides a clear and nearly unique ranking of candidates. Also, the model can handle both quantitative and qualitative attributes, making it applicable to a diverse range of evaluation criteria.

The case study demonstrates the model's ability to accurately identify the most suitable candidate, confirming its practical applicability and efficiency in enhancing decision-making in human resource management.

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