An Assessment Model for Evaluating MCDM Education's Effectiveness Under Interval-Valued Neutrosophic Sets

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Abstract

Multiple schools' alternatives are assessed by experts based on a wide range of factors, therefore evaluating school performance may be seen as a multiple criteria decision-making (MCDM) issue. In this research, we developed a MABAC approach for evaluating MCDM education's effectiveness under interval-valued neutrosophic sets, keeping in mind the constraints posed by the assessment setting's complexity and the psychological behaviour of experts. Before everything else, experts' opinions are included in the calculation of criterion weights. Next, a novel assessment framework for assessing academic achievement in schools is developed using the MABAC model. Our research aims to provide educational institutions with the tools they need to operate at peak efficiency. In addition, other schools and allied educational institutions may use the study's findings as a benchmark in their assessments, attempts to improve performance, and formulation of educational policy.

Keywords: MCDM; Neutrosophic sets; Assessment; educational institutions; MABAC

1. Introduction

When it comes to shaping the future of a country or the world, educational institutions are vital. They aid international plans for progress by supplying expert labour and cutting-edge study. Education, more than any other level, is optimal for developing the high-tech talent that is the primary means of boosting a country's quality and competitiveness. As a result, education has a significant bearing on the growth of a nation's competitive edge[1]–[3].

The official process used to assess schools is crucial in directing the growth of and the government's monetary help for every school due to the growing focus on the necessity of performance assessment and improvement[4]–[6]. These systems also have the potential to aid academic institutions in enhancing their study and classroom practices. Despite this, education lacks a credible assessment process or ranking criteria, since all evaluation indicators seem to be equal. Because of this, no school can offer the best education possible due to a lack of funding[7]–[9].

Specifically, we used a MABAC-based variant of a MCDM model to reach our objectives[10]–[12]. This model was chosen since it takes into account a wide variety of criteria and options for assessment[13]–[16].

MCDM is an integral aspect of contemporary decision science since it gives a systematic framework and algorithm to choose the best possible options in light of several criteria. The TOPSIS technique, the SAW methodology, the VIKOR technique, and so on have all been the subject of extensive study by researchers and academics to give decision assistance for addressing complicated choice issues[17]–[19]. To help evaluators refine their choice analysis, the MABAC approach was recently proposed[20]–[23]. The MABAC method boils down to picking a good choice by measuring how far away it is from the border approximation zone[24]–[27]. Due to its usefulness in advancing decision processes, the MABAC approach has been applied to extensive diversity of fuzzy configurations,

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including the Pythagorean fuzzy set, the interval-valued intuitionistic fuzzy, fuzzy set, the single-valued neutrosophic, and so on[28]–[32].

Zadeh created the idea of the fuzzy set (FS), which is characterised by a membership purpose, as a means of modelling information with uncertainty and incompleteness. Interval-valued fuzzy sets (IVFSs), hesitant fuzzy sets (HFSs), intuitionistic fuzzy sets (IFSs), interval-valued intuitionistic fuzzy sets (IVIFSs), and many other extensions of fuzzy sets have been investigated. MCDM issues are one application area where these sets are used as a model. Since these sets are better suited to representing uncertainty, they have recently involved a lot of attention in the context of modelling MCDM issues[33]. The decision-making process may benefit from these sets, which have been the subject of several publications[34], [35]. There are, nevertheless, varying degrees of ambiguity. In this scenario, a different modelling approach is required since it is inadequate to represent issues using these sets. Consequently, Smarandache established neutrosophic logic and neutrosophic sets (NSs). For NSs, there are three types of membership: truth member status, indeterminacy membership, and falsity member status. Now, instead of using the more common [0,1] range, membership degrees may take on any value in the more broad [0-,1+] range. Philosophical methods are available to NSs. Therefore, various neutrosophic sets of special instances are generated to apply the theory to concrete situations. There are new types of neutrosophic sets presented, such as the SVNS and the interval valued neutrosophic set (IVNS). Ye et al. put out the idea of a reduced SNS, outlined its operating principles, and then used it to solve MCDM issues.

2. Preliminaries

An interval-valued NS is defined by [36]–[42]

$$N = \{< x: [T_N^L \cdot (x), T_N^U \cdot (x)], \langle \quad [I_N^L \cdot (x), I_N^U \cdot (x)], \quad \rangle, [F_N^L \cdot (x), F_N^U \cdot (x)] >, x \in X\}$$

where

$$\langle \begin{matrix} T_N \cdot (x) = [T_N^L \cdot (x),_N^U \cdot (x)] \subseteq [0,1], \\ I_N \cdot (x) = [I_N^L \cdot (x), I_N^U \cdot (x)] \subseteq [0,1], \\ F_N \cdot (x) = [F_N^L \cdot (x), F_N^U \cdot (x)] \subseteq [0,1]0 \end{matrix} \rangle$$
$$\leq supT_N \cdot (x) + supI_N \cdot (x) + supF_N \cdot (x) \leq 3.$$

Definition 2:

Let

$$\langle \begin{matrix} N1 \cdot= \left\{ \begin{matrix} < x: [T_{N_1}^L \cdot, T_{N_1}^U \cdot], \\ [I_{N_1}^L \cdot, I_{N_1}^U \cdot], \\ [I_{N_1}^U 1 \cdot, F_{N_1}^U \cdot] >, x \in X \end{matrix} \right\} \\ N2 \cdot= \left\{ \begin{matrix} < x: [T_{N_2}^L \cdot, T_{N_2}^U \cdot], \\ [I_{N_2}^L \cdot, I_{N_2}^U \cdot], \\ [I_{N_2}^U \cdot, F_{N_2}^U \cdot] >, x \in X \end{matrix} \right\} \end{matrix} \rangle$$ be two Interval valued neutrosophic numbers (IVNNs)

$$N_1 \cdot \oplus N_2 \cdot= \langle \begin{matrix} \langle [T_{N_1}^L \cdot + T_{N_2}^L \cdot - T_{N_1}^L \cdot T_{N_2}^L \cdot, T_{N_1}^L \cdot + T_{N_2}^L \cdot - T_{N_1}^L \cdot T_{N_2}^L \cdot], \\ [I_{N_1}^L \cdot I_{N_2}^L \cdot, I_{N_1}^L \cdot I_{N_2}^L \cdot], \\ [F_{N_1}^L \cdot F_{N_2}^L \cdot, F_{N_1}^L \cdot F_{N_2}^L \cdot] \rangle \end{matrix} \rangle$$

$$N_1 \cdot\otimes N_2 \cdot\!= \langle \begin{matrix} \langle [T_{N_1}^L \cdot T_{N_2}^L \cdot, T_{N_1}^L \cdot T_{N_2}^L \cdot], \\ [I_{N_1}^L \cdot +I_{N_2}^L \cdot -I_{N_1}^L \cdot I_{N_2}^L \cdot, I_{N_1}^L \cdot +I_{N_2}^L \cdot -I_{N_1}^L \cdot I_{N_2}^L \cdot], \\ [F_{N_1}^L \cdot +F_{N_2}^L \cdot -F_{N_1}^L \cdot F_{N_2}^L \cdot, F_{N_1}^L \cdot +F_{N_2}^L \cdot -F_{N_1}^L \cdot F_{N_2}^L \cdot] \rangle \end{matrix} \rangle$$

$$\varphi N \cdot\!= \langle \begin{matrix} \langle [1-(1-T_N^L)\varphi, 1-(1-T_N^L)\varphi], \\ [(T_N^L)\varphi, (T_N^L)\varphi], \\ [(F_N^L)\varphi, (F_N^L)\varphi] \rangle \end{matrix} \rangle$$

$$N^{\varphi} = \langle \begin{matrix} [(T_N^L)\varphi, (T_N^L)\varphi], \\ [1-(1-I_N^L)\varphi, 1-(1-I_N^L)\varphi], \\ [1-(1-F_N^L)\varphi, 1-(1-F_N^L)\varphi] \end{matrix} \rangle$$

3. The MABAC Method

Pamucar and Cirovic introduced a novel methodology to multi-attribute decision-making called MABAC. The MABAC procedure is refined in this study to apply to neutrosophic sets. Here are the procedures involved in using the MABAC approach with data derived from interval-valued neutrosophic sets:

Step 1: Design the judgement background

The judgement background is built by the set of criteria (j=1,2,3….n) and alternatives (i=1,2,3….m).

Step 2: Compute the normalization matrix r_{ij}

Step 3: Calculate the weighted normalized decision matrix

Multiply the weights of the criteria by the normalization matrix.

$$d_{ij} = w_j * r_{ij}$$

Step 4: Calculate the value of b_j

The border approximation area is computed as:

$$b_j = \left(\prod_{i=1}^{m} d_{ij}\right)^{\frac{1}{m}}$$

Step 5: Calculate the distance between b_j and d_{ij}

$$C_{ij} = d_{ij} - b_j$$

Step 6: Calculate the value of E_i as:

$$E_i = \sum_{j=1}^{n} C_{ij}$$

Step 7: Rank the options. The options are ordered based on the highest value of E_i

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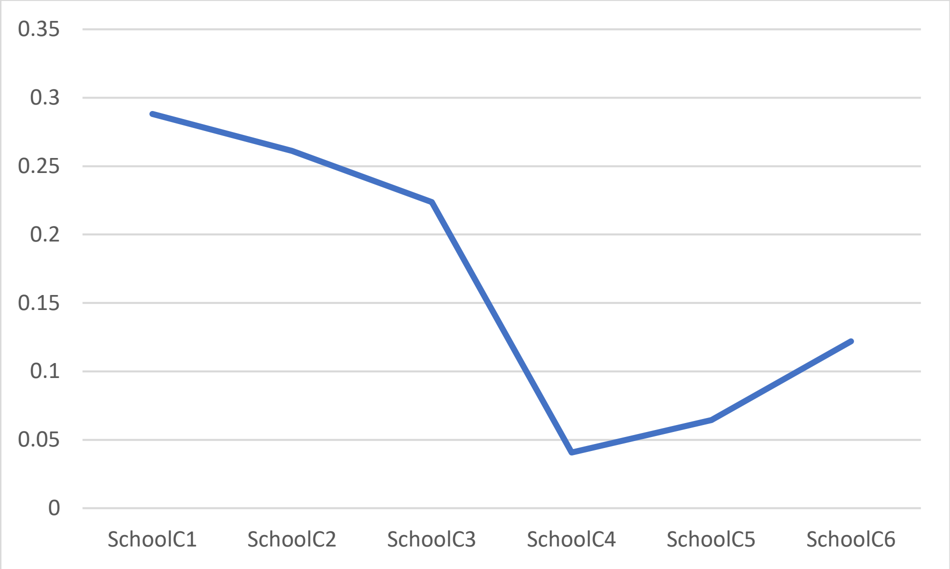

Figure 1: The weights of criteria.

5. The Results

The objective of this study, rank multiple schools based on their performance values. The MABAC is integrated with the interval-valued neutrosophic sets to rank these schools. Let experts evaluate the criteria and alternatives with the interval-valued neutrosophic numbers. Then compute the weights of criteria by the average method as shown in figure 1. This paper used multiple criteria such as teaching, resources, internationalization, quality of staff, and infrastructure. This paper used five private schools in this study.

Step 1: Design the judgement background

The judgement background build based on the views of experts.

Step 2: Calculate the normalization matrix r_{ij}

Table 1. shows the normalization decision matrix

Table 1: The normalization judgement background

	SchoolC1	SchoolC2	SchoolC3	SchoolC4	SchoolC5	SchoolC6
SchoolA1	1	0.946667	1	0.47619	1	0
SchoolA2	0.780822	1	0.125	0.190476	0	1
SchoolA3	0	0.013333	0.166667	1	0.7	0
SchoolA4	0.041096	0	1	0	0.066667	0.4
SchoolA5	0.849315	0.253333	0	0	0.7	0.745454545

Step 3: Calculate the weighted normalized judgement background

The weighted normalized judgement background is exposed in table 2.

Table 2: The weighted normalization judgement background

	SchoolC1	SchoolC2	SchoolC3	SchoolC4	SchoolC5	SchoolC6
SchoolA1	0.124	0.06424	0.082	0.020667	0.062	0.046
SchoolA2	0.110411	0.066	0.046125	0.016667	0.031	0.092
SchoolA3	0.062	0.03344	0.047833	0.028	0.0527	0.046
SchoolA4	0.064548	0.033	0.082	0.014	0.033067	0.0644
SchoolA5	0.114658	0.04136	0.041	0.014	0.0527	0.080290909

Step 4: Compute the b_j value

The border approximation area is computed

Step 5: Compute the distance between b_j and d_{ij}

The distance from the weighted judgement background and the border values is computed as in table 3.

Table 3: The distance from the border approximation area

	SchoolC1	SchoolC2	SchoolC3	SchoolC4	SchoolC5	SchoolC6
SchoolA1	-0.86136	-0.86906	-0.86818	-0.84318	-0.86536	-0.91776
SchoolA2	-0.87495	-0.8673	-0.90406	-0.84718	-0.89636	-0.87176
SchoolA3	-0.92336	-0.89986	-0.90235	-0.83585	-0.87466	-0.91776
SchoolA4	-0.92081	-0.9003	-0.86818	-0.84985	-0.89429	-0.89936
SchoolA5	-0.8707	-0.89194	-0.90918	-0.84985	-0.87466	-0.88346909

Step 6: Compute the value of E_i as:

The value of E_i is computed

Step 7: Rank the alternatives as shown in Figure 2

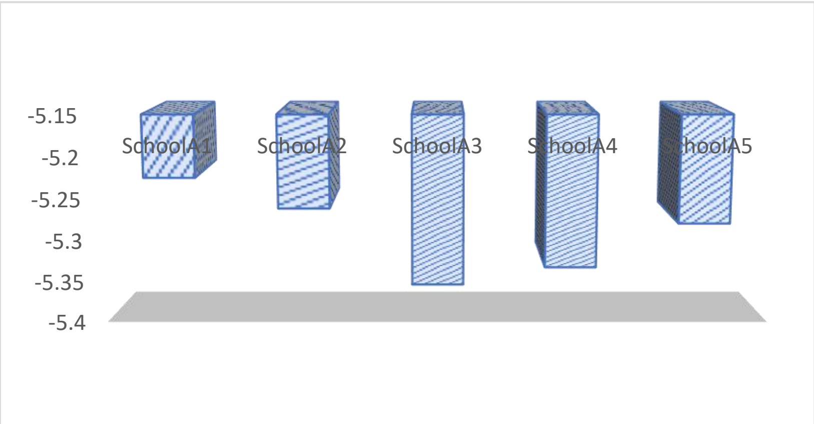

Figure 2: The rank of alternatives

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