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Single Valued Complex Neutrosophic Set for Innovative Teaching Begins with Training: Evaluating the Success of Faculty EdTech Programs

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Abstract:

As digital transformation continues to reshape the educational landscape, training programs aimed at equipping university faculty with technological competencies have become essential. Evaluating the effectiveness of these educational technology (EdTech) training initiatives is critical for ensuring quality instruction and meaningful technology integration. This study applies a Multi-Criteria Decision-Making (MCDM) approach to assess the success of faculty EdTech programs, identifying relevant criteria and evaluating a diverse range of training alternatives. The evaluation model not only prioritizes effectiveness but also aligns with institutional goals for innovation and sustainable professional development. The average method is used to compute the criteria weights. The MACONT method is used to rank the alternatives. The Single Valued Complex Neutrosophic set (SVCNS) is used with the MCDM approach to deal with uncertainty information. A case study is provided in this study.

Keywords: Single Valued Complex Neutrosophic Set; Innovative Teaching; Faculty EdTech Programs.

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1. Introduction

In recent years, the integration of educational technology into university teaching has emerged as a key driver for improving learning outcomes, enhancing student engagement, and promoting flexible instructional practices. As higher education institutions adopt new digital tools, the competency of faculty members in effectively utilizing these tools becomes a pivotal factor in success. Consequently, universities worldwide are investing in comprehensive EdTech training programs aimed at enhancing the pedagogical and technological skills of their educators[1], [2].

However, designing effective training is only part of the solution. The more complex challenge lies in evaluating these programs to ensure they meet their intended goals. A structured and objective assessment model is needed—one that not only captures measurable results but also considers the subjective experiences and long-term behavioral changes among faculty. This is where Multi-Criteria Decision-Making (MCDM) methods come into play.

MCDM provides a structured framework for dealing with diverse and often conflicting evaluation criteria. It enables decision-makers to analyze multiple facets of EdTech training programs, including content relevance, training delivery, engagement, scalability, and practical application. This multi-dimensional assessment approach supports evidence-based improvements in instructional development[3], [4].

Furthermore, an evaluation model grounded in MCDM enhances transparency in resource allocation, supports institutional accountability, and encourages continuous quality improvement. It facilitates informed decision-making at administrative levels, enabling stakeholders to refine training strategies and align them with broader educational objectives[5], [6].

Another aspect of this analysis is its forward-looking orientation. As technology evolves, so too must faculty training. The evaluation system must accommodate adaptability, ensuring that training programs remain relevant in an era of rapid digital innovation. Feedback mechanisms and data analytics are vital to this adaptability, providing real-time insights into training efficacy[7], [8].

The current study constructs a decision matrix encompassing key evaluation criteria and a set of practical training alternatives. Through expert input and analytical scoring, the study ranks these alternatives to highlight the most effective strategies. The results not only validate the strengths of certain programs but also expose critical gaps needing attention[9], [10]. By fostering a culture of data-driven evaluation, universities can more effectively support their faculty in navigating the digital education environment. This not only improves teaching quality but also promotes sustainable, institution-wide digital transformation[11], [12].

However, it is challenging for decision makers to articulate an evaluated quality with a clear value because of the impreciseness of human thought and the complexity and unpredictability of objective objects. Therefore, Smarandache was the first to suggest neutrosophic sets (NS), which are an extension of fuzzy sets (FS) and intuitionistic fuzzy sets (IFS)[13], [14]. However, NS was primarily proposed from a philosophical perspective, which makes it challenging to use in the scientific and technical domains. Thus, researchers proposed the single-valued neutrosophic set (SVNS)[15], [16].

The concept of the complex neutrosophic set (CNS) was introduced by Ali and Smarandache[17], who also discussed some properties of the CNS and set theoretic operations before applying them in signal processing. This was done in response to the generation of "big data," which involves periods and uncertainty. CNS later emerged as a novel neutrosophic theory issue.

2. Single Valued Neutrosophic Complex Set (SVNCS)

This section shows definitions of SVNCS[18], [19]. The SVNCS can be defined as:

$$S = \{(x, T_S(x), T_S(x), F_S(x)) : x \in X\} \tag{1}$$

$$T_S(x) = ps(x) \cdot e^{jw_s(x)} \tag{2}$$

$$I_S(x) = qs(x) \cdot e^{jy_s(x)} \tag{3}$$

$$F_S(x) = rs(x) \cdot e^{jz_s(x)}$$

Where $\sqrt{j} = -1, ps(x), qs(x), rs(x), ws(x), ys(x), zs(x)$ are real values

$$0 \leq ps(x) + \ qs(x) + rs(x) \leq 3 \tag{4}$$

We can obtain the complement of the SVNCS such as:

$$T_{c(S)}(x) = p_{c(s)}(x) \cdot e^{jw_{c(s)}(x)} = r_s(x) \cdot e^{j(2\pi - w_s(x))} \tag{5}$$

$$I_{c(S)}(x) = q_{c(s)}(x) \cdot e^{jy_{c(s)}(x)} = (1 - qs(x)) \cdot e^{j(2\pi - y_s(x))} \tag{6}$$

$$F_{c(S)}(x) = r_{c(s)}(x) \cdot e^{jz_{c(s)}(x)} = p_s(x) \cdot e^{j(2\pi - z_s(x))} \tag{7}$$

The operations of two SVNCS $T_A(x) = p_A(x) \cdot e^{jw_A(x)}, q_A(x) \cdot e^{jy_A(x)}, r_A(x) \cdot e^{jz_A(x)}$ (8)

$$T_B(x) = p_B(x) \cdot e^{jw_B(x)}, q_B(x) \cdot e^{jy_B(x)}, r_B(x) \cdot e^{jz_B(x)} \tag{9}$$

$$T_{A\oplus B}(x) = \begin{pmatrix} (p_A(x) + p_B(x) - p_A(x)p_B(x)) \\ \cdot e^{j2\pi\left(\frac{w_A(x)}{2\pi} + \frac{w_B(x)}{2\pi} - \frac{w_A(x)w_B(x)}{(2\pi)^2}\right)} \end{pmatrix} \tag{10}$$

$$I_{A\oplus B}(x) = \begin{pmatrix} (q_A(x) + q_B(x)) \\ \cdot e^{j2\pi\left(\frac{y_A(x)}{2\pi} \cdot \frac{y_B(x)}{2\pi}\right)} \end{pmatrix} \tag{11}$$

$$F_{A\oplus B}(x) = \left((r_A(x) + r_B(x)) \cdot e^{j2\pi\left(\frac{z_A(x)}{2\pi} \cdot \frac{z_B(x)}{2\pi}\right)}\right) \tag{12}$$

$$T_{A\otimes B}(x) = \left((p_A(x)p_B(x)) \cdot e^{j2\pi\left(\frac{w_A(x)}{2\pi} \cdot \frac{w_B(x)}{2\pi}\right)}\right) \tag{13}$$

$$I_{A\otimes B}(x) = \begin{pmatrix} (q_A(x) + q_B(x) - q_A(x)q_B(x)) \\ \cdot e^{j2\pi\left(\frac{y_A(x)}{2\pi} + \frac{y_B(x)}{2\pi} - \frac{y_A(x)y_B(x)}{(2\pi)^2}\right)} \end{pmatrix} \tag{14}$$

$$F_{A\otimes B}(x) = \begin{pmatrix} (r_A(x) + r_B(x) - r_A(x)r_B(x)) \\ \cdot e^{j2\pi\left(\frac{z_A(x)}{2\pi} + \frac{z_B(x)}{2\pi} - \frac{Z_A(x)z_B(x)}{(2\pi)^2}\right)} \end{pmatrix} \tag{15}$$

$$\beta T_B(x) = \left(1-\left(1-p_A(x)\right)^{\beta}\right)\cdot e^{j2\pi\left(1-\left(1-\frac{w_A(x)}{2\pi}\right)^{\beta}\right)} \tag{16}$$

$$\beta I_B(x) = \left(\left(q_A(x)\right)^{\beta}\right)\cdot e^{j2\pi\left(\left(\frac{y_A(x)}{2\pi}\right)^{\beta}\right)} \tag{17}$$

$$\beta F_B(x) = \left(\left(r_A(x)\right)^{\beta}\right)\cdot e^{j2\pi\left(\left(\frac{z_A(x)}{2\pi}\right)^{\beta}\right)} \tag{18}$$

$$T_B^{\beta}(x) = \left(\left(p_A(x)\right)^{\beta}\right)\cdot e^{j2\pi\left(\left(\frac{y_A(x)}{2\pi}\right)^{\beta}\right)} \tag{19}$$

$$I_B^{\beta}(x) = \left(1-\left(1-q_A(x)\right)^{\beta}\right)\cdot e^{j2\pi\left(1-\left(1-\frac{y_A(x)}{2\pi}\right)^{\beta}\right)} \tag{20}$$

$$T_B^{\beta}(x) = \left(1-\left(1-r_A(x)\right)^{\beta}\right)\cdot e^{j2\pi\left(1-\left(1-\frac{z_A(x)}{2\pi}\right)^{\beta}\right)} \tag{21}$$

We show the steps of the proposed approach such as:

We evaluate the criteria and alternatives to build the decision matrix using the SVNCS. These numbers are converted to crisp values and the decision matrix is combined. We compute the criteria weights by the average method. Next, we show the steps of the MACONT method.

For the positive and cost criteria, we normalize the decision matrix.

$$r_{ij}^1 = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{22}$$

$$r_{ij}^1 = \frac{1/x_{ij}}{\sum_{i=1}^{m} 1/x_{ij}} \tag{23}$$

$$r_{ij}^2 = \frac{x_{ij}}{\max x_{ij}} \tag{24}$$

$$r_{ij}^2 = \frac{\min x_{ij}}{x_{ij}} \tag{25}$$

$$r_{ij}^3 = \frac{(x_{ij}-\min x_{ij})}{(\max x_{ij}-\min x_{ij})} \tag{26}$$

$$r_{ij}^3 = \frac{(x_{ij}-\max x_{ij})}{(\min x_{ij}-\max x_{ij})} \tag{27}$$

Aggregate the normalized values.

$$A_{ij} = \alpha r_{ij}^1 + \beta r_{ij}^2 + (1-\alpha-\beta) r_{ij}^3 \tag{28}$$

Where $\alpha = \beta = 1/3$

Obtain the distance between reference alternative and every alternative

$$H_1(a_i) = \gamma \frac{p_i}{\sqrt{\sum_{i=1}^{m}(p_i)^2}} + (1-\gamma)\frac{Q_i}{\sqrt{\sum_{i=1}^{m}(q_i)^2}} \tag{29}$$

$$H_2(a_i) = \delta \max\left(w_j\left(A_{ij} - A_j^-\right)\right) + (1-\delta)\min\left(w_j\left(A_{ij} - A_j^-\right)\right) \tag{30}$$

Where A_j^- refers to the average value and the value of δ *and* γ are between 0 and 1.

Obtain the alternative score

$$H(a_i) = \frac{1}{2}\left(H_1(a_i) + \frac{H_2(a_i)}{\sqrt{\sum_{i=1}^{m}\left(H_2(a_i)\right)^2}}\right) \tag{31}$$

3. Case Study

This section shows the case study for Innovative Teaching Begins with Training: Evaluating the Success of Faculty EdTech Programs. This study gathered ten factors and ten options to be evaluated and select the best one as in Fig 1.

Fig 1. Set of datasets.

Three experts use the SVCNS to evaluate the factors and options as in Tables 1-3. These numbers are changed to crip values and combined into a singe matrix as in Fig 2.

The average method is used to obtain the weights of factors as in Fig 3.

Table 1. The first SVCNS.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
A_1	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))
A_2	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))
A_3	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))
A_4	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))
A_5	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))
A_6	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))
A_7	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))
A_8	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))
A_9	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))
A_{10}	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))

Table 2. The second SVCNS.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
A_1	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))
A_2	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))
A_3	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))
A_4	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))
A_5	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))

A6	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))
A7	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))
A8	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))
A9	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))
A10	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))

Table 3. The third SVCNS.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
A1	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))
A2	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))
A3	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))
A4	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))
A5	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))
A6	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))
A7	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))
A8	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))
A9	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))
A10	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))	(0.4ej(0.9π),0.6ej(0.9π),0.6ej(1.0π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.9ej(1.2π),0.2ej(0.6π),0.1ej(0.7π))	(0.2ej(0.8π),0.8ej(1.0π),0.7ej(1.1π))	(0.8ej(1.1π),0.4ej(0.7π),0.4ej(0.8π))	(0.6ej(1.0π),0.5ej(0.8π),0.5ej(0.9π))

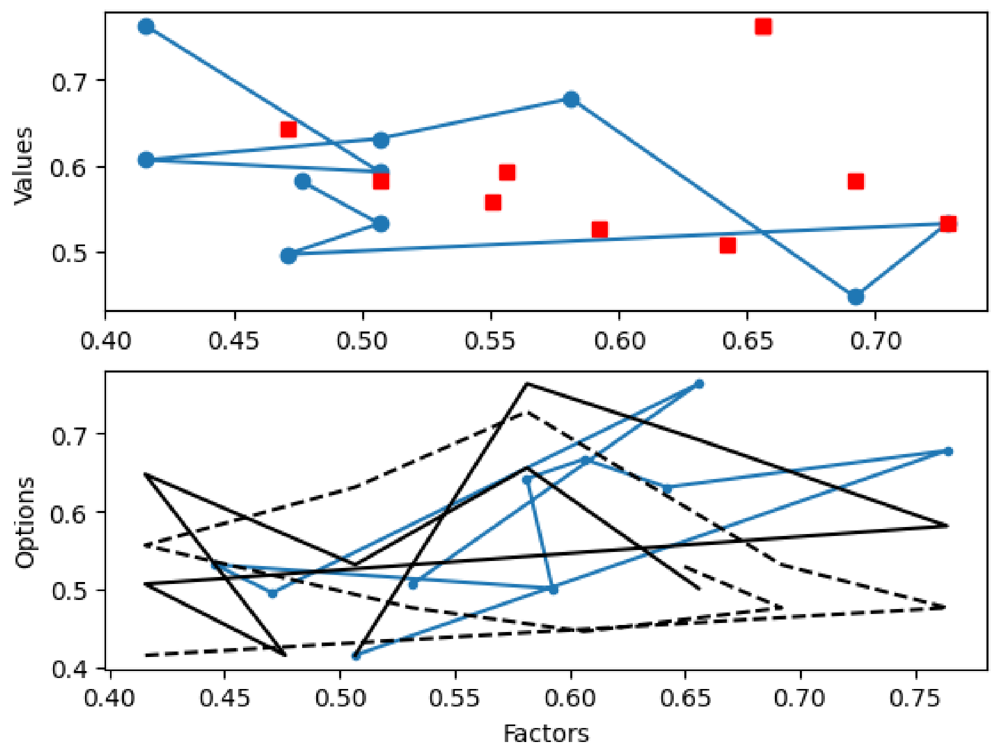

Fig 2. The combined matrix.

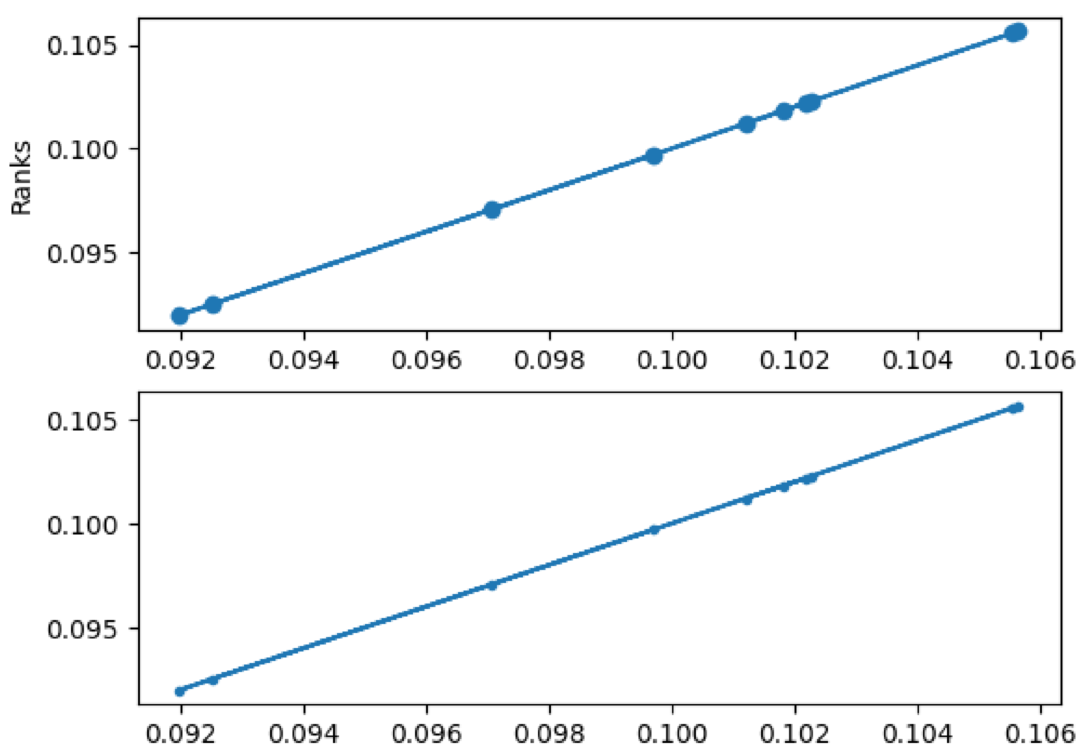

Fig 3. The weights of factors.

Three normalization matrices are computed using Eqs. (22-27) as in Fig 4, 5, and 6.

The aggregated normalized values are computed using eq. (28) as in Fig 7.

We obtain the distance between reference alternative and every alternative using eq. (29 and 30) as in Fig 8 and 9.

Fig 10 shows the comprehensive matrix of alternatives. Eq. (31) is used to obtain the alternative score as shown in Fig 11.

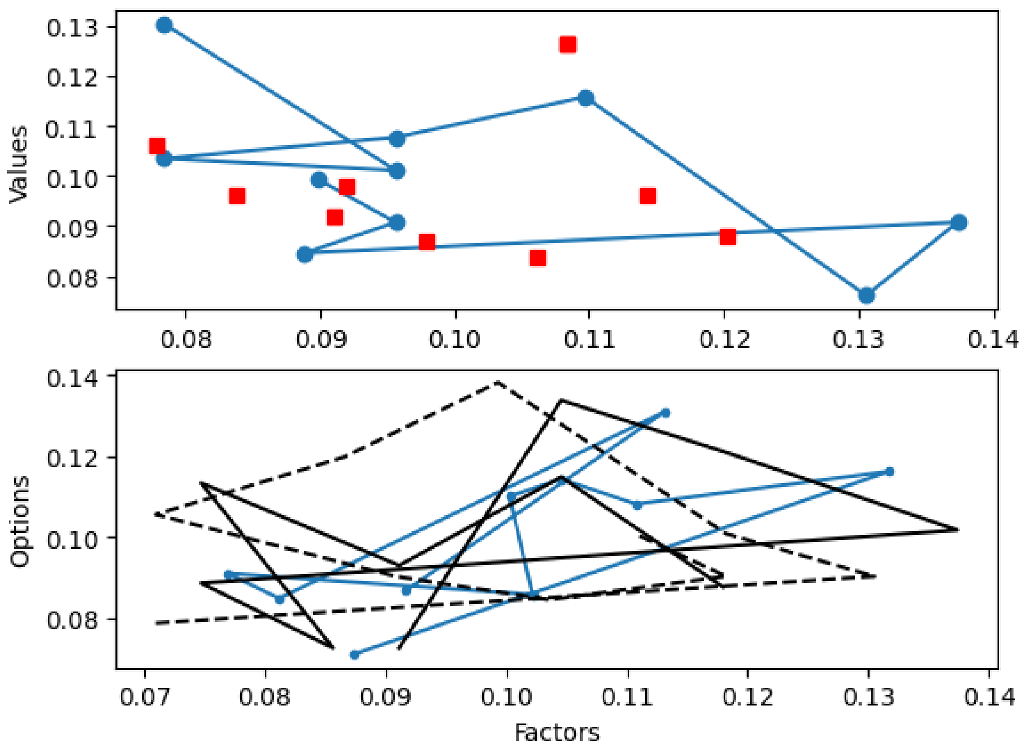

Fig 4. The first normalization matrix.

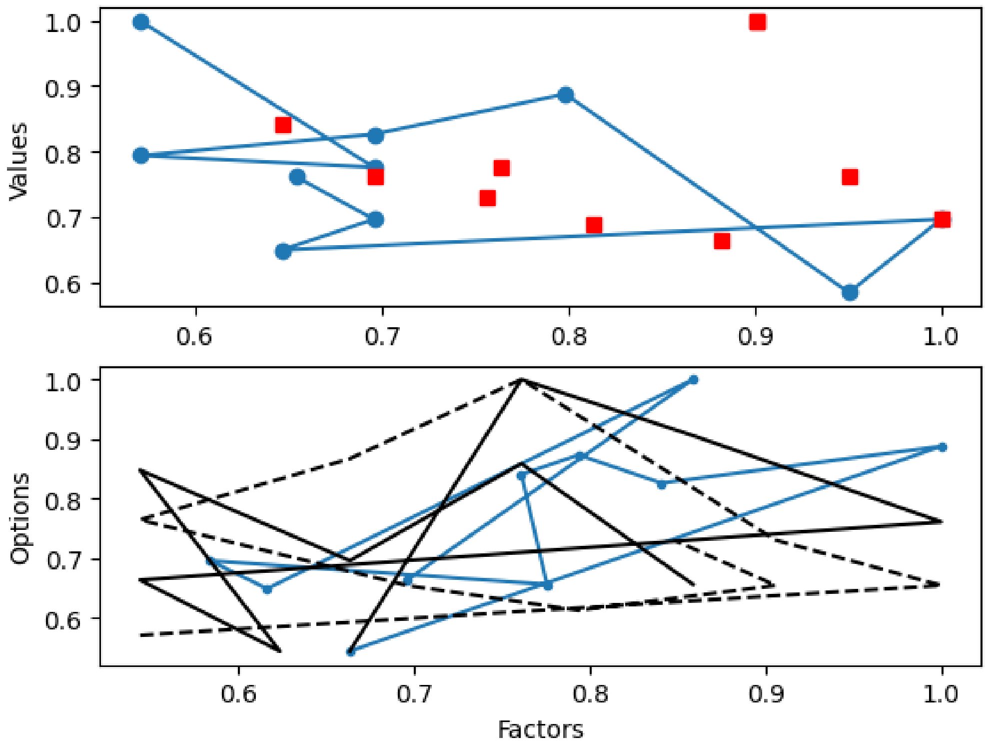

Fig 5. The second normalization matrix.

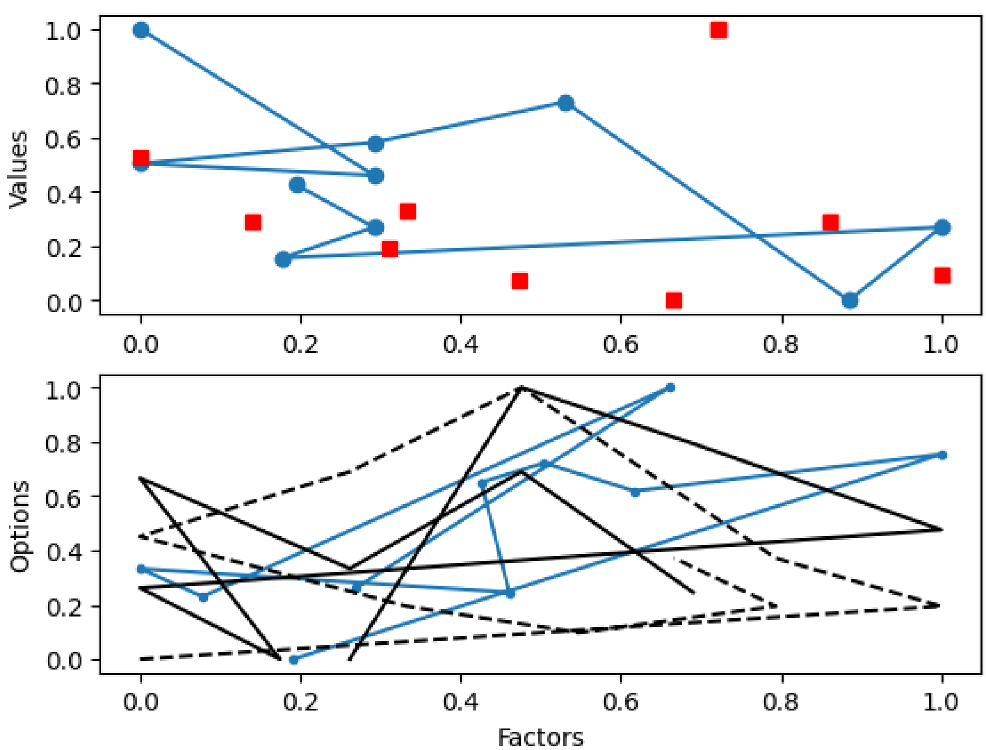

Fig 6. The third normalization matrix.

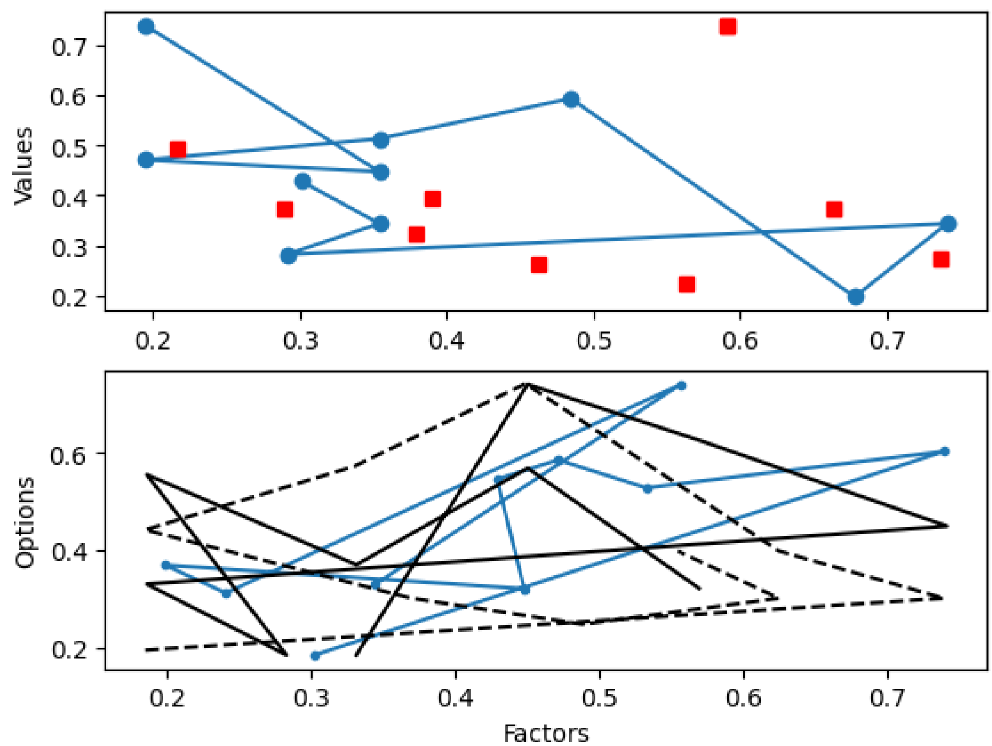

Fig 7. The aggregated normalized values.

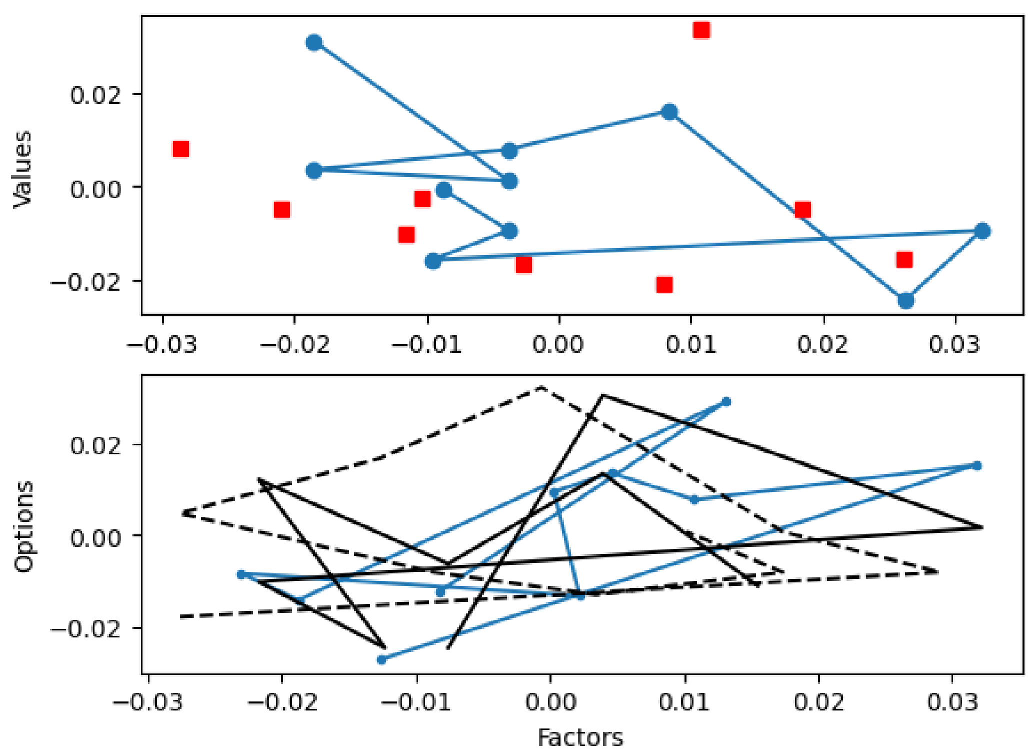

Fig 8. The first values of $H_1(a_i)$.

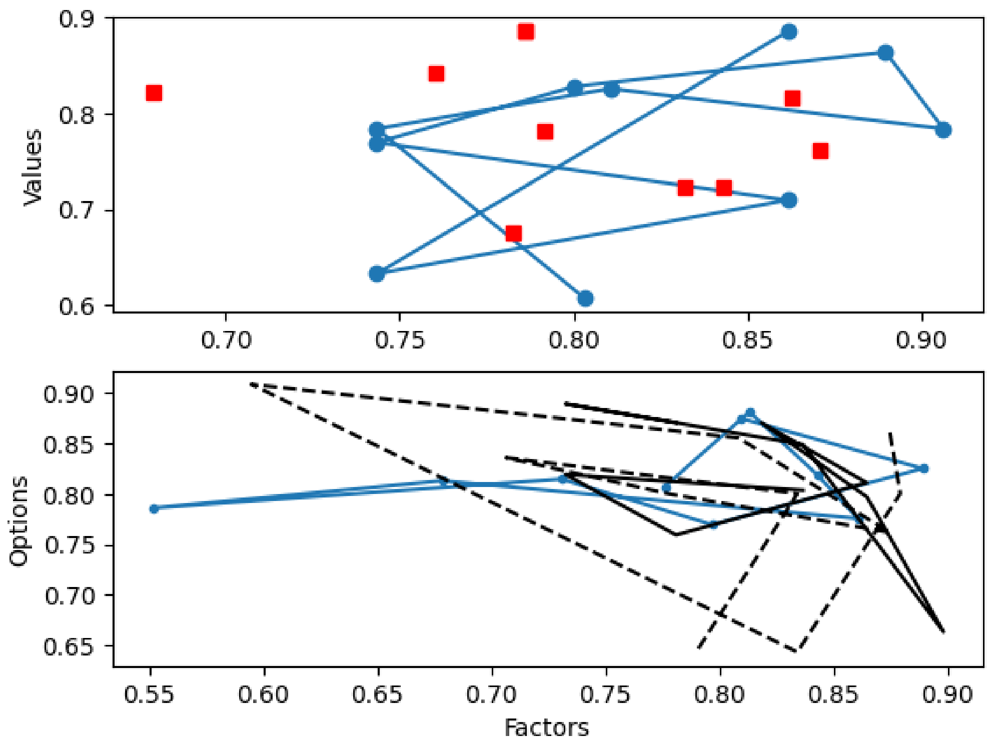

Fig 9. The values of $H_2(a_i)$.

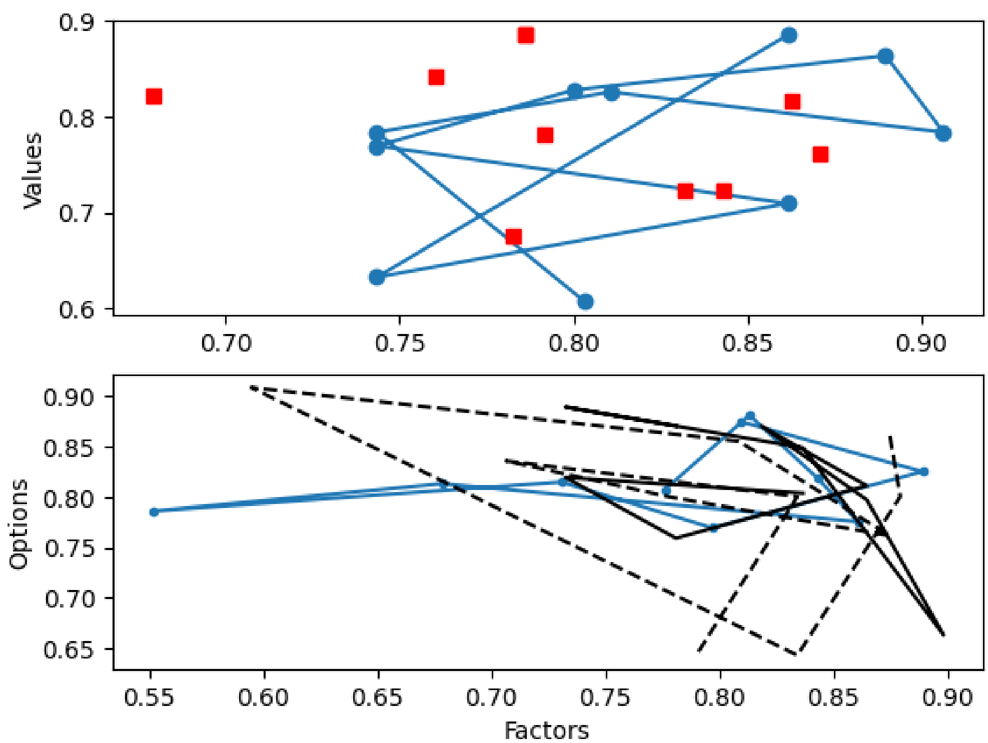

Fig 10. The comprehensive matrix.

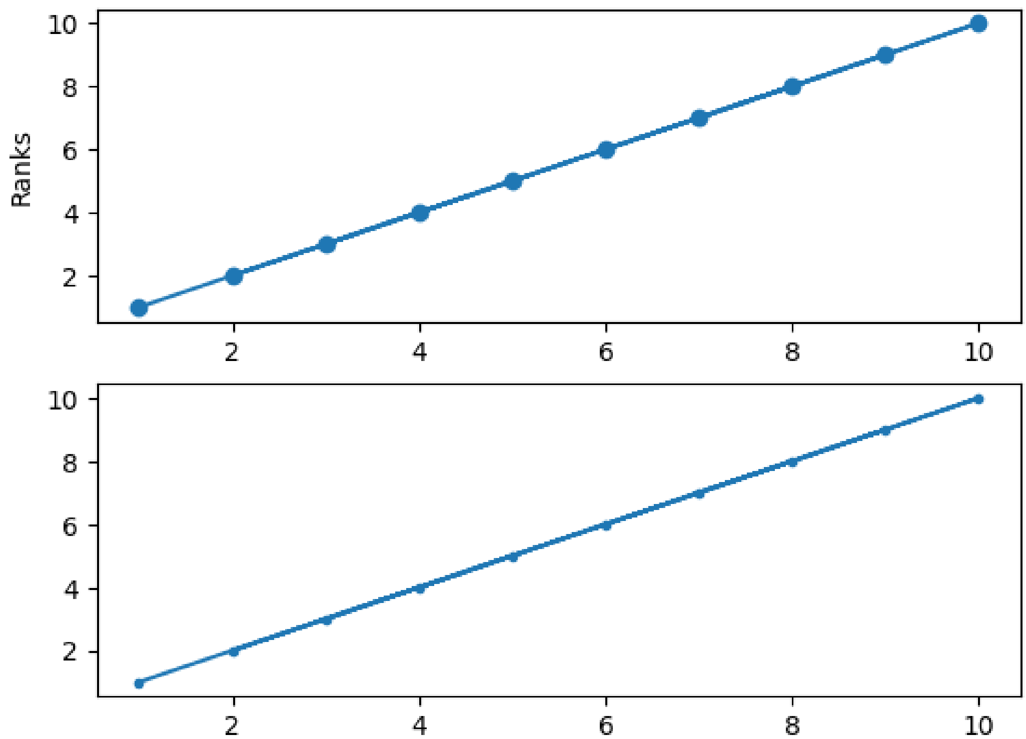

Fig 11. The alternative score.

4. Sensitivity Analysis

A methodological technique called sensitivity analysis is used to ascertain how changes in input parameters impact a model's or decision-making process's output or result. Essentially, it investigates "what if" situations to assist analysts in comprehending the extent to which each input affects the outcome. When handling complicated systems, ambiguity, or multi-criteria decision-making (MCDM) challenges, this method is quite helpful.

Fundamentally, sensitivity analysis enables decision-makers to determine which factors or criteria have the most influence and which have the least. Better resource allocation, enhanced risk management, and more robust model development are made possible by this. By demonstrating how minor variations in the input data may have a big impact on the outcomes, it also draws attention to how strong or weak a model is.

We represent the sensitivity analysis of ten criteria (C1 to C10) across ten different scenarios or cases (Case 1 to Case 10). The values in his study indicate the relative weights assigned to each criterion under each scenario.

The criteria used in a decision-making model, possibly in a Multi-Criteria Decision-Making (MCDM) context. These different scenarios or simulation cases, where the weight distribution of the criteria is slightly modified to test the robustness and stability of the final decision or ranking.

In each case, one criterion is given a higher weight of 0.124, while the others are assigned a uniform lower weight of approximately 0.0973.

- For example:
  - In Case 1, C1 is emphasized with a weight of 0.124.
  - In Case 2, C2 is emphasized instead, and so on until Case 10, where C10 gets the higher weight.

This controlled variation suggests that the analysis is designed to test the sensitivity of the model to changes in individual criteria weights while keeping the total weight constant (sum = 1 in each case).

Understand how changes in the importance of each criterion affect the overall ranking or outcome in a decision-making framework. Identify which criteria have a stronger influence on the final decision. Ensure that the model is robust and not overly sensitive to minor adjustments in weight values. Then we rank the alternatives under different cases.

The ranks of alternatives show cases the ranking results of ten alternatives (C1 to C10) across ten different sensitivity test cases (Case 1 to Case 10).

- C1 consistently ranks 1st across all cases (Case 1 to Case 10). This suggests C1 is the most robust and dominant alternative, unaffected by individual criterion weight changes.
- C10 consistently holds the 6th rank across all cases. It implies C10 maintains moderate performance and is relatively stable in its positioning.
- C6, C7, and C8 show slight variations in ranks but tend to cluster in the middle-to-upper tiers (Ranks 2–5), indicating reliable but slightly weight-sensitive performance.
  - C6 often secures 3rd or 2nd place.
  - C8 hovers around 2nd or 3rd place, showing strong resilience.
  - C7 fluctuates slightly between 4th and 5th place.
- C2, C4, and C9 experience more variation and lower rankings, suggesting that their performance is more sensitive to weight shifts in the criteria.
  - For instance, C2 mostly ranks 9th or 10th.
  - C4 varies between 8th and 10th, indicating performance instability.
  - C9 also fluctuates between 8th and 10th ranks, reinforcing sensitivity.
- The ranking pattern indicates which alternatives are more resilient to changes in evaluation priorities (weights).

- Alternatives like C1, C8, and C6 demonstrate high reliability across different scenarios and are potential top choices regardless of shifting preferences.
- Alternatives like C2, C4, and C9 may only perform well when specific criteria are heavily emphasized, indicating they may not be optimal in general cases.

5. Conclusions

This study highlights the necessity of a structured evaluation framework to assess faculty EdTech training programs. By leveraging the MCDM methodology, universities can identify the most impactful training strategies and allocate resources more effectively. The findings reveal the multifaceted nature of effective training, emphasizing the balance between content relevance, accessibility, engagement, and real-world application. As education continues to evolve in a digital age, sustained investment in high-quality, data-informed training programs will be crucial in ensuring the preparedness and adaptability of faculty across higher education institutions. We used the single valued complex neutrosophic set (SVCNS) to deal with uncertainty information. The SVCNS is used with the MCDM methods. The MACONT method is used to rank the alternatives. Ten criteria and ten alternatives are used to show the validation of the proposed approach.

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