University of New Mexico

Choosing the Best Investment according to the Financial Factors in the Neutrosophic Binary Environment

S.S.Surekha*
*Assistant Professor, Department of Mathematics,
Saveetha Engineering College, Chennai, (TN) India;
surekhasuresh97@gmail.com
*Correspondence: surekhasuresh97@gmail.com

Abstract. Investment analysis is a process of choosing the best investment sector that helps the employee to invest in a good manner. The process is done using the neutrosophic binary sets which contains the contains truth value, indeterminancy and falsehood value. This evaluating process needs experts knowledge and judgments. Neutrosophic binary set theory is a useful technique to capture experts evaluations. This paper proposes the new present worth and future worth analysis techniques with neutrosophic binary sets. An illustrative example shows the applicability of the techniques. Comparison analyses are realized with classical and simplified neutrosophic binary present and future worth techniques. The comparison results show that the proposed techniques helps the employee to choose the best investing sector.

Keywords: Neutrosophic Binary Sets, Neutrosophic Binary Similarity measure, Decision making problems, Investment Sectors.

1. Introduction

The higher returns of the stock market in the past long periods compared to other markets have made this market one of the suitable investment options [25]. Analysis of financial statements can be used to evaluate the performance and predict the future of companies [11]. There are different approaches to achieving this goal [16, 36]. Some believe that horizontal and vertical analyzes of financial statements depict a definite trend in a company's financial situation and provide appropriate information about the activities of the company in question [13]. Another approach is to use financial statements for short-term and long-term evaluations of a company's situation, which is critical to focus on parts of the financial statements according to each type of evaluation [18, 38].

For this reason, a different category can be assigned to the analysis of financial statements [20, 28]. Using financial ratio analysis techniques, a better understanding of the financial situation of companies can be obtained. Usually, the calculation of financial ratios is straightforward, but the analysis of these ratios is essential [8, 22]. Analyzing financial statements using some ratios is actually an effort to evaluate the strengths and weaknesses of a company by examining the figures stated in the reports. In addition, it was compared to the same ratio last year and with similar ratios in competing companies [29]. These comparisons show the trend of the company's situation during different periods as well as the strength of the company's competition with other companies in its industry. Therefore, investors need to choose the right investment sector, and financial ratios can help investors in this matter [10]. In the MCDM context, the ratings of the options provided by decision-makers can be expressed with the Neutrosophic binary Set Theory.

Fuzzy sets theory has been widely and successfully applied in many different areas to handle such uncertainty [35]. Nevertheless, it presents limitations to dealing with imprecise and vague information when various sources of vagueness appear simultaneously [23]. Between 2019-2024 Smarandache[32] introduced sixteen new types of topologies: Non Standard Topology, Largest Extended Non Standard Real Topology, Neutrosophic Triplet Weak/Strong Topologies, Neutrosophic Extended Triplet Weak/Strong Topologies, Neutrosophic Duplet Topology, Neutrosophic Extended Duplet Topology, Neutrosophic MultiSet Topology, NonStandard Neutrosophic Topology, NeutroTopology, AntiTopology, Refined Neutrosophic Topology, Refined Neutrosophic Crisp Topology, SuperHyperTopology, and Neutrosophic SuperHyperTopology. Smarandache [31, 41] germinated the notion of having a neutrosophic set (NS) holding three different fundamental elements (i) truth, (ii) indeterminate, and (iii) falsity. Each attribute of the neutrosophic sets is relevant to our real-life models [6]. The most exciting point is that all these three functions are entirely independent, and one function is not affected by another [30]. These NSs can handle indeterminate and inconsistent information quite well. Since NSs are difficult to apply in real engineering problems and scientific applications, a subclass of NS has been proposed by Wang et al. [37]. These sets are called single-valued neutrosophic sets. SVNSs are well suited for handling ambiguous, incomplete, imprecise information [21]. Since its appearance and the ability to tackle the indeterminacy at the initial stage of data, SVNS is one of the hot topics to tackle the DMPs [12]. SVNS is one of the most favorable environments to access the alternatives [7]. Ratings of criteria of decision problems can be expressed using linguistic variables that can be transformed into SVNNs [1]. Moreover, many information measures for the SVNS model have been proposed over the years, such as similarity, distance, entropy, inclusion, and correlation coefficients [5]. Many scholars and researchers have continuously proposed new similarity measures for fuzzy-based models, including the SVNS model,

and applied these measures to solve various practical problems related to MCDM [24]. In some real applications and related fields, the researcher uses similarity measure, an important mathematical tool [7].
In todays world, it is hard to tackle with a single universal set. For this purpose, two universal sets that is neutrosophic binary sets which was proposed by Surekha, Elekiah and Sindhu in 2022 [38] was used to solve the decision making problems. Neutrosophic binary sets helps the employees understand the investment analysis in a good manner. As choosing the suitable sector for investment is an MCDM one, including various factors and uncertainty, this article has addressed the idea of choosing that by considering the practical factors as the problem criteria in a neutrosophic binary environment.

2. **Preliminaries**

Definition 2.1. [38] A Neutrosophic binary topology from X to Y is a binary structure $M_{\mathcal{N}} \subseteq P(X) \times P(Y)$ that satisfies the following conditions:

(1) $(0_X, 0_Y) \in M_{\mathcal{N}}$ and $1_X, 1_Y \in M_{\mathcal{N}}$.
(2) $(A_1 \cap A_2, B_1 \cap B_2) \in M_{\mathcal{N}}$ whenever $(A_1, B_1) \in M_{\mathcal{N}}$ and $(A_2, B_2) \in M_{\mathcal{N}}$.
(3) If $(A_\alpha, B_\alpha)_{\alpha \in A}$ is a family of members of $M_{\mathcal{N}}$, then $(\cup_{\alpha \in A} A_\alpha, \cup_{\alpha \in A} B_\alpha) \in M_{\mathcal{N}}$.

The triplet $(\mathcal{X}, \mathcal{Y}, M_{\mathcal{N}})$ is called Neutrosophic Binary Topological space. The members of $M_{\mathcal{N}}$ are called the neutrosophic binary open sets and the complement of neutrosophic binary open sets are called the neutrosophic binary closed sets in the binary topological space $(\mathcal{X}, \mathcal{Y}, M_{\mathcal{N}})$.

Definition 2.2. [38] $(0_X, 0_Y)$ can be defined as
(0_1) $0_X = \{< x, 0, 0, 1 >: x \in X\}$, $0_Y = \{< y, 0, 0, 1 >: y \in Y\}$
(0_2) $0_X = \{< x, 0, 1, 1 >: x \in X\}$, $0_Y = \{< y, 0, 1, 1 >: y \in Y\}$
(0_3) $0_X = \{< x, 0, 1, 0 >: x \in X\}$, $0_Y = \{< y, 0, 1, 0 >: y \in Y\}$
(0_4) $0_X = \{< x, 0, 0, 1 >: x \in X\}$, $0_Y = \{< y, 0, 0, 0 >: y \in Y\}$

$(1_X, 1_Y)$ can be defined as
(1_1) $1_X = \{< x, 1, 0, 0 >: x \in X\}$, $1_Y = \{< y, 1, 0, 0 >: y \in Y\}$
(1_2) $1_X = \{< x, 1, 0, 1 >: x \in X\}$, $1_Y = \{< y, 1, 0, 1 >: y \in Y\}$
(1_3) $1_X = \{< x, 1, 1, 0 >: x \in X\}$, $1_Y = \{< y, 1, 1, 0 >: y \in Y\}$
(1_4) $1_X = \{< x, 1, 1, 1 >: x \in X\}$, $1_Y = \{< y, 1, 1, 1 >: y \in Y\}$

Definition 2.3. [38] Let $(A, B) = \{< \mu_A, \sigma_A, \gamma_A >, < \mu_B, \sigma_B, \gamma_B >\}$ be a neutrosophic binary set on $(\mathcal{X}, \mathcal{Y}, M_{\mathcal{N}})$, then the complement of the set $C(A, B)$ may be defined as

$$(C_1) \quad C(A,B) = \{x, < 1-\mu_A(x), \sigma_A(x), 1-\gamma_A(x) >: x \in X,$$
$$< y, 1-\mu_B(y), \sigma_B(y), 1-\gamma_B(y) >: y \in Y\}$$
$$(C_2) \quad C(A,B) = \{x, < \gamma_A(x), \sigma_A(x), \mu_A(x) >: x \in X,$$
$$< y, \gamma_B(y), \sigma_B(y), \mu_B(y) >: y \in Y\}$$
$$(C_3) \quad C(A,B) = \{x, < \gamma_A(x), 1-\sigma_A(x), \mu_A(x) >: x \in X,$$
$$< y, \gamma_B(y), 1-\sigma_B(y), \mu_B(y) >: y \in Y\}$$

Definition 2.4. [38] Let (A, B) and (C, D) be two neutrosophic binary sets which is in the form
$(A, B) = \{< \mu_A, \sigma_A, \gamma_A >, < \mu_B, \sigma_B, \gamma_B >\}$ and
$(C, D) = \{< \mu_C, \sigma_C, \gamma_C >, < \mu_D, \sigma_D, \gamma_D >\}$.
Then $(A, B) \subseteq (C, D)$ can be defined as

(1) $(A, B) \subseteq (C, D) \iff \mu_A(x) \leq \mu_C(x), \sigma_A(x) \leq \sigma_C(x), \gamma_A(x) \geq \gamma_C(x) \forall x \in X$
$\mu_B(X) \leq \mu_D(x), \sigma_B(x) \leq \sigma_D(x), \gamma_B(x) \geq \gamma_D(x) \forall y \in Y$
(2) $(A, B) \subseteq (C, D) \iff \mu_A(X) \leq \mu_C(x), \sigma_A(x) \geq \sigma_C(x), \gamma_A(x) \geq \gamma_C(x) \forall x \in X$
$\mu_B(X) \leq \mu_D(x), \sigma_B(x) \geq \sigma_D(x), \gamma_B(x) \geq \gamma_D(x) \forall y \in Y$

Definition 2.5. [38] Let (A, B) and (C, D) be two neutrosophic binary sets which is in the form
$(A, B) = \{< \mu_A, \sigma_A, \gamma_A >, < \mu_B, \sigma_B, \gamma_B >\}$ and
$(C, D) = \{< \mu_C, \sigma_C, \gamma_C >, < \mu_D, \sigma_D, \gamma_D >\}$.
(1) $(A, B) \cap (C, D)$ can be defined as

$$(A,B) \cap (C,D) = \{ < x, \mu_A(x) \wedge \mu_C(x), \sigma_A(x) \wedge \sigma_C(x), \gamma_A(x) \vee \gamma_A(x) >$$
$$< x, \mu_A(x) \wedge \mu_C(x), \sigma_A(x) \wedge \sigma_C(x), \gamma_A(x) \vee \gamma_A(x) >\}$$

$$(A,B) \cap (C,D) = \{ < x, \mu_A(x) \wedge \mu_C(x), \sigma_A(x) \vee \sigma_C(x), \gamma_A(x) \vee \gamma_A(x) >$$
$$< x, \mu_A(x) \wedge \mu_C(x), \sigma_A(x) \vee \sigma_C(x), \gamma_A(x) \vee \gamma_A(x) >\}$$

(2) $(A, B) \cup (C, D)$ can be defined as

$$(A,B) \cup (C,D) = \{ < x, \mu_A(x) \vee \mu_C(x), \sigma_A(x) \vee \sigma_C(x), \gamma_A(x) \wedge \gamma_A(x) >$$
$$< x, \mu_A(x) \vee \mu_C(x), \sigma_A(x) \vee \sigma_C(x), \gamma_A(x) \wedge \gamma_A(x) >\}$$

$$(A,B) \cap (C,D) = \{ < x, \mu_A(x) \vee \mu_C(x), \sigma_A(x) \wedge \sigma_C(x), \gamma_A(x) \wedge \gamma_A(x) >$$
$$< x, \mu_A(x) \vee \mu_C(x), \sigma_A(x) \wedge \sigma_C(x), \gamma_A(x) \wedge \gamma_A(x) >\}$$

Definition 2.6 (5)**.** Let A and B be the two neutrosophic sets over the universe X.The neutrosophic similarity measure based on set theoretic approach is defined by
$S(A,B) = S_T(A,B), S_I(A,B), S_F(A,B)$, where

$$S_T(A,B) = \frac{1}{n}\left[\frac{\sum_{i=1}^{n}[(T_A(x_i) \wedge (T_B(x_i)]}{\sum_{i=1}^{n}[T_A(x_i) \vee T_B(x_i)]}\right] \implies \text{Degree of similarity}$$

$$S_I(A,B) = 1 - \frac{1}{n}\left[\frac{\sum_{i=1}^{n}[(I_A(x_i) \wedge (I_B(x_i)]}{\sum_{i=1}^{n}[I_A(x_i) \vee I_B(x_i)]}\right] \implies \text{Degree of Indeterminancy}$$

$$S_F(A,B) = 1 - \frac{1}{n}\left[\frac{\sum_{i=1}^{n}[(F_A(x_i) \wedge (F_B(x_i)]}{\sum_{i=1}^{n}[F_A(x_i) \vee F_B(x_i)]}\right] \implies \text{Degree of non-similarity}$$

3. **Similarity measure based on set theoretic approach**

Definition 3.1. Let $\mathcal{S_U} = \{u_1, u_2, ..., u_n\}$ and $\mathcal{S_V} = \{v_1, v_2, ..., v_n\}$ be the two universal sets. Let (I_1, I_2) and (J_1, J_2) be the two neutrosophic binary sets over the universe $\mathcal{S_U} \times \mathcal{S_V}$. The neutrosophic binary similarity measure based on set theoretic approach is denoted by $S^M[(I_1, I_2), (J_1, J_2)]$ and is defined by
$S^M[(I_1, I_2), (J_1, J_2)] = S^M_\mu[(I_1, I_2), (J_1, J_2)], S^M_\sigma[(I_1, I_2), (J_1, J_2)], S^M_\gamma[(I_1, I_2), (J_1, J_2)]$, For all $u_i \in \mathcal{S_U}$ and $v_j \in \mathcal{S_V}$

$$S^M_\mu[(I_1, I_2), (J_1, J_2)] = \frac{1}{n}\left[\frac{\sum_{i=1}^{n}[(\mu_{I_1}(u_i) \wedge (\mu_{J_1}(u_i)]}{\sum_{i=1}^{n}[[(\mu_{I_1}(u_i) \vee (\mu_{J_1}(u_i)]} + \frac{\sum_{j=1}^{n}[(\mu_{I_2}(v_j) \wedge (\mu_{J_2}(v_j)]}{\sum_{j=1}^{n}[(\mu_{I_2}(v_j) \vee (\mu_{J_2}(v_j)]}\right]$$

$$S^M_\sigma[(I_1, I_2), (J_1, J_2)] = 1 - \frac{1}{n}\left[\frac{\sum_{i=1}^{n}[(\sigma_{I_1}(u_i) \wedge (\sigma_{J_1}(u_i)]}{\sum_{i=1}^{n}[[(\sigma_{I_1}(u_i) \vee (\sigma_{J_1}(u_i)]} + \frac{\sum_{j=1}^{n}[(\sigma_{I_2}(v_j) \wedge (\sigma_{J_2}(v_j)]}{\sum_{j=1}^{n}[(\sigma_{I_2}(v_j) \vee (\sigma_{J_2}(v_j)]}\right]$$

$$S^M_\gamma[(I_1, I_2), (J_1, J_2)] = 1 - \frac{1}{n}\left[\frac{\sum_{i=1}^{n}[(\gamma_{I_1}(u_i) \wedge (\gamma_{J_1}(u_i)]}{\sum_{i=1}^{n}[[(\gamma_{I_1}(u_i) \vee (\gamma_{J_1}(u_i)]} + \frac{\sum_{j=1}^{n}[(\gamma_{I_2}(v_j) \wedge (\gamma_{J_2}(v_j)]}{\sum_{j=1}^{n}[(\gamma_{I_2}(v_j) \vee (\gamma_{J_2}(v_j)]}\right]$$

Here, $S_\mu^M[(I_1, I_2), (J_1, J_2)]$ denotes the degree of similarity where the truth membership values are considered, $S_\sigma^M[(I_1, I_2), (J_1, J_2)]$ denotes the degree of indeterminancy where the indeterminant values are considered and $S_\gamma^M[(I_1, I_2), (J_1, J_2)]$ denotes the degree of non-similarity where the false membership values are considered.

Theorem 3.2 (**Axioms of Similarity**). *For the neutrosophic binary sets (I_1, I_2), (J_1, J_2) and (K_1, K_2) over the universe $\mathcal{S_U} \times \mathcal{S_V}$, the following are true:*

[label=()]$S^M[(I_1, I_2), (J_1, J_2)] = S^M[(J_1, J_2), (I_1, I_2)]$. $0 \leq S^M[(I_1, I_2), (J_1, J_2)] \leq 1$. $S^M[(I_1, I_2), (J_1, J_2)] = 1$ if and only if $(I_1, I_2) = (J_1, J_2)$. Let $(I_1, I_2) \subseteq (J_1, J_2) \subseteq (K_1, K_2)$, then $S^M[(I_1, I_2), (J_1, J_2)] \geq S^M[(I_1, I_2), (K_1, K_2)]$ and $S^M[(J_1, J_2), (K_1, K_2)] \geq S^M[(I_1, I_2), (K_1, K_2)]$.

(3) *Proof.* The proof for (i), (ii) and (iii) are obvious from the definition 3.1.

Let $(I_1, I_2) \subseteq (J_1, J_2) \subseteq (K_1, K_2)$.

For all $u_i \in \mathcal{S_U}$ and $v_j \in \mathcal{S_V}$

$\mu_{I_1}(u_i) \leq \mu_{J_1}(u_i) \leq \mu_{K_1}(u_i)$; $\mu_{I_2}(v_j) \leq \mu_{J_2}(v_j) \leq \mu_{K_2}(v_j)$.

$\sigma_{I_1}(u_i) \geq \sigma_{J_1}(u_i) \geq \sigma_{K_1}(u_i)$; $\sigma_{I_2}(v_j) \geq \sigma_{J_2}(v_j) \geq \sigma_{K_2}(v_j)$.

$\gamma_{I_1}(u_i) \geq \gamma_{J_1}(u_i) \geq \gamma_{K_1}(u_i)$; $\gamma_{I_2}(v_j) \geq \gamma_{J_2}(v_j) \geq \gamma_{K_2}(v_j)$.

Now, for all $u_i \in \mathcal{S_U}$ and $v_j \in \mathcal{S_V}$

$$\frac{\mu_{I_1}(u_i) \wedge \mu_{J_1}(u_i)}{\mu_{I_1}(u_i) \vee \mu_{J_1}(u_i)} + \frac{\mu_{I_2}(v_j) \wedge \mu_{J_2}(v_j)}{\mu_{I_2}(v_j) \vee \mu_{J_2}(v_j)} = \frac{\mu_{I_1}(u_i)}{\mu_{J_1}(u_i)} + \frac{\mu_{I_2}(v_j)}{\mu_{J_2}(v_j)}$$

$$\frac{\mu_{I_1}(u_i) \wedge \mu_{K_1}(u_i)}{\mu_{I_1}(u_i) \vee \mu_{K_1}(u_i)} + \frac{\mu_{I_2}(v_j) \wedge \mu_{K_2}(v_j)}{\mu_{I_2}(v_j) \vee \mu_{K_2}(v_j)} = \frac{\mu_{I_1}(u_i)}{\mu_{K_1}(u_i)} + \frac{\mu_{I_2}(v_j)}{\mu_{K_2}(v_j)}$$

$$\frac{\mu_{J_1}(u_i) \wedge \mu_{K_1}(u_i)}{\mu_{J_1}(u_i) \vee \mu_{K_1}(u_i)} + \frac{\mu_{J_2}(v_j) \wedge \mu_{K_2}(v_j)}{\mu_{J_2}(v_j) \vee \mu_{K_2}(v_j)} = \frac{\mu_{J_1}(u_i)}{\mu_{K_1}(u_i)} + \frac{\mu_{J_2}(v_j)}{\mu_{K_2}(v_j)}$$

Therefore,

$$\left[\frac{\mu_{I_1}(u_i)}{\mu_{K_1}(u_i)} + \frac{\mu_{I_2}(v_j)}{\mu_{K_2}(v_j)}\right] = \left[\frac{\mu_{J_1}(u_i)}{\mu_{K_1}(u_i)} + \frac{\mu_{J_2}(v_j)}{\mu_{K_2}(v_j)}\right] + \left[\frac{\mu_{I_1}(u_i) - \mu_{J_1}(u_i)}{\mu_{K_1}(u_i)} + \frac{\mu_{I_2}(v_j) - \mu_{J_2}(v_j)}{\mu_{K_2}(v_j)}\right]$$
$$\leq \left[\frac{\mu_{J_1}(u_i)}{\mu_{K_1}(u_i)} + \frac{\mu_{J_2}(v_j)}{\mu_{K_2}(v_j)}\right] \quad (1)$$

Also, since $\mu_{J_1}(u_i) \leq \mu_{K_1}(u_i)$ and $\mu_{J_2}(v_j) \leq \mu_{K_2}(v_j)$,

$$\frac{\mu_{I_1}(u_i)}{\mu_{K_1}(u_i)} + \frac{\mu_{I_2}(v_j)}{\mu_{K_2}(v_j)} \leq \frac{\mu_{I_1}(u_i)}{\mu_{J_1}(u_i)} + \frac{\mu_{I_2}(v_j)}{\mu_{J_2}(v_j)} \quad (2)$$

From (1) and (2),

$$\frac{\mu_{I_1}(u_i)}{\mu_{J_1}(u_i)} + \frac{\mu_{I_2}(v_j)}{\mu_{J_2}(v_j)} \geq \frac{\mu_{I_1}(u_i)}{\mu_{K_1}(u_i)} + \frac{\mu_{I_2}(v_j)}{\mu_{K_2}(v_j)}$$

Therefore, $S_{\mu}^{M}[(I_1,I_2),(J_1,J_2)] \geq S_{\mu}^{M}[(I_1,I_2),(K_1,K_2)]$.

Now,

$$\begin{aligned} S_{\sigma}^{M}[(I_1,I_2),(K_1,K_2)] &= 1-\left[\frac{\sigma_{I_1}(u_i)\wedge\sigma_{K_1}(u_i)}{\sigma_{I_1}(u_i)\vee\sigma_{K_1}(u_i)}+\frac{\sigma_{I_2}(v_j)\wedge\sigma_{K_2}(v_j)}{\sigma_{I_2}(v_j)\vee\sigma_{K_2}(v_j)}\right] \\ &= 1-\left[\frac{\sigma_{K_1}(u_i)}{\sigma_{I_1}(u_i)}+\frac{\sigma_{K_2}(v_j)}{\sigma_{I_2}(v_j)}\right] \\ &\geq 1-\left[\frac{\sigma_{J_1}(u_i)}{\sigma_{I_1}(u_i)}+\frac{\sigma_{J_2}(v_j)}{\sigma_{I_2}(v_j)}\right] \\ &[\text{Since},\sigma_{K_1}(u_i)\leq\sigma_{J_1}(u_i);\sigma_{K_2}(v_j)\leq\sigma_{J_2}(v_j)] \end{aligned}$$

This implies that, $S_{\sigma}^{M}[(I_1,I_2),(J_1,J_2)] \leq S_{\mu}^{M}[(I_1,I_2),(K_1,K_2)]$.

Similarly, $S_{\gamma}^{M}[(I_1,I_2),(J_1,J_2)] \leq S_{\gamma}^{M}[(I_1,I_2),(K_1,K_2)]$.

Hence, $S^{M}[(I_1,I_2),(J_1,J_2)] \geq S^{M}[(I_1,I_2),(K_1,K_2)]$, where

$$\begin{aligned} S^{M}[(I_1,I_2),(J_1,J_2)] &= (S_{\mu}^{M}[(I_1,I_2),(J_1,J_2)],S_{\sigma}^{M}[(I_1,I_2),(J_1,J_2)], \\ &\quad S_{\gamma}^{M}[(I_1,I_2),(J_1,J_2)]) \\ S^{M}[(I_1,I_2),(K_1,K_2)] &= (S_{\mu}^{M}[(I_1,I_2),(K_1,K_2)],S_{\sigma}^{M}[(I_1,I_2),(K_1,K_2)], \\ &\quad S_{\gamma}^{M}[(I_1,I_2),(K_1,K_2)]) \end{aligned}$$

. Similarly, $S_{\gamma}^{M}[(J_1,J_2),(K_1,K_2)] \geq S_{\gamma}^{M}[(I_1,I_2),(K_1,K_2)]$. □

4. Methodology

Let $M_1,M_2,...,M_n$ be the set of male employees and $F_1,F_2,...,F_n$ be the set of female employees; $I_{M_1},I_{M_2},...,I_{M_n}$ be the criteria (investment) of male employees and $I_{F_1},I_{F_2},...,I_{F_n}$ be the criteria (investment) of female employees; $J_{M_1},J_{M_2},...,J_{M_n}$ be the alternatives of male employees and $J_{F_1},J_{F_2},...,J_{F_n}$ be the alternatives of female employees. The ranking of the alternatives is based on the ideas of the employees against the investment chosen by them. This ranking method will be performed by the decision makers. For a MADM problem, the values associated with the alternatives of male and female employees can be represented in a decision matrix which is shown in table 1, table 2.

Here ϕ_{ij} and ψ_{ij} represents the neutrosophic binary sets.

The algorithm for this method is demonstrated below:

Step 1: Deliberate the association between the employees and the attributes.

	(J_{M_1}, J_{F_1})	(J_{M_2}, J_{F_2})	$\ldots$	$\ldots$	(J_{M_n}, J_{F_n})
(M_1, F_1)	ϕ_{11}	ϕ_{12}	$\ldots$	$\ldots$	ϕ_{1n}
(M_2, F_2)	ϕ_{21}	ϕ_{22}	$\ldots$	$\ldots$	ϕ_{2n}
$\vdots$	$\vdots$	$\vdots$	$\ldots$	$\ldots$	$\vdots$
$\vdots$	$\vdots$	$\vdots$	$\ldots$	$\ldots$	$\vdots$
(M_n, F_n)	ϕ_{n1}	ϕ_{n2}	$\ldots$	$\ldots$	ϕ_{nn}

Table 1. The relation between employees and attributes

	(I_{M_1}, I_{F_1})	(I_{M_2}, I_{F_2})	$\ldots$	$\ldots$	(I_{M_n}, I_{F_n})
(J_{M_1}, J_{F_1})	ψ_{11}	ψ_{12}	$\ldots$	$\ldots$	ψ_{1n}
(J_{M_2}, J_{F_2})	ψ_{21}	ψ_{22}	$\ldots$	$\ldots$	ψ_{2n}
$\vdots$	$\vdots$	$\vdots$	$\ldots$	$\ldots$	$\vdots$
$\vdots$	$\vdots$	$\vdots$	$\ldots$	$\ldots$	$\vdots$
(J_{M_n}, J_{F_n})	ψ_{n1}	ψ_{n2}	$\ldots$	$\ldots$	ψ_{nn}

Table 2. The relation between attributes and alternatives

	(J_{M_1}, J_{F_1})	(J_{M_2}, J_{F_2})	$\ldots$	$\ldots$	(J_{M_n}, J_{F_n})
(M_1, F_1)	$< \mu_{11}(x_i^\star), \sigma_{11}(x_i^\star),$ $\gamma_{11}(x_i^\star) >, < \mu_{11}(y_i^\star),$ $\sigma_{11}(y_i^\star), \gamma_{11}(y_i^\star) >$	$< \mu_{12}(x_i^\star), \sigma_{12}(x_i^\star),$ $\gamma_{12}(x_i^\star) >, < \mu_{12}(y_i^\star),$ $\sigma_{12}(y_i^\star), \gamma_{12}(y_i^\star) >$	$\ldots$	$\ldots$	$< \mu_{1n}(x_i^\star), \sigma_{1n}(x_i^\star),$ $\gamma_{1n}(x_i^\star) >, < \mu_{1n}(y_i^\star),$ $\sigma_{1n}(y_i^\star), \gamma_{1n}(y_i^\star) >$
(M_2, F_2)	$< \mu_{21}(x_i^\star), \sigma_{21}(x_i^\star),$ $\gamma_{21}(x_i^\star) >, < \mu_{21}(y_i^\star),$ $\sigma_{21}(y_i^\star), \gamma_{21}(y_i^\star) >$	$< \mu_{22}(x_i^\star), \sigma_{22}(x_i^\star),$ $\gamma_{22}(x_i^\star) >, < \mu_{22}(y_i^\star),$ $\sigma_{22}(y_i^\star), \gamma_{22}(y_i^\star) >$	$\ldots$	$\ldots$	$< \mu_{2n}(x_i^\star), \sigma_{2n}(x_i^\star),$ $\gamma_{2n}(x_i^\star) >, < \mu_{2n}(y_i^\star),$ $\sigma_{2n}(y_i^\star), \gamma_{2n}(y_i^\star) >$
$\ldots$	$\ldots$	$\ldots$	$\ldots$	$\ldots$	$\ldots$
(M_n, F_n)	$< \mu_{n1}(x_i^\star), \sigma_{n1}(x_i^\star),$ $\gamma_{n1}(x_i^\star) >, < \mu_{n1}(y_i^\star),$ $\sigma_{n1}(y_i^\star), \gamma_{n1}(y_i^\star) >$	$< \mu_{n2}(x_i^\star), \sigma_{n2}(x_i^\star),$ $\gamma_{n2}(x_i^\star) >, < \mu_{n2}(y_i^\star),$ $\sigma_{n2}(y_i^\star), \gamma_{n2}(y_i^\star) >$	$\ldots$	$\ldots$	$< \mu_{nn}(x_i^\star), \sigma_{nn}(x_i^\star),$ $\gamma_{nn}(x_i^\star) >, < \mu_{nn}(y_i^\star),$ $\sigma_{nn}(y_i^\star), \gamma_{nn}(y_i^\star) >$

Step 2: Deliberate the association between the attributes and the alternatives.

Step:3 Deliberate the similarity measure using the formula $S_M[(I_1, I_2), (J_1, J_2)]$ as proposed in the definition 3.1.

Step:4 Ranking of alternatives.

The alternatives are ranked by the decision makers and it is ranked in inclined form of similarity measure $S_M[(I_1, I_2), (J_1, J_2)]$. The towering value of the similarity measure gives the best alternative.

	(I_{M_1}, I_{F_1})	(I_{M_2}, I_{F_2})	$\dots\ \dots$	$(I_{\mathcal{M}_\mathcal{N}}, I_{F_n})$
(J_{M_1}, J_{F_1})	$< \mu_{11}(x_i^\star), \sigma_{11}(x_i^\star),$ $\gamma_{11}(x_i^\star) >, < \mu_{11}(y_i^\star),$ $\sigma_{11}(y_i^\star), \gamma_{11}(y_i^\star) >$	$< \mu_{12}(x_i^\star), \sigma_{12}(x_i^\star),$ $\gamma_{12}(x_i^\star) >, < \mu_{12}(y_i^\star$ $sigma_{12}(y_i^\star), \gamma_{12}(y_i^\star) >$	$\dots\ \dots$	$< \mu_{1n}(x_i^\star), \sigma_{1n}(x_i^\star),$ $\gamma_{1n}(x_i^\star) >, < \mu_{1n}(y_i^\star),$ $\sigma_{1n}(y_i^\star), \gamma_{1n}(y_i^\star) >$
$\dots$	$\dots$	$\dots$	$\dots\ \dots$	$\dots$
$\dots$	$\dots$	$\dots$	$\dots\ \dots$	$\dots$
$\dots$	$\dots$	$\dots$	$\dots\ \dots$	$\dots$
$(J_{\mathcal{M}_\mathcal{N}}, J_{F_n})$	$< \mu_{n1}(x_i^\star), \sigma_{n1}(x_i^\star),$ $\gamma_{n1}(x_i^\star) >, < \mu_{n1}(y_i^\star),$ $\sigma_{n1}(y_i^\star), \gamma_{n1}(y_i^\star) >$	$< \mu_{n2}(x_i^\star), \sigma_{n2}(x_i^\star),$ $\gamma_{n2}(x_i^\star) >, < \mu_{n2}(y_i^\star),$ $\sigma_{n2}(y_i^\star), \gamma_{n2}(y_i^\star) >$	$\dots\ \dots$	$< \mu_{nn}(x_i^\star), \sigma_{nn}(x_i^\star),$ $\gamma_{nn}(x_i^\star) >, < \mu_{nn}(y_i^\star),$ $\sigma_{nn}(y_i^\star), \gamma_{nn}(y_i^\star) >$

5. **Numerical Example**

For the employees, it is important to invest a sum of money in a good manner to reduce their annual income tax amount. Also, the investing amount should be safer and profitable. So, the employees struggles to decide which investment is better to choose. The investment should be chosen properly, otherwise the employees will face heavy loss or bad impact to their economic condition. The mathematical decision making method is used to find the proper investment opinion, so that the employees can add some amount of money for their future requirements and to less the money to be paid for income tax.

The proposed method includes neutrosophic binary truth membership, neutrosophic binary indeterminancy and neutrosophic binary false membership values.

Consider a set of employees: Male and Female. They were represented by $M = \{M_1, M_2, M_3, M_4, M_5\}$ and $F = \{F_1, F_2, F_3, F_4, F_5\}$. Here M_1 represents the male employees who are less than 25 years of age, M_2 represent the male employees of $25 - 35$ years of age, M_3 represent the male employees of $35 - 45$ years of age, M_4 represent the male employees of $45 - 55$ years of age and M_5 represent the male employees who are above 55 years. Similarly, F_1 represents the female employees who are less than 25 years of age, F_2 represent the female employees of $25 - 35$ years of age, F_3 represent the female employees of $35 - 45$ years of age, F_4 represent the female employees of $45 - 55$ years of age and F_5 represent the female employees who are above 55 years. Assume that, the employee decides to invest the money to a best investing sectors : Public Provident Fund (I_{M_1}, I_{F_1}), Stock Market (I_{M_2}, I_{F_2}), Gold bond (I_{M_3}, I_{F_3}), Postal Life Insurance (I_{M_4}, I_{F_4}) and Real Estate (I_{M_5}, I_{F_5}). The investment of money will be decided by the employees according to the following attributes: Growth Analysis (J_{M_1}, J_{F_1}), Risk Analysis (J_{M_2}, J_{F_2}), High Annual Return (J_{M_3}, J_{F_3}), Norms and conditions (J_{M_4}, J_{F_4}) and Market Analysis (J_{M_5}, J_{F_5}). Our aim is to find the perfect investing sector.

In this application part, the collection of investment data plays a vital role in understanding the decision making factors of individuals on the basis of investment. The Google form was used to collect these investment data from the employees of various sectors (both public and private). The google form consists of sixteen questions which includes Demographic Details, Income, Experience, Investment Preferences and the various attributes of the investment preferences.

The google form consists of multiple choice questions, open-ended responses and so on. The google form was send to the employees of different sector via email and other communicating media. More than hundred and fifty employees responded it. The collected data consists of the following key varaiables:

- Demographic details: It consists of age, gender, occupation etc.,
- Investement preference : It includes the type of investments, risk factors and investment goals.
- Investment Experience : It covers the previous investment experience and the knowledge level in investment
- Decision-making factors: It consists of the attributes of the investment sectors.

The relation between the employees and the attributes is represented in the form of neutrosophic binary sets in the table 3.

	(J_{M_1}, J_{F_1})	(J_{M_2}, J_{F_2})	(J_{M_3}, J_{F_3})	(J_{M_4}, J_{F_4})	(J_{M_5}, J_{F_5})
(M_1, F_1)	$< 0.6, 0.2, 0.4 >, < 0.8, 0.3, 0.2 >$	$< 0.65, 0.3, 0.35 >, < 0.7, 0.4, 0.3 >$	$< 0.45, 0.35, 0.53 >, < 0.5, 0.4, 0.5 >$	$< 0.17, 0.35, 0.82 >, < 0.3, 0.4, 0.7 >$	$< 0.25, 0.4, 0.75 >, < 0.3, 0.5, 0.7 >$
(M_2, F_2)	$< 0.68, 0.32, 0.32 >, < 0.7, 0.4, 0.3 >$	$< 0.75, 0.3, 0.25 >, < 0.65, 0.3, 0.35 >$	$< 0.3, 0.4, 0.7 >, < 0.45, 0.3, 0.53 >$	$< 0.29, 0.17, 0.17 >, < 0.3, 0.5, 0.7 >$	$< 0.3, 0.15, 0.7 >, < 0.4, 0.2, 0.6 >$
(M_3, F_3)	$< 0.32, 0.36, 0.68 >, < 0.45, 0.2, 0.53 >$	$< 0.45, 0.25, 0.55 >, < 0.65, 0.3, 0.55 >$	$< 0.7, 0.15, 0.3 >, < 0.8, 0.2, 0.2 >$	$< 0.58, 0.29, 0.41 >, < 0.35, 0.2, 0.65 >$	$< 0.5, 0.15, 0.5 >, < 0.65, 0.3, 0.35 >$
(M_4, F_4)	$< 0.4, 0.36, 0.6 >, < 0.25, 0.5, 0.75 >$	$< 0.35, 0.15, 0.65 >, < 0.58, 0.3, 0.41 >$	$< 0.6, 0.25, 0.9 >, < 0.5, 0.6, 0.5 >$	$< 0.7, 0.17, 0.29 >, < 0.68, 0.2, 0.32 >$	$< 0.4, 0.25, 0.6 >, < 0.25, 0.3, 0.75 >$
(M_5, F_5)	$< 0.36, 0.32, 0.64 >, < 0.4, 0.2, 0.6 >$	$< 0.75, 0.15, 0.25 >, < 0.9, 0.2, 0.1 >$	$< 0.65, 0.25, 0.35 >, < 0.5, 0.2, 0.5 >$	$< 0.88, 0.35, 0.11 >, < 0.9, 0.2, 0.1 >$	$< 0.75, 0.2, 0.25 >, < 0.7, 0.3, 0.3 >$

TABLE 3. Realtion between Employees and Attributes

The relation between the attributes and the alternatives is represented in the form of neutrosophic binary sets in the table 4.

	(I_{M_1}, I_{F_1})	(I_{M_2}, I_{F_2})	(I_{M_3}, I_{F_3})	(I_{M_4}, I_{F_4})	(I_{M_5}, I_{F_5})
(J_{M_1}, J_{F_1})	$< 0.8, 0.12, 0.2 >, < 0.6, 0.2, 0.4 >$	$< 0.8, 0.3, 0.2 >, < 0.7, 0.1, 0.3 >$	$< 0.7, 0.5, 0.3 >, < 0.4, 0.4, 0.6 >$	$< 0.2, 0.5, 0.7 >, < 0.4, 0.2, 0.6 >$	$< 0.75, 0.4, 0.25 >, < 0.4, 0.1, 0.6 >$
(J_{M_2}, J_{F_2})	$< 0.4, 0.32, 0.6 >, < 0.5, 0.2, 0.5 >$	$< 0.9, 0.15, 0.1 >, < 0.8, 0.2, 0.2 >$	$< 0.85, 0.25, 0.15 >, < 0.7, 0.1, 0.3 >$	$< 0.9, 0.2, 0.05 >, < 0.8, 0.1, 0.2 >$	$< 0.65, 0.35, 0.35 >, < 0.7, 0.3, 0.3 >$
(J_{M_3}, J_{F_3})	$< 0.6, 0.32, 0.4 >, < 0.8, 0.2, 0.2 >$	$< 0.35, 0.15, 0.75 >, < 0.4, 0.2, 0.6 >$	$< 0.9, 0.3, 0.1 >, < 0.8, 0.5, 0.2 >$	$< 0.29, 0.23, 0.7 >, < 0.3, 0.1, 0.7 >$	$< 0.95, 0.15, 0.05 >, < 0.8, 0.3, 0.2 >$
(J_{M_4}, J_{F_4})	$< 0.52, 0.2, 0.48 >, < 0.4, 0.1, 0.6 >$	$< 0.75, 0.4, 0.28 >, < 0.8, 0.3, 0.2 >$	$< 0.65, 0.25, 0.35 >, < 0.7, 0.1, 0.3 >$	$< 0.9, 0.47, 0.05 >, < 0.6, 0.5, 0.4 >$	$< 0.9, 0.15, 0.1 >, < 0.8, 0.3, 0.2 >$
(J_{M_5}, J_{F_5})	$< 0.8, 0.32, 0.2 >, < 0.7, 0.2, 0.3 >$	$< 0.9, 0.15, 0.1 >, < 0.9, 0.5, 0.1 >$	$< 0.75, 0.4, 0.25 >, < 0.8, 0.2, 0.2 >$	$< 0.88, 0.29, 0.12 >, < 0.9, 0.3, 0.1 >$	$< 0.35, 0.4, 0.65 >, < 0.7, 0.2, 0.3 >$

TABLE 4. Relation between the Attributes and Alternatives

The computation of Similarity measure between the employees and the investing sectors is shown in the following table:

	(I_{M_1}, I_{F_1})	(I_{M_2}, I_{F_2})	(I_{M_3}, I_{F_3})	(I_{M_4}, I_{F_4})	(I_{M_5}, I_{F_5})
(M_1, F_1)	0.2907	0.3005	0.2823	0.2428	0.2918
(M_2, F_2)	0.3139	0.3267	0.3957	0.2728	0.2986
(M_3, F_3)	0.3927	0.2888	0.3698	0.3955	0.3281
(M_4, F_4)	0.2844	0.2906	0.3191	0.3468	0.3999
(M_5, F_5)	0.4108	0.3773	0.3908	0.3778	0.3889

The highest similarity measure describes the best investigating sector. Therefore, the employees of less than 25 years of age chooses stock market, the employees of 25 to 35 years of age chooses Gold bond, the employess of 35 to 45 years chooses Postal Life Insurance and 45 to 55 years of age chooses Real Estate, the employees of above 55 years of age chooses Public Provident Fund as the best investing sector.

6. Conclusion

The main goal of this paper is to help a employee invest in a good manner. The basic purpose of this paper lies in ascertaining the good investment method. In addition, the researcher applied the neutrosophic binary sets in finding the highest unemployment rate. From this paper, it is evident that mathematics has been a key element to gather more information and is a best tool for solving the real life decision making problems.

7. Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Abdullah, L., Ong, Z., & Mohd Mahali, S. (2021). Single-valued neutrosophic DEMATEL for segregating types of criteria: a case of subcontractors' selection. Journal of mathematics, 2021, 1-12.
2. Aydemir, S. B., & Kaya, T. (2021). TOPSIS method for multi-attribute group decision making based on neutrality aggregation operator under single valued neutrosophic environment: A case study of airline companies. Neutrosophic Operational Research: Methods and Applications, 471-492.
3. Azar, A., & Sorourkhah, A. (2015). Designing a model for three-dimensional robustness analysis: A case study of Iran Khodro machine tools industries company. Indian Journal of Science and Technology, 8(28), 1.
4. Chadow, D., Robinson, N. B., Cancelli, G., Soletti Jr, G., Audisio, K., Rahouma, M., Perezgrovas, R., & Gaudino, M. (2022), Predictors of failure to reach target sample size in surgical randomized trials. British Journal of Surgery, 109(2), 176–177.
5. Chai, J. S., Selvachandran, G., Smarandache, F., Gerogiannis, V. C., Son, L. H., Bui, Q.-T., & Vo, B. (2021). New similarity measures for single-valued neutrosophic sets with applications in pattern recognition and medical diagnosis problems. Complex & Intelligent Systems, 7(2), 703–723.
6. Das. S. K., & Edalatpanah. S. A. (2020). A new ranking function of triangular neutrosophic number and its application in integer programming. International Journal of Neutrosophic Science, 4(2).
7. Deli, I. (2020). A New Multi-Attribute Decision-Making Method Based on Similarity Measures of SVTN-Numbers. In Neutrosophic Sets in Decision Analysis and Operations Research (pp. 59-81). IGI Global.
8. Durrah, O., Abdul Rahman, A. A., Jamil, S. A., & Ghafeer, N. A. (2016). Exploring the Relationship between Liquidity Ratios and Indicators of Financial Performance: An Analytical Study on Food Industrial Companies Listed in Amman Bursa. International Journal of Economics and Financial Issues, 6(2), 435–441.
9. Edalatpanah, S. A. (2020). Neutrosophic structured element. Expert Systems, 37(5), e12542.

10. Falavigna, G., & Ippoliti, R. (2022). Financial constraints, investments, and environmental strategies: An empirical analysis of judicial barriers. Business Strategy and the Environment, 31(5), 2002–2018. Imeni et alM. Imeni et al./ FOMJ 3(4) (2022) 9–16 15
11. Fuertes-Callén, Y., Cuellar-Fernández, B., & Serrano-Cinca, C. (2022). Predicting startup survival using first years financial statements. Journal of Small Business Management, 60(6), 1314–1350.
12. Garg, H., & Nancy. (2020). Algorithms for single-valued neutrosophic decision making based on topsis and clustering methods with new distance measure. AIMS Mathematics, 5(3), 2671–2693.
13. Gibson, C. H. (2012). Financial Reporting and Analysis (13th ed.). Cengage Learning.
14. Gregory, A. (2021). Complete Analysis of Netflix, Inc. The University of Mississippi.
15. Imeni, M. (2020). Fuzzy Logic in Accounting and Auditing. Journal of Fuzzy Extension and Applications, 1(1), 66–72.
16. Imeni, M., Rahnamay Roodposhti. F., & Banimahd, B. (2019). Relationship Real Activities Manipulation with Accrual-Based Earnings Management Using Recursive Equation System Approach. Journal of Management Accounting and Auditing Knowledge, 8(29), 1-14.
17. Jing, D., Imeni, M., Edalatpanah, S. A., Alburaikan, A., & Khalifa, H. A. (2023). Optimal Selection of Stock Portfolios Using Multi-Criteria Decision-Making Methods. In Mathematics (Vol. 11, Issue 2).
18. Largani, M. S., Zamani, M., Imeni, M., & Kaviani, M. (2013). Determine the Effects of Fundamental Variables and Mass Behaviors in Changes of Stock Price (Evidence from Iran Stock Exchange). Asian Journal of Finance & Accounting, 5(1).
19. Mahapatra, N. K., & Bera, T. (2020). Generalised Single-Valued Neutrosophic Number and Its Application to Neutrosophic Linear Programming. In M. Abdel-Basset & F. Smarandache (Eds.), Neutrosophic Sets in Decision Analysis and Operations Research (pp. 180–214).
20. Mohamed, M., Smarandache, F., & Voskoglou, M. (2024). BV2TrS Appraiser Model: Enforcing BHARAT Version2 in Tree Soft Modelling for Appraising E-Mobility Hurdles. Neutrosophic Systems With Applications, 16, 36-47
21. Paramasivan, C., & Subramanian, T. (2010). Financial Management. NEW AGE INTERNATIONAL.
22. Qiu, P., Sorourkhah, A., Kausar, N., Cagin, T., & Edalatpanah, S. A. (2023). Simplifying the Complexity in the Problem of Choosing the Best Private-Sector Partner. In Systems (Vol. 11, Issue 2).
23. Quesada, H. J. (2019). Analysis of Financial Statements Using Ratios. Virginia Tech, CNRE-43P, 1–16.
24. Rodríguez. R., Martinez. L., Torra. V., Xu. Z., & Herrera. F. (2014). Hesitant Fuzzy Sets: State of the Art and Future Directions. International Journal of Intelligent Systems, 29,
25. Saberhoseini, S. F., Edalatpanah, S. A., & Sorourkhah, A. (2022). Choosing the Best Private-Sector Partner According to the Risk Factors in Neutrosophic Environment. Big Data and Computing Visions, 2(2), 61–68.
26. Saha, S., Gao, J., & Gerlach, R. (2022). A survey of the application of graph-based approaches in stock market analysis and prediction. International Journal of Data Science and Analytics, 14(1), 1–15. -9
27. Şahin, M., & Kargın, A. (2020). New Similarity Measure Between Single-Valued Neutrosophic Sets and Decision-Making Applications in Professional Proficiencies. In M. Abdel-Basset & F. Smarandache (Eds.), Neutrosophic Sets in Decision Analysis and Operations Research (pp. 129–149). PA, USA:
28. Şahin, R., & Liu, P. (2017). Correlation coefficients of single valued neutrosophic hesitant fuzzy sets and their applications in decision making. Neural Computing and Applications, 28.
29. Samadi Lorgani, M., & Imeni, M. (2013). The relationship between working capital management and cash holding companies listed in Tehran stock exchange. Journal of management accounting and auditing knowledge, 2(5), 39-52.
30. Seifzadeh, M., Rajaeei, R., & Allahbakhsh, A. (2022). The relationship between management entrenchment and financial statement fraud. Journal of Facilities Management, 20(1), 102–119.

31. Smarandache, F., Broumi, S., Singh, P. K., Liu, C. -f., Venkateswara Rao, V., Yang, H.-L., & Elhassouny, A. (2019). 1 - Introduction to neutrosophy and neutrosophic environment. In Y. Guo & A. S. Ashour (Eds.), Neutrosophic Set in Medical Image Analysis (pp. 3–29). Academic Press.
32. Smarandache, F., Foundation of Revolutionary Topologies: An Overview, Examples, Trend Analysis, Research Issues, Challenges, and Future Directions, Neutrosophic Systems with Applications, Vol. 13, 2024.
33. Sorourkhah, A. (2022). Coping Uncertainty in the Supplier Selection Problem Using a Scenario-Based Approach and Distance Measure on Type-2 Intuitionistic Fuzzy Sets. Fuzzy Optimization and Modeling Journal, 3(1), 64–71.
34. Sorourkhah, A., Azar, A., Babaie-Kafaki, S., Shafiei-Nikabadi, M., & Author, C. (2018). Using Weighted-Robustness Analysis in Strategy Selection (Case Study: Saipa Automotive Research and Innovation Center). Industrial Management Journal, 9(4), 665– 690.
35. Sorourkhah, A., Babaie-Kafaki, S., Azar, A., & Shafiei Nikabadi, M. (2019). A Fuzzy-Weighted Approach to the Problem of Selecting the Right Strategy Using the Robustness Analysis (Case Study: Iran Automotive Industry). Fuzzy Information and Engineering, 11(1), 39–53.
36. Sorourkhah, A., Babaie-Kafaki, S., Azar, A., & Shafiei-Nikabadi, M. (2018). Matrix Approach to Robustness Analysis for Strategy Selection. International Journal of Industrial Mathematics, 10(3), 261–269.
37. Sorourkhah, A., & Edalatpanah, S. A. (2021). Considering the Criteria interdependency in the Matrix Approach to Robustness Analysis with Applying Fuzzy ANP. Fuzzy Optimization and Modeling Journal, 3(2), 22–33.
38. S.S.Surekha, J.Elekiah and G.Sindhu, A study on Neutrosophic Binary Topological space, Stochastic Modelling and applications, Vol 26(3), 479-486.
39. Taghvaei, F., & Safa, R. (2021). Efficient energy consumption in smart buildings using personalized NILM-based recommender system. Big Data and Computing Visions, 1(3), 161–169.
40. Vahini T, V., & Pricilla M, T. . (2025). A Neutrosophic Micro Vague Correlation Measure: Application to Multi-Criteria Decision Making Problems. Neutrosophic Systems With Applications, 25, 30-37.
41. Wang, H., Smarandache, F., Zhang, Y., & Sunderraman, R. (2010). Single Valued Neutrosophic Sets. Rev Air Force Acad, 1(16), 10–14.
42. Welc, J. (2022). Financial Statement Analysis BT - Evaluating Corporate Financial Performance: Tools and Applications (J. Welc, Ed.; pp. 131–212). Springer International Publishing.
43. Ye, J. (2015). Multiple-attribute decision-making method under a single-valued neutrosophic hesitant fuzzy environment. Journal of Intelligent Systems, 24(1), 23–36.
44. Ye, J., Yong, R., & Du, W. (2024). MAGDM Model Using Single-Valued Neutrosophic Credibility Matrix Energy and Its Decision-Making Application. Neutrosophic Systems With Applications, 17, 1-20.
45. Zayat, W., Kilic, H. S., Yalcin, A. S., Zaim, S., & Delen, D. (2023). Application of MADM methods in Industry 4.0: A literature review. Computers & Industrial Engineering, 177, 109075.
46. Zhang, K., Xie, Y., Noorkhah, S. A., Imeni, M., & Das, S. K. (2023). Neutrosophic management evaluation of insurance companies by a hybrid TODIM-BSC method: a case study in private insurance companies. Management decision, 61(2), 363-381.

Received: Dec. 6, 2024. Accepted: June 10, 2025