II

A Scientific Decision Framework for Supplier Selection under Neutrosophic Moora Environment

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Abstract

In this paper, we present a hybrid model of Neutrosophic-MOORA for supplier selection problems. Making a suitable model for supplier selection is an important issue to amelioration competitiveness and capability of the organization, factory, project etc. selecting of the best supplier selection is not decrease delays in any organizations but also maximum profit and saving of material costs. Thus, now days supplier selection is become competitive global environment for any organization to select the best alternative or taking a decision. From a large number of availability alternative suppliers with dissimilar strengths and weaknesses for different objectives or criteria, requiring important rules or steps for supplier selection. In the recent past, the researchers used various multi criteria decision-making (MCDM) methods successfully to solve the problems of supplier selection. In this research, Multi-Objective Optimization based on Ratio Analysis (MOORA) with neutrosophic is applied to solve the real supplier selection problems. We selected a real life example to present the solution of problem that how ranking the alternative based on decreasing cost for each alternative and how formulate the problem in steps by Neutrosophic- MOORA technique.

Keywords

MOORA; Neutrosophic; Supplier selection; MCDM.

1 Introduction

The purpose of this paper is to present a hybrid method between MOORA and Neutrosophic in the framework of neutrosophic for the selection of suppliers with a focus on multi-criteria and multi-group environment. These days, Companies, organizations, factories seek to provide a fast and a good service to meet the requirements of peoples or customers [1, 2].The field of multi criteria decision-making is considered for the selection of suppliers [3]. The selecting of the best supplier increasing the efficiency of any organization whether company, factory according to [4].

Hence, for selecting the best supplier selection there are much of methodologies we presented some of them such as fuzzy sets (FS), Analytic network process (ANP), Analytic hierarchy process (AHP), (TOPSIS) technique for order of preference by similarity to ideal solution, (DSS) Decision support system, (MOORA) multi-objective optimization by ratio analysis. A classification of these methodologies to two group hybrid and individual can reported in [4, 5].

We review that the most methodologies shows the supplier selection Analytic hierarchy process (AHP), Analytic network process (ANP) with neutrosophic in [6].

1.1 Supplier Selection Problem

A Supplier selection is considered one of the most very important components of production and vulgarity management for many organizations service.

The main goal of supplier selection is to identify suppliers with the highest capability for meeting an organization needs consistently and with the minimum cost. Using a set of common criteria and measures for abroad comparison of suppliers.

However, the level of detail used for examining potential suppliers may vary depending on an organization's needs. The main purpose and objective goal of selection is to identify high-potential suppliers. To choose suppliers, the organization present judge of each supplier according to the ability of meeting the organization consistently and cost effective it's needs using selection criteria and appropriate measure.

Criteria and measures are developed to be applicable to all the suppliers being considered and to reflect the firm's needs and its supply and technology strategy.

We show Supplier evaluation and selection process [7].

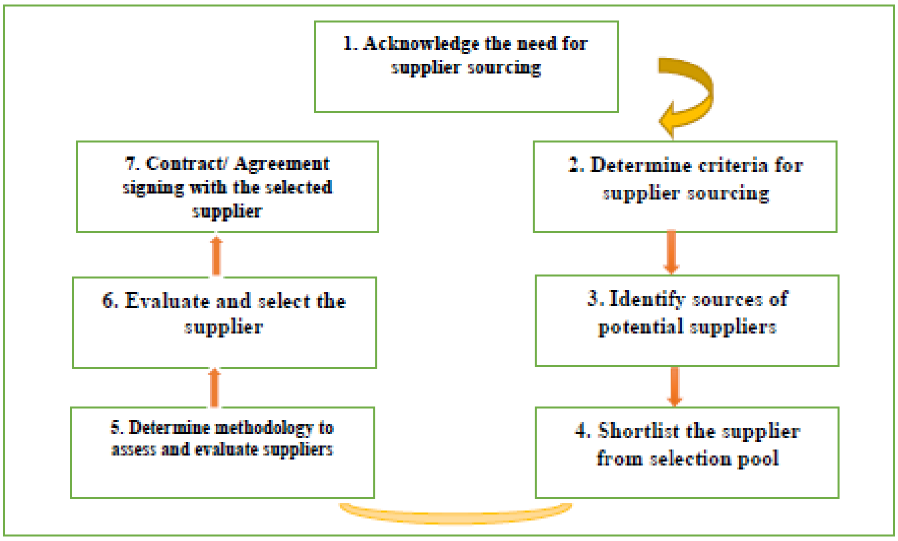

Figure 1. Supplier evaluation and selection process.

1.2 MOORA Technique

Multi-Objective Optimization on the basis of Ratio Analysis (MOORA), also known as multi criteria or multi attribute optimization. (MOORA) method seek to rank or select the best alternative from available option was introduced by Brauers and Zavadskas in 2006 [8].

The (MOORA) method has a large range of applications to make decisions in conflicting and difficult area of supply chain environment. MOORA can be applied in the project selection, process design selection, location selection, product selection etc. the process of defining the decision goals, collecting relevant information and selecting the best optimal alternative is known as decision making process.

The basic idea of the MOORA method is to calculate the overall performance of each alternative as the difference between the sums of its normalized performances which belongs to cost and benefit criteria.

This method applied in various fields successfully such as project management [9].

Table 1. Comparison of MOORA with MADM approaches

MADM method	Computational Time	Simplicity	Mathematical Calculations required
MOORA	Very less	Very simple	Minimum
AHP	Very high	Very critical	Maximum
ANP	Moderate	Moderately critical	Moderate
TOPSIS	Moderate	Moderately critical	Moderate
GRA	Very high	Very critical	Maximum

1.3 Neutrosophic Theory

Smarandache first introduced neutrosophy as a branch of philosophy which studies the origin, nature, and scope of neutralities. Neutrosophic set is an important tool which generalizes the concept of the classical set, fuzzy set, interval-valued fuzzy set, intuitionistic fuzzy set, interval-valued intuitionistic fuzzy set, paraconsistent set, dial theist set, paradoxist set, and tautological set[14-22]**.** Smarandache (1998) defined indeterminacy explicitly and stated that truth, indeterminacy, and falsity-membership are independent and lies within]-*0, 1+[*. which is the non-standard unit interval and an extension of the standard interval]-*0, 1+[*.

We present some of methodologies that it used in the multi criteria decision making and presenting the illustration between supplier selection, MOORA and Neutrosophic. Hence the goal of this paper to present the hybrid of the MOORA (Multi-Objective Optimization on the basis of Ratio Analysis) method with neutrosophic as a methodology for multi criteria decision making (MCDM).

This is ordered as follows: Section 2 gives an insight into some basic definitions on neutrosophic sets and MOORA. Section 3 explains the proposed methodology of neutrosophic MOORA model. In Section 4 a numerical example is presented in order to explain the proposed methodology. Finally, the conclusions.

2 Preliminaries

In this section, the essential definitions involving neutrosophic set, single valued neutrosophic sets, trapezoidal neutrosophic numbers and operations on trapezoidal neutrosophic numbers are defined.

2.1 Definition [10]

Let X be a space of points and $x \in X$. A neutrosophic set A in X is definite by a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$ and a falsity-membership function $F_A(x)$, $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard or real nonstandard subsets of]-*0, 1+[*. That is $T_A(x)$:$X \rightarrow]^-0, 1^+[$, $I_A(x)$:$X \rightarrow]^-0, 1^+[$ and $F_A(x)$:$X \rightarrow]^-0, 1^+[$. There is no restriction on the sum of $T_A(x)$, $I_A(x)$ and $F_A(x)$, so $0^- \leq$ sup (x) + sup x + sup $x \leq 3^+$.

2.2 Definition [10, 11]

Let X be a universe of discourse. A single valued neutrosophic set A over X is an object taking the form $A = \{\langle x, T_A(x), I_A(x), F_A(x), \rangle : x \in X\}$, where $T_A(x)$:$X \rightarrow [0,1]$, $I_A(x)$:$X \rightarrow [0,1]$ and $F_A(x)$:$X \rightarrow [0,1]$ with $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$ for all $x \in X$. The intervals $T_A(x)$, $I_A(x)$ and $F_A(x)$ represent the truth-membership degree, the indeterminacy-membership degree and the falsity membership degree of x to A, respectively. For convenience, a SVN number is represented by A= (a, b, c), where a, b, $c \in [0, 1]$ and $a+b+c \leq 3$.

2.3 Definition [12]

Suppose that $\alpha_{\tilde{a}}$, $\theta_{\tilde{a}}$, $\beta_{\tilde{a}} \in [0,1]$ and $a_1, a_2, a_3, a_4 \in$ R where $a_1 \leq a_2 \leq a_3 \leq a_4$. Then a single valued trapezoidal neutrosophic number, $\tilde{a} = \langle (a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \theta_{\tilde{a}}, \beta_{\tilde{a}} \rangle$ is a special neutrosophic set on the real line set R whose truth-membership, indeterminacy-membership and falsity-membership functions are defined as:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}} \left(\frac{x-a_1}{a_2-a_1}\right) & (a_1 \leq x \leq a_2) \\ \alpha_{\tilde{a}} & (a_2 \leq x \leq a_3) \\ \alpha_{\tilde{a}} \left(\frac{a_4-x}{a_4-a_3}\right) & (a_3 \leq x \leq a_4) \\ 0 & otherwise \end{cases} \quad (1).$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\theta_{\tilde{a}}(x-a_1))}{(a_2-a_1)} & (a_1 \leq x \leq a_2) \\ \alpha_{\tilde{a}} & (a_2 \leq x \leq a_3) \\ \frac{(x-a_3+\theta_{\tilde{a}}(a4-x))}{(a_4-a_3)} & (a_3 \leq x \leq a_4) \\ 1 & otherwise \end{cases} , \quad (2).$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2 - x + \beta_{\tilde{a}}(x - a_1))}{(a_2 - a_1)} & (a_1 \le x \le a_2) \\ \alpha_{\tilde{a}} & (a_2 \le x \le a_3) \\ \frac{(x - a_3 + \beta_{\tilde{a}}(a4 - x))}{(a_4 - a_3)} & (a_3 \le x \le a_4) \\ 1 & otherwise \end{cases}, \quad (3).$$

where $\alpha_{\tilde{a}}$, $\theta_{\tilde{a}}$ and $\beta_{\tilde{a}}$and represent the maximum truth-membership degree, minimum indeterminacy-membership degree and minimum falsity-membership degree respectively. A single valued trapezoidal neutrosophic number $\tilde{a}$=$\langle(a_1 , a_2 , a_3 , a_4); \alpha_{\tilde{a}} , \theta_{\tilde{a}} , \beta_{\tilde{a}}\rangle$ may express an ill-defined quantity of the range, which is approximately equal to the interval $[a_2 , a_3]$.

2.4 Definition [11, 10]

Let $\tilde{a}$=$\langle(a_1 , a_2 , a_3 , a_4); \alpha_{\tilde{a}} , \theta_{\tilde{a}} , \beta_{\tilde{a}}\rangle$ and $\tilde{b}$=$\langle(b_1 , b_2 , b_3 , b_4); \alpha_{\tilde{b}} , \theta_{\tilde{b}} , \beta_{\tilde{b}}\rangle$ be two single valued trapezoidal neutrosophic numbers and $\Upsilon \neq 0$ be any real number. Then,

1. Addition of two trapezoidal neutrosophic numbers

$$\tilde{a} + \tilde{b} = \langle(a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \theta_{\tilde{a}} \vee \theta_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}\rangle$$

2. Subtraction of two trapezoidal neutrosophic numbers

$$\tilde{a} - \tilde{b} = \langle(a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \theta_{\tilde{a}} \vee \theta_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}\rangle$$

3. Inverse of trapezoidal neutrosophic number

$$\tilde{a}^{-1} = \langle(\frac{1}{a_4}, \frac{1}{a_3}, \frac{1}{a_2}, \frac{1}{a_1}); \alpha_{\tilde{a}} , \theta_{\tilde{a}} , \beta_{\tilde{a}}\rangle \quad \text{where } (\tilde{a} \neq 0)$$

4. Multiplication of trapezoidal neutrosophic number by constant value

$$\Upsilon\tilde{a} = \begin{cases} \langle(\Upsilon a_1 , \Upsilon a_2 , \Upsilon a_3 , \Upsilon a_4); \alpha_{\tilde{a}} , \theta_{\tilde{a}} , \beta_{\tilde{a}}\rangle & \text{if } (\Upsilon > 0) \\ \langle(\Upsilon a_4 , \Upsilon a_3 , \Upsilon a_2 , \Upsilon a_1); \alpha_{\tilde{a}} , \theta_{\tilde{a}} , \beta_{\tilde{a}}\rangle & \text{if } (\Upsilon < 0) \end{cases}$$

5. Division of two trapezoidal neutrosophic numbers

$$\frac{\tilde{a}}{\tilde{b}} = \begin{cases} \langle(\frac{a_1}{b_4}, \frac{a_2}{b_3}, \frac{a_3}{b_2}, \frac{a_4}{b_1}); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \theta_{\tilde{a}} \vee \theta_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}\rangle & \text{if } (a_4 > 0 , b_4 > 0) \\ \langle(\frac{a_4}{b_4}, \frac{a_3}{b_3}, \frac{a_2}{b_2}, \frac{a_1}{b_1}); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \theta_{\tilde{a}} \vee \theta_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}\rangle & \text{if } (a_4 < 0 , b_4 > 0) \\ \langle(\frac{a_4}{b_1}, \frac{a_3}{b_2}, \frac{a_2}{b_3}, \frac{a_1}{b_4}); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \theta_{\tilde{a}} \vee \theta_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}\rangle & \text{if } (a_4 < 0 , b_4 < 0) \end{cases}$$

6. Multiplication of trapezoidal neutrosophic numbers

$$\tilde{a}\tilde{b} = \begin{cases} \langle(a_1 b_1 , a_2 b_2 , a_3 b_3 , a_4 b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \theta_{\tilde{a}} \vee \theta_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}\rangle & \text{if } (a_4 > 0 , b_4 > 0) \\ \langle(a_1 b_4 , a_2 b_3 , a_3 b_2 , a_4 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \theta_{\tilde{a}} \vee \theta_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}\rangle & \text{if } (a_4 < 0 , b_4 > 0) \\ \langle(a_4 b_4 , a_3 b_3 , a_2 b_2 , a_1 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \theta_{\tilde{a}} \vee \theta_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}\rangle & \text{if } (a_4 < 0 , b_4 < 0) \end{cases}$$

3 Methodology

In this paper, we present the steps of the proposed model MOORA-Neutrosophic, we define the criteria based on the opinions of decision makers (DMs) using neutrosophic trapezoidal numbers to make the judgments on criteria more accuracy, using a scale from 0 to 1 instead of the scale (1-9) that have many drawbacks illustrated by **[13]**. We present a new scale from 0 to 1 to avoid this drawbacks. We use (n-1) judgments to obtain consistent trapezoidal neutrosophic preference relations instead of $\frac{n \times (n-1)}{2}$ to decrease the workload and not tired decision makers. (MOORA-Neutrosophic) method is used for ranking and selecting the alternatives. To do this, we first present the concept of AHP to determine the weight of each criteria based on opinions of decision makers (DMs). Then each alternative is evaluated with other criteria and considering the effects of relationship among criteria.

The steps of our model can be introduced as:

Step - 1. Constructing model and problem structuring.

a. Constitute a group of decision makers (DMs).
b. Formulate the problem based on the opinions of (DMs).

Step - 2. Making the pairwise comparisons matrix and determining the weight based on opinions of (DMs).

a. Identify the criteria and sub criteria C = {C1, C2, C3…Cm}.
b. Making matrix among criteria n × m based on opinions of (DMs).

$$
\begin{array}{cc}
 & \begin{array}{cccc} C_1 & C_2 & \cdots & C_m \end{array} \\
W = \begin{array}{c} C_1 \\ C_2 \\ C_3 \\ Cn \end{array} &
\begin{bmatrix}
(l_{11}, m_{11l}, m_{11u}, u_{11}) & (l_{11}, m_{11l}, m_{11u}, u_{11}) & \cdots & (l_{1n}, m_{1nl}, m_{1nu}, u_{1n}) \\
(l_{21}, m_{21l}, m_{21u}, u_{21}) & (l_{22}, m_{22l}, m_{22u}, u_{22}) & \cdots & (l_{2n}, m_{2nl}, m_{2nu}, u_{2n}) \\
\cdots & \cdots & \cdots & \cdots \\
(l_{n1}, m_{n1l}, m_{n1u}, u_{n1}) & (l_{n2}, m_{n2l}, m_{n2u}, u_{n2}) & \cdots & (l_{nn}, m_{nnl}, m_{nnu}, u_{nn})
\end{bmatrix}
\end{array} \quad (4)
$$

Decision makers (DMs) make pairwise comparisons matrix between criteria compared to each criterion focuses only on (n-1) consensus judgments instead of using $\frac{n \times (n-1)}{2}$ that make more workload and Difficult.

c. According to, the opinion of (DMs) should be among from 0 to 1 not negative. Then, we transform neutrosophic matrix to pairwise comparisons deterministic matrix by adding (α, θ, β) and using the following equation to calculate the accuracy and score.

$$S(\tilde{a}_{ij}) = \frac{1}{16}[a_1 + b_1 + c_1 + d_1] \times (2 + \alpha_{\tilde{a}} - \theta_{\tilde{a}} - \beta_{\tilde{a}}) \quad (5)$$

and

$$A(\tilde{a}_{ij}) = \frac{1}{16}[a_1 + b_1 + c_1 + d_1] \times (2 + \alpha_{\tilde{a}} - \theta_{\tilde{a}} + \beta_{\tilde{a}}) \quad (6)$$

d. We obtain the deterministic matrix by using S ($\tilde{a}_{ij}$).

e. From the deterministic matrix we obtain the weighting matrix by dividing each entry on the sum of the column.

Step - 3. Determine the decision-making matrix (DMM). The method begin with define the available alternatives and criteria

$$R = \begin{matrix} & C_1 & C_2 & \dots & C_m \\ A_1 & (l_{11}, m_{11l}, m_{11u}, u_{11}) & (l_{11}, m_{11l}, m_{11u}, u_{11}) & \cdots & (l_{1n}, m_{1nl}, m_{1nu}, u_{1n}) \\ A_2 & (l_{21}, m_{21l}, m_{21u}, u_{21}) & (l_{22}, m_{22l}, m_{22u}, u_{22}) & \cdots & (l_{2n}, m_{2nl}, m_{2nu}, u_{2n}) \\ A_3 & \cdots & \cdots & \cdots & \cdots \\ An & (l_{n1}, m_{n1l}, m_{n1u}, u_{n1}) & (l_{n2}, m_{n2l}, m_{n2u}, u_{n2}) & \cdots & (l_{nn}, m_{nnl}, m_{nnu}, u_{nn}) \end{matrix} \quad (7)$$

where A_i represents the available alternatives where i = 1… n and the C_j represents criteria

a. Decision makers (DMs) make pairwise comparisons matrix between criteria compared to each criterion focuses only on (n-1) consensus judgments instead of using $\frac{n \times (n-1)}{2}$ that make more workload and Difficult.

b. According to, the opinion of (DMs) should be among from 0 to 1 not negative. Then, we transform neutrosophic matrix to pairwise comparisons deterministic matrix by using equations 5 &6 to calculate the accuracy and score.

c. We obtain the deterministic matrix by using S ($\tilde{a}_{ij}$).

Step - 4. Calculate the normalized decision-making matrix from previous matrix (DMM).

a. Thereby, normalization is carried out **[14].** Where the Euclidean norm is obtained according to eq. (8) to the criterionE_j.

i. $\left|Ey_j\right| = \sqrt{\sum_1^n E_i^2}$ (8)

The normalization of each entry is undertaken according to eq. (9)

ii. $$NE_{ij} = \frac{E_{ij}}{|E_j|} \quad (9)$$

Step - 5. Compute the aggregated weighted neutrosophic decision matrix (AWNDM) as the following:

i. $$\acute{R} = R \times W \quad (10)$$

Step - 6. Compute the contribution of each alternative Ny_i the contribution of each alternative

i. $$Ny_i = \sum_{i=1}^{g} Ny_i - \sum_{j=g+1}^{m} Nx_j \quad (11)$$

Step - 7. Rank the alternatives.

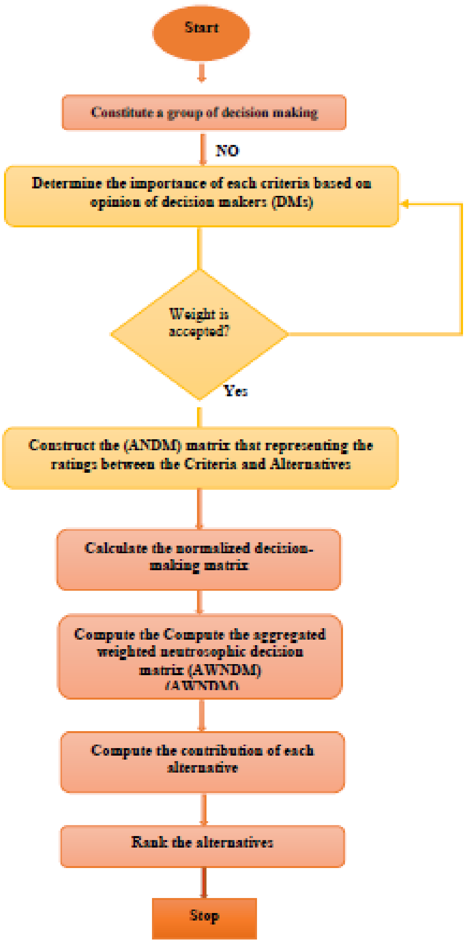

Figure 2 Schematic diagram of MOORA with neutrosophic.

4 Implementation of Neutrosophic – MOORA Technique

In this section, to illustrate the concept of MOORA with Neutrosophic we present an example. An accumulation company dedicated to the production of the computers machines has to aggregate several components in its production line. When failure occurred from suppliers (alternatives), a company ordered from another alternative based on the four criteria C_j (j = 1, 2, 3, and 4), the four criteria are as follows: C_1 for Total Cost, C_2 for Quality, C_3 for Service, C_4 for On-time delivery. The criteria to be considered is the supplier selections are determined by the DMs from a decision group. The team is broken into four groups, namelyDM_1,DM_2,DM_3 and DM_4, formed to select the most suitable alternatives. This example is that the selecting the best alternative from five alternative. A_i (i = 1, 2, 3, 4 and 5). Representing of criteria evaluation:

- Cost (C_1) Minimum values are desired.
- Quality (C_2) Maximum evaluations.
- Service (C_3) maximum evaluation.
- On-time delivery (C_4) maximum evaluation.

Step - 1. Constitute a group of decision makers (DMs) that consist of four (DM).

Step - 2. We determine the importance of each criteria based on opinion of decision makers (DMs).

$$W = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C4 \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & C_3 & C_4 \end{array} \\ \begin{bmatrix} (0.5\,,0.5,0.5,0.5) & (0.6,0.7,0.9,0.1) & (0.7\,,0.2,0.4,0.6) & (0.3\,,0.6,0.4,0.7) \\ (0.6\,,0.3,0.4,0.7) & (0.5\,,0.5,0.5,0.5) & (0.6\,,0.7,0.8,0.9) & (0.3\,,0.5,0.2,0.5) \\ (0.3\,,0.5,0.2,0.5) & (0.3\,,0.7,0.4,0.3) & (0.5\,,0.5,0.5,0.5) & (0.2\,,0.5,0.6,0.8) \\ (0.4\,,0.3,0.1,0.6) & (0.1\,,0.4,0.2,0.8) & (0.5\,,0.3,0.2,0.4) & (0.5\,,0.5,0.5,0.5) \end{bmatrix} \end{array}$$

Then the last matrix appears consistent according to definition 6. And then by ensuring consistency of trapezoidal neutrosophic additive reciprocal preference relations, decision makers (DMs) should determine the maximum truth-membership degree (α), minimum indeterminacy-membership degree (θ) and minimum falsity-membership degree (β) of single valued neutrosophic numbers.

$$W = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C4 \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & C_3 & C_4 \end{array} \\ \begin{bmatrix} (0.5\,,0.5,0.5,0.5) & (0.6,0.7,0.9,0.1;0.4,0.3,0.5) & (0.7,0.2,0.4,0.6;0.8,0.4,0.2) & (0.3,0.6,0.4,0.7;0.4,0.5,0.6) \\ (0.6,0.3,0.4,0.7;0.2,0.5,0.8) & (0.5\,,0.5,0.5,0.5) & (0.6,0.7,0.8,0.9;0.2,0.5,0.7) & (0.3,0.5,0.2,0.5;0.5,0.7,0.8) \\ (0.3,0.5,0.2,0.5;0.4,0.5,0.7) & (0.3,0.7,0.4,0.3;0.2,0.5,0.9) & (0.5\,,0.5,0.5,0.5) & (0.2,0.5,0.6,0.8;0.4,0.3,0.8) \\ (0.4,0.3,0.1,0.6;0.2,0.3,0.5) & (0.1,0.4,0.2,0.8;0.7,0.3,0.6) & (0.5,0.3,0.2,0.4;0.3,0.4,0.7) & (0.5\,,0.5,0.5,0.5) \end{bmatrix} \end{array}$$

From previous matrix we can determine the weight of each criteria by using the following equation of S ($\tilde{a}_{ij}$)

$$S(\tilde{a}_{ij}) = \frac{1}{16}[a_1 + b_1 + c_1 + d_1] \times (2 + \alpha_{\tilde{a}} - \theta_{\tilde{a}} - \beta_{\tilde{a}})$$

and

$$A(\tilde{a}_{ij}) = \frac{1}{16}[a_1 + b_1 + c_1 + d_1] \times (2 + \alpha_{\tilde{a}} - \theta_{\tilde{a}} + \beta_{\tilde{a}})$$

The deterministic matrix can obtain by S ($\tilde{a}_{ij}$) equation in the following step:

$$W = \begin{matrix} \\ C_1 \\ C_2 \\ C_3 \\ C4 \end{matrix} \begin{matrix} \begin{matrix} C_1 & C_2 & C_3 & C_4 \end{matrix} \\ \begin{bmatrix} 0.5 & 0.23 & 0.261 & 0.163 \\ 0.113 & 0.5 & 0.188 & 0.10 \\ 0.113 & 0.085 & 0.5 & 0.17 \\ 0.123 & 0.169 & 0.105 & 0.5 \end{bmatrix} \end{matrix}$$

From this matrix we can obtain the weight criteria by dividing each entry by the sum of each column.

$$W = \begin{matrix} \\ C_1 \\ C_2 \\ C_3 \\ C4 \end{matrix} \begin{matrix} \begin{matrix} C_1 & C_2 & C_3 & C_4 \end{matrix} \\ \begin{bmatrix} 0.588 & 0.234 & 0.237 & 0.175 \\ 0.133 & 0.508 & 0.171 & 0.107 \\ 0.133 & 0.086 & 0.455 & 0.182 \\ 0.145 & 0.172 & 0.095 & 0.536 \end{bmatrix} \end{matrix}$$

Step - 3. Construct the (ANDM) matrix that representing the ratings given by every DM between the Criteria and Alternatives.

$$\tilde{R} = \begin{matrix} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \end{matrix} \begin{matrix} \begin{matrix} C_1 & C_2 & C_3 & C_4 \end{matrix} \\ \begin{bmatrix} (0.5, 0.3, 0.2, 0.4) & (0.6, 0.7, 0.9, 0.1) & (0.7, 0.9, 1.0, 1.0) & (0.4, 0.7, 1.0, 1.0) \\ (0.0, 0.1, 0.3, 0.4) & (0.7, 0.6, 0.8, 0.3) & (0.6, 0.7, 0.8, 0.9) & (0.3, 0.5, 0.9, 1.0) \\ (0.4, 0.2, 0.1, 0.3) & (0.3, 0.0, 0.5, 0.8) & (0.4, 0.2, 0.1, 0.3) & (0.2, 0.5, 0.6, 0.8) \\ (0.7, 0.3, 0.3, 0.6) & (0.6, 0.1, 0.7, 1.0) & (0.2, 0.4, 0.5, 0.8) & (0.3, 0.4, 0.2, 0.5) \\ (0.5, 0.4, 0.2, 0.6) & (0.4, 0.6, 0.1, 0.2) & (0.6, 0.1, 0.3, 0.5) & (0.7, 0.1, 0.3, 0.2) \end{bmatrix} \end{matrix}$$

Then the last matrix appears consistent according to definition 6. And then by ensuring consistency of trapezoidal neutrosophic additive reciprocal preference relations, decision makers (DMs) should determine the maximum truth-membership degree (α), minimum indeterminacy-membership degree (θ) and minimum falsity-membership degree (β) of single valued neutrosophic numbers.

$$R = \begin{matrix} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \end{matrix} \begin{matrix} \begin{matrix} C_1 & C_2 & C_3 & C_4 \end{matrix} \\ \begin{bmatrix} (0.5, 0.3, 0.2, 0.4; 0.3, 0.4, 0.6) & (0.6, 0.7, 0.9, 0.1; 0.3, 0.4, 0.5) & (0.7, 0.9, 1.0, 1.0; 0.2, 0.5, 0.3) & (0.4, 0.7, 1.0, 1.0; 0.1, 0.3, 0.4) \\ (0.0, 0.1, 0.3, 0.4; 0.6, 0.1, 0.4) & (0.7, 0.6, 0.8, 0.3; 0.4, 0.8, 0.1) & (0.6, 0.7, 0.8, 0.9; 0.2, 0.3, 0.5) & (0.3, 0.5, 0.9, 1.0; 0.2, 0.4, 0.6) \\ (0.4, 0.2, 0.1, 0.3; 0.3, 0.5, 0.2) & (0.3, 0.0, 0.5, 0.8; 0.5, 0.7, 0.2) & (0.4, 0.2, 0.1, 0.3; 0.5, 0.7, 0.5) & (0.2, 0.5, 0.6, 0.8; 0.1, 0.2, 0.5) \\ (0.7, 0.3, 0.3, 0.6; 0.5, 0.3, 0.1) & (0.6, 0.1, 0.7, 1.0; 0.2, 0.6, 0.3) & (0.2, 0.4, 0.5, 0.8; 0.1, 0.4, 0.8) & (0.3, 0.4, 0.2, 0.5; 0.3, 0.8, 0.7) \\ (0.5, 0.4, 0.2, 0.6; 0.9, 0.4, 0.6) & (0.4, 0.6, 0.1, 0.2; 0.1, 0.5, 0.4) & (0.6, 0.1, 0.3, 0.5; 0.8, 0.6, 0.2) & (0.7, 0.1, 0.3, 0.2; 0.3, 0.9, 0.6) \end{bmatrix} \end{matrix}$$

From previous matrix we can determine the weight of each criteria by using the following equation of S ($\tilde{a}_{ij}$)

S ($\tilde{a}_{ij}$) = $\frac{1}{16}[a_1 + b_1 + c_1 + d_1] \times (2 + \alpha_{\tilde{a}} - \theta_{\tilde{a}} - \beta_{\tilde{a}})$

and

A ($\tilde{a}_{ij}$) = $\frac{1}{16}[a_1 + b_1 + c_1 + d_1] \times (2 + \alpha_{\tilde{a}} - \theta_{\tilde{a}} + \beta_{\tilde{a}})$

The deterministic matrix can obtain by S ($\tilde{a}_{ij}$) equation in the following step:

$$R = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & C_3 & C_4 \end{array} \\ \begin{bmatrix} 0.11 & 0.20 & 0.32 & 0.27 \\ 0.11 & 0.23 & 0.26 & 0.20 \\ 0.10 & 0.16 & 0.08 & 0.18 \\ 0.25 & 0.19 & 0.11 & 0.07 \\ 0.20 & 0.09 & 0.19 & 0.07 \end{bmatrix} \end{array}$$

Step - 4. Calculate the normalized decision-making matrix from previous matrix.

By this equation = $|X_j| = \sqrt{\sum_1^n x_i^2}$,

$NX_{ij} = \frac{x_{ij}}{|x_j|}$

a. Sum of squares and their square roots

	C_1	C_2	C_3	C_4
A_1	0.11	0.20	0.32	0.27
A_2	0.11	0.23	0.26	0.20
A_3	0.10	0.16	0.08	0.18
A_4	0.25	0.19	0.11	0.07
A_5	0.20	0.09	0.19	0.07
Sum of square	0.14	0.16	0.22	0.16
Square root	0.37	0.40	0.47	0.40

b. Objectives divided by their square roots and MOORA

$$R = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & C_3 & C_4 \end{array} \\ \begin{bmatrix} 0.30 & 0.50 & 0.68 & 0.67 \\ 0.30 & 0.58 & 0.55 & 0.50 \\ 0.27 & 0.40 & 0.17 & 0.45 \\ 0.68 & 0.48 & 0.23 & 0.18 \\ 0.54 & 0.23 & 0.40 & 0.18 \end{bmatrix} \end{array}$$

Step - 5. Compute the aggregated weighted neutrosophic decision matrix (AWNDM) as the following:

$\acute{R}$ = R × W

$$= \begin{bmatrix} 0.30 & 0.50 & 0.68 & 0.67 \\ 0.30 & 0.58 & 0.55 & 0.50 \\ 0.27 & 0.40 & 0.17 & 0.45 \\ 0.68 & 0.48 & 0.23 & 0.18 \\ 0.54 & 0.23 & 0.40 & 0.18 \end{bmatrix} \times \begin{bmatrix} 0.588 & 0.234 & 0.237 & 0.175 \\ 0.133 & 0.508 & 0.171 & 0.107 \\ 0.133 & 0.086 & 0.455 & 0.182 \\ 0.145 & 0.172 & 0.095 & 0.536 \end{bmatrix} =$$

$$= \begin{bmatrix} 0.43 & 0.20 & 0.49 & 0.59 \\ 0.40 & 0.49 & 0.47 & 0.48 \\ 0.29 & 0.59 & 0.25 & 0.36 \\ 0.52 & 0.45 & 0.36 & 0.31 \\ 0.42 & 0.31 & 0.37 & 0.29 \end{bmatrix}$$

Step - 6. Compute the contribution of each alternative Ny_i the contribution of each alternative

$$Ny_i = \sum_{i=1}^{g} Ny_i \; - \; \sum_{j=g+1}^{m} Nx_j$$

	C_1	C_2	C_3	C_4	Y_i	Rank
A_1	0.43	0.20	0.49	0.59	0,85	3
A_2	0.40	0.49	0.47	0.48	0.99	1
A_3	0.29	0.59	0.25	0.36	0.91	2
A_4	0.52	0.45	0.36	0.31	0.60	4
A_5	0.42	0.31	0.37	0.29	0.55	5

Step - 7. Rank the alternatives. The alternatives are ranked according the min cost for alternative as alternative $A_2 > A_3 > A_1 > A_4 > A_5$

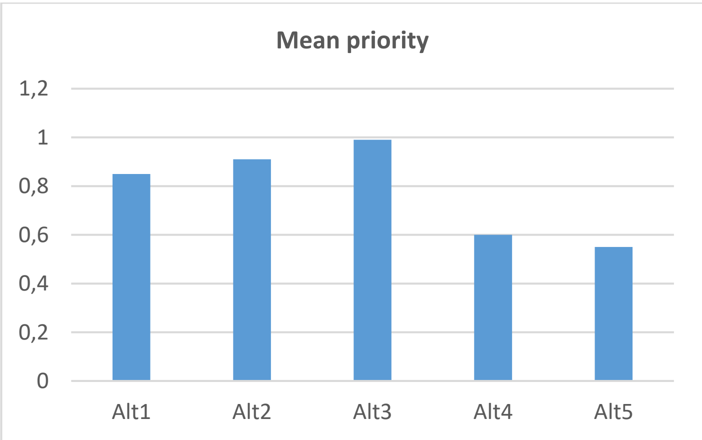

Figure 3. The MOORA- Neutrosophic ranking of alternatives.

5 Conclusion

This research presents a hybrid of the (MOORA) method with Neutrosophic for supplier selection. We presented the steps of the method in seven steps and a numerical case was presented to illustrate it. The proposed methodology provides a good hybrid technique that can facilitate the selecting of the best alternative by decision makers. Then neutrosophic provide better flexibility and the capability of handling subjective information to solve problems in the decision making. As future work, it would be interesting to apply MOORA-Neutrosophic technique in different areas as that is considered one of the decision making for selection of the best alternatives. For example, project selection, production selection, etc. The case study we presented is an example about selecting the alternative that the decision makers (DMs) specify the criteria and how select the best alternatives.

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