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APPLICATION OF NEUTROSOPHIC SET TO MULTICRITERIA DECISION MAKING BY COPRAS

Abstract. *The paper presents multicriteria decision making method with single value neutrosophic sets (SVNS), namely COPRAS-SVNS. The complex proportional assessment method (COPRAS) has shown accurate results for the solution of various multicriteria decision making problems in the engineering field. In this paper, a new extension of the crisp COPRAS method has been proposed. This extension is developed in the context of single value neutrosophic sets. The information processing flow has been proposed for the solution of the multicriteria decision-making problems. The proposed approach consists of the following steps: neutrosophication, solution of MCDM by the operations of the neutrosophic sets, de-neutrosophication. For the execution of the de-neutrosophication step a new version of the score function is proposed. The solution of the practical example of the selection of location for a liquefied natural gas terminal has been provided to illustrate correctness and the effectiveness of the proposed technique.*

Key words*: multi-criteria decision making(MCDM), complex proportional assessment (COPRAS) method, neutrosophic set, selection of location, liquefied natural gas terminal, Baltic sea.*

JEL Classification: C02, C44, C61, C63

1. Introduction

During the last decade a lot of the research efforts have been made to incorporate the vagueness of the initial information for the solution of the complex nature practical problems by multi-criteria decision making (MCDM) methods. Although the different types of the fuzzy sets have been introduced and applied to

the solution of the MCDM problems(Esbouei *et al* (2014), Ghadikolaei *et al* (2014), Kaya and Kahraman (2014)**,** Yazdani-Chamzini (2014),Meng and Chen (2014),Yu (2013)), they cannot take into account all sorts of uncertainties that arise in the solution of the real engineering problems.

A theory of the neutrosophic sets originally proposed by Smarandache (1999, 2014) allows to deal with "knowledge of neural thought" and this "neutral" component distinct this set from the other approaches that are to model uncertain phenomena of information (Mardani *et al* (2015)).

In fact the neutrosophic sets are a generalization of the "fuzzy" and "intuitionistic fuzzy" sets. However, the existing methods governed by fuzzy sets and their particular types are not convenient to solve decision making problem with neutrosophic information. By the logic of the neutrosophic sets each aspect of the problem is represented by the degree of the truth (T), a degree of the indeterminacy (I) and a degree of the falsity (F). In contrast to intuitionistic fuzzy sets where the degree of the uncertainty depends on the degree of membership and the degree of non-membership, by neutrosophic logic the value of the indeterminacy degree is independent of truth and falsity degrees.

Recently the researches proposed some applications of the neutrosophic sets for the solution multi-criteria decision making problems. Recently, Ye (2013) and Majundar and Samanta (2014) have been studied similarity and entropy aspects applying single-valued neutrosophic sets in multi-criteria decision making approaches. Zhang and Wu (2014) develop a novel method for the solution of the single-valued neutrosophic multi-criteria decision making problems under the assumption of the incomplete weight information.

During the recent years a lot of the approaches are proposed to extend the crisp MCDM methods into fuzzy environment in order to deal with uncertain information (Balezentis et al (2014), Baležentis and Zeng (2013), Patrascu (2013),Hajiagha*et al* (2013), Zavadskas *et al* (2014), Zeng *et al* (2013)).

The purpose of the present paper is to extend the crisp COPRAS method by application of the single valued neutrosophic set therefore proposing COPRAS-SVNS. The COPRAS method was developed by Zavadskas *et al* (1994).

The structure of the paper is organized in the following way. Section 2 presents a description of the crisp COPRAS method. Section 3 brings the main concepts of a single valued neutrosophic set. Section 4 focuses on the description of the COPRAS-SVNS method and the application of the proposed method to the selection of a location for a liquefied natural gas terminal at east Baltic sea given Section 5.

2. The COPRAS method

This multicriteria decision making technique was proposed by Zavadskas *et al.* (1994) can be generally expressed as follows. We consider decision-making

problem, which consists of *m* alternatives that must be assessed considering *n* criteria, and x_{ij} can be expressed as the value of the i^{th} alternative by the j^{th}criterion. The main idea of the COPRAS technique consists of the steps described below:

Step1. Select the appropriate set of criteria that describes the chosen alternatives.

Step2. Prepare decision-making matrix *X*:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Step 3. Determine the weights of the criteria w_j.

Step 4. Normalize decision-making matrix $\overline{X}$. The values of the normalized matrix are determined as

$$\bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}; i = 1,2,...,m; j = 1,2,...,n. \quad (2)$$

Step 5. Compute weighted normalized decision-making matrix *D*, which components are calculated as

$$d_{ij} = \bar{x}_{ij} \cdot w_j; i = 1,2,...,m; j = 1,2,...,n. \quad (3)$$

Step 6. Compute summation of the criterion values with respect to optimization direction for the each alternative

$$P_{+i} = \sum_{j=1}^{L_{max}} d_{+ij}; P_{-i} = \sum_{j=1}^{L_{min}} d_{-ij}; \quad (4)$$

where d_{+ij} values correspond to the criteria to be maximized and d_{-ij} values correspond to the criteria to be minimized.

Step 7. Determine the minimal component of the P_{-i}

$$P_{-min} = \min_i P_{-i}; i = 1,2,...,L_{min} \quad (5)$$

Step 8. Determine the score value of each alternative Q_i:

$$Q_i = P_{+i} + \frac{\left(P_{-min}\sum_{j=1}^{L_{min}} P_{-j}\right)}{\left(P_{-i}\sum_{j=1}^{L_{min}} \frac{P_{-min}}{P_{-j}}\right)}; j = 1,...,L_{min} \quad (6)$$

Step 9. Determine optimality criterion *K* for the alternatives:

$$K = \max_i Q_i; i = 1,2,...,m. \quad (7)$$

Step 10. Determine the priority of the alternatives. The greater score value Q_i for the alternative corresponds to the higher priority (rank) of the alternative.

3. Neutrosophic sets

We present a brief review of general concepts of neutrosophic set (Smarandache (1999)).

Definition 1. Let *X* be space of the objects and $x \in X$. A neutrosophic set *A* in *X* is defined by three functions: truth-membership function $T_A(x)$, an indeterminacy- membership function $I_A(x)$ and falsity-membership function $F_A(x)$. These functions $T_A(x)$, $I_A(x)$ and $F_A(x)$ are defined on real standard or real non-standard subsets of $]0^-,1^+[$. That is $T_A(x): X \to]0^-,1^+[$, $I_A(x): X \to]0^-,1^+[$ and $F_A(x): X \to]0^-,1^+[$. We have no any restriction on the sum of $T_A(x), I_A(x)$ and $F_A(x)$, so $0^- \le \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \le 3^+$.

3.1. Single valued neutrosophic set

A single valued neutrosophic set (SVNS) has been defined as described in (Wang *et al* (2010)).

Definition 2. Let *X* be a universal space of the objects and $x \in X$. A single valued neutrosophic set (SVNS) $\tilde{N} \subset X$ can be expressed as

$$\tilde{N} = \left\{ \left\langle x, T_{\tilde{N}}(x), I_{\tilde{N}}(x), F_{\tilde{N}}(x) \right\rangle : x \in X \right\} \quad (8)$$

where $T_{\tilde{N}}(x): X \to [0,1]$, $I_{\tilde{N}}(x): X \to [0,1]$ and $F_{\tilde{N}}(x): X \to [0,1]$ with $0 \le T_{\tilde{N}}(x) + I_{\tilde{N}}(x) + F_{\tilde{N}}(x) \le 3$ or all $x \in X$. The values $T_{\tilde{N}}(x)$, $I_{\tilde{N}}(x)$ and

$F_{\tilde{N}}(x)$ correspond to truth-membership degree, the indeterminacy-membership degree and the falsity-membership degree of x to $\tilde{N}$, respectively. For the case when X consists of the single element, $\tilde{N}$ is called a single valued neutrosophic number (Peng *et al* (2014)).For the sake of the simplicity, a single valued neutrosophic number is expressed by $\tilde{N}_A = (t_A, i_A, f_A)$ where $t_A, i_A, f_A \in [0,1]$ and $0 \le t_A + i_A + f_A \le 3$.

Definition 3. (Zhang and Wu (2014)) If $\tilde{N}_1 = (t_1, i_1, f_1)$ and $\tilde{N}_2 = (t_2, i_2, f_2)$ are two single valued neutrosophic numbers (SVNN), then the summation between $\tilde{N}_1$ and $\tilde{N}_2$ can be expressed as follows

$$\tilde{N}_1 \oplus \tilde{N}_2 = (t_1 + t_2 - t_1 t_2, i_1 i_2, f_1 f_2) \tag{9}$$

Definition 4. (Zhang and Wu (2014)) If $\tilde{N}_1 = (t_1, i_1, f_1)$ and $\tilde{N}_2 = (t_2, i_2, f_2)$ are two single valued neutrosophic numbers, then multiplication between $\tilde{N}_1$ and $\tilde{N}_2$ can be expressed as follows

$$\tilde{N}_1 \otimes \tilde{N}_2 = (t_1 t_2, i_1 + i_2 - i_1 i_2, f_1 + f_2 - f_1 f_2) \tag{10}$$

Definition 5. (Zhang and Wu (2014)) If $\tilde{N}_1 = (t_1, i_1, f_1)$ is a single valued neutrosophic number and $\lambda \in \Re$ is an arbitrary positive real number then

$$\lambda \tilde{N}_1 = \left(1 - (1 - t_1)^{\lambda}, i_1^{\lambda}, f_1^{\lambda}\right), \lambda > 0 \tag{11}$$

Definition 6. (Majumdar and Samanta (2014)) If $A = (A_1, A_2, ..., A_n)$ and $B = (B_1, B_2, ..., B_n)$ $B = \left(B_1, B_2, ..., B_n\right)$ are two single valued neutrosophic sets, then separation measure between A and B applying the normalized Euclidian distance can be expressed as follows

$$q_n(A,B) = \sqrt{\frac{1}{3n}\sum_{i=1}^{n}\left(t_A(x_i) - t_B(x_i)\right)^2 + \left(i_A(x_i) - i_B(x_i)\right)^2 + \left(f_A(x_i) - f_B(x_i)\right)^2}$$
$$(i = 1,2,...,n) \tag{12}$$

Definition 5. If $\tilde{N}_A = (t_A, i_A, f_A)$ is a single valued neutrosophic number, a score function is mapped $\tilde{N}_A$ into the single crisp output $S(\tilde{N}_A)$ as follows

$$S(\tilde{N}_A) = \frac{3 + t_A - 2i_A - f_A}{4} \tag{13}$$

Where $S(\tilde{N}_A) \in [0,1]$. This score function is the modification of the score function proposed by Sahin and Kucuk (2014) and allows us to have the results in the same interval as we deal with single valued neutrosophic numbers.

Definition 6. Let $\tilde{N}_1$ and $\tilde{N}_2$ be any two SVNNs. Therefore,

If $S(\tilde{N}_1) < S(\tilde{N}_2)$ then $\tilde{N}_1$ is smaller than $\tilde{N}_2$, $\tilde{N}_1 < \tilde{N}_2$.

4. COPRAS with a single value neutrosophic set (COPRAS-SVNS)

In this section, the extended COPRAS method is presented. The extension is performed by the application of the neutrosophic sets to model the information for the decision making problem. The general framework for the information processing of the proposed MCDM method can be illustrated as presented in Fig.1.

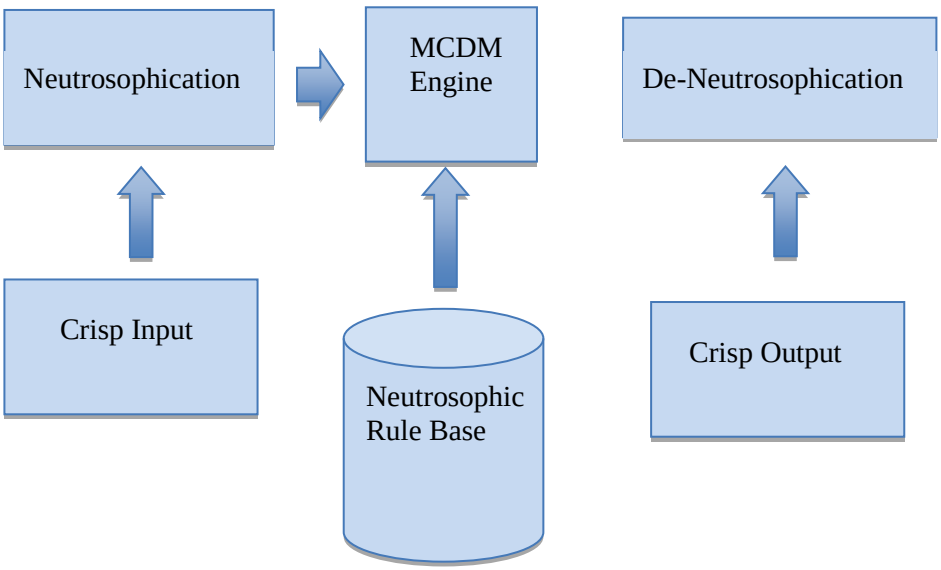

Figure 1. Information processing flow for MCDM with neutrosophic set

All information concerning the importance of the decision makers, individual expert evaluations regarding the ratings of alternatives via attributes and attribute weights usually are expressed in the crisp form. In the neutrosophication step we perform conversion of all crisp initial information into the single valued neutrosophic set. For this purpose weapply relationships between linguistic terms and single valued neutrosophic numbers. The set of linguistic terms used to rate the importance of the alternatives for the decision makers is presented in Table 1.

Table 1. Linguistic terms to rate importance of the alternatives

Linguistic terms	SVNNs
Extremely good (EG)/ 10 points	(1.00, 0.00, 0.00)
Very very good (VVG)/ 9 points	(0.90, 0.10, 0.10)
Very good (VG)/ 8 points	(0.80, 0.15, 0.20)
Good (G) / 7 points	(0.70, 0.25, 0.30)
Medium good (MG) / 6 points	(0.60, 0.35, 0.40)
Medium (M) / 5 points	(0.50, 0.50, 0.50)
Medium bad (MB) / 4 points	(0.40, 0.65, 0.60)
Bad (B) / 3 points	(0.30, 0.75, 0.70)
Very bad (VB) / 2 points	(0.20, 0.85, 0.80)
Very very bad (VVB) / 1 point	(0.10, 0.90, 0.90)
Extremely bad (EB) / 0 points	(0.00, 1.00, 1.00)

The performance of the group decision making applying COPRAS-SVNS approach can be described by the following steps.

Step 1. Determine the importance of the experts. In the case when the decision is made by a group of the experts (decision makers), firstly the importance or share to the final decision of the each expert is determined. If a vector $\lambda = (\lambda_1, \lambda_2, ..., \lambda_k)$ is the vector describing the importance of the each expert, where $\lambda_k \geq 0$ and $\sum_{k=1}^{K} \lambda_k = 1$.

Step 2. In the framework of this step, each decision maker performs his evaluations concerning the ratings of the alternatives with respect to the attributes and the attribute weights. If we denote by $x_{ij}^k, i = 1,2,...,m; j = 1,2,...,n$ the k^{th} expert's evaluation of the i^{th} alternative by the j^{th} criterion. This evaluation is expressed in linguistic terms presented in the table 1. So the decision matrix for any particular expert can be constructed

$$X^k = \begin{bmatrix} x^k{}_{11} & x^k{}_{12} & \cdots & x^k{}_{1n} \\ x^k{}_{21} & x^k{}_{22} & \cdots & x^k{}_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ x^k{}_{m1} & x^k{}_{m2} & \cdots & x^k{}_{mn} \end{bmatrix} \tag{14}$$

Step 3. Calculate the weights of the criteria. The aggregated weights of the criteria are determined by

$$w_j = \lambda_1 w_j^{(1)} \bigcup \lambda_2 w_j^{(2)} \bigcup ... \bigcup \lambda_k w_j^{(k)} = \left\langle \left(1 - \prod_{k=1}^{K} \left(1 - t_j^{(w_k)} \right)^{\lambda_k} \right), \prod_{k=1}^{K} \left(i_j^{(wk)} \right)^{\lambda_k}, \prod_{k=1}^{K} \left(f_j^{(w_k)} \right)^{\lambda_k} \right\rangle \tag{15}$$

Step 4.Construction of the aggregated weighted single valued decision matrix

$$\tilde{X} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix} \tag{16}$$

where any particular element $\tilde{x}_{ij} = \left(\tilde{t}_{ij}, \tilde{i}_{ij}, \tilde{f}_{ij} \right)$ represents the rating of the alternative A_i with respect to *j* criterion and is determined as follows

$$\tilde{x}_{ij} = \lambda_1 x_{ij}^{(1)} \bigcup \lambda_2 x_{ij}^{(2)} \bigcup ... \bigcup \lambda_k x_{ij}^{(k)} = \left\langle \left(1 - \prod_{k=1}^{K} \left(1 - t_{ij}^{(x_k)} \right)^{\lambda_k} \right), \prod_{k=1}^{K} \left(i_{ij}^{(x_k)} \right)^{\lambda_k}, \prod_{k=1}^{K} \left(f_{ij}^{(x_k)} \right)^{\lambda_k} \right\rangle \tag{17}$$

Step 5. Determine the weighted decision matrix. Following Eq. (3), the weighted decision matrix can be expressed as $D = \lfloor d_{ij} \rfloor, i = 1,2,...,m; j = 1,2,...,n,$ where $d_{ij} = \tilde{x}_{ij} \cdot w_j$. Applying Eq. (10), a single element of the weighted decision matrix can be calculated

$$d_{ij} = \left(t_{ij}^{\tilde{x}} t_j^w, i_{ij}^{\tilde{x}} + i_j^w - i_{ij}^{\tilde{x}} i_j^w, f_{ij}^{\tilde{x}} + f_j^w - f_{ij}^{\tilde{x}} f_j^w \right) \tag{18}$$

Step 6. Perform summation of the values for the benefit. Let $L_+ = \{1,2,...,L_{max}\}$ be a set of the criteria to be maximized. Then the index of the benefit for each alternative can be determined

$$P_{+i} = \sum_{j=1}^{L_{max}} d_{+ij} \tag{19}$$

where this summation of the single value neutrosophic numbers is performed applying Eq.(9).

Step 7. Perform summation of the values for cost. Let $L_- = \{1,2,...,L_{min}\}$ be a set of the criteria to be minimized. Then the index of the cost of each alternative can be determined

$$P_{-i} = \sum_{j=1}^{L_{min}} d_{-ij} \tag{20}$$

Step 8. Determine the minimal value of the P_{-i}.

Step 9. Determine the score value of each alternative Q_i. At the beginning the score values are calculated from the aggregated values for benefit and the cost $S(P_{+i})$ and $S(P_{-i})$ applying Eq.(13). The score values of the alternatives van be expressed as

$$Q_i = S(P_{+i}) + \frac{\left(S(P_{-min})\sum_{i=1}^{L_{min}} S(P_{-i})\right)}{\left(S(P_{-min})\sum_{i=1}^{L_{min}} \frac{S(P_{-min})}{S(P_{-i})}\right)} \tag{21}$$

Step 10. Determine optimality criterion *K* for the alternatives:

$$K = \max_i Q_i; i = 1,2,...,m \tag{22}$$

Step 10. Determine the priority of the alternatives. The greater score value Q_i for the alternative corresponds to the highest priority (rank) of the alternative.

5. Numerical examples

As the numerical experiment, application example of the MCDM problem is solved in order to study the aspects of the implementation of the neutrosophic sets. A quite actually are location selection problems by the MCDM application: Dhenna and Mohanraj(2011) presented solution of the distribution center location problem; Elevli (2014) performed an evaluation of locations for the logistics center at Samsun (Turkey), Zavadskas *et al* (2015) solved a decision problem concerning the selection of the location for a liquefied natural gas terminal.

We solved the same decision problem concerning the selection of the location site for liquefied natural gas terminal in order to study the performance of the proposed COPRAS-SVNS method. This problem consists of three alternatives and four groups of the criteria: social, environmental, economic and technical. All initial data transformed into neutrosophic sets. The provided decision matrix can be expressed as follows in Table 2. The weighted decision matrix is constructed applying Eq. (19) and is presented in Table 3.

In the considered case S_1-S_3, A_1-A_5, E_1-E_2 andT_1 are criteria for the benefit and E_3-E_4 andT_2-$T_3$are the cost criteria, the computed values P_{+i}, $P_{-i}$and Q_i for each alternative are shown in Table 3. Therefore, the final ranking is $A_1 \succ A_3 \succ A_2$ and this result completely coincides with the results obtained by crisp COPRAS approach (Zavadskas *et al* (2015)). These results are presented in Table 4.

Analyzing the results presented in Table 4, it is not difficult to observe that Q_i score values determined by COPRAS-SVNS approach are lower than the score values obtained by crisp COPRAS method. The proposed COPRAS-SVNS approach takes into account indeterminacy factor of the initial information and due this fact the score values are lower but this aspect do not change ranking results. On the basis of the results presented above, it is possible to conclude that COPRAS method provides robust and efficient framework for the solution of the MCDM problems applying the different set environments.

6. Conclusions

There are a lot of the cases when solving multicriteria decision making problem it is necessary to deal with uncertain, imprecise and inconsistent information. Recently proposed neutrosophic sets enable us to model all types of the uncertainties in the most consistent way.

In this paper, we have proposed the extended COPRAS method to deal with neutrosophic information. Neutrosophication step is performed applying a set of the linguistic terms that are used to express the rating of the alternatives in the neutrosophic environment. For the execution of the de-neutrosophication step a

Table 2. Initial decision matrix

Criteria	Alternatives	
	I	II
Social		
S_1 max	(0.6, 0.35, 0.4)	(1.0, 0.0, 0.0)
S_2 max	(0.7, 0.25, 0.3)	(0.9, 0.1, 0.1)
S_3 max	(0.3, 0.75, 0.7)	(0.5, 0.5, 0.5)
Environmental		
A_1 max	(0.7, 0.25, 0.3)	(0.7, 0.25, 0.3)
A_2 max	(1.0, 0.0, 0.0)	(0.7, 0.25, 0.3)
A_3 max	(1.0, 0.0, 0.0)	(0.8, 0.15, 0.2)
A_4 max	(0.9, 0.1, 0.1)	(1.0, 0.0, 0.0)
A_5 max	(0.9, 0.1, 0.1)	(1.0, 0.0, 0.0)
Economic		
E_1 max	(0.9, 0.1, 0.1)	(0.7, 0.25, 0.3)
E_2 max	(1.0, 0.0, 0.0)	(0.7, 0.25, 0.3)
E_3 min	(0.148, 0.874, 0.852)	(0.426, 0.61, 0574)
E_4 min	(0.27, 0.78, 0.73)	(0.351, 0.7, 0.649)
Technical		
T_1 max	(1.0, 0.0, 0.0)	(0.6, 0.35, 0.4)
T_2 min	(0.228, 0.822, 0.772)	(0.3798, 0.6702, 0.6202)
T_3 min	(0.217, 0.833, 0.783)	(0.391, 0.659, 0.609)
Criteria	Alternatives	Weights
	III	
Social		(0.15, 0.875, 0.85)
S_1 max	(0.3, 0.75, 0.7)	(0.4, 0.65, 0.4)
S_2 max	(1.0, 0.0, 0.0)	(0.35, 0.7, 0.65)
S_3 max	(1.0, 0.0, 0.0)	(0.25, 0.8, 0.75)
Environmental		(0.3, 0.75, 0.7)
A_1 max	(1.0, 0.0, 0.0)	(0.35, 0.7, 0.65)
A_2 max	(0.7, 0.25, 0.3)	(0.25, 0.8, 0.75)
A_3 max	(0.9, 0.1, 0.1)	(0.25, 0.8, 0.75)
A_4 max	(1.0, 0.0, 0.0)	(0.1, 0.9, 0.9)

A_5 max	(1.0, 0.0, 0.0)	(0.05, 0.95, 0.95)
Economic		(0.35, 0.7, 0.65)
E_1 max	(1.0, 0.0, 0.0)	(0.2, 0.85, 0.8)
E_2 max	(1.0, 0.0, 0.0)	(0.15, 0.875, 0.85)
E_3 min	(0.426, 0.61, 0574)	(0.4, 0.65, 0.6)
E_4 min	(0.378, 0.672, 0.622)	(0.25, 0.8, 0.75)
Technical		(0.2, 0.85, 0.8)
T_1 max	(0.6, 0.35, 0.4)	(0.35, 0.7, 0.65)
T_2 min	(0.3925, 0.6575, 0.6075)	(0.45, 0.575, 0.55)
T_3 min	(0.391, 0.659, 0.609)	(0.2, 0.85, 0.8)

Table 3. Weighted decision matrix

Criteria	Alternatives		
	I	II	III
S_1	(0.036, 0.972, 0.964)	(0.06, 0.956, 0.94)	(0.018, 0.989, 0.982)
S_2	(0.037, 0.972, 0.963)	(0.047, 0.966, 0.953)	(0.053, 0.963, 0.948)
S_3	(0.011, 0.994, 0.989)	(0.019, 0.988, 0.981)	(0.037, 0.975, 0.963)
A_1	(0.074, 0.944, 0.926)	(0.073, 0.944, 0.927)	(0.105, 0.925, 0.895)
A_2	(0.075, 0.95, 0.925)	(0.053, 0.963, 0.947)	(0.053, 0.963, 0.947)
A_3	(0.075, 0.95, 0.925)	(0.06, 0.9575, 0.94)	(0. 068, 0.955, 0.932)
A_4	(0.027, 0.978, 0.973)	(0.03, 0.975, 0.97)	(0.03, 0.975, 0.97)
A_5	(0.014, 0.989, 0.987)	(0.015, 0.988, 0.985)	(0.015, 0.988, 0.985)
E_1	(0.063, 0.969, 0.937)	(0.049, 0.974, 0.951)	(0.07, 0.965, 0.93)
E_2	(0.053, 0.971, 0.947)	(0.037, 0.9784, 0.963)	(0.053, 0.97125, 0.947)
E_3	(0.021, 0.99, 0.979)	(0.06, 0.967, 0.94)	(0.06, 0.965, 0.94)
E_4	(0.024, 0.99, 0.976)	(0.031, 0.986, 0.969)	(0.033, 0.985, 0.967)
T_1	(0.07, 0.955, 0.93)	(0.042, 0.971, 0.958)	(0.042, 0.971, 0.958)
T_2	(0.021, 0.987, 0.979)	(0.034, 0.979, 0.966)	(0.035, 0.978, 0.965)
T_3	(0.009, 0.996, 0.991)	(0.016, 0.992, 0.984)	(0.016, 0.992, 0.984)
P_{+i}	(0.423, 0.694, 0.688)	(0.392, 0.707, 0.697)	(0.429, 0.692, 0.68)
P_{-i}	(0.072, 0.965, 0.952)	(0.133, 0.928, 0.912)	(0.137, 0.926, 0.909)
$S(P_{+i})$	0.3366	0.3203	0.3413
$S(P_{-i})$	0.0474	0.0914	0.094
Q	0.4517	0.38	0.3993

Table 4. Comparison of the ranking results by COPRAS and COPRAS-SVNS

Location alternative A_i	COPRAS		COPRAS-SVNS	
	Q_i	Rank	Q_i	Rank
A_1	0.949	1	0.4517	1
A_2	0.587	3	0.38	3
A_3	0.593	2	0.3993	2

new version of the score function is proposed, which is defined in the interval [*0, 1*]. This interval is more consistent with general neutrosophic theory.

The aspects of the application of the proposed COPRAS-SVNS method are studied considering the selection of the location site for liquefied natural gas terminal. The performed experiment shows numerical stability and consistency of the COPRAS method applying different set environments. This COPRAS-SVNS method enables us to deal with n-value neutrosophic logic.

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