Assessment of Entrepreneurship Orientation of P2P Online Lending Platforms based on Neutrosophic Structured Element

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Abstract

The goal of this study is to bring neutrosophic structured element theory into the assessment of the entrepreneurial orientation of online peer-to-peer lending platforms, as well as to simplify the complicated processes of conventional neutrosophic decision making. This study discusses several methods for assessing the entrepreneurial orientation of online P2P lending systems. Two strategies are offered to deal with the triangular single-valued neutrosophic number multiple attribute decision making issues with incomplete definite knowledge on criteria's weights using the neutrosophic structured element approach. In terms of computational efficiency and performance, the recommended techniques produced encouraging results. The proposed methodologies are easy in understanding and computation, have a great lot of practical utility, and provide new concepts for applying neutrosophic structured element theory to neutrosophic MADM issues and other fields.

Keywords: P2P online lending platform; neutrosophic sets; multi-attribute decision making; neutrosophic structured elements; TOPSIS approach; peer to peer.

1. Introduction

Because of the fast growth of Internet technology, the Internet not only creates new businesses and forms, but it also continually enters the conventional sector. Peer-to-Peer (P2P) lending is one of its products; it is a revolutionary financial transaction platform with borrowers and lenders trading directly on it [1-3]. The phrase online P2P refers to the loan origination process between private persons on online platforms where financial institutions just act as needed intermediaries. P2P network lending, an innovative Internet finance model, is a vital aspect of a country's inclusive finance, and its healthy and orderly functioning is critical to economic and social growth.

It incorporates the ancient concept of personal certificates into the World Wide Web. The involvement of financial institutions is not necessary in this type of loan business [4, 5]. The loan inauguration decision is placed in the hands of private lenders, borrowers, and some websites provide a forum for them to interact with one another [6]. P2P lending examples are PPDai in China and Zopa in Europe. Borrowers often specify the aim of their loan request and share data about their existing financial condition, such as income or available credit lines, on these platforms. Lenders can then issue a loan with an interest rate determined by this information [7]. For borrowers, online P2P lending is a means to get a loan without involving a financial company in the decision-making process, and it may also provide better terms than the conventional banking. It may be viewed by lenders as an investment model in which the investment risk is linked to the credit rating of the financed loans [8]. Platforms frequently gain from rising fees after successfully completed transactions [9]. Since the debut of P2 P network lending in 2006, it has been warmly accepted by operators and investors, faced rapid

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expansion, and occupied a large role in the area of Internet finance due to its advantages of ease, flexibility, high efficiency, and cheap cost [10].

Despite the fact that online P2P lending is a relatively new topic of study, a growing number of scholarly contributions have been published in recent years.

Klafft [11] addressed the issue by giving economic figures from the US marketplace Prosper. Though overall investment performance for most classify has been unsatisfactory, it has been demonstrated that some basic investing principles increase portfolio profitability and lead to satisfactory returns for all credit rating categories except the high-risk one. Based on trust theories, Chen et al. [12] created a comprehensive trust model tailored to the online P2P lending setting in order to better understand the essential aspects that influence lenders' trust. The model is then empirically evaluated using data from 785 online lenders on PPDai, China's first and biggest online P2P network. According to the findings, both confidence in borrowers and trust in intermediaries are important factors affecting lenders' lending intentions. Wei and Lin [13] explored rigorous research on the consequences of market actors' preferences for transaction outcomes and societal welfare. They created a game-theoretic strategy to generate experimentally testable hypotheses while accounting for the platform's motivation. They also discover that loans are financed with a higher likelihood under platform-mandated posted pricing, yet the preset interest rates are higher than borrowers' beginning interest rates and contract interest rates in auctions. Chen et al. [14] investigated the link between the lending results and individuals' group social capital in the online P2P financial credit market. These findings were made possible thanks to an examination of transaction data obtained from one of the major U.S.-based online P2P lending platforms, which revealed that the borrower's structural social capital had a negative influence on his or her ability to obtain financing and to repay the loan. Online P2P lending in capital-constrained supply networks was studied by Gao et al. [15] to determine the equilibrium strategies of supply chain finance system players. They also investigated the linkages between operational and financial choices and discovered that the online P2P lending platform may strike a balance between earnings and possible dangers. Liu et al. [16] created a conceptual background that incorporated two distinct elements of P2P lending and shown that under fairly broad conditions, low-risk borrowers might push high-risk borrowers out of the market. They also identified the important operational parameters for P2P success, as well as the effects of these settings on the welfare of borrowers.

Wang et al. [17] investigated the soft factors and their valid verification in P2P lending activities and discussed borrowers' profiles in their listing issuing and loan repayment. In addition, they discovered that the lenders had accurately detected signals from the better educational backgrounds of the borrowers and their position as owners of automobiles and residences, but had incorrectly recognized signals from the greater income of the borrowers and the length of loan descriptions. To show the usefulness of the topic model, Jiang et al. [18] created four default prediction models based on the attributes extracted from the descriptive text about loans. They also created a two-stage process for selecting an effective feature set that includes both soft and hard data. Using a series of equations and models, Wang et al. [19] established a misclassification cost matrix for P2P credit grading. Their findings demonstrated that cost-sensitive classifiers may dramatically lower total cost, which is critical for P2P platform survival and profitability. Based on the cognitive assessment theory and replies to a survey of 630 investors of the Funding Circle platform, Pierrakis [20] detailed the personal traits, investment criteria, and motivations of investors who use online P2P lending platforms. Omarini [21] explored the P2P business model, emphasizing the significance of having a platform business model.

Because of the benefits of great capital integration ability, high docking efficiency, strong timeliness, and high investment rate of return, the P2P online lending platform has grown fast in recent years. However, as the online lending market has expanded and competition has become increasingly fierce, problems in the development of online lending platforms, such as unclear service objects, poor risk control capabilities, and imperfect regulatory systems, have gradually emerged, and how to evaluate the true strength and development status of these platforms has become a common concern of the current state and society. Although all of these efforts are fascinating, few studies have looked at Multiple Attribute Decision Making (MADM) in the context of P2P lending systems.

In order to arrive at a decision, one must be able to articulate clearly what one wants to achieve, consider a variety of options, weigh the pros and cons of each, and then apply the chosen answer. The success of plans and programming, as well as the efficacy of strategies and the quality of the results that may be expected as a result of their implementation, are all directly tied to the manager's ability to make sound judgments. In the majority of instances, decision-making is desired and to the decision-satisfaction maker's when numerous factors are considered. In Multi-Criteria Decision-Making

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models (MCDM), which have been considered by academics in recent decades, many assessment criteria are employed rather than a single ideal measure. The (MCDM) models are classified into two categories: Multiple-Objective Decision-Making (MODM) and Multiple-Objective Decision-Making (MADM). In general, multi-objective models are employed during the design phase, whereas multi-attribute models are employed when picking an improved option.

The primary distinction between the MODM and MADM models is that the former is specified in a continuous decision space while the latter is described in a discrete space. In light of the fact that MADM applications are more prevalent in real-world situations than MODM applications, researchers have spent the past 60 years developing MADM.

Online P2P lending platforms are businesses that must develop entrepreneurial skills in order to thrive. The processes of strategy formulation and the organizational styles of organizations engaged in entrepreneurial activities are referred to together as "entrepreneurship orientation" (EO) [22]. Several research have identified a link between EO and corporate performance (e.g., [23, 24]). As a result, assessing the EO of online P2P lending platforms is critical for businesses and organizations like as governments, business angels, and venture investors. The few available techniques in this field are as follows: Chen et al. [25] created a strategy and assessment tool for analyzing the entrepreneurial orientation of peer-to-peer lending platforms based on MADM. Ji et al. [26] based on the TODIM model, developed an expanded technique to produce a fairer evaluation of personal default risk in P2P online lending platforms, which minimizes uncertainty while taking the psychological traits of lenders into consideration to prevent risk. In this study, we examine this topic and explore the finest uncertainty and indeterminacy evaluation tools, known as neutrosophic logic, for real-world assessment.

Smarandache's neutrosophic theory [27] represents a further expansion of fuzzy set (FS) [28], intuitionistic fuzzy set (IFS) [29], spherical fuzzy set (SFS) [30], Pythagorean fuzzy set [31], Picture fuzzy set [32], etc. In neutrosophic set (NS), each component in the universe of discourse set has variable degrees of truth, indeterminacy, and falsity membership degrees with values between 0 and 1, and these three components are completely independent of one another. It is able to effectively display uncertain, partial, and inconsistent information and overcomes some of the limitations of the existing approaches in depicting uncertain decision information [27]. NSs have also been extended to include bipolar neutrosophic sets [33, 34], single-valued neutrosophic sets [35-37], simplified neutrosophic sets [38-40], interval neutrosophic sets [41-43], and multi-valued neutrosophic sets [44-45]. There are also various applications of NS in science and engineering; e.g. [45-60].

One of the significant extension of NS is the neutrosophic structured element (NSE). Edalatpanah [61] pioneered the idea of NSE theory to express NS as a linear structure. Some techniques in the current modeling of neutrosophic issues accurately manage original neutrosophic information, which can easily lead to information loss and potentially biased outcomes. In a formal sense, these techniques have not strayed far from the realm of conventional decision-making. Furthermore, parameter ergodicity issues might occasionally disrupt the calculating process. For example, the α-cut set approach needs the parameter to be set to [0, 1], which is not practical. Neutrosophic numbers can be compared and sequenced based on the link between truth, indeterminacy, and falsity membership functions, but the formulae are cumbersome and certain techniques to doing so do not meet the rational hypothesis of economic man. However, modelling with NSE can remove these shortcomings. Homeomorphic feature between a closed neutrosophic number space and a collection of limited functions on [-1, 1] is the foundation for NSE. The NSE was used to represent NSs and their operations, avoiding the ergodicity of the extension concept. In addition, it is possible to implement the NSs inheritance of the calculation process and the analytic expression of calculation results.

In this paper, we present some efficient MADM algorithms based on NSE and use them to assess the EO of online P2P lending platforms.

The rest of the paper is structured as follows: Section 2 covers the fundamentals of NSE as well as other important terminology. Section 3 presents two MADM approaches based on NSEs. Section 4 employs the new models to assess the entrepreneurial orientation of online P2P lending platforms. Section 5 summarizes the study paper's key results.

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2. Neutrosophic Structured Element

In this section, some basic concepts and relations of NSE are reviewed [61].

Definition 1. Consider $\Lambda =< (\delta_1,\delta_2,\delta_3),(\iota_1,\iota_2,\iota_3),(\xi_1,\xi_2,\xi_3) >$ as the Triangular Single Valued Neutrosophic number (TSVNN). Then the truth ($T_\Lambda(x)$), indeterminacy ($\Gamma_\Lambda(x)$), and falsity ($\Psi_\Lambda(x)$) membership functions are described as follows:

$$T_\Lambda(x)=\begin{cases}\dfrac{(x-\delta_1)}{(\delta_2-\delta_1)} & \delta_1\le x<\delta_2,\\ 1 & x=\delta_2,\\ \dfrac{(\delta_3-x)}{(\delta_3-\delta_2)} & \delta_2<x\le\delta_3,\\ 0 & otherwise.\end{cases}\qquad \Gamma_\Lambda(x)=\begin{cases}\dfrac{(\iota_2-x)}{(\iota_2-\iota_1)} & \iota_1\le x<\iota_2,\\ 0 & x=\iota_2,\\ \dfrac{(x-\iota_2)}{(\iota_3-\iota_2)} & \iota_2<x\le\iota_3,\\ 1 & otherwise.\end{cases}$$

$$\Psi_\Lambda(x)=\begin{cases}\dfrac{(\xi_2-x)}{(\xi_2-\xi_1)} & \xi_1\le x<\xi_2,\\ 0 & x=\xi_2,\\ \dfrac{(x-\xi_2)}{(\xi_3-\xi_2)} & \xi_2<x\le\xi_3,\\ 1 & otherwise.\end{cases}$$

Where,

$$0\le T_\Lambda(x)+\Gamma_\Lambda(x)+\Psi_\Lambda(x)\le 3, x\in\Lambda. \tag{1}$$

Definition 2. For TSVNN $\Lambda =< (\delta_1,\delta_2,\delta_3),(\iota_1,\iota_2,\iota_3),(\xi_1,\xi_2,\xi_3) >$, there are $p,q,r:[-1,1]\to[0,1]$ such that $T_\Lambda(x)=p_x(E),\ \Gamma_\Lambda(x)=q_x(E),$ and $\Psi_\Lambda(x)=r_x(E),$ where:

$$p_x(E)=\begin{cases}(\delta_2-\delta_1)x+\delta_2, & -1\le x\le 0,\\ (\delta_3-\delta_2)x+\delta_2, & 0\le x\le 1,\\ 0, & others,\end{cases} \tag{2}$$

$$q_x(E)=\begin{cases}(\iota_2-\iota_1)x+\iota_2, & -1\le x\le 0,\\ (\iota_3-\iota_2)x+\iota_2, & 0\le x\le 1,\\ 0, & others,\end{cases} \tag{3}$$

and,

$$r_x(E)=\begin{cases}(\xi_2-\xi_1)x+\xi_2, & -1\le x\le 0,\\ (\xi_3-\xi_2)x+\xi_2, & 0\le x\le 1,\\ 0, & others,\end{cases} \tag{4}$$

Note: $\Lambda =< p_\Lambda(E),q_\Lambda(E),r_\Lambda(E) >,$ and $\Lambda=\{(x,p_x(E),q_x(E),r_x(E))\mid x\in X\}$ are called NSE number (NSEN), and NSE set (NSES), respectively.

Definition 3. For $M =< p_M(E),q_M(E),r_M(E) >,$ and $n =< s_M(E),t_M(E),u_M(E) >,$ we have:

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$$(i) M \oplus N =< (p_M + s_M - p_M s_M)(E), (q_M t_M)(E), (r_M u_M)(E) >, \quad (5)$$

$$(ii) M \otimes N =< (p_M s_M)(E), (q_M + t_M - q_M t_M)(E), (r_M + u_M - r_M u_M)(E) >, \quad (6)$$

$$(iii) \lambda M =< 1-[1-[(1-p_M(E))]^{\lambda}], [q(E)]^{\lambda}, [r(E)]^{\lambda} >, \quad (7)$$

$$(iv) M^{\lambda} =< [p_M(E)]^{\lambda}, [1-(1-q_M(E))]^{\lambda}, [1-(1-r_M(E))]^{\lambda} >, \lambda > 0. \quad (8)$$

Definition 4. Suppose $M =< p_M(E), q_M(E), r_M(E) >$, is an NSEN, then

$$S(M) = \frac{1}{9}\int_{-1}^{1} \omega(x)(2 + p_M(x) - q_M(x) - r_M(x))dx, \quad (9)$$

and,

$$H(\mathrm{P}) = \frac{1}{9}\int_{-1}^{1} \omega(x)(2 + p_M(x) - q_M(x) + r_M(x))dx, \quad (10)$$

Are called the score and accuracy function of NSEN M , respectively. Also:

$$\omega(x) = \begin{cases} 1+x, & -1 \le x \le 0, \\ 1-x, & 0 \le x \le 1, \\ 0, & others. \end{cases} \quad (11)$$

Definition 5. Suppose M and N are two NSENs;

1. If $S(M) < S(N)$, then $M \prec N$,
2. When $S(M) = S(N)$;
   (a) If $H(M) < H(N)$, then $M \prec N$,
   (b) If $H(M) = H(N)$, then $M = N$.

Definition 6. For two NSEN $M =< p_M(E), q_M(E), r_M(E) >$, and $n =< s_M(E), t_M(E), u_M(E) >$, Hamming distance can be defined as:

$$Ham(M, N) = \frac{1}{3}\int_{-1}^{1} \omega(x)(|p_M(x) - s_M(x)| + |q_M(x) - t_M(x)| + |r_M(x) - u_M(x)|)dx. \quad (12)$$

3. Proposed MADM Methods

For a neutrosophic MADM problem, let A= {A_1, A_2, …, A_m} be the alternative set and C= {C_1, C_2, …, C_n} be the criterion set. Let the decision maker use the TSVNNs $\theta_{ij} =< (\delta_{1_{ij}}, \delta_{2_{ij}}, \delta_{3_{ij}}), (\iota_{1_{ij}}, \iota_{2_{ij}}, \iota_{3_{ij}}), (\xi_{1_{ij}}, \xi_{2_{ij}}, \xi_{3_{ij}}) >, i = 1,2,\ldots,m; j = 1,2,\ldots,n$ to represent the criterion value information of the decision scheme $A_i \in A$ under the criterion $C_j \in C$, and get the decision matrix $R = (\theta_{ij})_{m\times n}$. Decision makers may supply incomplete or ambiguous data on criteria weight information $\Phi = (\varphi_1, \varphi_2, \ldots, \varphi_n)^T$. This data might be presented in the mathematical forms such as: $\varphi_i \ge \varphi_j$, $a_1 \le \varphi_i \le a_2$, etc. Let Ξ denote the set of incomplete information about the criterion weights given by the decision maker. The aim of the problem is to determine a ranking of alternatives or rating them, to enable decision makers for choosing their final alternative(s) or ranking them. In this section, based on the neutrosophic structured element theory, we present two neutrosophic MADM methods with incomplete criterion weight information.

3.1 Scoring method based NSE

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Step 1. Consider the decision matrix $R=\left(\theta_{ij}\right)_{m\times n}$ in form of an TSVNN. Using Definition 2, transform it to the NSE decision matrix $R_{NSE}=\left(\Lambda_{ij}\right)_{m\times n}=\left(< p_{ij}(E), q_{ij}(E), r_{ij}(E) >\right)_{m\times n}$.

Step 2. Using Eq. (9), construct the scoring matrix of R_{NSE} as $SCORE_{NSE}=\left(s_{ij}\right)_{m\times n}$.

Step 3. Create an optimization model based on the total difference between the criteria value score and the ideal point score, as well as the criterion weight's unpredictability, and determine the optimal criterion weight. Assume that the optimal criterion weight obtained according to the incomplete information of criterion weight is $\Phi=(\varphi_1,\varphi_2,\ldots,\varphi_n)^T$. Then based on the scoring matrix, the comprehensive criterion value of each alternative is defined as:

$$S_i(\Phi)=\sum_{j=1}^{n}\varphi_j s_{ij}, \quad i=1,2,...,m. \tag{13}$$

Obviously, the larger $S_i(\Phi)$, the better scheme A$_i$. Let $\theta_j^+ =< p_j^+(E), q_j^+(E), r_j^+(E) >$, $(j=1,2,...,n)$ be the n largest NSENs, then $A^+=(\theta_1^+,\theta_2^+,\ldots,\theta_n^+)^T$ is called the ideal point of neutrosophic number, and $S(A^+)=(S(b_1^+),S(b_2^+),\ldots,S(b_n^+))^T$. Here, we consider $p_j^+(E)=1$, $q_j^+(E)=0$, and $r_j^+(E)=0$. So,

$$S(b_j^+)=\frac{1}{9}\int_{-1}^{1}\omega(x)(2+p_j^+(E)-q_j^+(E)-r_j^+(E))dx=1. \tag{14}$$

Given the scoring matrix $SCORE_{NSE}=\left(s_{ij}\right)_{m\times n}$, an acceptable standard weight should lead in the minimum total deviation of the scores between all alternatives A$_i$ and the ideal point A^+, i.e., minimization. So, we have:

$$\min \quad D(\Phi)=\sum_{j=1}^{n}\sum_{i=1}^{m}\varphi_j(1-S_{ij})$$
$$s.t\begin{cases}\Phi\in\Xi,\\ \sum_{j=1}^{n}\varphi_j=1,\\ \varphi_j\ge 0,(j=1,\ldots,n).\end{cases}$$
(15)

Simultaneously, because the true weight of each criterion is a random variable, there is uncertainty. To characterize this uncertainty, the criterion weight φ_j may be viewed as the probability of the jth index C$_j$ in the criteria set, allowing Shannon information entropy to be employed to represent the uncertainty of the criterion weight:

$$K=-\sum_{j=1}^{n}\varphi_j \ln\varphi_j$$
(16)

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According to the Jaynes maximum entropy principle [62, 63], a fair criteria weight should maximize the Jaynes entropy, i.e.,

$$K = -\sum_{j=1}^{n} \varphi_j \ln\varphi_j$$
$$s.t\begin{cases}\Phi \in \Xi, \\ \sum_{j=1}^{n}\varphi_j = 1, \\ \varphi_j \geq 0, (j = 1,\dots,n).\end{cases}$$

(17)

To accomplish the aforementioned objectives, determining the best criteria weight is equivalent to solving the following optimization problem:

$$\min \beta\sum_{j=1}^{n}\sum_{i=1}^{m}\varphi_j(1-S_{ij}) + (1-\beta)\sum_{j=1}^{n}\varphi_j \ln\varphi_j$$
$$s.t\begin{cases}\Phi \in \Xi, \\ \sum_{j=1}^{n}\varphi_j = 1, \\ \varphi_j \geq 0, (j = 1,\dots,n).\end{cases} \quad (18)$$

The parameter $\beta \in [0,1]$ reflects the balancing coefficient between the two aforementioned objectives, which can be specified beforehand based on the actual situation.

Step 4. According to the optimal criterion weight obtained in Step 3, the comprehensive criterion value score $S_i(\Phi)$, $i = 1, 2, \cdots, m$ of the alternative A_i is calculated by Eq.(13).

Step 5. Use $S_i(\Phi)$ ($i = 1, 2, \cdots, m$) to sort the solutions and select the best ones.

3.2 TOPSIS method based NSE

Step 1. This step is the same as Step 1 of the Scoring method based NSE.

Step 2. Determine the ideal point of neutrosophic number (see Step 3 of the Scoring method based NSE). For the anti-ideal point, let $\theta_j^- =< p_j^{+-}(E), q_j^-(E), r_j^-(E) >$, $(j = 1, 2, ..., n)$ be the n smallest NSENs, then $A^- = (\theta_1^-, \theta_2^-, \dots, \theta_n^-)^T$ is called the negative ideal point of neutrosophic number, where $p_j^-(E) = 0$, $q_j^-(E) = 1$, and $r_j^-(E) = 1$.

Step 3. By solving model (18), at first, obtain the optimal criterion weight $\Phi = (\varphi_1, \varphi_2, \dots, \varphi_n)^T$. The weighted distances between the solution and the ideal point and the negative ideal are then calculated with the following equations:

$$d_i^+ = d(A_i, A^+) = \sum_{j=1}^{n}\varphi_j Ham(\theta_{ij}, \theta_{ij}^+) \quad (19)$$

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$$d_i^- = d(A_i, A^-) = \sum_{j=1}^{n} \varphi_j Ham(\theta_{ij}, \theta_{ij}^-) \quad (20)$$

Step 4. According to Eqs. (19-20) calculate the relative closeness as follows:

$$d_i^* = \frac{d_i^-}{d_i^- + d_i^+}, \quad i = 1, 2, \ldots, m. \quad (21)$$

Step 5. Sort the solutions according to the value of d_i^* $(i = 1, 2, \cdots, m)$ and select the best solution. The greater d_i^*, the better option.

4. Numerical Analysis

In this part, we use the presented approaches to assess the entrepreneurial orientation of online peer-to-peer lending platforms. We use these methodologies to assess and rank the EO of five online P2P lending platforms based on their final EO ratings. Three evaluation factors are taken into account: proactiveness (C_1), risk-taking (C_2), and creativeness (C_3) [64, 65]. In this scenario, the lending expert is only comfortable delivering his/her judgment of each option on each characteristic as a TSVNNs, as indicated in Table 1. Furthermore, the lending expert could only supply the following limited details on the weights:

$$0.28 \le \varphi_1 \le 0.37, \quad 0.33 \le \varphi_2 \le 0.38, \quad \varphi_3 \le 0.32.$$

Table 1: Decision matrix with TSVNNs information.

	C_1	C_2	C_3
A_1	$<(0.5, 0.6, 0.7), (0.1, 0.2, 0.3), (0.3, 0.4, 0.5)>$	$<(0.5, 0.7, 0.9), (0.2, 0.2, 0.2), (0.1, 0.2, 0.3)>$	$<(0.3, 0.4, 0.5), (0.2, 0.3, 0.4), (0.2, 0.4, 0.6)>$
A_2	$<(0.4, 0.5, 0.6), (0.2, 0.3, 0.4), (0.1, 0.3, 0.5)>$	$<(0.3, 0.5, 0.7), (0.1, 0.2, 0.3), (0.2, 0.3, 0.4)>$	$<(0.6, 0.7, 0.8), (0.0, 0.1, 0.2), (0.3, 0.5, 0.7)>$
A_3	$<(0.6, 0.7, 0.8), (0.0, 0.1, 0.2), (0.0, 0.2, 0.4)>$	$<(0.4, 0.5, 0.6), (0.2, 0.3, 0.4), (0.3, 0.4, 0.5)>$	$<(0.5, 0.7, 0.9), (0.1, 0.1, 0.1), (0.3, 0.4, 0.5)>$
A_4	$<(0.5, 0.6, 0.7), (0.1, 0.2, 0.3), (0.2, 0.4, 0.6)>$	$<(0.3, 0.4, 0.5), (0.3, 0.4, 0.5), (0.1, 0.2, 0.3)>$	$<(0.5, 0.6, 0.7), (0.0, 0.1, 0.2), (0.1, 0.2, 0.3)>$
A_5	$<(0.7, 0.8, 0.9), (0.1, 0.1, 0.1), (0.2, 0.3, 0.4)>$	$<(0.6, 0.7, 0.8), (0.1, 0.2, 0.3), (0.0, 0.1, 0.2)>$	$<(0.4, 0.5, 0.6), (0.1, 0.3, 0.5), (0.2, 0.3, 0.4)>$

Now, we solve this problem with two new methods:

(i) Scoring method based NSE

Step 1. Consider Table1. Using Definition 2, we have NSE decision matrix shown in Table 2, (see also Table 3 as scoring functions of Table 2)

Table 2: Decision matrix with NSE information.

	C_1	C_2	C_3
A_1	$<0.1x + 0.6, 0.1x + 0.2, 0.1x + 0.4>$	$<0.2x + 0.7, 0.0x + 0.2, 0.1x + 0.2>$	$<0.1x + 0.4, 0.1x + 0.3, 0.2x + 0.4>$
A_2	$<0.1x + 0.5, 0.1x + 0.3, 0.2x + 0.3>$	$<0.2x + 0.5, 0.1x + 0.2, 0.1x + 0.3>$	$<0.1x + 0.7, 0.1x + 0.1, 0.2x + 0.5>$
A_3	$<0.1x + 0.7, 0.1x + 0.1, 0.2x + 0.2>$	$<0.1x + 0.5, 0.1x + 0.3, 0.1x + 0.4>$	$<0.2x + 0.7, 0.0x + 0.1, 0.1x + 0.4>$
A_4	$<0.1x + 0.6, 0.1x + 0.2, 0.2x + 0.4>$	$<0.1x + 0.4, 0.1x + 0.4, 0.1x + 0.2>$	$<0.1x + 0.6, 0.1x + 0.1, 0.1x + 0.2>$
A_5	$<0.1x + 0.8, 0.0x + 0.1, 0.1x + 0.3>$	$<0.1x + 0.7, 0.1x + 0.2, 0.1x + 0.1>$	$<0.1x + 0.5, 0.2x + 0.3, 0.1x + 0.3>$

Table 3: Score of NSE decision matrix.

	C_1	C_2	C_3
A_1	0.6667	0.7667	0.5667
A_2	0.6333	0.6667	0.7000
A_3	0.8000	0.6000	0.7333

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A_4	0.6667	0.6000	0.7667
A_5	0.8000	0.8000	0.6333

Step 2. Use the optimization model (18) (let $\beta = 0.5$) to obtain the optimal criterion weight vector as $\Phi = (0.3430, 0.3667, 0.2903)^T$.

Step 3. Use Eq. (13) to obtain the scheme's comprehensive criteria value score based on the optimal criterion weight. So, we have:

$$S_1(\Phi) = 0.6743, \quad S_2(\Phi) = 0.6649, \quad S_3(\Phi) = 0.7073, \quad S_4(\Phi) = 0.6713, \quad S_5(\Phi) = 0.7516.$$

Step 4. Based on ranking of Step 3, $A_5 \succ A_3 \succ A_1 \succ A_4 \succ A_2$. Therefore, the best alternative is A_5. Next, we solve the problem by TOPSIS method based NSE. The initial steps are same as the first method. The Hamming distances between the solution and the ideal point and the negative ideal are then calculated using (Eq. (12)). The results have been shown in Tables 4 and 5.

Table 4: Hamming distances between the solution and the ideal point.

	C_1	C_2	C_3
A_1	1.0000	0.7000	1.3000
A_2	1.1000	1.0000	0.9000
A_3	0.6000	1.2000	0.8000
A_4	1.0000	1.2000	0.7000
A_5	0.6000	0.6000	1.1000

Table 5: Hamming distances between the solution and the negative ideal point.

	C_1	C_2	C_3
A_1	2.0000	2.3000	1.7000
A_2	1.9000	2.0000	2.1000
A_3	2.4000	1.8000	2.2000
A_4	2.0000	1.8000	2.3000
A_5	2.4000	2.4000	1.9000

After computation of the optimal criterion weight vector, the d_i^+ and d_i^- can compute with Eqs.(19-20). Table 6 shows the results.

Table 6: weighted distances between the solution and the negative ideal point.

	d_i^+	d_i^-
A_1	0.9771	2.0229
A_2	1.0053	1.9947
A_3	0.8781	2.1219
A_4	0.9863	2.0137
A_5	0.7451	2.2549

According to Table 6, we can calculate the relative closeness as follows:

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$$d_1^* = 0.6743,\quad d_2^* = 0.6649,\quad d_3^* = 0.7073, d_4^* = 0.6713,\quad d_5^* = 0.7516.$$

As a result, the ranking order of the five choices is $A_5 \succ A_3 \succ A_1 \succ A_4 \succ A_2$.

As a consequence, we may conclude that alternative A_5 is the greatest option among all of them.

Clearly, the aforementioned two types of ranking orders and the best alternative are the same.

6. Conclusions and future work

The study of bounded neutrosophic numbers may be reduced to the study of homologous monotone bounded functions on [1, 1] by using neutrosophic structured elements (NSE) to describe the triangular single-valued neutrosophic number (TSVNN). This study offers two methods for assessing the entrepreneurial orientation of online peer-to-peer lending platforms. Next, based on the neutrosophic structured element representation of TSVNNs, the element order of neutrosophic numbers, the scoring function and distance measure of them are integrated and expanded. Then two MADM methods in which the criterion weight information is not completely determined have been presented. The proposed methodologies yielded promising results in terms of computing efficiency and performance. The developed approaches are straightforward in thinking, simple in computation, have tremendous practical usefulness, and offer up new ideas for applying neutrosophic structured element theory to deal with neutrosophic MADM problems and apply it to other domains. The theoretical NSE information integration operator and its application in decision-making will be the subject of further research.

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