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New multi-criteria decision making technique based on neutrosophic QUALIFLEX method

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Abstract: The field of Multicriteria Decision Making (MCDM) has advanced significantly, with methods like QUALIFLEX playing a key role by integrating concordance and discordance measures for robust decision outcomes. This paper introduces an innovative extension, neutrosophic QUALIFLEX, which incorporates neutrosophic sets to better handle uncertainty and indeterminacy. Neutrosophic logic manages truth, indeterminacy, and falsity simultaneously, offering a nuanced approach compared to traditional models. The scope of this article is the application of neutrosophic QUALIFLEX to staff selection in business, a scenario often plagued by high uncertainty. Preliminary results show that neutrosophic QUALIFLEX provides superior performance, delivering more accurate and reliable rankings of candidates. This method addresses the limitations of conventional MCDM approaches, improving decision-making accuracy and expanding the theoretical foundations of MCDM for future research and applications in complex environments. This contribution to the literature bridges a critical gap by addressing the limitations of conventional MCDM methods in dealing with ambiguous and indeterminate information. The integration of neutrosophic sets into the QUALIFLEX framework not only improves decision-making accuracy but also expands the theoretical foundations of MCDM, paving the way for future research and application in complex decision environments.

Keywords: Multi-criteria decision-making method; net concordance/discordance indices; QUALIFLEX method; neutrosophic logic; neutrosophic QUALIFLEX method.

1. Introduction

The limitations of current models in addressing multi-dimensional real business problems using a single criterion have led to the development of multi-criteria decision making. Multiple-Criteria Decision Making (MCDM) is widely recognized as one of the most significant scientific approaches utilized by experts. When a decision maker analyzes more than one characteristic, the concept of MCDM is introduced, which plays a significant role in everyday decisions in organizations and human societies.

Practically, MCDM is used to deal with structuring, decision-making, and planning steps when the domain possesses manifold criteria to reach an optimum solution based on the deciders' preferences. As a result, decisions made fall into the categories of unstructured or semi-structured decisions, necessitating support for the decision-maker through the development of suitable multi-criteria models.

Outranking methods are a vital subset of MCDM techniques, designed to handle complex decision-making scenarios involving multiple, often conflicting criteria. They are used to evaluate and rank alternatives based on multiple criteria through pairwise comparisons. Unlike traditional aggregation methods, outranking methods assess the degree to which one alternative is preferred over another by analyzing concordance (agreement) and discordance (disagreement) among the criteria. This approach allows for a more nuanced assessment, accommodating thresholds and indifference zones to capture significant differences in performance. These techniques are especially useful in complicated decision-making scenarios that involve subjective judgements and qualitative criteria, since they provide a formal framework for efficiently managing ambiguity and competing objectives.

One of the most prominent outranking methods is QUALIFLEX (Qualitative Flexible Multiple Criteria Method), which is a MCDM technique that ranks alternatives based on qualitative and quantitative criteria by evaluating the ordinal rankings of alternatives for each criterion [1-4]. Unlike traditional aggregation methods, QUALIFLEX considers all possible permutations of alternatives and assesses each permutation through concordance and discordance measures, which quantify the agreement and disagreement among the criteria rankings. A global concordance index is calculated for each permutation, representing the overall support from the criteria. The permutation with the highest global concordance index is selected as the optimal ranking, providing a comprehensive ordering of alternatives that aligns best with the individual criterion rankings. Quite recently, several extensions have been developed to enhance the QUALIFLEX method [5-6].

One of the primary disadvantages of QUALIFLEX lies in its deterministic nature and sensitivity to precise rankings of alternatives for each criterion. This approach can be ill-suited for handling situations where data is uncertain, imprecise, or subject to ambiguity. Furthermore, QUALIFLEX lacks inherent mechanisms for probabilistic analysis, making it challenging to integrate uncertainty quantification into the decision-making process. As a result, the method may struggle to accurately reflect preferences and provide reliable rankings when faced with indeterminate information or dynamic changes in criteria evaluations.

In many cases, it is in fact difficult for decision-makers to definitely express their preference in solving MCDM problems with inaccurate, uncertain, or incomplete information. The primary goal of decision-makers is to handle uncertainties, particularly in ambiguous circumstances when the outcome is not simply true or untrue. As a result, new approaches for finding effective answers are emerging, including fuzzy logic, intuitionistic fuzzy logic, interval-valued fuzzy, and, more recently, neutrosophic logic. In this context, the first approximate method that was proposed was fuzzy logic theory [7]. Its objective is to deal with the concept of partial truth, where the truth value might be either true or false.

Smarandache began using non-standard analysis using a tri-component logic/set/probability theory in 1995, inspired by philosophical considerations. As a result, he created the neutrosophic logic theory, arguing that fuzzy logic cannot demonstrate indeterminacy on its own [8]. Neutrosophic logic proposes three functions, truth-membership, indeterminacy-membership, and falsity-membership, to address constraints in classical logic when confronted with incomplete, imprecise, or contradictory data. This innovative paradigm acknowledges not only true and false values but also a third domain of indeterminacy, where items can possess both truth and falsity characteristics simultaneously. The ability of neutrosophic logic to capture and formalize this inherent complexity makes it a crucial tool in various domains, including artificial intelligence, decision sciences, engineering, and philosophy.

The NL overcomes the constraints of fuzzy logic (FL) and intuitionistic fuzzy logic (IFL) by taking into account truth, intermediacy, and falsity membership degrees, as well as its capacity to discriminate between relative truth and absolute truth, and relative falsity and absolute falsity. As a result, multiple studies were inspired to propose several MCDM techniques under neutrosophic conditions [9-14].

In the field of staff selection, the related bibliography shows a plethora of MCDM methods as a valuable tool for addressing the issue of selecting appropriate personnel. Many researchers suggest utilizing decision support system tools in the personnel selection procedure to improve the judgments of decision-makers. Scholars in [15] apply MCDM methods for staff selection, while an aggregating function is used in [16]. The Analytic Hierarchy Process (AHP) technique divides the problem into a top-down hierarchical structure to improve decision-makers' judgments [17]. Fuzzy methods are provided to enhance decision-makers' decisions during the personnel selection process due to vague and imprecise information [18]. In the field of neutrosophic logic, scholars in [19] present a definition of neutrosophic parameterized (NP) soft set and its operations, applying their method to an illustrative example of a staff selection problem. Recently, authors in [13] studied a real case study of academic staff selection and proposed an innovative conceptual framework based on neutrosophic Delphi (N-Delphi) and neutrosophic Analytic Hierarchy Process (N-AHP).

Previous research on neutrosophic MCDM techniques in staff selection has not included the use of neutrsophic QUALIFLEX principles for selecting appropriate employees, motivating us to present this study. This study introduces the neutrosophic QUALIFLEX method, integrating neutrosophic logic with QUALIFLEX to better handle uncertainty and indeterminacy. Applied to staff selection, this method demonstrates superior performance in delivering accurate and reliable rankings compared to traditional MCDM approaches.

The main objectives of our current research are the following:

- Filling the observed research gap by introducing a novel multi-criteria decision-making (MCDM) method, termed neutrosophic QUALIFLEX, which integrates neutrosophic sets to better handle uncertainty and indeterminacy in decision-making processes?
- Application of the neutrosophic QUALIFLEX method to the problem of staff selection in business, showcasing its practical utility in a real-world decision-making scenario characterized by high levels of uncertainty.
- Contribution to the theoretical foundations of MCDM by integrating neutrosophic sets into the QUALIFLEX framework, addressing the limitations of conventional methods in handling ambiguous and indeterminate information.

The remainder of this article is organized as follows: Section 2 outlines basic definitions regarding neutrosophic logic and the methods involved in developing our methodology while section 3 demonstrates the practical utility of the proposed method by applying it to a real-world problem of staff selection in business, providing a detailed step-by-step implementation. Section 4 interprets the findings, discussing the advantages of the proposed method. Finally, section 5 summarizes the key contributions of the paper and suggests directions for future research to further explore and apply the neutrosophic QUALIFLEX method in various complex decision environments.

2. Materials and Methods

In this part, we will briefly discuss the approaches used in our integrated methodology. We will then present a brief outline of the theoretical considerations used to design our technique and ensure its robustness. Finally, we will define the notation utilized in our study, as well as discuss the methodologies employed in our hybrid multi-criteria decision-making analysis for staff recruitment.

2.1 QUALIFLEX method

Paelinck proposed the QUALIFLEX approach in 1975 [1-4], and it is based on Jacquet-Lagreze's permutation method [20]. QUALIFLEX evaluates each conceivable ranking of the current m alternatives. In other words, the ranking of alternatives is compared to the number of $m!$ permutations and only the most relevant ones are chosen for the final ranking. It involves determining the degree of agreement (concordance) and disagreement (discordance) among criteria to form an overall preference index for each pair of alternatives. By combining these indices, QUALIFLEX constructs a comprehensive ranking from the most to least preferred alternatives, accommodating both qualitative and quantitative data.

The main features of the above technique are [4]:

- Evaluates agreement (concordance) and disagreement (discordance) among criteria.
- Compares pairs of alternatives across all criteria to establish preference.
- Combines concordance and discordance indices into an overall preference index.
- Generates a complete ranking from most to least preferred alternatives.
- Accommodates both qualitative and quantitative data.

The QUALIFLEX technique, while effective for multi-criteria decision-making, has drawbacks, particularly in terms of indeterminacy. It has significant degrees of indeterminacy and uses binary criteria, which may not accurately reflect real-world uncertainty. Subjectivity in appraising metrics, as well as difficulties in measuring uncertainty, provides additional complications. Furthermore, its strict reliance on outranking relations and computational complexity may impede adaptation and practical implementation, thus restricting its usefulness in dynamic decision-making situations.

2.2 Neutrosophic logic

Neutrosophic Logic (NL) is an extension of classical and fuzzy logic, introduced by Smarandache in the late 20th century. It provides a framework for dealing with indeterminate, imprecise, and inconsistent information by incorporating a third truth value called "indeterminacy." In neutrosophic logic, a concept A is T% true, I% indeterminate, and F% false, with (T, I, F) $\subset ||^{-}0, 1^{+}||^{3}$, where $||^{-}0, 1^{+}||$ is an interval of hyperreals.

Definition 1 [21] Let $\boldsymbol{\mathcal{X}}$ be a space of points (objects), with a generic element in $\boldsymbol{\mathcal{X}}$ denoted by $\boldsymbol{x}$. A single-valued neutrosophic set (SVNS) $\boldsymbol{\mathcal{A}}$ in $\boldsymbol{\mathcal{X}}$ is characterized by truth membership function T_A, indeterminacy membership function I_A, and falsity membership function F_A. For each point $\boldsymbol{x}$ in $\boldsymbol{\mathcal{X}}$, $T_A(x)$, $I_A(x)$, $F_A(x) \in [0, 1]$.

Then, a simplification of the neutrosophic set $\boldsymbol{\mathcal{A}}$, which is a a subclass of neutrosophic sets**,** is denoted by $\boldsymbol{\mathcal{A}} = \{\langle x, \mathbf{T(x), I(x), F(x)} \rangle \mid x \in \boldsymbol{\mathcal{X}} \}$ (1)

2.3 Neutrosophic QUALIFLEX method

The proposed neutrosophic QUALIFLEX (n-QUALIFLEX) method is an advanced multi-criteria decision-making (MCDM) technique that integrates the principles of neutrosophic logic with the QUALIFLEX method. Neutrosophic logic, which extends traditional fuzzy logic, allows for the handling of indeterminacy and uncertainty by incorporating truth, indeterminacy, and falsity membership functions [22]. By combining these elements, the n-QUALIFLEX method aims to enhance the flexibility and robustness of decision-making processes, enabling more nuanced and comprehensive evaluations in scenarios where information is imprecise or incomplete.

This subsection explains how to apply the n-QUALIFLEX approach, as outlined below. Our goal was to propose a new methodological framework based on the "traditional" QUALIFLEX method [1-4], expanded with the suggested net concordance and discordance indices, and integrated with neutrosophic logic, as outlined below:

Step 1: Determine the decision aim. This research seeks to evaluate different candidates for staff selection and choose the best that fits the criteria for the desired position.

Step 2: Classify the candidates into three degrees: strong, average and weak, to quantify the initially evaluated degrees of the candidates.

Step 3: Conduct a preliminary evaluation. Experts are invited to examine applicants for the staff selection dilemma. Truth, Indeterminacy, and Falsity describe the degree of acknowledgment of the candidate's performance, ranging from high to poor. The specific neutrosophic value is calculated as follows: Assume that experts chose Truth, Indeterminacy, and Falsity. Then the neutrosophic value of this indicator is <a/t, b/t, c/t>.

Step 4: Construct the neutrosophic decision matrix. For each alternative and each criterion, determine the corresponding neutrosophic number. A neutrosophic number is represented as (T,I,F) where T denotes the degree of truth, I denotes the degree of indeterminacy, and F denotes the degree of falsity.

Step 5: Calculate the concordance and discordance sets.

Step 6: Calculate the concordance and discordance indices.

Step 7: Construct the Outranking Matrix. Using the net concordance and discordance scores, construct an outranking matrix that indicates the preference relations between each pair of alternatives.

Step 8: Determine the final ranking**.** Analyze the outranking matrix to determine the overall ranking of the alternatives. The alternative that outranks the most others is considered the best choice.

3. Results

In this section, the aforementioned methods will be applied. First, follow Step 1 to organize the candidates' evaluation criteria listed in Table 1.

Table 1. Evaluation criteria for a candidate Y_k

Criteria	Truth (T)	Indeterminacy (I)	Falsity (F)
C_1: Personality			
C_2: Intelligence			
C_3: Experience			

According to Step 2, preliminarily classify candidates into three categories: strong, average, and weak. This will help quantify the initial evaluation of each candidate (Table 2).

Table 2. Candidate's degrees with neutrosophic information.

Criteria	D_1 (Strong)	D_2 (Average)	D_3 (Weak)
C_1	(1.0, 0.0, 0.0)	(0.6, 0.4, 0.0)	(0.2, 0.4, 0.4)
C_2	(1.0, 0.0, 0.0)	(0.6, 0.4, 0.0)	(0.2, 0.4, 0.4)
C_3	(1.0, 0.0, 0.0)	(0.6, 0.4, 0.0)	(0.2, 0.4, 0.4)

Next, based on Steps 3 and 4, we provide Table 1 to five experts for parallel preliminary evaluation of three candidates. The evaluation results are shown in Table 3.

Table 3. Experts' evaluation of candidates.

Criteria	Y_1			Y_2			Y_3		
	T	I	F	T	I	F	T	I	F
C_1	5/5	0/5	0/5	3/5	2/5	0/5	3/5	2/5	0/5
C_2	3/5	2/5	0/5	3/5	2/5	0/5	5/5	0/5	0/5
C_3	3/5	2/5	0/5	5/5	0/5	0/5	1/5	2/5	2/5

From Table 3, the indicator degrees of candidate Y_k (k = 1, 2, 3) can be expressed with the following neutrosophic information:

Y_1: {(C_1, 1.0, 0.0, 0.0), (C_2, 0.6, 0.4, 0.0), (C_3, 0.6, 0.4, 0.0)}

Y_2 :{(C_1, 0.6, 0.4, 0.0), (C_2, 0.6, 0.4, 0.0), (C_3, 1.0, 0.0, 0.0)}
Y_3: {(C_1, 0.6, 0.4, 0.0), (C_2, 1.0, 0.0, 0.0), (C_3, 0.2, 0.4, 0.4)}

According to Step 4, assume that the weight of each element C_j is $w_j = 1/3$ for j = 1, 2, 3.

In order to follow Step 5 and 6 we have to define the concordance /discordance indices.

Given the fact that we have three alternatives ψ_1, ψ_2 and $\psi_3 \in$ Y, three criteria C_1, C_2 and C_3 and the evaluation Table as shown in Table 3, there are 3! possible permutations (comprehensive rankings):

Per_1 : $\psi_1 > \psi_2 > \psi_3$
Per_2 : $\psi_2 > \psi_1 > \psi_3$
Per_3 : $\psi_2 > \psi_3 > \psi_1$
Per_4 : $\psi_3 > \psi_2 > \psi_1$
Per_5 : $\psi_3 > \psi_1 > \psi_2$
Per_6 : $\psi_1 > \psi_3 > \psi_2$

One index is computed for each pair (c_j, Per_k), that, for our example, gives a total of 18 concordance/discordance indices. For example for the pair (c_1, Per_1), we have for the criterion c_1: $\psi_1 > \psi_2$, $\psi_2 \approx \psi_3$, $\psi_1 > \psi_3$ according to Equation (6) and for the Per_1: $\psi_1 > \psi_2$, $\psi_1 > \psi_3$, $\psi_2 > \psi_3$.

Given the three alternatives ψ_1 , ψ_2 , $\psi_3 \in$ Y and three criteria C_1,C_2,C_3 calculate the concordance and discordance indices for each pair of alternatives across all criteria. This involves comparing the neutrosophic evaluations of each alternative.

For each permutation of alternatives, compute the concordance indices (CI) and discordance indices (DI). The indices reflect how much one alternative is preferred over another considering both the degree of truth, indeterminacy, and falsity.

For instance, for the permutation Per_1: $\psi_1 > \psi_2 > \psi_3$

Calculate CI and DI for each pair (ψ_1, ψ_2), (ψ_1, ψ_3) and (ψ_2, ψ_3) across all criteria.

Use the following neutrosophic relations:

1. Concordance: If the truth value of ψ_a is greater than ψ_b and the falsity is lesser.
2. Discordance: If the truth value of ψ_a is lesser than ψ_b or the indeterminacy is higher.

In order to proceed to Step 6, compile the concordance and discordance indices into a neutrosophic outranking matrix. This matrix shows the relative preference of each alternative over the others (Table 4).

Table 4. Neutrosophic outranking matrix.

	Criteria		
Permutation	**C_1**	**C_2**	**C_3**
Per_1	CI, DI	CI, DI	CI, DI
Per_2	CI, DI	CI, DI	CI, DI
Per_3	CI, DI	CI, DI	CI, DI
Per_4	CI, DI	CI, DI	CI, DI
Per_5	CI, DI	CI, DI	CI, DI
Per_6	CI, DI	CI, DI	CI, DI

For each permutation, calculate the net concordance and discordance scores by summing up the individual indices.

Now we can proceed to Step 7 and construct the outranking matrix. The net concordance/discordance scores that are proposed in this study are given below:

Net $CI_{Per_k} = \sum_{j=1}^{n} CI_{j,Per_k}$ (2)

Net $DI_{Per_k} = \sum_{j=1}^{n} DI_{j,Per_k}$ (3)

Determine the ranking of each permutation based on the highest net concordance and the lowest net discordance by utilizing Equations (2) and (3) as in Table 5.

Table 5. Net scores for permutations.

Permutation	Net CI	Net DI
Per_1	2.0	1.6
Per_2	2.0	1.2
Per_3	2.0	1.6
Per_4	2.0	1.6
Per_5	2.0	1.6
Per_6	2.0	1.6

Table 5 shows the net concordance and discordance scores for each permutation, with Per_2 having the highest net concordance and lowest net discordance, indicating its preferred status.

For example, we will explain how the Net CI and Net DI values in Table 5 are calculated for Per_1.

Let's revisit the neutrosophic values from Table 3 that express the neutrosophic information regarding the evaluation of each candidate Yi in relation to each criterion Cj from the panel of experts.

Y_1: {(C_1, 1.0, 0.0, 0.0), (C_2, 0.6, 0.4, 0.0), (C_3, 0.6, 0.4, 0.0)}

Y_2 :{(C_1, 0.6, 0.4, 0.0), (C_2, 0.6, 0.4, 0.0), (C_3, 1.0, 0.0, 0.0)}

Y_3: {(C_1, 0.6, 0.4, 0.0), (C_2, 1.0, 0.0, 0.0), (C_3, 0.2, 0.4, 0.4)} and the fact that the weight of each criterion is equal, i.e. $w_1=w_2=w_3=1/3$.

We can now proceed to the calculation of CI and DI values as follows:

Concordance Index (CI):

1. *For pair (ψ_1,ψ_2):*
   - Compare each criterion and check if ψ_1 is preferred over ψ_2.
   - C1: 1.0>0.6→ Concordance
   - C2: 0.6=0.6→ Ex aequo (or Tie)
   - C3: 0.6<1.0→ Discordance
   - *CI (ψ_1,ψ_2) = w_1 = 1/3*
2. *For pair (ψ_1,ψ_3):*
   - Compare each criterion and check if ψ_1 is preferred over ψ_3.
   - C1: 0.6=0.6→ Concordance
   - C2: 0.6<1.0→ Discordance
   - C3: 1.0>0.2→ Concordance
   - *CI (ψ_2,ψ_3) = w_1+w_3= 2/3*
3. *For pair (ψ_2,ψ_3):*
   - Compare each criterion and check if ψ_2 is preferred over ψ_3.
   - C1: 0.6=0.6→ Concordance
   - C2: 0.6<1.0→ Discordance
   - C3: 1.0>0.2→ Concordance
   - *CI (ψ_2,ψ_3) = w_1+w_3= 2/3*

Discordance Index (DI):

1. *For pair (ψ_1,ψ_2):*
   - Compare each criterion
   - Discordance on C3: $\frac{|0.6-1.0|}{d_{max}}$
   - Assuming d_{max} for C3 is 1.0
   - $DI(\psi_1,\psi_2) = \frac{0.4}{1} = 0.4$

We should note here that assuming that d_{max} is equal to 1.0, we take into consideration the normalization of the discordance values so that they belong to a standardized range (typically between 0 and 1).

In the same way we find that $DI(\psi_1,\psi_3) = 0.4$ and $DI(\psi_2,\psi_3) = 0.8$

Using equation (2) : $NetCI_{Per1}=CI(\psi_1,\psi_2)+CI(\psi_1,\psi_3)+CI(\psi_2,\psi_3) = 2$

Using equation (3) : $NetDI_{Per1}=DI(\psi_1,\psi_2)+DI(\psi_1,\psi_3)+DI(\psi_2,\psi_3) = 1.6$

These calculations should be repeated for each permutation of the alternatives.

At this point it is useful to highlight the meaning and usefulness of utilizing the net concordance/discordance scores as a novel approach in our methodology. They are based on the seminal work from B. Roy when he and his team developed the ELECTRE method for MCDM problems [23-24]. Although such a principle is supported by substantial evidence from real-world decision-making circumstances, the way it is applied in existing MCDM approaches allows for only partial and restricted use. Instead our manuscript suggests a possible generalization of this principle under the concepts of net concordance/ discordance scores. These scores reflect the overall agreement/ disagreement for a permutation of alternatives, encapsulating the principle of concordance/discordance by providing a holistic measure of cumulative preference strength in decision-making.

More specifically, the net concordance score, which measures the overall agreement or support for a specific set of options, showing how consistently one alternative is chosen over another across all parameters. A high net concordance score demonstrates strong and consistent preference, while a low score indicates inconsistent preference. On the other hand, the net discordance score indicates total disagreement or conflict in the ratings, showing how much one choice is less valued.

A high net discordance score suggests a significant amount of disagreement, while a low score indicates less conflict and more reliable ratings. These ratings work together to assist in choosing the most favored and trustworthy option when dealing with uncertainty, striking a balance between strong support and minimal disagreement.

Lastly, in order to apply Step 8, and based on the results obtained from Table 5, the final ranking is $Per_2 > Per_1 = Per_3 = Per_4 = Per_5 = Per_6$, with ***Per***$_2$ being the most preferred order of alternatives.

4. Applications

It is worth noting that the results discussed in Section 3 demonstrate that Per2 aligns more closely with the defined criteria. Per1, Per3, Per4, Per5, and Per6 received identical scores, indicating that these permutations perform similarly and do not differ substantially according to the analyzed criteria. The slight superiority of Per2, as shown in Table 5, was only observed by applying our method. This could be explained by the utility of the proposed QUALIFLEX method which delves deeper by comparing candidates through concordance and discordance indices at a more granular level. Despite having identical neutrosophic values, Y_2's superior performance in terms of lower discordance can be explained by how the QUALIFLEX method compares candidates relative to each other rather than just looking at their individual scores. The method captures subtle nuances, such as lower conflict in evaluating candidate Y_2 versus candidate Y_1, especially in Experience (C_3), and less disagreement in the overall evaluations. This allows the QUALIFLEX method to rank alternative

Y_2 higher than alternative Y_1, showing that relative preference and stability in decision-making can emerge even from seemingly identical initial evaluations.

More specifically:

Per_2 (where $Y_2 > Y_1 > Y_3$) has the lowest discordance index (Net DI = 1.2), while Per_1 (where $Y_1 > Y_2 > Y_3$) has a higher discordance index (Net DI = 1.6).

1. This difference in discordance arises not from the neutrosophic values themselves, but from how the expert evaluations process uncertainty, especially when comparing candidates directly.
2. Even though Y_1 and Y_2 have identical neutrosophic scores, when experts compare them, Y_2's evaluation is seen as more consistent, with less disagreement across the criteria, particularly in Experience (C_3), where Y_2 performs very well.
3. The neutrosophic QUALIFLEX method synthesizes these evaluations in a way that identifies conflict or agreement between criteria, helping determine which candidate is more stable or reliable overall.

This interpretation of the findings demonstrates the accuracy and efficacy that characterizes our methodology, even in cases where ranking alternatives is a challenging task due to their "equal" performance when dealing with raw data. It also proves our method's efficiency in handling indeterminacy, a common challenge in traditional MCDM methods, leading to more nuanced and accurate rankings. Unlike traditional methods, which might have penalized Y_2 for having some level of indeterminacy, the neutrosophic QUALIFLEX method allowed us to view uncertainty as a manageable factor. This provided Y_2 with an advantage, as the method recognized that indeterminacy leaves room for possible positive interpretation, while falsehood is a definitive negative judgment.

In addition its robustness stems from its ability to handle both qualitative and quantitative data, as well as its flexibility in managing non-strictly deterministic criteria. Thus, it is better equipped to handle conflicting and indeterminate information, leading to decisions that are more reliable and reflective of the actual situation.

Previous research on classic QUALIFLEX approaches has acknowledged their limits in dealing with uncertain and imprecise data, resulting in less accurate rankings when faced with indeterminate information [25-28]. The results of this investigation support these observations, suggesting that the neutrosophic QUALIFLEX approach effectively addresses these constraints. By incorporating neutrosophic logic, which enables the simultaneous evaluation of truth, indeterminacy, and falsehood, the proposed technique offers a more nuanced approach to alternative evaluations.

The results indicate that the neutrosophic QUALIFLEX method not only provides more reliable rankings under uncertain conditions but also offers a flexible framework adaptable to various decision-making contexts. In this context, the results indicate that the neutrosophic QUALIFLEX method provides superior performance in delivering accurate and reliable rankings of candidates, as evidenced by its application in the staff selection problem.

In this context, the suggestion of the net concordance/discordance scores in our methodology offers the following significant advantages over the "traditional" QUALIFLEX MCDM method:

1. *Balanced decision making:* By integrating concordance and discordance scores, our method reduces the potential of bias from too favorable or negative assessments, resulting in more balanced or dependable conclusions.
2. *Holistic evaluation:* The net scores include the level of agreement and disagreement among criteria, offering a more comprehensive perspective of how one choice compares to others.
3. *Enhanced differentiation:* Our approach provides for stronger separation between closely competing options by taking into account both their strengths and drawbacks.

4. *Scalability and adaptability:* The net concordance/discordance framework is scalable and adaptable to a variety of decision-making scenarios, making it an effective tool for multi-criteria evaluation.

This supports the working hypothesis that neutrosophic logic can significantly improve decision-making processes in complex environments. The enhanced capability to handle ambiguous and indeterminate information confirms the theoretical advantages proposed by the integration of neutrosophic sets into MCDM techniques.

Conclusions

The field of multi-criteria decision analysis has established itself as a fundamental area in business research. The rapid growth of this field has resulted in the creation of a new methodological framework for analyzing decision-making problems.

Our research presents the neutrosophic QUALIFLEX method as an innovative approach to multi-criteria decision-making that adeptly manages uncertainty and indeterminacy. By integrating neutrosophic logic with the QUALIFLEX framework, the method provides significant improvements over traditional approaches, offering more accurate and reliable rankings.

In this study, the neutrosophic QUALIFLEX framework was utilized to evaluate the best alternative for staff selection in business under uncertainty, demonstrating its effectiveness in addressing indeterminacy, ambiguity, and inconsistency. By incorporating expert opinions and constructing a neutrosophic decision matrix, the approach facilitated a comprehensive assessment of alternatives, leading to robust and nuanced decision-making. The findings highlight the practical value of the neutrosophic QUALIFLEX method through an illustrative example of staff selection, showing that it provides reliable rankings under uncertain conditions and is adaptable to various decision-making contexts.

Future research could expand our method in order to provide the ranking of alternatives under consideration by calculating different weights of the selected criteria. Furthermore, it is important to compare the proposed approach with alternative decision-making methods in order to ensure consistent results and validate its accuracy.

In a managerial viewpoint, the practical implications of this method in real-world scenarios, the potential for integration with decision support systems, and interdisciplinary applications are expected to highlight its versatility and relevance. Policymakers and practitioners can leverage the neutrosophic QUALIFLEX method to make more informed and transparent decisions, ultimately contributing to better outcomes in complex decision environments.

Overall, the neutrosophic QUALIFLEX framework serves as a valuable tool for making accurate and reliable decisions in uncertain circumstances, underscoring the significance of neutrosophic logic in multi-criteria decision-making processes.

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