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Neutrosophic Analysis of Strategies to Improve Productivity in an Restaurant Chain

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Abstract. The study analyzed productivity in an Ecuadorian restaurant chain using a multicriteria approach within a neutrosophic framework. The research focused on identifying effective strategies to optimize processes and addressing specific challenges such as staff turnover and compensation management. The TOPSIS method, combined with bipolar neutrosophic numbers, was employed to evaluate a group of strategies based on high-impact criteria. The results highlighted the implementation of economic incentives, training and retention programs, and performance management systems as the most effective alternatives. In contrast, internal communication campaigns and flexible schedules were found to be less prioritized. The research demonstrated the utility of neutrosophic logic in handling uncertainty and ambiguity, offering a replicable model for decision-making in complex business sectors.

Keywords: neutrosophic logic, multicriteria decision, business strategy, operational optimization, TOPSIS, bipolar neutrosophic sets.

1 Introduction

Productivity in the restaurant industry is a critical aspect that directly influences the sustainability and competitiveness of businesses. In Ecuador, restaurant chains face growing challenges due to the need to adapt to changing consumer demands, intense competition, and economic fluctuations. In this context, identifying and prioritizing strategies that optimize processes, reduce costs, and increase operational efficiency has become a priority for managers of these chains [1]. However, designing effective strategies requires considering multiple interrelated variables, which poses a significant challenge in decision-making.

In scientific literature, multicriteria decision-making (MCDM) methods have proven to be robust and versatile tools for addressing complex problems that involve diverse and often conflicting criteria [2]. These methods allow decision-makers to evaluate alternatives by considering both quantitative and qualitative factors, providing a systematic framework for making informed decisions [3]. One of the most widely adopted methods is TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), developed by Hwang and Yoon, recognized for its ability to identify the best alternative by comparing its proximity to an ideal solution. Its popularity stems from its simplicity, effectiveness, and applicability in various fields, such as operations management, strategic planning, and policy analysis [4].

However, classical multicriteria decision-making methods have limitations when addressing the uncertainty and indeterminacy inherent in many real-world situations [5], [6]. Decisions in business environments, such as in the case of restaurant chains, are influenced not only by precise data but also by subjective factors, imprecision, and dynamic contexts that are not always reflected in traditional models. This challenge has driven the development of more advanced approaches that integrate concepts from fuzzy and neutrosophic logic, offering new perspectives to handle the complexities of uncertainty [7], [8].

Neutrosophy, introduced by Florentin Smarandache, is an extension of classical logic that recognizes and models the coexistence of truth, falsehood, and indeterminacy within the same framework.

This approach represents a significant advancement by allowing the incorporation of degrees of uncertainty and ambiguity in decision-making processes [9]. In the evolution of this theory, tools such as bipolar neutrosophic numbers have been developed, which integrate the polarity of linguistic information, enabling a richer and more detailed representation of phenomena [10]. These tools have been applied in diverse fields such as supplier evaluation, technology selection, and educational quality management, demonstrating their relevance in addressing complex problems [11].

In this sense, the introduction of neutrosophic logic in the analysis of business strategies offers a promising approach for restaurant chains. This theoretical framework can model the uncertainty inherent in various factors within the system. In particular, the combination of the TOPSIS method with a neutrosophic environment can provide an innovative means to evaluate and prioritize strategies, considering multiple criteria and adapting to the complexities of the sector.

In this context, the present study aims to determine and prioritize effective strategies to increase productivity in an Ecuadorian restaurant chain by applying a multicriteria decision-making approach within a neutrosophic framework. This objective responds to the need to provide practical tools that allow managers to face current challenges with a more comprehensive and flexible perspective. The research emphasizes the importance of integrating advanced analysis methods to address the multidimensional nature of productivity problems, offering a significant contribution to the field of strategic management.

The purpose of this work lies not only in identifying key strategies but also in demonstrating how advancements in neutrosophic theory can enrich decision-making processes in complex business environments. Through this approach, the goal is not only to improve the productivity of restaurant chains but also to establish a replicable model in other industries, promoting more effective and adaptive management. The relevance of this study transcends the academic realm, offering practical solutions that contribute to the sustainable development of the restaurant sector in Ecuador.

2 Preliminaries

2.1 Definition of the Bipolar Neutrosophic Set

According to [4], C is considered a nonempty set, and a bipolar neutrosophic set (BNS) $\tilde{B}$ in C is defined as: [12]

$$\tilde{B} = \{c, \langle T_{\tilde{B}}^{+}(c), I_{\tilde{B}}^{+}(c), F_{\tilde{B}}^{+}(c), T_{\tilde{B}}^{-}(c), I_{\tilde{B}}^{-}(c), F_{\tilde{B}}^{-}(c)\rangle \mid c \in C\},$$

where the functions $T_{\tilde{B}}^{+}(c), I_{\tilde{B}}^{+}(c), F_{\tilde{B}}^{+}(c): C \to [0,1]$ represent positive degrees of membership of truth, indeterminacy, and falsity, respectively. On the other hand, the functions $T_{\tilde{B}}^{-}(c), I_{\tilde{B}}^{-}(c), F_{\tilde{B}}^{-}(c): C \to [-1,0]$ describe the corresponding degrees for the negative domain. This model allows to simultaneously capture the positive and negative characteristics of the elements in complex situations.

2.2 Bipolar TOPSIS method

The TOPSIS method, extended to the bipolar neutrosophic environment, constitutes a robust tool for multicriteria decision-making. The key steps are described below:

1. Let A be a set of alternatives $S = \{S_1, S_2, \cdots, S_m\}$ evaluated against a set of attributes $T = \{T_1, T_2, \cdots, T_n\}$. Let $W = [w_{1w_2} \cdots w_n]^T$ be a vector of weights, where $W = [w_{1w_2} \cdots w_n]^T$ and $\sum j = 1nwj = 1$. Each alternative Si, (i=1,2,⋯,m) is scored in terms of the attributes Tj, (j=1,2,⋯,n) using bipolar neutrosophic sets (BNSs). The steps of the bipolar neutrosophic TOPSIS method are described as follows [13]:

1. Construction of the Decision Matrix

Each value of the alternative is estimated with respect to n criteria. The value of each alternative under each criterion is provided in the form of BNSs organized in a decision matrix[14]:

$$K=[k_{ij}]_{m\times n}=\begin{bmatrix} k_{11} & k_{12} & \cdots & k_{1n} \\ k_{21} & k_{22} & \cdots & k_{2n} \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ k_{m1} & k_{m2} & \cdots & k_{mn} \end{bmatrix}$$

where $k_{ij}=< T_{ij}^{+}, I_{ij}^{+}, F_{ij}^{+}, T_{ij}^{-}, I_{ij}^{-}, F_{ij}^{-} >$. The values satisfy the constraints $T_{ij}^{+}, I_{ij}^{+}, F_{ij}^{+}\in[0,1]$, $T_{ij}^{-}, I_{ij}^{-}, F_{ij}^{-}\in[-1,0]$, and $0\le T_{ij}^{+}, I_{ij}^{+}, F_{ij}^{+}, T_{ij}^{-}, I_{ij}^{-}, F_{ij}^{-}\le 6$, where i =1,2,3,…,m and j=1,2,3,…,n

2. Calculation of attribute weights

In the absence of predetermined weights, the deviation maximization method is used to determine the w_j values, defined as [15, 16]:

$$w_j=\frac{\sum_{i=1}^{m}\sum_{l=1}^{m}|k_{ij}-k_{lj}|}{\sqrt{\sum_{j=1}^{n}\left(\sum_{i=1}^{m}\sum_{l=1}^{m}|k_{ij}-k_{lj}|\right)^2}}, \tag{1}$$

followed by normalization:

$$w_j^{*}=\frac{\sum_{i=1}^{m}\sum_{l=1}^{m}|k_{ij}-k_{lj}|}{\sum_{j=1}^{n}\left(\sum_{i=1}^{m}\sum_{l=1}^{m}|k_{ij}-k_{lj}|\right)}. \tag{2}$$

3. Weighted decision matrix

The weighted matrix is constructed by multiplying the calculated weights by each entry in the decision matrix [16, 17]:

$$K*W=[k_{ij}^{w_j}]_{m\times n}=\begin{bmatrix} k_{11}^{w_1} & k_{12}^{w_2} & \cdots & k_{1n}^{w_n} \\ k_{21}^{w_1} & k_{22}^{w_2} & \cdots & k_{2n}^{w_n} \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ k_{m1}^{w_1} & k_{m2}^{w_2} & \cdots & k_{mn}^{w_n} \end{bmatrix}$$

where each weighted element $k_{ij}^{w_j}$ is defined by transformations that adjust the membership degrees of truth, indeterminacy, and falsity for both positive and negative domains, as shown in equation (3)

$$\begin{aligned} k_{ij}^{w_j} &=< T_{ij}^{w_j+}, I_{ij}^{w_j+}, F_{ij}^{w_j+}, T_{ij}^{w_j-}, I_{ij}^{w_j-}, F_{ij}^{w_j-} > \\ &=< 1-(1-T_{ij}^{+})^{w_j}, (I_{ij}^{+})^{w_j}, (F_{ij}^{+})^{w_j}, -(-T_{ij}^{-})^{w_j}, -(-I_{ij}^{-})^{w_j}, -(1-(1-(-F_{ij}^{-}))^{w_j}) >, \end{aligned} \tag{3}$$

4. Determination of ideal solutions

In practical scenarios, attributes are classified as either benefit or cost types. For both cases, the positive ideal solutions (BNRPIS) and negative ideal solutions (BNRNIS) are determined by considering the bipolar neutrosophic characteristics [18,19, 20].

$$\begin{aligned} BNRPIS &= (\langle {}^{+}T_1^{w_1+}, {}^{+}I_1^{w_1+}, {}^{+}F_1^{w_1+}, {}^{+}T_1^{w_1-}, {}^{+}I_1^{w_1-}, {}^{+}F_1^{w_1-}\rangle, \langle {}^{+}T_2^{w_2+}, {}^{+}I_2^{w_2+}, {}^{+}F_2^{w_2+}, {}^{+}T_2^{w_2-}, \\ &\quad {}^{+}I_2^{w_2-}, {}^{+}F_2^{w_2-}\rangle, \dots, \langle {}^{+}T_n^{w_n+}, {}^{+}I_n^{w_n+}, {}^{+}F_n^{w_n+}, {}^{+}T_n^{w_n-}, {}^{+}I_n^{w_n-}, {}^{+}F_n^{w_n-}\rangle), \\ BNRNIS &= (\langle {}^{-}T_1^{w_1+}, {}^{-}I_1^{w_1+}, {}^{-}F_1^{w_1+}, {}^{-}T_1^{w_1-}, {}^{-}I_1^{w_1-}, {}^{-}F_1^{w_1-}\rangle, \langle {}^{-}T_2^{w_2+}, {}^{-}I_2^{w_2+}, {}^{-}F_2^{w_2+}, {}^{-}T_2^{w_2-}, \\ &\quad {}^{-}I_2^{w_2-}, {}^{-}F_2^{w_2-}\rangle, \dots, \langle {}^{-}T_n^{w_n+}, {}^{-}I_n^{w_n+}, {}^{-}F_n^{w_n+}, {}^{-}T_n^{w_n-}, {}^{-}I_n^{w_n-}, {}^{-}F_n^{w_n-}\rangle), \end{aligned} \tag{4}$$

Thus, for benefit type criteria, j=1, 2, …,n

$$\begin{aligned}\langle {}^{+}T_j^{w_j+},{}^{+}I_j^{w_j+},{}^{+}F_j^{w_j+},{}^{+}T_j^{w_j-},{}^{+}I_j^{w_j-},{}^{+}F_j^{w_j-}\rangle &= \langle max(T_{ij}^{w_j+}), min(I_{ij}^{w_j+}), min(F_{ij}^{w_j+}),\\ &\quad min(T_{ij}^{w_j-}), max(I_{ij}^{w_j-}), max(F_{ij}^{w_j-})\rangle,\\ \langle {}^{-}T_j^{w_j+},{}^{-}I_j^{w_j+},{}^{-}F_j^{w_j+},{}^{-}T_j^{w_j-},{}^{-}I_j^{w_j-},{}^{-}F_j^{w_j-}\rangle &= \langle min(T_{ij}^{w_j+}), max(I_{ij}^{w_j+}), max(F_{ij}^{w_j+}),\\ &\quad max(T_{ij}^{w_j-}), min(I_{ij}^{w_j-}), min(F_{ij}^{w_j-})\rangle.\end{aligned} \tag{5}$$

Similarly, for cost type criteria, j=1, 2, …,n

$$\begin{aligned}\langle {}^{+}T_j^{w_j+},{}^{+}I_j^{w_j+},{}^{+}F_j^{w_j+},{}^{+}T_j^{w_j-},{}^{+}I_j^{w_j-},{}^{+}F_j^{w_j-}\rangle &= \langle min(T_{ij}^{w_j+}), max(I_{ij}^{w_j+}), max(F_{ij}^{w_j+}),\\ &\quad max(T_{ij}^{w_j-}), min(I_{ij}^{w_j-}), min(F_{ij}^{w_j-})\rangle,\\ \langle {}^{-}T_j^{w_j+},{}^{-}I_j^{w_j+},{}^{-}F_j^{w_j+},{}^{-}T_j^{w_j-},{}^{-}I_j^{w_j-},{}^{-}F_j^{w_j-}\rangle &= \langle max(T_{ij}^{w_j+}), min(I_{ij}^{w_j+}), min(F_{ij}^{w_j+}),\\ &\quad min(T_{ij}^{w_j-}), max(I_{ij}^{w_j-}), max(F_{ij}^{w_j-})\rangle.\end{aligned} \tag{6}$$

5. Calculation of the normalized Euclidean distance with respect to BNRPIS and BNRNIS

The normalized Euclidean distance for each alternative represented by the set $\langle T_{ij}^{w_j+}, I_{ij}^{w_j+}, F_{ij}^{w_j+}, T_{ij}^{w_j-}, I_{ij}^{w_j-}, F_{ij}^{w_j-}\rangle$ with respect to BNRPIS, denoted as $\langle {}^{+}T_j^{w_j+},{}^{+}I_j^{w_j+},{}^{+}F_j^{w_j+},{}^{+}T_j^{w_j-},{}^{+}I_j^{w_j-},{}^{+}F_j^{w_j-}\rangle$ is calculated as follows[21, 22]:

$$d_N(S_i, BNRPIS) = \sqrt{\frac{1}{6n}\sum_{j=1}^{n}\begin{Bmatrix}(T_{ij}^{w_j+} - {}^{+}T_j^{w_j+})^2 + (I_{ij}^{w_j+} - {}^{+}I_j^{w_j+})^2 + (F_{ij}^{w_j+} - {}^{+}F_j^{w_j+})^2 + \\ (T_{ij}^{w_j-} - {}^{+}T_j^{w_j-})^2 + (I_{ij}^{w_j-} - {}^{+}I_j^{w_j-})^2 + (F_{ij}^{w_j-} - {}^{+}F_j^{w_j-})^2\end{Bmatrix}}, \tag{7}$$

Similarly, the normalized Euclidean distance of each alternative from the bipolar neutrosophic negative relative ideal solution $\langle T_{ij}^{w_j+}, I_{ij}^{w_j+}, F_{ij}^{w_j+}, T_{ij}^{w_j-}, I_{ij}^{w_j-}, F_{ij}^{w_j-}\rangle$ is determined by the formula:

$$d_N(S_i, BNRNIS) = \sqrt{\frac{1}{6n}\sum_{j=1}^{n}\begin{Bmatrix}(T_{ij}^{w_j+} - {}^{-}T_j^{w_j+})^2 + (I_{ij}^{w_j+} - {}^{-}I_j^{w_j+})^2 + (F_{ij}^{w_j+} - {}^{-}F_j^{w_j+})^2 + \\ (T_{ij}^{w_j-} - {}^{-}T_j^{w_j-})^2 + (I_{ij}^{w_j-} - {}^{-}I_j^{w_j-})^2 + (F_{ij}^{w_j-} - {}^{-}F_j^{w_j-})^2\end{Bmatrix}} \tag{8}$$

6. Calculation of the revised degree of proximity

The revised degree of proximity of each alternative to the BNRPIS, represented as $\rho(S_i)$, is calculated using the following formula[23]:

$$\rho(S_i) = \frac{d_N(S_i, BNRNIS)}{max\{d_N(S_i, BNRNIS)\}} - \frac{d_N(S_i, BNRPIS)}{min\{d_N(S_i, BNRPIS)\}}, i = 1,2, \dots, m. \tag{9}$$

7. Determination of the lower relationship

Based on the reviewed degrees of proximity, the lower ratio of each alternative $IR(i)$ is calculated as follows[23]:

$$IR(i) = \frac{\rho(S_i)}{\min_{1 \le i \le m}(\rho(S_i))} \tag{10}$$

It is evident that every value of $IR(i)$ lies in the closed unit interval [0,1].

8. Classification of alternatives

Finally, the alternatives are ordered according to the ascending values of the relationship $IR(i)$. The optimal alternative is selected as the one with the lowest choice value in this order.

3 Results

Based on the historical analysis carried out, a detailed evaluation of productivity was conducted in relation to key variables such as employee turnover, remuneration, inflation, and unemployment in four branches of a restaurant chain in Ecuador. The results highlighted the urgency of implementing strategies that address employee turnover and optimize remuneration management in order to improve productivity in the analyzed work centers.

In this context, a set of strategies was proposed to improve productivity and efficiency indicators in the branches studied. The proposed strategies include: (1) restructuring salary policies; (2) training and employee retention programs; (3) automation of operational processes to reduce reliance on human capital and improve efficiency; (4) adjustment of product prices; (5) internal communication campaigns; (6) implementation of economic incentives linked to individual and group productivity; (7) implementation of performance management systems; and (8) introduction of flexible schedules that promote work-life balance. See Figure 1.

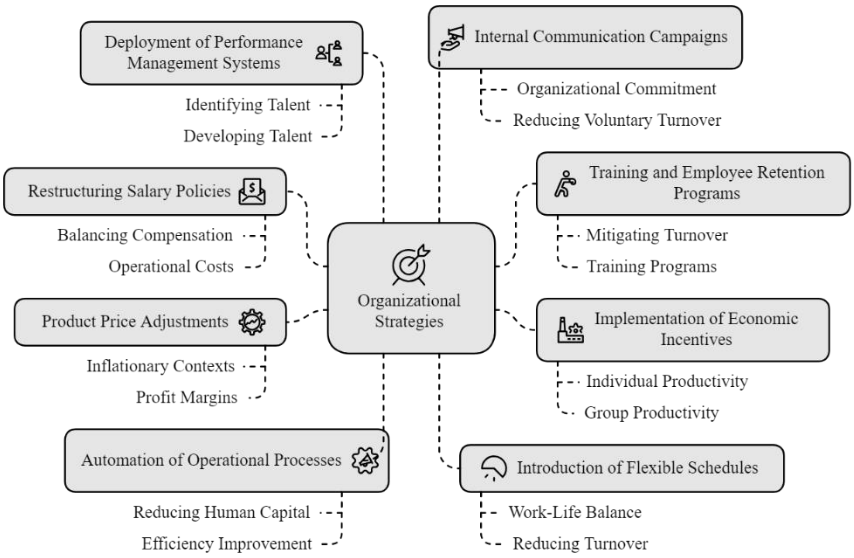

Figure 1: Strategies to be evaluated proposed by experts

To assess the effectiveness of these strategies, a series of criteria were selected, based on expert opinions, which were considered essential for the current context of the company. The evaluated criteria were: impact on productivity (C1), implementation costs (C2), operational feasibility (C3), and long-term sustainability (C4), to identify the most effective and feasible strategies for the specific business context. For each criterion, a specific level of importance was considered. For this study, the evaluation criteria weight vector was $w_j = [0.3; 0.2; 0.25; 0.25]$.

The strategies were assessed by the experts considering each of the evaluation criteria. The resulting initial evaluation matrix is presented in Table 1.

Table 1: Initial decision matrix

	C1	C2	C3	C4
S1	(0.8, 0.4, 0.7, -0.6, -0.4, -0.4)	(0.2, 0.6, 0.1, -0.5, -0.3, -0.7)	(0.2, 0.7, 0.5, -0.4, -0.4, -0.3)	(0.4, 0.6, 0.5, -0.3, -0.7, -0.4)
S2	(0.3, 0.6, 0.1, -0.5, -0.7, -0.5)	(0.2, 0.6, 0.1, -0.5, -0.3, -0.7)	(0.4, 0.2, 0.5, -0.6, -0.3, -0.1)	(0.2, 0.7, 0.5, -0.5, -0.3, -0.2)
S3	(0.3, 0.5, 0.2, -0.4, -0.3, -0.7)	(0.4, 0.5, 0.2, -0.3, -0.8, -0.5)	(0.2, 0.6, 0.1, -0.5, -0.3, -0.7)	(0.3, 0.7, 0.6, -0.5, -0.5, -0.4)
S4	(0.6, 0.7, 0.5, -0.2, -0.1, -0.3)	(0.2, 0.6, 0.1, -0.5, -0.3, -0.7)	(0.6, 0.3, 0.6, -0.1, -0.4, -0.2)	(0.8, 0.3, 0.2, -0.1, -0.3, -0.1)
S5	(0.4, 0.5, 0.2, -0.3, -0.8, -0.5)	(0.9, 0.5, 0.7, -0.3, -0.4, -0.3)	(0.3, 0.7, 0.6, -0.5, -0.5, -0.4)	(0.8, 0.4, 0.6, -0.1, -0.3, -0.4)

	C1	C2	C3	C4
S6	(0.5, 0.3, 0.3, -0.7, -0.2, -0.4)	(0.8, 0.4, 0.6, -0.1, -0.3, -0.4)	(0.6, 0.3, 0.6, -0.1, -0.4, -0.2)	(0.4, 0.2, 0.5, -0.6, -0.4, -0.4)
S7	(0.2, 0.6, 0.1, -0.5, -0.3, -0.7)	(0.4, 0.2, 0.5, -0.6, -0.4, -0.4)	(0.2, 0.6, 0.1, -0.5, -0.3, -0.7)	(0.2, 0.6, 0.1, -0.5, -0.3, -0.7)
S8	(0.4, 0.6, 0.5, -0.3, -0.7, -0.4)	(0.2, 0.6, 0.1, -0.5, -0.3, -0.7)	(0.4, 0.7, 0.5, -0.2, -0.1, -0.3)	(0.2, 0.6, 0.1, -0.5, -0.3, -0.7)

From this initial matrix, a weighted matrix can be obtained, which incorporates the weights initially assigned to the criteria. Using equation (3), the following is obtained:

Table 2: Weighted decision matrix

	C1	C2	C3	C4
S1	(0.383, 0.76, 0.899, -0.858, -0.76, -0.142)	(0.044, 0.903, 0.631, -0.871, -0.786, -0.214)	(0.054, 0.915, 0.841, -0.795, -0.795, -0.085)	(0.12, 0.88, 0.841, -0.74, -0.915, -0.12)
S2	(0.101, 0.858, 0.501, -0.812, -0.899, -0.188)	(0.044, 0.903, 0.631, -0.871, -0.786, -0.214)	(0.12, 0.669, 0.841, -0.88, -0.74, -0.026)	(0.054, 0.915, 0.841, -0.841, -0.74, -0.054)
S3	(0.101, 0.812, 0.617, -0.76, -0.697, -0.303)	(0.097, 0.871, 0.725, -0.786, -0.956, -0.129)	(0.054, 0.88, 0.562, -0.841, -0.74, -0.26)	(0.085, 0.915, 0.88, -0.841, -0.841, -0.12)
S4	(0.24, 0.899, 0.812, -0.617, -0.501, -0.101)	(0.044, 0.903, 0.631, -0.871, -0.786, -0.214)	(0.205, 0.74, 0.88, -0.562, -0.795, -0.054)	(0.331, 0.74, 0.669, -0.562, -0.74, -0.026)
S5	(0.142, 0.812, 0.617, -0.697, -0.935, -0.188)	(0.369, 0.871, 0.931, -0.786, -0.833, -0.069)	(0.085, 0.915, 0.88, -0.841, -0.841, -0.12)	(0.331, 0.795, 0.88, -0.562, -0.74, -0.12)
S6	(0.188, 0.697, 0.697, -0.899, -0.617, -0.142)	(0.275, 0.833, 0.903, -0.631, -0.786, -0.097)	(0.205, 0.74, 0.88, -0.562, -0.795, -0.054)	(0.12, 0.669, 0.841, -0.88, -0.795, -0.12)
S7	(0.065, 0.858, 0.501, -0.812, -0.697, -0.303)	(0.097, 0.725, 0.871, -0.903, -0.833, -0.097)	(0.054, 0.88, 0.562, -0.841, -0.74, -0.26)	(0.054, 0.88, 0.562, -0.841, -0.74, -0.26)
S8	(0.142, 0.858, 0.812, -0.697, -0.899, -0.142)	(0.044, 0.903, 0.631, -0.871, -0.786, -0.214)	(0.12, 0.915, 0.841, -0.669, -0.562, -0.085)	(0.054, 0.88, 0.562, -0.841, -0.74, -0.26)

This matrix serves as the basis for obtaining the BNRPIS and BNRNIS, from which equations (7) - (10) are applied to obtain the following table:

Table 3: Strategies evaluated. Relationship index calculated for each alternative.

Proposed strategies	ϱ	$IR(i)$
(1) Restructuring salary policies;	-0.381	0.74733
(2) Staff training and retention programs;	-0.178	0.34866
(3) Automation of operational processes;	-0.195	0.38344
(4) Adjustment of product prices;	-0.179	0.35014
(5) Internal communication campaigns	-0.510	1
(6) Implementation of economic incentives	-0.012	0.02307
(7) Implementation of performance management systems;	-0.080	0.15631
(8) Introduction of flexible schedules;	-0.425	0.83379

The results obtained showed that the strategy of implementing economic incentives had the lowest value of the lower relationship, indicating that this was the alternative closest to the positive ideal and, therefore, the most prioritized for improving productivity in the restaurant chain. This was followed by the strategies of implementing performance management systems (IR = 0.15631) and training and employee retention programs (IR = 0.34866), which also demonstrated a high proximity to the positive ideal.

In contrast, strategies such as internal communication campaigns and the introduction of flexible schedules had the highest IR values, positioning them as the least effective under the evaluated criteria. These results allow for the prioritization of resource allocation towards strategies with lower IR values, maximizing their impact on productivity.

4 Discussion

The implementation of the TOPSIS method in its neutrosophic variant was fundamental in addressing the inherent complexity of prioritizing strategies aimed at increasing productivity. This methodology allowed for the evaluation of alternatives by considering not only the direct relationships between criteria but also the uncertainties and contradictions typical of the business context. The ability to integrate neutrosophic values expanded the scope of traditional analysis by incorporating degrees of truth, falsehood, and indeterminacy, enriching the interpretation of results and increasing their accuracy.

The use of this variant of TOPSIS offered clear advantages. First, it allowed for the handling of imprecise and ambiguous data with a robust approach, overcoming the limitations of classical methods. Additionally, it provided a flexible framework for comparing strategies across multiple criteria, offering a more comprehensive view of the potential impact of each alternative. In this case, it was possible to prioritize those strategies with greater proximity to the positive ideal, thus ensuring informed decisions aimed at achieving specific organizational goals.

The methodology employed was not only applicable to the current context but also demonstrated its potential for use in other sectors. In industries with similar challenges, where evaluation criteria are diverse and operating conditions are subject to constant variations, the neutrosophic approach could facilitate strategic decision-making with a high level of confidence.

In conclusion, the neutrosophic TOPSIS method provided an analytical framework that transcended the limits of subjectivity, becoming a versatile tool for multicriteria evaluation. Its ability to adapt to different environments and disciplines positions it as an indispensable methodology for strategic analysis in high-complexity scenarios.

5 Conclusion

The present study focused on determining and prioritizing effective strategies to increase productivity in a restaurant chain in Ecuador, applying a multicriteria decision-making approach within a neutrosophic framework. A comprehensive analysis was conducted that allowed for the identification of the most relevant strategies by considering key criteria. The application of the TOPSIS method in its neutrosophic variant and the use of bipolar neutrosophic sets allowed handling the uncertainty inherent in the business context, effectively modeling the interaction between criteria and alternatives. This contributed to prioritizing strategies such as the implementation of economic incentives and performance management systems, which showed greater proximity to the positive ideal. In this way, the study provided a robust tool for strategically allocating resources, maximizing the impact on productivity, and adapting to the complexities of the studied environment.

This study provided empirical evidence of the potential of multicriteria decision-making methods with neutrosophic logic in business management. Additionally, it established a replicable framework that can be applied to other industries facing similar challenges. Future research could focus on expanding the use of this methodology to dynamic contexts or exploring its combination with advanced technological approaches, promoting more adaptive and sustainable decision-making.

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