Design of a Business Sustainability Measurement Method for Based on NeutroAlgebras Generated by the Combining Function in Prospector and Neutrosophic 2-tuple Linguistic Models

Ketty Marilú Moscoso-Paucarchuco [1,*], Manuel Michael Beraún-Espíritu [2], Uriel Rigoberto Quispe-Quezada[3], Silvia Marina Alvarez-Bernuy [4], Miguel Angel Quispe Solano [5], Edson Hilmer Julca-Marcelo [5], Wilfredo Ramirez-Salas [5], Arturo Gamarra-Moreno [5]

[1]National Autonomous Highland University of Tarma, Peru.
[2]Continental University, Peru.
[3]National Autonomous University of Huanta, Peru.
[4]Technological University of Peru, Peru.
[5]National University of the Center of Peru, Peru.

Emails: kmoscoso@unaat.edu.pe; mberaun@continental.edu.pe; uquispe@unah.edu.pe; c26802@utp.edu.pe; mquispe@uncp.edu.pe; edsonjm@uncp.edu.pe; wramirez@uncp.edu.pe; ahgamarra@uncp.edu.pe

Abstract

Business sustainability has become a global imperative in response to the environmental, social, and economic challenges facing our world. In this context, the measurement and evaluation of business sustainability have become crucial to guide the actions of organizations towards more responsible and sustainable practices. However, the lack of specific measurement instruments for specific regional contexts may limit the ability of companies to evaluate and improve their sustainability performance. In this paper, we present the design of a business sustainability measurement method adapted to the context of Tarma, Peru. Tarma, a region located in the heart of the Peruvian Andes, is characterized by its cultural, environmental, and economic diversity, making it a unique context to address business sustainability. This article proposes a method for measuring business sustainability based on the Neutrosophic 2-tuple Linguistic Model, which includes an aggregation operation based on a NeutroAlgebra generated by Combining Functions in Prospector.

Keywords: Sustainability Business; Neutrosophic 2-tuple Linguistic Model; Computing with Words; NeutroAlgebra, NeutroGroup; Prospector; OffUninorm; Offset

1 Introduction

Tarma, known as the "Pearl of the Andes", is a picturesque and dynamic region that is home to a variety of industries, from agriculture to tourism. Agriculture is a predominant economic activity in the region, with crops such as potatoes, corn, cereals, and fruits playing a crucial role in the food security and livelihood of the local population. Furthermore, sustainable tourism has emerged as a growing industry in Tarma, taking advantage of its stunning natural landscapes and rich cultural heritage.

Despite the importance of business sustainability in Tarma, the lack of measurement tools specific to the local context has been a limitation for companies seeking to evaluate and improve their performance in this area. Adaptation of existing measurement methods often does not reflect the unique realities of Tarma, underscoring the need to develop a business sustainability measurement method that is sensitive to local conditions and culturally relevant.

In this paper, we describe a method of measuring business sustainability in the context of Tarma, Peru. This process involved a comprehensive review of existing literature on business sustainability, as well as consultations with local experts and business owners to ensure the relevance and validity of the indicators included in the method.

DOI: https://doi.org/10.54216/IJNS.240426
Received: March 26, 2023 Revised: April 30, 2024 Accepted: May 23, 2024

The method developed in this study has the potential to be a valuable tool for companies in Tarma, Peru, and other similar regions, seeking to evaluate and improve their sustainability performance. By providing a tool adapted to the local context, we hope to encourage more responsible business practices and contribute to the sustainable development of the region. We designed the method to satisfy certain conditions. The simplicity of use is basic because the tool will be used by entrepreneurs who are not specifically experts in mathematics. The other component to consider is accuracy, we consider that this is achieved using neutrosophic tools since decision-making has uncertainty and indeterminacy as components. If they are excluded, paradoxically, less accurate models will be obtained. The third characteristic is that the results can be aggregated. That is why we select linguistic models to be used by decision-makers. A very popular linguistic model is the 2-tuple Linguistic Model which is an example of Computing with Words proposed by L. Zadeh [1-2]. In these models, accuracy is not lost in the aggregation of the results, preserving the symbolism of the operations.

A Neutrosophic 2-tuple Linguistic Model is a generalization of this model, which includes three components, one of truthfulness, another of indeterminacy, and a third one of falsity [3-5]. This allows greater accuracy in the model results. It is also essential to have within the model a way to aggregate the results, for this we propose an algebra generated by a Combining Function in Prospector [6-8]. NeutroAlgebras are algebraic structures defined by F. Smarandache where the elements satisfy the axioms, properties, definitions, theorems, etc. only partially [9-14].

The Combining Function used in Prospector has historical importance in the use of expert systems, in this case, applied to the mining field. It is also an example of uninorm, which generalizes the fuzzy t-norm and t-conorm to both interval $[0, 1]$ and interval $[-1, 1]$ [15]. OffUninorms are uninorms defined in an interval $[m, n]$ where $m, n \in \mathbb{R}$ [16]. This allows aggregation in the context of offsets, which are fuzzy, intuitionistic fuzzy, or neutrosophic sets defined outside of $[0, 1]$ [17].

One of the properties of uninorms based on Prospector's Combining Function is that it allows the generation of NeutroAlgebras, specifically NeutroGroups, and that it has found applications in various contexts, especially social ones.

In summary, with this work, we propose to measure business sustainability in Tarma, Peru with elements of the Neutrosophic 2-tuple Linguistic Model. These results are aggregated using a Cayley table of a NeutroAlgebra where indeterminacy is included. The proposed method is friendly and easy to use by decision-makers since it is based on natural language. It is sufficiently accurate because it incorporates uncertainty and indeterminacy. An aggregation operation based on a NeutroGroup is also proposed [7-8, 17].

The article contains the following structure, a Preliminaries section summarizes the concepts of the Neutrosophic 2-tuple Linguistic Models and NeutroAlgebras. Section 3 explains the details of the proposed method, which is illustrated with an example. In the last section, the conclusions of the article are given.

2 Preliminaries

This section contains the basics of the Neutrosophic 2-tuple Linguistic Model and NeutroAlgebras needed to understand this article.

2.1 Neutrosophic 2-tuple Linguistic Model

Definition 1. ([2-4]) Let $S = \{s_0, s_1, \dots, s_g\}$ be a set of linguistic terms and $\beta \epsilon [0, g]$ a value that represents the result of a symbolic operation, then the linguistic 2-tuple that expresses the information equivalent to β is obtained using the following function:

$\Delta: [0, g] \to S \times [-0.5, 0.5)$

$\Delta(\beta) = (s_i, \alpha)$ (1)

Where s_i is such that $i = \text{round}(\beta)$ and $\alpha = \beta - i, \alpha \in [-0.5, 0.5)$ and "round" is the usual rounding operator, s_i is the index label closest to β and α is the value of the symbolic translation.

It should be noted that $\Delta^{-1}: \langle S \rangle \to [0, g]$ is defined as $\Delta^{-1}(s_i, \alpha) = i + \alpha$. Thus, a linguistic 2-tuple $\langle S \rangle$ is identified with its numerical value in $[0, g]$.

Suppose that $S = \{s_0, \dots, s_g\}$ is a *2-Tuple Linguistic Set* (2TLS) with odd cardinality g+1. It is defined as $(s_T, a), (s_I, b), (s_F, c) \in L$ and a, b, c $\in [0, g]$, where $(s_T, a), (s_I, b), (s_F, c) \in L$ independently expresses the degree of truthfulness, indeterminacy, and falsehood by 2TLS. *2-Tuple Linguistic Neutrosophic Number* (2TLNN) is defined as follows:

DOI: https://doi.org/10.54216/IJNS.240426
Received: November 16, 2023 Revised: February 01, 2024 Accepted: May 23, 2024

$$l_j = \left\{(s_{T_j}, a), (s_{I_j}, b), (s_{F_j}, c)\right\} \qquad (2)$$

Where $0 \le \Delta^{-1}(s_{T_j}, a) \le g$, $0 \le \Delta^{-1}(s_{I_j}, b) \le g$, $0 \le \Delta^{-1}(s_{F_j}, c) \le g$, and $0 \le \Delta^{-1}\left(s_{T_j}, a\right) + \Delta^{-1}\left(s_{I_j}, b\right) + \Delta^{-1}(s_{F_j}, c) \le 3g$.

The scoring and accuracy functions allow us to rank 2TLNN.

Let $l_1 = \left\{(s_{T_1}, a), (s_{I_1}, b), (s_{F_1}, c)\right\}$ be a 2TLNN in L, the scoring and accuracy functions in l_1 are defined as follows, respectively:

$$S(l_1)=\Delta\left\{\frac{2g+\Delta^{-1}(s_{T_1},a)-\Delta^{-1}(s_{I_1},b)-\Delta^{-1}(s_{F_1},c)}{3}\right\}, \Delta^{-1}(S(l_1)) \in [0, g] \qquad (3)$$

$$H(l_1)=\Delta\left\{\frac{g+\Delta^{-1}(s_{T_1},a)-\Delta^{-1}(s_{F_1},c)}{2}\right\}, \Delta^{-1}(H(l_1)) \in [0, g] \qquad (4)$$

2.2 NeutroGroups generated by OffUninorms

The theory of NeutroAlgebras introduced by F. Smarandache generalizes the classical theory of Algebra and Partial Algebras within the framework of Neutrosophy [9]. NeutroAlgebras continue to study algebraic structures based on ordered pairs formed by a set of elements and an operation. The main difference between NeutroAlgebras concerning the others is that they contain at least one NeutroAxiom, which is an axiom where there are two types of elements, those that comply with the axiom and those that do not comply with it.

Continuing with the main idea of Neutrosophy, given an Algebra (axiom) <A>, there exists a triad (<A>, <NeutA> , <AntiA>) where the algebra (axiom) <A> is 100% true or true for all elements, NeutroAlgebras (NeutroAxioms) <NeutA> are also admitted that are satisfied only by a part of the elements, while AntiAlgebras (AntiAxioms) <AntiA> are not satisfied by any of the elements of the set.

This new approach to one of the most classic branches of mathematics constitutes a challenge to the understanding of these new ideas. Keep in mind that classical algebra is based on mathematical logic where only 100% true axioms are admitted.

A uninorm is a mapping that generalizes the definitions of t-norm and t-conorm. Where there is a neutral element, it is commutative, associative, and non-decreasing concerning each of the components. In [18] it is generalized to the field of neutrosophy and in [16] it is generalized even more to the field of OffSets, which are sets defined outside the interval $[0, 1]$ or $[-1, 1]$ and in general, are defined for intervals $[m, n]$ where $m, n \in \mathbb{R}$, in particular for $[-n, n]$ where the neutral is $e = 0$.

By setting $n > 0$, a NeutroGroup can be defined from the Combining Function of Prospector, which is the function used to aggregate elements of a well-known Expert System obtained to model mining problems. This NeutroGroup contains the symbolic element I within its structure which means indeterminacy.

Specifically, we will use the NeutroGroup with the operation $\oplus_5$ for the elements $G = \{-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, I\}$. This operation is commutative, associative and the null element is 0. In addition, the following properties derived from the properties of the generating OffUninorm are fulfilled, taking only the truthfulness component:

- If $x, y < 0$ then $x \oplus_5 y \le min(x, y)$,
- If $x, y > 0$ then $x \oplus_5 y \ge max(x, y)$,
- If $x < 0$ and $y > 0$ or if $x > 0$ and $y < 0$, we have $min(x, y) \le x \oplus_5 y \le max(x, y)$.
- $\forall x \in G, x \oplus_5 0 = x$.
- $(-5) \oplus_5 5 = 5 \oplus_5 (-5) = I$.

In [7] is summarized in the following Cayley Table:

Table 1: Cayley table corresponding to $\oplus_5$. Source: [7].

$\oplus_5$	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**I**	**1**	**2**	**3**	**4**	**5**
-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	I
-4	-5	-5	-5	-5	-4	-4	-4	-4	-3	-2	0	5
-3	-5	-5	-4	-4	-4	-3	-3	-2	-1	0	2	5
-2	-5	-5	-4	-3	-3	-2	-2	-1	0	1	3	5
-1	-5	-4	-4	-3	-2	-1	-1	0	1	2	4	5
0	-5	-4	-3	-2	-1	0	I	1	2	3	4	5
I	-5	-4	-3	-2	-1	I	I	I	I	I	I	I
1	-5	-4	-2	-1	0	1	I	2	3	4	4	5

DOI: https://doi.org/10.54216/IJNS.240426
Received: November 16, 2023 Revised: February 01, 2024 Accepted: May 23, 2024

2	-5	-3	-1	0	1	2	I	3	3	4	5	5
3	-5	-2	0	1	2	3	I	4	4	4	5	5
4	-5	0	2	3	4	4	I	4	5	5	5	5
5	I	5	5	5	5	5	I	5	5	5	5	5

3 Proposed Measurement Method

To design a business sustainability measurement method specific to the context of Tarma, Peru, it is essential to identify predictors that reflect the unique characteristics of the region and the particular concerns of local businesses. Here are the fundamental predictors that will be considered:

F1. Environmental impact: This predictor would evaluate the impact of business activities on the local environment, such as waste management, consumption of natural resources (water, energy), and greenhouse gas emissions. Given the mountainous environment and the importance of biodiversity in Tarma, the conservation of natural resources and the reduction of the ecological footprint could be key aspects.

F2. Social responsibility: This predictor would focus on the company's actions to contribute to the social and economic well-being of the local community. It could include measures such as local job creation, support for community initiatives, promotion of gender equality, and respect for labor rights. Given the cultural diversity in Tarma, sensitivity to local needs and values would be crucial.

F3. Economic profitability: Although business sustainability is not limited to economic considerations, financial viability remains an important factor. This predictor would evaluate the ability of companies to maintain a balance between economic profitability and sustainable practices. In the Tarma context, where agriculture is a key economic activity, indicators related to resource use efficiency and income diversification could be relevant.

F4. Adaptation to climate change: Given the vulnerability of the Tarma region to the effects of climate change, indicators related to the ability of companies to adapt and mitigate these impacts could be critical. This could include measures such as implementing resilient agricultural practices, crop diversification, and climate risk management.

F5. Innovation and technology: This predictor would assess the degree to which companies in Tarma are adopting innovative practices and sustainable technologies in their operations. This could include the use of advanced agricultural techniques, such as precision agriculture or agroecology, as well as the incorporation of clean technologies in other economic sectors.

The expert must evaluate each of the above aspects on a linguistic scale that $S = \{s_{-5}, s_{-4}, s_{-3}, s_{-2}, s_{-1}, s_0, s_1, s_2, s_3, s_4, s_5\}$ Individually means the following, shown in Table 2:

Table 2: Linguistic meaning of each element of the *S* scale.

Scale element	**Linguistic Meaning**
s_{-5}	Extremely Low
s_{-4}	Very Low
s_{-3}	Low
s_{-2}	Somewhat Low
s_{-1}	Lower than High
s_0	As Low as High
s_1	Higher than Low
s_2	Somewhat High
s_3	High
s_4	Very high
s_5	Extremely High

In this method, another scale of importance of the expert's opinion is added, which is shown in Table 3 with the scale $W = \{w_{-5}, w_{-4}, w_{-3}, w_{-2}, w_{-1}, w_0, w_1, w_2, w_3, w_4, w_5\}$.

Table 3: Linguistic meaning of each element of the *W* scale

Scale element	**Linguistic Meaning**
w_{-5}	Extremely Insignificant
w_{-4}	Very Insignificant
w_{-3}	Insignificant
w_{-2}	Somewhat Insignificant
w_{-1}	More Insignificant than Important
w_0	As insignificant as important
w_1	More Important than Insignificant

DOI: https://doi.org/10.54216/IJNS.240426
Received: November 16, 2023 Revised: February 01, 2024 Accepted: May 23, 2024

w_2	Somewhat important
w_3	Important
w_4	Very important
w_5	Extremely important

The elements that are part of the measurement are:

The group $E = \{e_1, e_2, \cdots, e_p\}$ denotes the $p > 0$ experts who measure the sustainability of the company, the town, the region, etc.

$F = \{F_1, F_2, F_3, F_4, F_5\}$ are the five factors to measure.
Therefore, the steps to measure economic sustainability are as follows:

Economic Sustainability
1. Each expert e_i is associated with a weight on the scale shown in Table 3 depending on their knowledge of the factor to be measured F_j. Let us denote this weight by ω_{ij} $(i = 1, 2, \ldots, p; j = 1, 2, \ldots, 5)$. In this case, to maintain the simplicity of the measurement, it is accepted a single value of W. 2. Each expert e_i evaluates each factor in a triad of elements in Table 2, that is, we have a_{ij} $(i = 1, 2, \ldots, p;$ $j = 1, 2, \ldots, 5)$ is the evaluation of the ith expert on the jth factor; where $a_{ij} = \left(s_{T_{ij}}, s_{I_{ij}}, s_{F_{ij}}\right)$ and $s_{T_{ij}}, s_{I_{ij}}, s_{F_{ij}} \in S$. 3. An index a_{ij} is associated with (s_r, s_s, s_t), so taken $r, s, t \in \{-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5\}$: $ind_{ij} = r \oplus_5 s \oplus_5 (-t)$ (5) See that $ind_{ij} \in G$. 4. The evaluation of each expert for each factor is calculated using the formula given in Equation 6: $\bar{a}_{ij} = \frac{ind_{ij} + ind_{w_{ij}}}{2}$ (6) That is, the mean is calculated between ind_{ij} calculated in Equation 5 and $ind_{w_{ij}}$ which is the index of the weight on the scale W associated with the expert, regarding his/her knowledge about this factor. 5. The evaluation of each factor is given by the formula given in Equation 7: $\tilde{a}_j = \frac{\sum_{i=1}^{p} \bar{a}_{ij}}{p}$ (7) Also, to convert it to an integer so $\tilde{a}_j \in [-5, 5]$, formula 8 is used: $\tilde{a}_j = round\left(\tilde{a}_j\right)$ (8) 6. To calculate economic sustainability in general, formula 9 should be used: $A = \tilde{\alpha}_1 \oplus_5 \tilde{\alpha}_2 \oplus_5 \tilde{\alpha}_3 \oplus_5 \tilde{\alpha}_4 \oplus_5 \tilde{\alpha}_5$ (9) Based on the operation in Table 1. 7. A is a result in the set $\{-5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, I\}$. If this is a numerical value it is interpreted as s_A on the S scale. 8. If $A = I$, it is interpreted as disagreement in the experts' opinion and they are asked to repeat the process. For example, a Neutrosophic Delphi method and others can be found in [19-21]. This can serve as a guide on what to do in case of disagreement.

Figure 1: contains the flowchart of the proposed method.

DOI: https://doi.org/10.54216/IJNS.240426
Received: November 16, 2023 Revised: February 01, 2024 Accepted: May 23, 2024

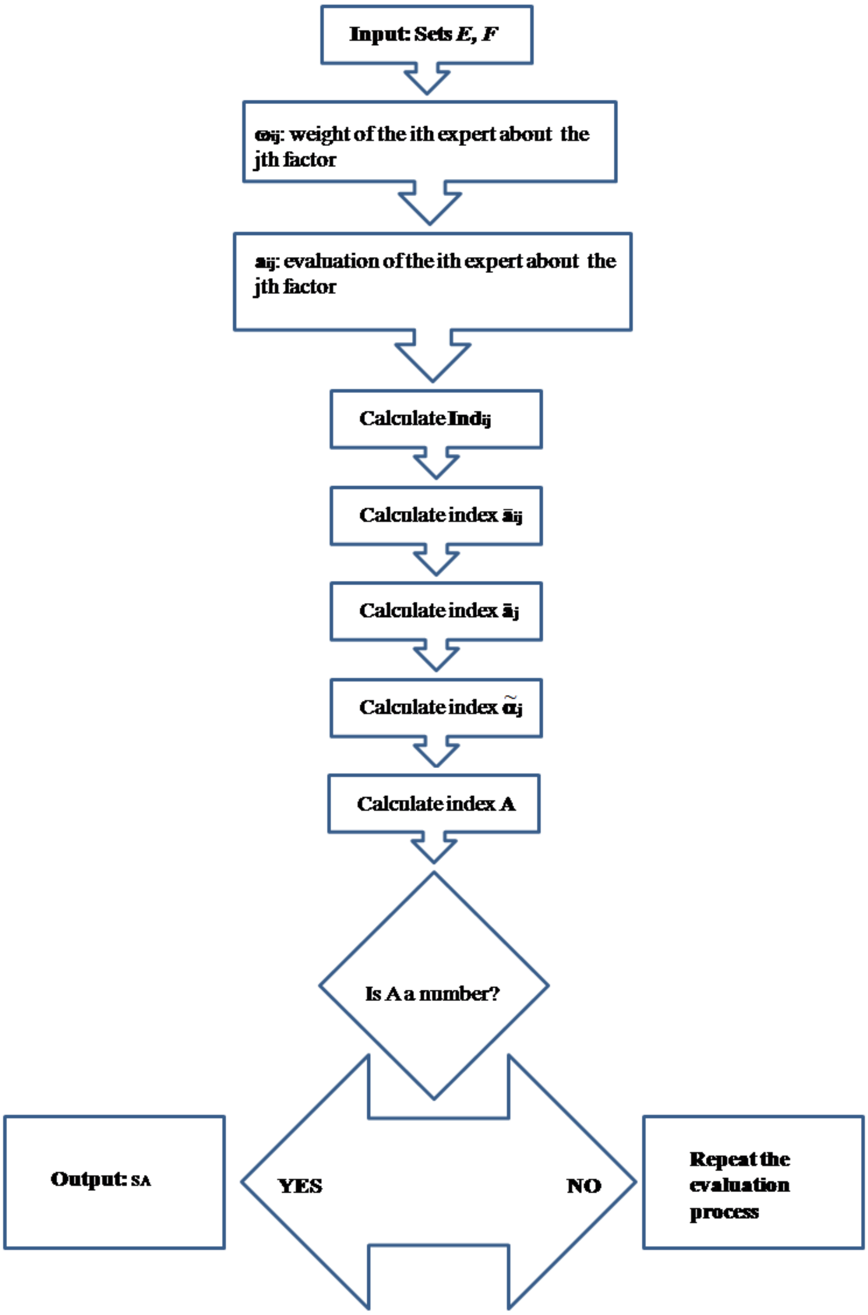

Figure 2: Flowchart of measuring economic sustainability method.

Next, we will illustrate this measurement method with an example.

Example 1. Suppose we have 3 experts on economic sustainability. Table 4 contains the results of the weights associated with each of them for each factor and the evaluation for each of the factors.

Table 4: Evaluation of each factor and the weights associated with each expert.

Expert/Factor	F_1	F_2	F_3	F_4	F_5
e_1	$(s_1, s_0, s_{-1})(w_2)$	$(s_2, s_1, s_{-2})(w_1)$	$(s_1, s_2, s_{-2})(w_2)$	$(s_1, s_2, s_{-2})(w_{-1})$	$(s_3, s_2, s_{-4})(w_2)$
e_2	$(s_3, s_2, s_{-3})(w_{-2})$	$(s_4, s_3, s_{-5})(w_2)$	$(s_{-1}, s_0, s_1)(w_1)$	$(s_2, s_1, s_{-3})(w_3)$	$(s_4, s_3, s_{-3})(w_0)$
e_3	$(s_2, s_1, s_{-3})(w_1)$	$(s_0, s_1, s_{-1})(w_{-1})$	$(s_1, s_2, s_{-2})(w_{-1})$	$(s_2, s_1, s_{-4})(w_3)$	$(s_5, s_4, s_{-5})(w_{-2})$

DOI: https://doi.org/10.54216/IJNS.240426
Received: November 16, 2023 Revised: February 01, 2024 Accepted: May 23, 2024

Table 5: Evaluation of each factor and the weights associated with each expert.

Expert/Factor	F_1	F_2	F_3	F_4	F_5
e_1	2	2.5	3	1.5	3.5
e_2	1.5	3.5	-0.5	3.5	2.5
e_3	2.5	0.5	1.5	4	1.5

The final indices for each of the factors are given below in Table 6.

Table 6: Values obtained for $\tilde{a}_j$ and $\tilde{\alpha}_j$.

Factor	F_1	F_2	F_3	F_4	F_5
$\tilde{a}_j$	2	2.1667	1.3333	3	2.5
$\tilde{\alpha}_j$	2	2	1	3	2

Finally, from Equation 9 we have $A = 5$. Note that according to the characteristics of the operator $\oplus_5$, extreme results will be obtained, either with optimism when all the values are positive or with pessimism when all the values are negative. So, this method will be more valuable when the final values are of different signs and non-extreme values, therefore, when there is more indeterminacy between individual opinions. This is related to the interpretation of the Combining function for Prospector, where values indicate evidence and extreme evidence (5 or -5 in this case) exercises a veto over other values. For example, $A = -1 \oplus_5 2 \oplus_5 -3 \oplus_5 0 \oplus_5 1 = -1$ [22,23,24].

4. Conclusion

The measurement of economic sustainability has gained great importance today because it is a guarantor of the good economic performance of a locality. To objectively determine the state of business sustainability in the region of Tarma, Peru, we propose a method that is easy to apply by decision-makers due to its simplicity. This is based on the Neutrosophic 2-tuple linguistic model where linguistic values are taken into account in the form of a triad that measures, in addition to the evaluation of truthfulness, also one of indeterminacy and falsity, which improves the accuracy of the evaluation. These indices were aggregated with the help of an operator on the indices defined by a NeutroGroup generated by the Combining function of Prospector. This last feature allows us to take advantage of the properties of uninorms and OffUninorms such as commutativity and associativity, and an indeterminacy value can be obtained as output when the result is contradictory. We should point out that this method is more useful when the values associated with the factors have different evaluations in terms of being positive or negative, and that in these cases the NeutroGroup tends to compensate for the results. The use of this NeutroGroup is an approach to a function that was used in a classic Artificial Intelligence tool such as Prospector.

Acknowledgment:
The authors extend their gratitude to the Universidad Nacional Autónoma Altoandina de Tarma, Peru, for the opportunity and support provided for the development of this study, which was conducted within the "Research Group: Sustainable Development Goal," "GIODS." This group is aligned with the university's research line: SOCIAL SCIENCES, ECONOMICS AND BUSINESS, BUSINESS AND MANAGEMENT.

References

[1] Malhotra, T., and Gupta, A. (2023). A systematic review of developments in the 2-tuple linguistic model and its applications in decision analysis. Soft Computing, 27, 1871-1905.
[2] Muhuri, P. K., and Gupta, P. K. (2020). A novel solution approach for multiobjective linguistic optimization problems based on the 2-tuple fuzzy linguistic representation model. Applied Soft Computing, 95, 106395.
[3] Wei, G., Wu, J., Guo, Y., Wang, J., and Wei, C. (2021). An extended COPRAS model for multiple attribute group decision making based on single-valued neutrosophic 2-tuple linguistic environment. Technological and Economic Development of Economy, 27, 353-368.
[4] Chen, H. (2023). A multi-attribute decision-making framework for enterprise competitive intelligence system evaluation with 2-tuple linguistic neutrosophic information. Journal of Intelligent & Fuzzy Systems, 45, 5955-5970.
[5] Liu, H. (2023). Performance evaluation of family business strategic transition based on the 2-tuple linguistic neutrosophic number multiple attribute group decision making. Journal of Intelligent & Fuzzy Systems, 44, 3271-3283.
[6] Jiménez, D. S., Ubilla, M. E. R., and Batista-Hernández, N. (2021). NeutroAlgebra for the evaluation of barriers to migrants' access in Primary Health Care in Chile based on PROSPECTOR function. Neutrosophic Sets and Systems, 39, 1-9.

DOI: https://doi.org/10.54216/IJNS.240426
Received: November 16, 2023 Revised: February 01, 2024 Accepted: May 23, 2024

[7] Batista-Hernández, N., González-Caballero, E., Cruzaty, L. E. V., Ortega-Chávez, W., Huarac, C. F. P., and Chamorro, S. L. C. (2022). Theoretical study of the NeutroAlgebra generated by the combining function in Prospector and some pedagogical notes. In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 116-140). IGI Global.
[8] González-Caballero, E., Leyva, M., Ricardo, J. E., and Batista-Hernández, N. (2022). NeutroGroups Generated by Uninorms: A Theoretical Approach. In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 155-179). IGI Global.
[9] Smarandache, F. (2020). NeutroAlgebra is a generalization of partial algebra. Infinite Study.
[10] Smarandache, F., & Al-Tahan, M. (2022). NeutroAlgebra and AntiAlgebra Are Generalizations of Classical Algebras. In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 1-10). IGI Global.
[11] Smarandache, Florentin. NeutroAlgebra is a Generalization of Partial Algebra. International Journal of Neutrosophic Science, vol. 2, no. 1, 2020, pp. 08-17.
[12] Das, S., Das, R., & Pramanik, S. (2022). Neutro algebra and neutro group. In Theory and applications of neutroalgebras as generalizations of classical algebras (pp. 141-154). IGI Global.
[13] Kandasamy, I., Vasantha, W. B., & Smarandache, F. (2022). NeutroAlgebra of Ideals in a Ring. In Theory and Applications of NeutroAlgebras as Generalizations of Classical Algebras (pp. 260-273). IGI Global.
[14] Smarandache, F. (2022). Introduction to Super-Hyper-Algebra and Neutrosophic Super-Hyper-Algebra. Neutrosophic Computing and Machine Learning, 20(1), 1-6.
[15] Wang, P., Fu, Y., Liu, P., Zhu, B., Wang, F., and Pamucar, D. (2024). Evaluation of ecological governance in the Yellow River basin based on Uninorm combination weight and MULTIMOORA-Borda method. Expert Systems with Applications, 235, 121227.
[16] González-Caballero, E., Smarandache, F., and Leyva Vázquez, M. (2019). On neutrosophic offuninorms. Symmetry, 11, 1136.
[17] Smarandache, F., Quiroz-Martínez, M. A., Estupiñán-Ricardo, J., Batista-Hernández, N., and Leyva-Vázquez, M. (2020). Application of Neutrosophic Offsets for Digital Image Processing. Investigación Operacional, 41, 603-612.
[18] González-Caballero, E., Leyva-Vázquez, M., and Smarandache, F. (2021). On neutrosophic uninorms. Neutrosophic sets and systems, 45, 340-348.
[19] Leyva-Vázquez, M., Hernández, J. H., Batista-Hernández, N., Salvatierra, J. A. A., and Baryolo, O. G. (2018). A framework for PEST analysis based on fuzzy decision maps. Espacios, 39, 13.
[20] F. F. Ali, S. Javed, and M. Mahmood, "The Delphi technique in educational research: A systematic review of the applications, challenges, and future directions," Educational Research Review, vol. 35, pp. 100420, 2021, DOI: 10.1016/j.edurev.2021.100420.
[21] Joselyne, I. Marina, C. P., P. Cagin, T. (2024). Fusion of Expert Judgment using the Neutrosophic Delphi Method to Evaluate Tax Behavior. Journal of International Journal of Neutrosophic Science, 23(4), 302-307.
[22] A., R. L., M. L., E. (2024). A Multi-Criteria Decision Making TOPSIS Fusion Approach for Selection Best Strategy Charging for Electric Bus Systems. Journal of Intelligent Systems and Internet of Things, 11(1), 65-74.
[23] Z. Khan, M. Jan, S. Ahmad, and A. Shah, "Digital Forensic Analysis of Mobile Devices: Challenges, Techniques, and Future Directions," Forensic Science International: Reports, vol. 3, pp. 100201, 2021, DOI: 10.1016/j.fsir.2021.100201.
[24] J. Wu, G. Wei, and Z. Zhang, "Multi-Criteria Decision-Making Framework with Linguistic Aggregation Operators and Its Application in Complex Scenarios," Knowledge-Based Systems, vol. 204, pp. 106259, 2020, DOI: 10.1016/j.knosys.2020.106259.

DOI: https://doi.org/10.54216/IJNS.240426
Received: November 16, 2023 Revised: February 01, 2024 Accepted: May 23, 2024