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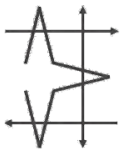

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The submitted papers should be professional, in good English, containing a brief review of a problem and obtained results.

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This theory considers every notion or idea <A> together with its opposite or negation <antiA> and with their spectrum of neutralities <neutA> in between them (i.e. notions or ideas supporting neither <A> nor <antiA>). The <neutA> and <antiA> ideas together are referred to as <nonA>.

Neutrosophy is a generalization of Hegel's dialectics (the last one is based on <A> and <antiA> only).

According to this theory every idea <A> tends to be neutralized and balanced by <antiA> and <nonA> ideas - as a state of equilibrium.

In a classical way <A>, <neutA>, <antiA> are disjoint two by two. But, since in many cases the borders between notions are vague, imprecise, Sorites, it is possible that <A>, <neutA>, <antiA> (and <nonA> of course) have common parts two by two, or even all three of them as well.

Neutrosophic Set and *Neutrosophic Logic* are generalizations of the fuzzy set and respectively fuzzy logic (especially of intuitionistic fuzzy set and respectively intuitionistic fuzzy logic). In neutrosophic logic a proposition has a degree of truth

(*T*), a degree of indeterminacy (*I*), and a degree of falsity (*F*), where *T, I, F* are standard or non-standard subsets of $]^{-}0, 1^{+}[$.

Neutrosophic Probability is a generalization of the classical probability and imprecise probability.

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What distinguishes the neutrosophics from other fields is the <neutA>, which means neither <A> nor <antiA>.

<neutA>, which of course depends on <A>, can be indeterminacy, neutrality, tie game, unknown, contradiction, ignorance, imprecision, etc.

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PREFACE

Neutrosophy as science has inclusive attributes that make possible to extract the contributions of neutral values in the analysis of data sets; it builds a unified field of logic for transdisciplinary studies that transcend the boundaries between natural and social sciences. Neutral philosophy seeks to solve the problems of indeterminacy that appear universally, to reform the current natural or social sciences, with an open methodology to promote innovation.

The research products related in this special issue start from the premise that the difficulty is not the complexity of the social environment, but the instrumental obsolescence to observe, interpret and manage that complexity [1], there are bold approaches and proposals for valid solutions that come to enrich the universe of resolution through the use of neutral methods.

In the last year, the use of tools related to neutrosophy and its application to the social sciences, modeling of social phenomena based on simulation agents, problems associated with health, psychology, education, environmental management and sustainability solutions and legal sciences has increased in the events organized by the Asociacion Latinoamericana de Ciencias Neutrosoficas (ALCN in Spanish). The methods of higher incidence are cognitive maps, neutral Iadovs, neutral Delphi, analytical hierarchy process methods, neutral statistics, neutral personality models, among the most significant.

In this special issue, there is a predominance of research from Ecuadorian universities, demonstrating how neutrosophy and its methods are consolidated as instruments of analysis, inference and research validation.

[1] M. L. VÁZQUEZ, N. B. HERNANDEZ, and F. SMARANDACHE, *MÉTODOS MULTICRITERIOS PARA DETERMINACIÓN DE LA EFECTIVIDAD DE LA GESTIÓN PÚBLICA Y EL ANÁLISIS DE LA TRASPARENCIA*: Infinite Study.

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Neutrosophic Psychology for Emotional Intelligence Analysis in Students of the Autonomous University of Los Andes, Ecuador

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Abstract. Emotional intelligence is a relatively recent and important concept in psychology, where the individual's ability to control his (her) emotions and to deal with the behavior of those around him (her) is taken into account. This implies a dynamic relationship between concepts such as the opposite which are rationality and emotion, where the emotionally intelligent individual would be located in the right middle of these two poles. A very recent way of representing these triadic relationships is the neutrosophical psychology theory, where if A is a psychological concept, the dynamical interaction of the concept is represented by the scheme (<A> <NeutA> <AntiA>). This paper studies the behavior of the emotional intelligence in a group of university students from the Autonomous University of Los Andes in Ecuador using classical statistical inference tools, according to the triad (<EI> <NeutEI> <antiEI >). The main motivation of this paper is to study the state of EI in the students of this university since a high EI will guarantee better future professionals and higher quality learning.

Keywords: Emotional intelligence, group emotional intelligence, neutrosophical psychology theory, higher education.

1 Introduction

Gardner ([1]) is the main exponent of the studies of the mind structure, he is the author who determined the eight multiple intelligences kinds, which are viz., bodily-kinesthetic, logical-mathematical, linguistic, naturalist, musical, spatial-visual, interpersonal and intrapersonal. With the support of multiple intelligences, according to Galera ([2]), learning-teaching models could be "modified (...), the academic performance would improve as the teaching would be more individualized, the skills of each student would be appreciated and we can work with every intelligence from the most outstanding ones."

"The term Emotional Intelligence refers to the human ability to feel, understand, control and modify emotional states in oneself and also of others; emotional intelligence does not mean drown the emotions, but to direct and balance", see [3].

Students have different forms of learning, therefore not all learn in the same way or at the same pace, in the case of standardized education, with a methodology for the group, teachers can show that there is a diversity of students with different needs, ways of thinking and learning, so there will always be those who do not assimilate the information at the same speed, causing low academic performance, to this end, the teacher must be prepared and trained to use strategies to level those that require special support, see [4-7].

The learning that articulates theory and practice is classified as the best strategy, that is why in the university classrooms, fieldwork is contemplated as part of the training process, as well as collaborative and group work, in this case, there are students with a low level of interpersonal intelligence who do not adapt to the groups, preferring to do them independently.

Goleman in [8], argues that the success of a professional, is not precisely for the one who has the best mark, but who manages human skills, of knowing how to relate to social groups, to be accepted, to work independently and in a group, who knows himself or herself and knows how to control emotions, therefore he/she raises questions about the education, about if it is valid to educate to: "learning to be", "have", "be", or "co-create" in life.

This research analyses the emotional intelligence of students at the Autonomous University of Los Andes Ibarra extension, taking into account the importance of the management and control of personal emotions, the

ability to work as a team and the interrelationship between classmates because the educational environment is a variable that affects the quality of the training of professionals, as well as the assimilation of knowledge. The objective is to identify the management of interpersonal and intrapersonal intelligence and to determine the influence on the educational environment of the students of this university.

To this end, a survey was administered to 245 students of the faculties of accounting and auditing, tourism, management, system, and law, determining relevant factors, and sufficient to establish the management of emotional intelligence in this reference group.

The results of the survey were evaluated from the neutrosophic psychology, see [9], Neutropsyche is the psychological theory that studies the soul or spirit using the neutrosophy and neutrosophic theories, that is to say, Neutrosophic Psychological Theory. It is based on triadic neutrosophic psychological concepts of the form (<A>, <neutA>, <antiA>).

Neutropsychic Personality is a neutrosophic dynamic open psychological system of tendencies to feel, think, and act specifically to each individual, based on Neutrosophic Refined Memory: that restructures the division of memory into consciousness, aconsciousness (which is a blend of consciousness and unconsciousness), and unconsciousness. Aconscious is subdivided into preconscious, subconscious, semiconscious = semiunconscious, subunconscious, and preunconscious.

In other words, the Neutrosophic Psychological Theory studies the concepts of traditional psychology from a new point of view, from a triad of possible states (<A> <neutA> <antiA>), where <A> and <antiA> are considered opposite states of the concept, while the <neutA> state is considered neither <A> nor <antiA>, but an undetermined state. An example is the Freudian concept of "ego", where the triad (<id> <ego> <superego>) contains the ego as a state of balance between “id” and “superego”. Smarandache renames the “id” as “underego”, to define the triad (<undergo> <ego> <superego>) with the intention of highlighting symmetry. This idea is generalized when using refined neutrosophy, where the aforementioned triad extends to more possible states, provided that at least one state of neutrality is included.

We used the tools of this theory to assess the results of the survey in terms of the emotional intelligence of the group of students. Despite our main interest is to obtain a collective measure of the individual EI degree in the group of students, this measure is a necessary and not sufficient measure of Group Emotional Intelligence (GEI), [10, 11]. GEI is defined in [10], as: “the ability to develop a set of norms that manage emotional processes to cultivate trust, group identity, and group efficacy. We argue that these collective beliefs facilitate the development of group member cooperation and collaboration.” We follow the criterion that the greater the individual EI in the group, the greater the GEI.

The use of neutrosophic psychology has to do with the fact that the students in the group can clearly be considered either emotionally intelligent, or clearly emotionally non-intelligent, or a third option that is an intermediate-range of indefiniteness, therefore, here we will consider not only the <A> or <antiA> states but also the <neutA>, where A would mean emotional intelligence in the group, which we emphasize it is more particular than the GEI.

Beyond conducting a study on collective emotional intelligence in a student group, a theoretical contribution of this paper is to identify collective emotional intelligence as a concept whose states can be represented in the form of the aforementioned triad or by the refined neutrosophy. In this way, this paper represents this concept in the form of (<EI> <neutEI> <antiEI>), which means that the individual or the group possesses emotional intelligence, or an intermediate indeterminate state of emotional intelligence, or does not possess emotional intelligence, respectively.

This paper is divided into as follows; first, we have a section dedicated to exposing the main concepts of the Theory of Neutrosophic Psychology. The next section contains the results of the study of the emotional intelligence of students at the University of Los Andes, Ibarra extension, in Ecuador. The last section contains the conclusions.

2 Preliminaries

This section is dedicated to describing the psychological concepts used in this paper. Firstly, emotional intelligence is explained in subsection 2.1., whereas subsection 2.2. is devoted to explaining the main ideas on the Neutrosophical Psychology Theory.

2.1. Emotional Intelligence

Goleman ([12]) classifies emotional intelligence (EI) into intrapersonal and interpersonal, see Figure 1. Interpersonal intelligence is related to the way the person can interact with others, in the case of students, the empathy they have among their classmates, the ease of working as a team, the consensus obtained from the different debates, the respect of the ways of thinking, the ways of living and acting.

Interpersonal intelligence makes it possible to understand the others and communicate, taking into account their different moods, temperaments, motivations, and abilities, including the ability to establish and maintain social relationships and to assume different roles within groups. The important matter about analyzing

interpersonal intelligence is that like every behavior, it is transmitted from parents to children, especially from the models that the former create, it includes abilities such as empathy and the ability to manage interpersonal relationships, see [13].

Based on the aforementioned ideas, interpersonal intelligence is the ability to understand others and interact effectively with them. It "includes sensitivity to facial expressions, voice, gestures, and postures, and the ability to respond", see [14]. On the other hand, intrapersonal intelligence, according to Campbell et al., see [15], has to do with "understand our thoughts and feelings. To the extent that we can raise our awareness, the relationship between our inner world and the outer world of experiences will be stronger". Like it is stated in [12]: "The development of emotional, intrapersonal, indicates the way how the person manages and controls himself, according to the tools acquired from their environment, expressing their feelings appropriately and effectively."

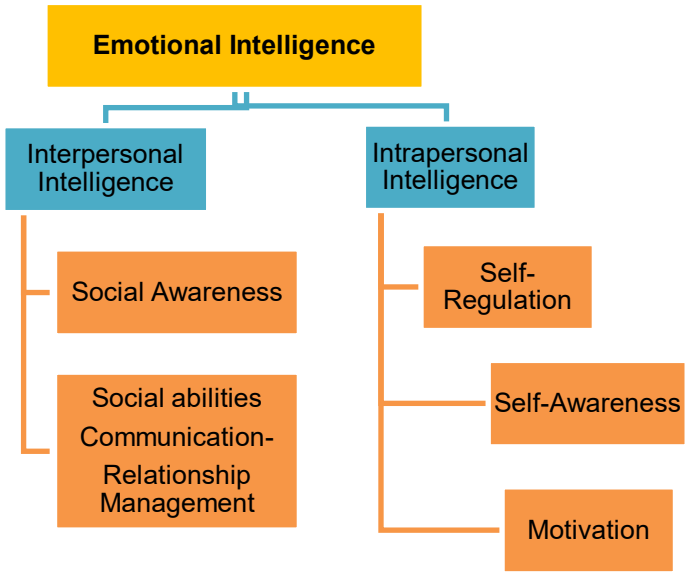

Figure 1: Emotional Intelligence components (Source [12])

The management of intrapersonal and interpersonal intelligence allows the individual to develop abilities and skills that differentiate him/her from other people, becoming worthy of society's recognition. Thus, the good control of emotional intelligence allows establishing relationships of friendship, work, studies, to know how to behave, to manage their different moods and feelings.

The little development of the emotional intelligence in students has an impact on low performance in the area of emotional and academic, therefore it is important to know what are the emotions experienced during the academic day so that they can somehow modulate and manage emotions, develop tolerance to control the frustrations of every day, to adopt a positive attitude with classmates, or prevent interpersonal conflict, improve the quality of life of the university, sort out the feelings and states of mind.

2.2. Neutrosophical Psychology Theory: Basic Concepts

This section is dedicated to summarizing the main concepts and methods of the Neutrosophical Psychology Theory.

In [9] Smarandache makes reference to Sigmund Freud which divides memory into: conscious, preconscious, and unconscious. In the framework of neutrosophic psychology, it is defined as a third state which is called "aconscious", which means: to be ignorant, impassive, indifferent, senseless, and unfeeling.

Similarly, to the neutrosophic theory, neutrosophic psychology deals with concepts represented by (<A>, <neutA>, <antiA>), one of them is described as follows:

1) Conscious, meaning things that we are currently aware of, it corresponds to <A>.

2) Unconscious, which comprises things that we are not aware of; they are hard to access because they are deep inside our minds. It is the opposite of conscious, corresponding to <antiA>.

3) Aconscious, which etymologically means away from conscious and unconscious, or neither conscious nor unconscious, but in between, or a mixture of conscious and unconscious, a vague buffer zone between them. It corresponds to <neut A> or Indeterminacy, as in Neutrosophy.

Thus, the consciousness, aconsciousness, and unconsciousness are the sources of positive, neutral (or blended), and negative emotions, thoughts, and behaviors throughout our lifespan.

In human behavior, there exists a permanent interaction and discussion among conscious, unconscious, and aconscious. Sometimes people are mostly rational, sometimes they are mostly irrational, and others are indifferent.

The triple $(< A >, < neut\ A >, < antiA >)$ is extended to the *discrete refined neutrosophic memory*, where $(< A >_1, < A >_2, \dots, < A >_l; < neutA >_1, < neutA >_2, \dots, < neutA >_m; < antiA >_1, < antiA >_2, \dots, < antiA >_n)$ are defined based on the refined neutrosophy, see [9, 16-17].

Also Smarandache in [9] cites Carl Jung who divided the unconsciousness into ([18]):

- Personal unconscious, which is specific to each individual, and comprises forgotten or suppressed conscious;
- Collective unconsciousness, which is characteristic to the whole human species, and comprises ancestral memories called "archetypes" (universal meaning images) and mental patterns as inherited psychic structures.

Smarandache adds the group unconscious, which is:

- Group unconsciousness, which is between the personal and collective unconsciousness. It is characteristic to a specific group that the individual belongs to, and has marked him/her mostly.

Equivalently, he extends the Jung's personal conscious and collective conscious to group conscious.

The aconsciousness has a degree of conscious (c), and a degree of the unconscious (u), where $c \in [0,1]$, and $0 \leq c + u \leq 2$.

In the neutrosophic psychology there is the following notation:

$$\text{NL(entity)} = (\text{c}, \text{a}, \text{u}) \qquad (1)$$

Where c = degree of conscious (truth), a = degree of acounscious (indeterminacy): not sure if it is conscious or unconscious, or a blend of both, and u = degree of the unconscious (falsehood), whereas, NL is the notation for Neutrosophic Logic semantic ([19,20]).

$\text{NL(conscious)} = (1, 0, 0)$; $\text{NL(acounscious)} = (0, 1, 0)$; and $\text{NL(unconscious)} = (0, \text{a}, 1)$, where $\text{a} \in (0, 1]$, leaving room for indeterminacy (unknown, unclear).

Given U a universe of discourse, A, B, and C subsets, then Neutrosophic Crisp Set of Type 2 satisfies the axioms: $\text{A} \cap \text{B} = \emptyset$, $B \cap C = \emptyset$, $C \cap A = \emptyset$, and $A \cup B \cup C = U$. Therefore, A, B, C form a disjoint partition of the universe of discourse U.

Refined Neutrosophic Crisp Set of Type 2 (and similarly for Types 1 and 3) is defined as: $A = A_1 \cup A_2 \cup \dots \cup A_p$, $B = B_1 \cup B_2 \cup \dots \cup B_r$, $C = C_1 \cup C_2 \cup \dots \cup C_s$, with $A \cap B = B \cap C = C \cap A = \emptyset$, where p, r, s are integers ≥ 1, $p + r + s \geq 4$, and $A_i \cap A_j = \emptyset$ for $i, j \in \{1,2, \dots, p\}$, $i \neq j$; $B_k \cap B_l = \emptyset$ for $k, l \in \{1,2, \dots, r\}$, $k \neq l$; and $C_m \cap C_n = \emptyset$ for $m, n \in \{1,2, \dots, s\}$, $m \neq n$.

The Neutrospsychic Crisp Personality considers a human person as a universe of discourse U, and three disjoint sets which are the following ([9, 21]):

E = set of emotions of this person;

H = set of thoughts of this person;

B = set of behaviors of this person.

Therefore, $U = E \cup H \cup B$, with $E \cap H = \emptyset$, $H \cap B = \emptyset$, and $B \cap E = \emptyset$. Thus, $U = < E, H, B >$.

Also, the trait is measured by degrees of <trait> and degrees of <anti trait>, such that each person is classified in a range between these two opposites and it is dynamic. Additionally, they include a middle position where there exists indeterminacy.

The most common pair trait-anti trait, are the following:

- Extraversion – Introversion
- Conscientiousness – Unconscientiousness
- Perfectionism – Imperfectionism
- Sensitivism – Insensitivism
- Novator – Conservator
- Self Esteem – Self NonEsteem
- Agreeableness – Disagreeableness
- Openness to Intellect & Experience – Closeness to Intellect & Experience
- Inhibition – Disinhibition
- Flexibility – Rigidity
- Emotivism [Neuroticism (Hans Eysenck)] – Non-Emotivism
- Obsessionality – Nonobsessionality
- Cautiousness – Impulsivity
- Shyness – Boldness
- Honesty – Dishonesty
- Hostility [Psychoticism (Hans Eysenck)] – Nonhostility.

The *Neutrosophic Trait Operator* is the cumulative degree of individual x concerning both the Trait and the antiTrait, and it is defined as:

$$d_{Trait\&antiTrait}: S \rightarrow [-1, 1] \qquad (2)$$

Where, $d_{Trait\ \&\ antiTrait}(x) = d_{Trait}(x) + d_{antiTrait}(x)$.

To classify an individual as belonging to the trait or the anti trait, a threshold is defined and denoted by Thr

for the trait, and antiThr for the anti trait, so that:

- If $d_{Trait\&antiTrait}(x) \geq +Thr$, then the individual is categorized as definitively belonging to the Trait,
- $If\ d_{Trait\&antiTrait}(x) \leq -antiThr$, then the individual is categorized as definitively belonging to the antiTrait.
- $If\ d_{Trait\&antiTrait}(x) \in (-\varepsilon, +\varepsilon)$, then the individual is categorized as been in a totally indeterminate state between the Trait and antiTrait.
- If $d_{Trait\&antiTrait} \in (\varepsilon, Thr)$, then the individual is categorized as mostly belonging to the Trait.
- If $d_{Trait\&antiTrait}(x) \in (-antiThr, -\varepsilon)$, then the individual is categorized as mostly belonging to the antiTrait.

The way to deal with $d_{Trait\&antiTrait}$ is illustrated as follows:

"Assume a psychiatrist, after many sessions, neutrosophic questionnaires and observations measured with neutrosophic statistics, has gotten to the conclusion that George P.'s two temperament dimensions are estimated with a certain accuracy as:

- degree of stable (trait) is $d_{GP}(stable) = 0.2 \in [0,1]$,
- degree of unstable (antiTrait) is $d_{GP}(unstable) = -0.5 \in [-1,0]$;and
- degree of extroverted (trait) is $d_{GP}(extroverted) = 0.9 \in [0,1]$,
- degree of introverted (antiTrait) is $d_{GP}(introverted) = -0.3 \in [-1,0]$.

Then $d_{GD<stable>\&<unstable>}(x) = d_{GP(stable)} + d_{GP(unstable)} = 0.2 + (-0.5) = -0.3$, and $d_{GD<extroverted>\&<introverted>}(x) = d_{GP(extroverted)} + d_{GP(introverted)} = 0.9 + (-0.3) = +0.6$."

3 Results and Discussion

From now on, this section contains the results and discussion for measuring the emotional intelligence in students of The Autonomous University of Los Andes, Ecuador.

3.1. Results

In this subsection, it is described the results obtained from the survey and its processing using statistical and neutrosophic psychology tools. The details of the statistical sampling are the following:

The population under study was made up of 674 students of the Autonomous University of Los Andes, Ibarra extension, being a relatively large number; the sample was calculated using formula 3.

$$n = \frac{Nz^2pq}{d^2(N-1)+z^2pq} \qquad (3)$$

Where:

N = Size of the students' population (674).

z = 1.96 (95% confidence level).

p = probability of success (in this case 50% or 0.5).

$q = 1 - p$ (in this case 1-0.5 = 0.5).

d = Permissible error (5% or 0.05).

$$n = \frac{674 * 1.96^2 * 0.5 * 0.5}{0.05^2 * (674-1) + 1.96^2 * 0.5 * 0.5} \approx 245$$

Let us recall that Equation 3 is widely used to calculate the size of a random sample drawn from the population being studied so that this sample is significant for the entire population. The value of z is obtained as the confidence level according to the values of the standard normal distribution N (0, 1). d is the sampling error, the smaller it is, the more accurate the inference of the population parameters will be from the calculated parameters of the extracted sample. The value of p corresponds to the proportion of elements in the population that satisfy the study characteristic, while q is the proportion of those that do not. When this proportion is unknown, p = q = 0.5 is considered, [22].

The data collection technique was the semi-structured survey, consisting of three informative questions such as age, career, and course, as well as 15 questions related to the management of intrapersonal and interpersonal intelligence. The instrument was applied to 245 students of the full-time teaching modality, of the studies of accounting and auditing, administration, systems, tourism, and law.

The following variables were measured according to the questions that were asked in the survey, where the used measurement scales appear between parentheses:

V_1: Knowledge about emotional intelligence (Much, More or less, Little, Nothing),

V_2: Relationship with classmates (Very good, Good, Regular, Bad),

V_3: Tolerance to their peers for their way of being (Much, More or less, Little, Nothing),

V_4: Relationship with classmates and forms of work (Very good, Good, More or less, Bad),

V_5: Sudden mood swings (Common, Uncommon, Never),

V_6: Extra-verbal demonstration form of problems (To know how to control the impulses, Gestures, Sweating, Actions, Expressions),

V_7: Emotions during the exhibitions (Adequate, Tremors, Sweating, Stress, Headaches).

Each of the above results was classified as an Emotional Intelligence Indicator (Much, Very Good, Good, Never, Uncommon, To know how to control the impulses, and Adequate), which are denoted by <EI>, Indicator of Emotional Non-Intelligence (Little, Nothing, Bad, Frequent, Common, Gestures, Sweating, Actions, Expressions, Tremors, Sweating, Stress,), which are denoted by <Anti EI>, and finally indicators of indeterminacy denoted by <Neut EI>, which are (More or less, Regular).

The results of the survey were shown in Table 1.

Variable	<EI>	<Neut EI>	<Anti EI>
V_1	51%	10%	39%
V_2	57%	4%	39%
V_3	63.8%	6%	30.2%
V_4	89%	5%	6%
V_5	50.6%	0%	49.4%
V_6	49%	0%	51%
V_7	72%	0%	28%

Table 1: Results of the survey classified in percent of <EI>, <Neut EI>, and <Anti EI> responses.

The results in Table 1, were processed as follows:

1. The data were divided by 100, to normalize in the interval [0, 1].
2. The normalized <Anti EI> values are multiplied by -1, the normalized <EI> values remain positive. An index was determined for each of the variables with the support of formula 2, with $d_{<EI>\&<Anti\ EI>}(x)$.
3. The general state of the individual Emotional Intelligence for the members of the group of study is calculated by the mean of the values of the previous point, thus, the mean over <EI>, and over <Anti EI> are calculated, and formula 2 is applied to the results.

Let us note that the extension to the interval [-1, 1] corresponds to the bipolar representation of neutrosophy, [16].

The calculations are given in Table 2.

Variable	<EI>	<Neut EI>	<Anti EI>	$d_{<EI>\&<Anti\ EI>}$
V_1	+0.51	0.10	-0.39	0.12
V_2	+0.57	0.04	-0.39	0.18
V_3	+0.638	0.06	-0.302	0.336
V_4	+0.89	0.05	-0.06	0.83
V_5	+0.506	0.00	-0.494	0.012
V_6	+0.49	0.00	-0.51	-0.02
V_7	+0.72	0.00	-0.28	0.44
Aggregated results	+0.61771	0.035714	-0.34657	0.27114

Table 2: Processing of <EI>, <Neut EI>, and <Anti EI>, utilizing $d_{<EI>\&<Anti\ EI>}$ for each variable and the final result.

It can be seen that according to Table 2, although the <EI><Anti EI> balance is favorable to the first one, the index 0.27114 is not very high, where the variables V_1, V_2, V_5, and V_6, are either negative or not high.

3.2. Discussion

The subject of neutrosophic psychology is still unexplored in terms of creating tools to study classical branches of psychology from this novel point of view. In this paper, we have set out to address the issue of collective emotional intelligence in student groups at a university in Ecuador. Basically, it is a statistical study where the data is processed in a non-classical way. Instead of interpreting the results according to the percentage of students who meet certain characteristics that indicate emotional intelligence, this paper proposes a neutrosophic approach where explicitly takes into account the intermediate state of indeterminacy or borderline.

It is important to consider this borderline state because we are studying a complex phenomenon, which depends not only on the personality of the group members but also on the social interaction among them; see [23-25]. The complexity is also consequence of the way that classmates and teachers are gathered, which is not based on

empathy or spontaneity. On the other hand, classic statistical study allows us to make inferences on the situation of a population regarding certain characteristics that are investigated at a certain moment in the time, and do not consider the dynamic of human interactions.

Borderline states in dynamic phenomena are indeterminate, imprecise, thus, we cannot predict easily what the trend of the phenomenon is, either to a desirable state or an undesirable state. In this research, there is an indeterminate state of existence of group emotional intelligence, since the obtained index is not high, which is why the result is very close to being borderline, and therefore we do not know if the groups evolve to a not emotional intelligence state, or conversely if the collective emotional intelligence will be reinforced.

Let us point out that the study that is carried out can be deepened even more, where two rational principles are followed, but they need to be corroborated experimentally. These principles are, (1) We considered that the variables used to measure emotional intelligence in this paper are sufficient to measure the collective emotional intelligence of a group of university students (2) A high individual emotional intelligence of all students positively entails a high collective emotional intelligence. Both principles deserve a deeper study, although in this research they are regarded as axioms because of their rationality.

An interesting matter to explore in the future is to substitute the classical statistic by the emergent neutrosophic statistics, which is applied in many fields, see [26-30].

Conclusion

This paper was dedicated to analyze and evaluate emotional intelligence in a group of 245 randomly selected students at the Autonomous University of Los Andes, Ibarra extension, Ecuador. The study was conducted through a survey of these students, to measure seven variables, the results of which were classified as Emotional Intelligence indicator (<EI>), non-Emotional Intelligence indicator (<Anti EI>), and Indeterminate (<Neut EI >). The balance <EI><Anti EI> was calculated, for each variable as well as the total average, and the following deficiencies were detected:

- There is not sufficient knowledge of the concept of emotional intelligence in the group.
- The relationship among classmates is not sufficiently good.
- Students have sudden mood swings in a manner not sufficiently adequate.
- The extra-verbal demonstration of problems is slightly negative.

Because a significant random sample of the student population was used, these results can be generalized to the entire student population of the University.

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Priorization of educational strategies on nutrition and its correlation in anthropometry in children from 2 to 5 years with neutrosophic topsis

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Abstract. The study carried out at the Tajamar Health Center allows the evaluation of the educational strategies to be followed by the mothers of children aged from 2 to 5 years, leading to the definition of a correct nutrition pattern and its correlation with the value of anthropometry by applying the TOPSIS Neutrosophic method. A descriptive, qualitative, quantitative and field study was conducted. In order to determine the level of knowledge of the children's mothers, we used the survey as a technique; which allowed to identify the status of nutrition in which they are and whether the growth and development of each child is according to their age or not. While carrying out the investigation, it was confirmed that there is an eating disorder in children, since 50% of the mothers prepare their food based on carbohydrates. In addition, only 20% of the mothers indicate that they put fruit in their children's lunchboxes; 55% refers to the consumption of junk food. The lack of physical activity is often a risk factor for diseases due to eating disorder. The obtained results allow the implementation of strategies based on the assessment of nutritional status in order to improve the lifestyle of each children.

Keywords: nutrition, anthropometry, eating habits, quality of life.

1 Introduction

Having a balanced diet is a very important factor in the life of every human being. From the birth itself, we can see that this life cycle is the most important thing until adulthood because all the predisposing factors in his life are those who lead to good growth and development and avoid diseases and other complications. [1]

Vargas (2011) carried out a transversal descriptive study "eating habits, nutrition and the level of physical activity not only affect health in the present, but also determine the risk of contracting chronic diseases in the future". The goal of this study was to identify the perception of healthy eating, and the association between eating habits, nutritional status, and level of physical activity in schoolchildren.

Castillo (2016), in a study carried out in Colombia, considers that the general development context is fundamental for children, and within this context the nutritional situation plays a very important role. It was determined that nutrition is one of the decisive factors providing the "context", and no other factor has so much to do with situations that can be controlled by society, institutions and the State.[2-3]

González (2010) about the "nutritional situation of schoolchildren in the community of Madrid. Family conditions" whose objective is to determine the nutritional status and associated factors in the diet, it was determined that according to the results obtained in this paper, where approximately one third of the schoolchildren analyzed have a weight overload, that it is necessary to take actions to reverse this problem. With this regard, it is a priority to improve the living and feeding habits of parents, since they directly influence their children, and they must know the conditions that may affect the aforementioned habits. In this sense, the educational level of the mother seems to be the factor that most influences the type of behaviors that occur in the family. The higher the educational level of the mother the healthier these behaviors are. [1]

This research has a great impact in the field of health, because it makes it possible to determine the nutrition strategies that will allow the implementation of educational strategies contributing to good nutrition in children, ensuring their appropriate growth and development, by encouraging them from a very early age to maintain a good

health status. The chosen strategies must be consistent with a correct anthropometric development. A balanced nutrition in conjunction with physical activity will help them stay in good physical condition allowing growth and development according to their age.

The goal of this research is to determine the best nutrition strategies that will lead to educational improvements to the mothers' knowledge, respecting their beliefs, and educating them with scientifically proven information. That's why the application of education strategies will be of great contribution to the improvement of the quality of life of the inhabitants.

Health professionals have long recognized the importance of establishing healthy nutrition practices. "The diet and exercise adopted during these years are fundamental for development and prepare the ground to acquire lifelong habits that can make the difference between vitality and the absence of it in future years" [5]

Anthropometry has been widely used as a summary indicator of health and nutrition related conditions [6]

Nutrition, meanwhile, includes all those processes through which the body incorporates, transforms and uses the chemical substances (nutrients) contained in food, to carry out different functions such as: covering energy needs, forming and maintaining body structures, regulate metabolic processes and prevent diseases related to nutrition [7]

Infants are vulnerable to food restrictions, which leave sequels in basic areas of their development in medium and long term. It is essential to ensure that the people have access to a healthy diet that contributes to the prevention of alterations of child development. These days, low weight is frequent; and therefore, chronic malnutrition is the most common one and it is expressed in short stature. This form of malnutrition seems to affect mental development, language and motor development [2].

This research will have a great impact in the health field, because it allows to determine in order of analytical hierarchy [8] the best nutrition strategies for a normal anthropomorphic development of the child, guaranteeing to implement educational strategies that contribute to a good nutrition in children ensuring their appropriate growth and development, by encouraging from an early age to maintain a good health status. The eating habits that you implement at this age will keep you until adulthood[3]. A balanced nutrition in conjunction with physical activity will help you stay in a good physical condition allowing growth and development according to your age.

The research is based on improving the knowledge of mothers, respecting their beliefs, and educating with scientifically proven information, which is why the application of education strategies will be of great contribution to the improvement of the quality of life of the inhabitants.

2. Development

2.1. Definition of the criteria to evaluate

To make a correct selection of the nutrition strategy in the case of studies of Tajamar Health Center, according to a correct anthropomorphic development of children, the criteria to be evaluated must first be defined, but first it is necessary to define for this case study. The set of **alternatives** is defined as Ai and the set of **criteria** to evaluate as Cj.

We will consider as alternatives, *acceptable nutrition strategies for a correspondence with an adequate anthropometry, which will eventually constitute educational strategies to be followed by mothers*. As a result from the combination of the breakfast food group, the snack food group and the time of physical exercises, and we will define it as follows:

Breakfast: Bj = (BAj, BBj, BCj) for three basic foods in the breakfast diet
Snack: Sk = (SAk, SBk, SCk) for three basic foods in the diet for the snack
Exercise: Ei, the time spent in physical exercises

These *alternatives* were obtained from the combinations of the related patterns in the table (2.1)

Breakfast	**Snack**	**Physical exercises**
Coffee, Bread, Eggs	Apple, Yogurt, Cookies	1 hour
Fruit, Yogurt, Juice	Potatoes, Chitos, Chocolate	2-3 hours
Rice , Meat, Chocolate	Juice, Sandwich	4 hours
Candies, cookies	Fruits	none

Table 2.1 possible feeding strategies

To these three variables that make up the health education strategic *alternatives*, we add a purely quantitative

variable, the anthropometry measure, which allows us to know the growth pattern of each individual.

Anthropometry: ANt = (AN1, AN2, .. ANn) is the anthropometric pattern of individual t that has a nutrition pattern (Bt, St, Et)

Therefore, in order to get a child t to develop with an optimal and adequate anthropometric pattern At, the educational feeding strategy that the mother must follow is (Bj, Sk, Ei).[4, 5] This will achieve a good performance of the biological functions, avoid alterations, predict their health and chances of survival. In the field of populations, it constitutes a valuable element for decision-making in matters of education for public health.

In order to establish a hierarchical order to the strategies in accordance with an adequate nutrition pattern and corresponding to the appropiate growth and development of the child (Anthropometry), we will define as alternatives Ai = (X1, X2 ... Xn) the possible educational strategies to follow by mothers, taking into account a pattern of nutrition for their children at breakfast, snack and a measure of physical exercise. These data are extracted from the surveys carried out in the Tajamar Health Center for mothers with children aged from 2 to 5 years. See table 2.1

As criteria C = (C1, C2, … Cn) the anthropometric patterns defined as

c1: Beneficial

c2: Feasible

c3: neutral

c4: dangerous

These 4 criteria will be weighted through the Analytical Hierarchy Process (AHP) [9] using triangular neutrosophic numbers, [10-11] which implies assigning a relative priority to each criterion according to the degree of influence of the educational strategy with the anthropometric development.

Value	Meaning	NTS
1	Equal influence	(1,1,1); (0.50, 0.50, 0.50)
3	Moderate influence	(2, 3,4); (0.30, 0.75, 0.70)
5	Remarkable influence	(4,5,6); (0.80, 0.15, 0.20)
7	very noticeable influence	(6,7,8); (0.90, 0.10.0.10)
9	absolute influence	(9,9,9); (1.0, 0.0, 0.0)

Table 2.2 Priority scale of the AHP criteria according to the degree of influence using triangular neutrosophic numbers.

The preparation of the table with the surveys has a thorough and careful manual processing so that the information is not biased, the three chosen patterns of the surveys are shown in Table 2.3

Child	Breakfast	Snack	Physical exercises	Cx
one	Candies, cookies	Potatoes, Chitos, Chocolate	none	dangerous
two	Rice, Meat, Chocolate	Fruits	2-3 hours	Beneficial
3	Fruit, Yogurt, Juice	Fruits	1 hour	Feasible

Table 2.3 Strategies for child, breakfast, snack, physical exercises and anthropometry

Only 3 patterns were taken to explain the calculation methodology.

We used the experts' criteria to construct the matrix of binary comparisons Table (2.4) analyzing the degree of influence of the education strategy with the degree of anthropometry, using the correspondence of table (2.2) and (2.3)

	C1	C2	C3	C4
C1	1	3	5	7
C2	7	1	0,5	1
C3	5	1	0,5	0,5
C4	3	2	0,5	3

Table 2.4 Matrix of binary comparisons

2.2. Determination of the relative weights of the criteria

To determine the relative weight, importance or influence of each of the criteria in the final result, we used the binary comparisons method defined in the AHP method, proposed by Saaty in 1980. [14-15]

In order to take into account the dissimilar importance that different strategies may have in the collaborative environment, the weighted average aggregation operator WA, for its acronym in English, is used in this proposal with the calculation of weights through the Analytical Hierarchy Process (AHP) using triangular neutrosophic numbers from table (2.2)

Calculating the average by rows through Equation (2.2), an approximation to the relative weight of each of the criteria C*j* is obtained. It is an approximation since it is based on the subjectivity of the decision maker.

$$Wj = \frac{\sum_{j=m}^{j=1} X_{ij}\ Normalizado}{m} \tag{2.2}$$

The relative weights W*j* are shown in Table 2.4

C*j*	W*j*
C1	4
C2	2,375
C3	1,75
C4	2,125

Table 2.4 Relative weights of the binary comparison matrix

In the previous table it is noticeable how the neutral criterion of anthropometry C3 has the smaller value, which implies an uncertainty in any strategy to follow oriented by this criterion, so it is the least appropriate to choose. It is better to choose strategies that we know where they will lead to, so that we can prevent the consequences of a bad eating habit. It is clear that the best educational strategies are the beneficial and feasible (C1 and C2, respectively).

2.3 Application of the TOPSIS method

Once the values of the relative weights of the criteria have been obtained, the TOPSIS method itself has been applied[13].

First, the decision matrix must be assembled in which the values D*ij* of each of the alternatives A*i* are included for the different criteria C*j*. These values are input data from the results of the surveys and have been worked by the specialist to decide the nutrition educational strategy of the Tajamar Health Center.

As the TOPSIS method requires that all criteria should be aimed at maximizing their values, in those that do not meet this condition the inverse values (1/D*ij*) have been used and the criteria have been converted to maximization.

Table 2.5 shows the values of the decision matrix of the problem to be solved with the TOPSIS method, having already converted the criteria from minimization to maximization in the necessary cases.

	C1	C2	C3	C4
A1	0,0006	0,4	0,1	0,008
A2	0,0003	0,6	0,2	0,0083
A3	0,0003	0,5	0,1	0,0071

Table 2.5 Decision Matrix

Below in Table 5, the values of the Decision Matrix after being normalized using equation (2.3) are shown

$$DN_{ij} = D_{ij} / \sum_{k=n}^{k=1} D_{ij} \tag{2.3}$$

	C1	C2	C3	C4
A1	0,5	0,2811	0,2408	0,3407
A2	0,25	0,3836	0,4379	0,3549
A3	0,25	0,3351	0,3211	0,3042

Table 2.6 Normalized decision matrix

After normalizing and applying the relative weights to the BN*ij*. The BP*ij* results are reflected in table 2.7

Table 2.7 Weighted decision matrix

	C1	C2	C3	C4
A1	0,0142	0,0079	0,0146	0,0737
A2	0,0071	0,0109	0,0266	0,0768
A3	0,0071	0,0095	0,0195	0,0658

Then, the distance of each alternative A*i* to the positive and the negative (or anti) ideal is calculated according to the following formulas:

$$S^{+}{}_{i} = \left[\sum_{i}^{n} |DP_{ij} - DPmax_{i}|^{p}\right]^{1/p} \qquad S^{-}{}_{i} = \left[\sum_{i}^{n} |DP_{ij} - DPmin_{i}|^{p}\right]^{1/p}$$

Where:

- $S^{+}{}_{i}$= distance from A*i* to the positive ideal.
- DP_{ij}= D_{ij} normalized and weighted.
- $S^{-}{}_{i}$= distance from A*i* to the anti-ideal.

In this case p = 1 since the Manhattan distance is used. Table 2.8 shows the values of S + and S - for each alternative.

	S+	S-
A1	0,2175137	0,0374422
A2	0,0723424	0,1826134
A3	0,0489931	0,2059628

Table 2.8 Ideal and anti-ideal distance

Finally, the coefficient of similarity C* has been calculated for each alternative according to equation (2.5)

$$C_{i}^{*} = \frac{S^{-}{}_{i}}{S^{+}{}_{i} + S^{-}{}_{i}} \tag{2.5}$$

3. Results

The results obtained are shown in table 2.9

	C*i* *
A1	0,14685741
A2	0,81625518
A3	0,70783707

Table 2.9 Similarity coefficient.

The final result of the study demonstrates that alternative 2 constitutes the most convenient educational alternative, then the number 3 and finally the number 1, this is in terms of health: A1 = Beneficial, A2 = Feasible and A3 = dangerous. See table 2.3

So, the food health education of the mothers should be oriented through the last two nutrition patterns in order to achieve an adequate development in children's health.

4. Conclusion

After applying the TOPSIS method, we have concluded that Alternative 2 is the one that best meets the criteria established by the assessment of eating habits collected in the surveys at the Tajamar Health Center.

It is very important to emphasize that the objective characterization by the specialist when preparing table 2.3 that evaluates the educational strategy to follow with a food habit to obtain the appropriate anthropometry for each particular child coincides with the selection of the priorities of the TOPSIS method. The application of this method, taking into account the influence of all the criteria, adapts very well to the differences in food cultures and possibilities of any population group.

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Neutrosophic AHP in the analysis of Business Plan for the company Rioandes bus tours

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Abstract: Tourism development represents a key area for the economy. Its development depends largely on the ability to capture new sources of income. The city of Riobamba of Ecuador has the problem of not having a comfortable route that meets the current demands of tourists, which causes low levels of income. This research aims to develop a method for the analysis of the business plan through the Hierarchical Neutrosophics Analytical Process. The proposal is implemented in the Rioandes Company from which it is achieved as a result that the proposed plan represents a satisfactory alternative for its implementation.

Keywords: Business Plan; AHP; Neutrosophic.

1 Introduction

Tourism is a competitive sector in the international market. Guaranteeing new forms of income for companies represents the way to sustain oneself in the market. At present, tourism represents for Ecuador the third activity in economic importance, after oil and bananas. It implies an average of 700,000 foreign visitors per year and around 800 million dollars enter the country for this concept [1], [2].

In all the parishes of the Riobamba canton it is possible to find places with tourist potential, which are still unknown even to the inhabitants of the canton. In general the resources of the canton constitute its great natural heritage with the presence of mountains and volcanoes, lagoons and the landscape together with the enormous cultural wealth of its people [3], [4].

The company RioAndes Bus Tours in the city of Riobamba in Ecuador, specializes in transportation to the different destinations in the area [5], [6]. However, there is no structured proposal for tourists to know the most important sites in the city through tourist circuits with guarantee and safety during the tour [7], [8].

The business plans allow to know the viability and profitability before starting a new business [9], [10]. The development of the plans represents a complex task that many companies tend to overlook [11], [12] . In general, a business plan has a set of criteria to consider in order assessing the feasibility. [13], [14], [15].

Based on the nature of the business plans, they can be modeled as a decision-making problem. A set of criteria that represent the inputs of the process to which an assessment is made based on a classification method is required and a weighting that represents your evaluation is obtained [16], [17]. Figure 1 shows a scheme that illustrates a business plan through a multi-criteria approach.

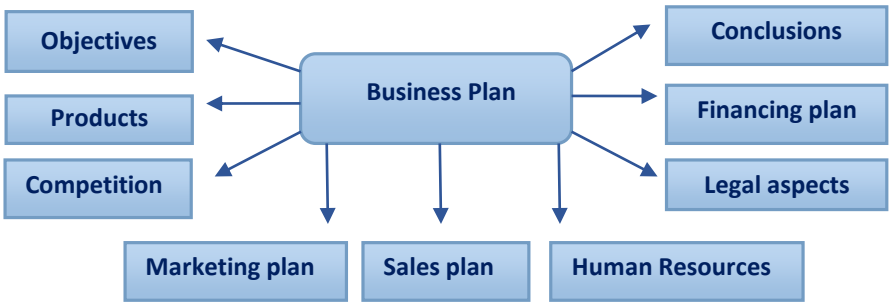

Figure 1. Scheme of a business plan with multi-criteria approach.

2 Preliminaries

This section introduces a study of the fundamental theoretical references associated with the problem being modeled. Business plans are defined as essential elements for the development of research which are modeled through a set of criteria. Multicriteria decision making problems are introduced using the Analytic Hierarchy Process (AHP) method. In addition, the theory of neutrophic numbers is presented as an extension of the AHP method.

2.1 Business Plan

A business plan represents a procedure where a business to be carried out is explained and described, as well as different aspects related to it, such as its objectives, the strategies that will be used to achieve these objectives, the production process, the required investment and expected return [18], [19], [20].

A typical structure that includes all the parts or sections that a business plan should have is as follows:

- The executive summary: the executive summary is a summary of the most important points of the other parts of the business plan.
- The business definition: the business definition describes the business to be carried out, as well as basic aspects related to it.
- The market study: the market study describes aspects related to the market in which the business will operate.
- The technical study: the technical study describes technical aspects related to the business.
- The organization of the business: in the organization of the business it is described how the business will be organized and how the different areas, departments or organic units that will comprise it will be related to each other.
- The study of investment and financing: in the study of investment and financing, the structure of investment and business financing is indicated.
- The study of income and expenses: the study of income and expenses shows an estimate of the income and expenses that the business will have.
- The financial evaluation: the financial evaluation shows the development of the financial evaluation performed on the business.

The elements that make up the structure are considered as criteria in the process of preparing the business plan. From which it can be modeled as a multi-criteria decision making problem.

2.2 Neutrosophic Analytic Hierarchy Process

The hierarchical analytical process was proposed by Thomas Saaty 1980 [21]. It is one of the most widespread methods in solving multi-criteria decision making problems. This technique models the problem that leads to the formation of a hierarchy representative of the associated decision-making scheme. This hierarchy presents at the upper level the goal pursued in solving the problem and at the lower level the different alternatives from which a decision must be taken are included. The intermediate levels detail the set of criteria and attributes considered [22], [23].

The process is based on several stages. The formulation of the decision-making problem in a hierarchical structure is the first and main stage. This stage is where the decision maker must break down the problem into its relevant components. The basic hierarchy is made up of: general goals or objectives, criteria and alternatives [24], [25, 26]. The hierarchy is constructed so that the elements are of the same order of magnitude and can be related to some of the next level.

In a typical hierarchy the highest level locates the problem of decision making. The elements that affect decision making are represented at the intermediate level, the criteria occupying the intermediate levels. At the lowest level the decision options are understood [27]. Figure 2 shows the hierarchical structure of AHP.

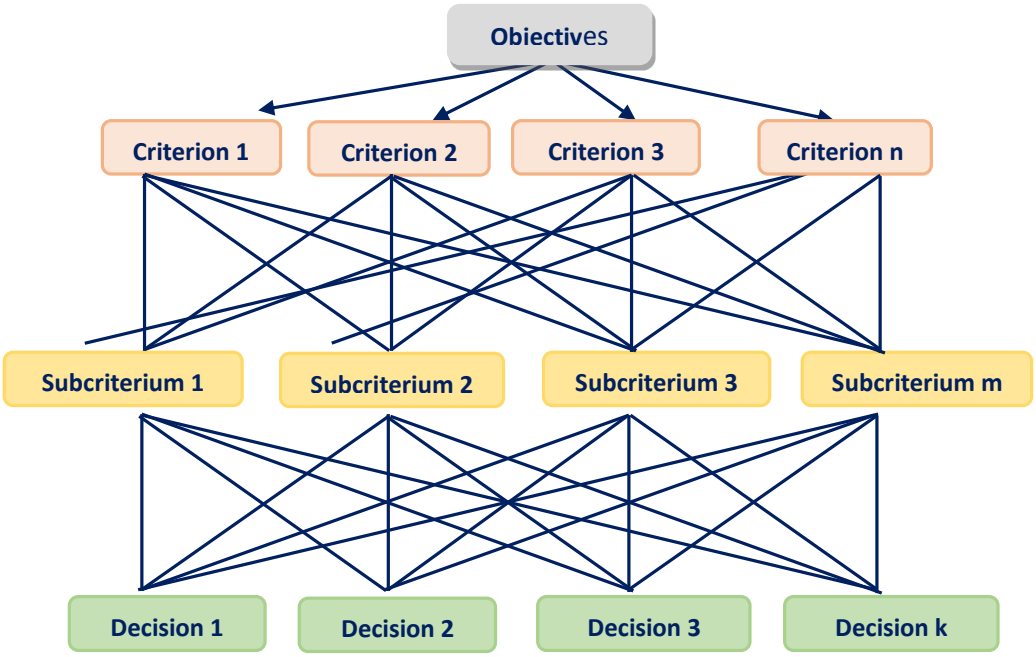

Figure 2. Scheme of a generic tree representing an Analytical Hierarchy Process.

2 Design a method for analyzing business plans

The method consists of three main processes. It begins with the selection of the criteria, then the multicriteria evaluation is carried out and finally the classification is carried out. The operation of the method is based on Neutrosophic Analytic Hierarchy Process (NAHP). Figure 3 shows the general structure of the proposed method.

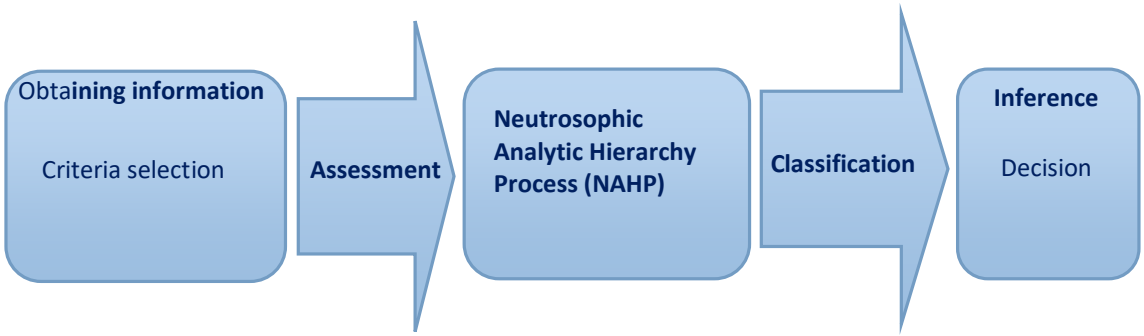

Figure 3. General structure of the proposed method.

The levels of importance or weighting of the criteria are estimated by means of paired comparisons between them. This comparison is carried out using a scale, as expressed in equation (1) [28].

$$S = \left\{\frac{1}{9}, \frac{1}{8}, \frac{1}{7}, \frac{1}{6}, \frac{1}{5}, \frac{1}{4}, \frac{1}{3}, \frac{1}{2}, 1,2,3,4,5,6,7,8,9\right\} \quad (1)$$

In the case of n attributes, the paired comparison of the element i with the element j is placed in the aij position of the matrix A of paired comparisons, as shown in equation (2)

$$\tilde{A} = \begin{vmatrix} & \vdots & \ddots & \vdots \\ & & & \end{vmatrix} \quad (2)$$

The reciprocal values of these comparisons are placed in the aji position of A, in order to preserve the consistency of the judgment. The participating decision maker must compare the relative importance of an element with respect to a second, using the 9-point scale shown in table 1. For example, if element 1 was rated with strong dominance over element 2, then in position a12 a 5 is placed and reciprocally in position of a21, 1/5 is placed.

Table 1. Saaty's scale translated to a neutrosophic triangular scale.

Saaty scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\tilde{1} = \langle(1,1,1);0.50,0.50,0.50\rangle$
3	Slightly influential	$\tilde{3} = \langle(2,3,4);0.30,0.75,0.70\rangle$
5	Strongly influential	$\tilde{5} = \langle(4,5,6);0.80,0.15,0.20\rangle$
7	Very stronglyinfluential	$\tilde{7} = \langle(6,7,8);0.90,0.10,0.10\rangle$
9	Absolutely influential	$\tilde{9} = \langle(9,9,9);1.00,1.00,1.00\rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\tilde{2} = \langle(1,2,3);0.40,0.65,0.60\rangle$
		$\tilde{4} = \langle(3,4,5);0.60,0.35,0.40\rangle$
		$\tilde{6} = \langle(5,6,7);0.70,0.25,0.30\rangle$
		$\tilde{8} = \langle(7,8,9);0.85,0.10,0.15\rangle$

On the other hand, Saaty established that Consistency Index (CI) should depend on λmax, the maximum eigenvalue of the matrix. He defined the equation $CI = \frac{\lambda_{max}-n}{n-1}$, where n is the order of the matrix. Additionally, he defined the Consistency Ratio (CR) with equation CR = CI/RI, where RI is given in Table 2.

Table 2. RI associated to every order.

Order (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

If CR≤0.1 we can consider that experts' evaluation is sufficiently consistent and hence we can proceed to use AHP.

AHP aims to score criteria, sub-criteria and alternatives, and to rank every alternative according to these scores. For more details about this technique can be consulted [29-31].

AHP can also be used in group assessment. In such a case, the final value is calculated by the weighted geometric mean, see Equations 1 and 2.

$$\bar{x} = \left(\prod_{i=1}^{n} x_i^{w_i}\right)^{1/\sum_{i=1}^{n} w_i} \quad (1)$$

If expert's weights sum up one, i.e. $\sum_{i=1}^{n} w_i = 1.$, Equation 1 converts to Equation 2,

$$\bar{x} = \prod_{i=1}^{n} x_i^{w_i} \quad (2)$$

3 Result and discussions

To demonstrate the applicability of the proposed method, a case study was introduced for the analysis of Business Plan for the company Rioandes bus tours. The main elements that describe the implementation are described below.

The information gathering stage uses a multi-expert multicriteria approach, expressed by:

The set of criteria that describe the nature of the decision-making problem such that:

$C = \{c_1, c_2, \ldots, c_m\}, m \geq 1$,

where: $\forall C_m \notin \phi, 1 \leq m \leq i$.

The group of experts involved in the decision-making problem such that:

$E = \{e_1, e_2, \ldots, e_n\}, n \geq 1$,
where: $\forall E_m \not\in \phi, 1 \leq n \leq i$.

The set of decision alternatives for the proposed decision-making problem such that:

$A = \{a_1, a_2, \ldots, a_k\}, k \geq 1$,
where:
$\forall A_k \not\in \phi, 1 \leq k \leq i$

From the analysis carried out in section 2.1, the main criteria to be taken into account are obtained.

The alternative for evaluating are the following:

A_1: The proposal is viable for its implementation.

A_2: The proposal is not viable for its implementation.

The criteria for evaluating are the following:

C_1: The executive summary

C_2: The definition of the business.

C_3: The market study.

C_4: The technical study

C_5: The organization of the business.

C_6: The study of investment and financing.

C_7: The study of income and expenses.

C_8: The financial evaluation

The evaluation stage is described below:

The three obtained pair-wise matrices corresponding to criteria, one per expert are summarized in Tables 3, 4 and 5. Let us note that the values are expressed in form of the scale given in Table 1.

Table 3: Comparison pairs corresponding to the criteria given by the expert 1.

Criteria	A_1	A_2
A_1	$\tilde{1}$	$\tilde{3}$
A_2	$\tilde{3}^{-1}$	$\tilde{1}$

Table 4: Comparison pairs corresponding to the criteria given by the expert 2.

Criteria	A_1	A_2
A_1	$\tilde{1}$	$\tilde{3}$
A_2	$\tilde{3}^{-1}$	$\tilde{1}$

Table 5: Comparison pairs corresponding to the criteria given by the expert 3.

Criteria	A_1	A_2
A_1	$\tilde{1}$	$\tilde{3}$
A_2	$\tilde{3}^{-1}$	$\tilde{1}$

Tables 6, 7 and 8, contain the average evaluation for the total of experts corresponding to the Requirements, one per each criterion.

Table 6: Average crisp pair-wise matrix corresponding to requirements given by the experts according to criterion C_1.

Requirement	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
R_1	1	0.28	0.26	0.20	0.98	1.99	1.76	2.24
R_2	3.42	1	0.83	0.83	2.25	2.94	2.53	2.94
R_3	3.78	1.20	1	0.98	2.94	3.42	2.94	3.97
R_4	4.84	1.20	0.98	1	3.42	3.78	3.78	3.96
R_5	0.98	0.44	0.34	0.29	1	1.99	1.99	2.94
R_6	0.50	0.34	0.29	0.26	0.43	1	0.70	1.99
R_7	0.56	0.39	0.34	0.26	0.43	1.43	1	1.62
R_8	0.45	0.34	0.26	0.25	0.34	0.50	0.62	1

Table 7: Average crisp pair-wise matrix corresponding to requirements given by the experts according to criterion C_2.

Requirement	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
R_1	1	0.29	0.26	0.20	0.98	1.99	1.76	2.25
R_2	3.42	1	0.83	0.83	2.25	2.94	2.53	2.94
R_3	3.78	1.20	1	0.98	2.94	3.42	2.94	3.97
R_4	4.84	1.20	0.98	1	3.42	3.78	3.78	3.96
R_5	0.98	0.44	0.34	0.29	1	1.99	1.99	2.94
R_6	0.50	0.34	0.29	0.26	0.43	1	0.70	1.99
R_7	0.56	0.39	0.34	0.26	0.43	1.43	1	1.62
R_8	0.44	0.34	0.25	0.25	0.34	0.50	0.62	1

Table 8: Average crisp pair-wise matrix corresponding to requirements given by the experts according to criterion C_2.

Requirement	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
R_1	1	0.27	0.26	0.20	0.98	1.99	1.76	2.23
R_2	3.42	1	0.83	0.83	2.25	2.94	2.53	2.94
R_3	3.78	1.20	1	0.98	2.94	3.42	2.94	3.97
R_4	4.84	1.20	0.98	1	3.42	3.78	3.78	3.96
R_5	0.98	0.44	0.34	0.29	1	1.99	1.99	2.94
R_6	0.50	0.34	0.29	0.26	0.43	1	0.70	1.99
R_7	0.56	0.39	0.34	0.26	0.43	1.43	1	1.62
R_8	0.43	0.34	0.24	0.25	0.34	0.50	0.62	1

The classification stage is described below:

From the application of equation 1, let us remark that we shall apply formula 8 for converting the pair-wise matrices in crisp matrices. The obtained CRs were 0.0014, 0.0243, and 0.0034 for Expert 1, Expert 2 and Expert 3, respectively, which are smaller than 0.1. Whereas, for the matrices of Requirements we obtained the CRs are smaller than 0.1 respect to every expert and every criterion.

Table 9 summarizes the priority vectors of the three experts for the criteria, applying Equation 2 with weights $w_i = 1/3$ for $i = 1, 2, 3$.

Table 9: Average of priority vectors obtained for every criterion over the experts and their order.

Criteria	Average over experts of Criteria Priority Vectors	Order
A_1	0.62	1
A_2	0.38	2

From which it is concluded that: The proposal is viable for its implementation.

Table 10 summarizes the weights for every requirement and the final order.

Table 10: The requirements priority vectors and the final order of requirements.

Requirement\Criterion	A_1(0.62)	A_2(0.38)	Requirements Priority Vector	Order
R_1	0.05	0.08	0.06	8
R_2	0.10	0.06	0.09	4
R_3	0.21	0.03	0.17	1
R_4	0.19	0.03	0.15	2
R_5	0.08	0.05	0.08	5
R_6	0.16	0.04	0.14	3

R_7	0.06	0.10	0.07	7
R_8	0.04	0.16	0.07	6

According to the results summarized in Table 10 the requirements are ordered as follows:

$R_2 \succ R_4 \succ R_6 \succ R_2 \succ R_5 \succ R_8 \succ R_7 \succ R_1$.

5 Conclusions

The present investigation proposed a method for the feasibility analysis of business plans. The Neutrosophical Hierarchical Analytical Process was applied for the development of the proposal. The research was applied to the analysis of Business Plan for the company Rioandes bus tours. Among the main results obtained, it was shown that the proposed business plan according to the inference method applied represents a viable solution for its implementation.

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An integrative neutrosophic model focused on personality (inmfp) for the adequate management of the level of work stress

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Abstract. Stress is an inevitable way of adapting each individual to the challenges of the surrounding environment. When the adaptation is done in a negative way and produces physiological or psychological imbalances in the person, then stress is called distress. However, stress is not always harmful to the person, there is stress in situations of joy or happiness, which is known by eustress. In the work environment, distress can cause physical and mental health problems for workers and therefore damage to the dynamics of the job. This paper aims to propose an index of occupational stress measurement based on the Integrative Model Focused on Personality and the Neutrosophical Psychology Theory. The Integrative Model Focused on Personality considers personality as the result of a combination of dynamically interacting elements, while Neutrosophical Psychology understands personality traits as a triad (<A>, <neutA>, <antiA>), where A is a personality trait, antiA is its opposite, and the trait manifests itself in each person in an intermediate way between <A> and <antiA>, where <neutA> is an intermediate state of indeterminacy, where it is neither A nor antiA. Particularly, we explicitly consider the case in which the individual is identified in an intermediate state of stress and therefore has a risk to be conducted towards either the distress or the eustress.

Keywords: Workplace stress, eutress, distress, Integrative Model Focused on Personality, Neutrosophical Psychology Theory..

1 Introduction

It is well known that stress is a serious problem that has to be solved because it causes serious difficulties for those who suffer it. The word "stress" derives from the Latin word *stringo* (squeeze), and this from the Greek word *sfigo* (squeeze). This word was first used in the fourteenth century and thereafter it was used in different English texts like stress, stresse, strest, and straisse. One of the purposes is that people learn to differentiate that stress such as distress and eustress are ways of quantifying a healthy lifestyle, see [1].

There are normal situations of daily life that cause stress, but do not conduct to sickness. Other people who are stressed, when they perceive that an environmental stimulus threatens their own well-being they feel this incapacitates them to face the stimulus in an appropriate way. These are the labor risk factors to which each worker is exposed, which we will explain later, those are the psychosocial risks.

On the other hand, people are stressed by the presence of stressors that are the stimuli that overload the individual and produce a biological and psychological stress response. When a stimulus is considered threatening to the health and general well-being of the person, and when it also makes the individual feel that their ability to cope with it is reduced, then, he/she is in the presence of a stressor.

Positive stress or Eustress is an essential part of human life, in many ways we cannot avoid it. It helps us to be attentive and allows us to overcome the different situations with which we face daily. When the effects are not negative, then, the stress is positive. It helps the body to function properly and interact with its environment in an optimal way. Positive situations such as success, joy, love, creative work, can result in stress. The search for success may become in a competitive issue, which is why the promotion of an adequate work environment by changing to a positive attitude would generate maintenance factors for proper stress management.

In dangerous situations, some people develop an unsuspected force; they can jump over large obstacles or perform prodigious maneuvers. This happens due to the effect of stress, because the body produces a large amount of adrenaline in the bloodstream that promotes this unusual response.

Negative stress or distress is the most worrisome, especially if it becomes chronic, because the individual feels that the situation that causes stress exceeds its ability to overcome it. The individual feels permanently threatened, which can cause a physiological or psychological imbalance.

The most important issue is how people adapt to the different stressors they have to deal with. For a person to have a good response to stress, there exists many aspects in personality, attitude, way of thinking, the way to relate to other people, their way of distraction, their lifestyle, the work they do and other factors that can exist in the human being.

Workplace stress is based on the general concept of stress. This can be caused by many difficulties, such as adaptation to technologically changing environments, excessive workload, isolation, conflict of roles, ambiguity of roles, lack of autonomy, impediment to professional development, difficulties in the relationships with the administration or coworkers, to suffer for administrative bullying, adverse organizational climate, among others.

All these factors can cause psychological reactions of the labor type, such as irritability at work, absenteeism, depression, and can even cause diseases such as increased cholesterol, hypertension, diabetes, among others. Either way, distress in the workplace decreases employee performance, the proper functioning of the organization, and can even be the cause of an accident at work.

There are some theories to study stress such as PE fit theory, which considers the lack of adjustment between the person and the environment as stressor, the Cybernetic Theory considers the lack of balance as the stressor, while the Control Theory considers the perception of the person's control over the stressor as a stress moderator, see [2].

This research is based on the Personality-Focused Integrative Model (PFIM), specifically designed according to the idiosyncrasy of the Ecuadorian individual. The PFIM is characterized to study personality traits more than the models explained in the previous paragraph. Under this model, personality is understood not as the sum of elements, but as their integration of them to generate a new product, see [3-6].

The reason for which considering an Ecuadorian model and not assume others that already exist since two decades or more, is because we take into account that each human being has unique characteristics within its environment, which unfolds in a given context, influential factors such as culture, education and idiosyncrasy, such is the case of Ecuadorian people, their roots, their own characteristics such as immediacy, magical thinking, avoidance to commit to change.

When the Ecuadorian patient goes to the clinic, seeks: quick, concrete, specific solutions, to know what is happening to him/her or what is happening to us and, primarily, what should He/she do to solve it? "To look for a recipe."

This paper proposes a method to measure work stress with the help of the Neutrosophical Psychology Theory. Neutropsyche is the psychological theory that studies the soul or spirit using the neutrosophy and neutrosophic theories, that is to say, Neutrosophic Psychological Theory. It is based on a triadic of neutrosophic psychological concepts of the form (<A>, <neutA>, <antiA>), see [7].

Neutropsychic Personality is a neutrosophic dynamic open psychological system of tendencies to feel, think, and act specific to each individual, based on Neutrosophic Refined Memory: that restructures the division of memory into: consciousness, aconsciousness (which is a blend of consciousness and unconsciousness) , and unconsciousness. Aconscious is subdivided into preconscious, subconscious, semiconscious = semiunconscious, subunconscious, and preunconscious.

We base on the fact that stress is a dynamic process, where the intermediate, indeterminate state, at the midpoint between the two opposite poles of stress, which are eustress-distress, must also be identified. This intermediate point is transitory and it is important to determine which pole the workplace stress will tend to.

This paper consists of the following structure; Section 2 is dedicated to giving some notions of the Integrative Model Focused on Personality and the basic concepts of the Neutrosophical Psychology Theory. Section 3 explains the design of the proposed method. The conclusions of this paper are given in Section 4.

2 Preliminaries

This section describes the main features of the Personality-Focused Integrative Model in subsection 2.1. In subsection 2.2 the main concepts of the Neutrosophical Psychology Theory are presented.

2.1 Description of the Personality-Focused Integrative Model (PFIM)

The most supra-ordered aspects of all theoretical development reside in the meta-theoretical foundation. Constructivist epistemology fulfills this central role in this approach.

The common point of the current constructivist elaborations is given by the affirmation that knowledge is not the result of a mere copy of the pre-existing reality, but the effect of a dynamic and interactive process through which external information is interpreted by the mind that is progressively building explanatory models increasingly complex and powerful.

The model of integrative psychotherapy focused on the personality, without neglecting the principles of

causality that are evident in a large part of the psychic phenomena, takes as an epistemological basis the moderate or relative constructivism, validated in the perception of each individual as a human being with their own characteristics , biological or social that structure their psyche.

Considering that the psychological dynamics of people is framed in a multi-causality, which causes their well-being and discomfort to be mobilized in the same way, it makes necessary the construction and development of a model capable of agglutinating these variables that interrelates them to achieve an explanation and psychotherapeutic application more attached to its reality, which gives us the possibility of promoting the necessary changes, more limited to its problem, without losing sight of that particular worldview, which will mark a differentiation with a parallel vision, achieving a more therapeutic process effective and contributing to the patient. ([6]).

Then, from this starting point, stress will be addressed according to this typology, taking into account all those factors that shape and influence personality; the phenomena of relationship in the psychotherapeutic process, appropriate intervention techniques for each personality style; and using cognition in the constructive elaboration of the subject's reality.

The multidisciplinary vision brings a broad perspective to the knowledge process, in which it is contributed by philosophy, physics, biology, cybernetics among other disciplines. The basic idea focuses on the exploration of the multidisciplinary foundations of constructivism at a meteoric level, which aims to insert the constructivist proposal into psychology and psychotherapy, see Figure 1.

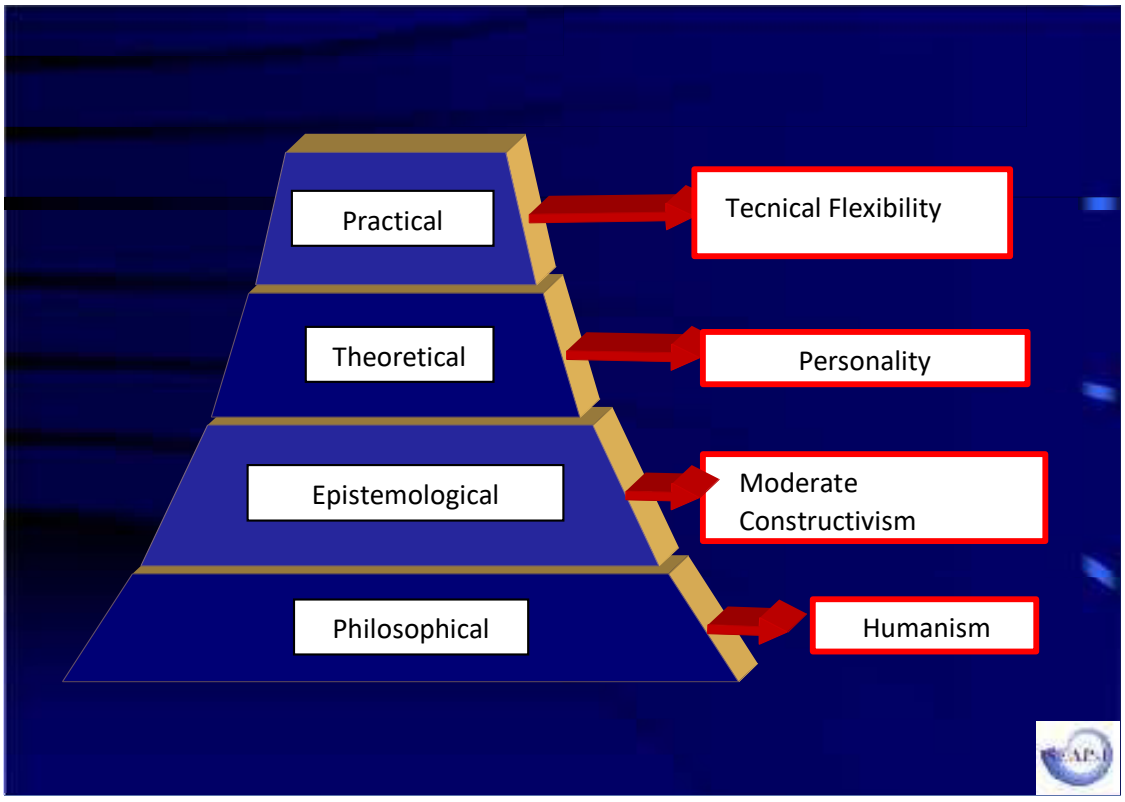

Figure 1: Levels of the integrative model

In the particular and singular perception of the world, elaborated on the basis of meanings through language, reality is constructed, the same that is determined and processed within the family and social context in which the individual develops, being a permanent process and constant exchange and interaction that modifies their behavior and attitude towards life over time. Integrative psychotherapy from this position allows us to get in touch with the patient in a more direct, warm way and closer to reality.

It helps us to discern more clearly and try an understanding approach to his/her lifestyle and the way of conceiving the world. This attitude of the therapist is the one that ultimately brings us closer to change and allows the differentiation of all the elements and factors acting during the therapeutic process; it broadens our perspective to approach its problem from a consensual perception of the human being, as a part and a whole, interacting permanently and also allows us to validate in a coherent framework, the use of a diversity of therapeutic tools from different approaches, considering them as complementary elements, applicable to each particular case, approaching us with greater certainty towards obtaining more effective achievements and results, always aimed at human well-being ([6]).

Personality is considered as an internal structure formed by biological, psychological and social factors that are in continuous interaction. This interaction makes each human being develop different ways of thinking, perceiving, acting and interacting with others.

We take personality as the fundamental axis of the model. Our model considers personality as a dynamically integrated structure of biological, psychological and socio-cultural factors that establish a way of perceiving, thinking, feeling and acting by granting individuality to the human being. We recognize personality as the integrative structure of psychic functions resulting from the interrelation of biological and socio-cultural factors that determine a peculiar and singular behavior in the individual.

Despite emphasizing the individuality of the subject in their psychic activity, there are constructions that are similar in individuals, a fact that is linked to the family social experience allowing group references that are valid in the exercise of assisting.

In this way we take cognition, affectivity, behavior and interpersonal relationships as basic axes of human behavior. Since these components are general for all subjects, these characteristics are present in all personalities, highlighting the fact that the predominance of a condition does not mark a perspective that excludes other factors. The bio-psycho-social appreciation of the model, which is present in the analysis of the origin of these processes, indicates in turn, primacy requirements in each subject, whether by predominance or deficit, allowing establishing general affinity groups in its expression.

What is appreciable is that a higher level of psychic equilibrium denotes the personalities that have predominance, while those with deficits maintain greater personal and social difficulties.

2.2 Basic Concepts of Neutrosophic Psychology Theory

In this subsection we summarize the main concepts and methods of the Neutrosophical Psychology Theory.

According to Smarandache in [7], Sigmund Freud divides memory into: conscious, preconscious, and unconscious. In the framework of this book, Smarandache defines a third state which he called "aconscious", which means: to be ignorant, impassive, indifferent, senseless, and unfeeling.

Thus, we can identify similarities between neutrosophic theory and neutrosophic psychology, especially the second one also represents psychological concepts in the form of a triple (<A>, <neutA>, <antiA>), one of them is described as follows:

1) Conscious, meaning things that we are currently aware of, it corresponds to <A>.

2) Unconscious, which comprises things that we are not aware of; they are hard to access because they are deep inside our mind. It is the opposite of conscious, corresponding to <antiA>.

3) Aconscious, which etymologically means away from conscious and unconscious, or neither conscious nor unconscious, but in between, or a mixture of conscious and unconscious, a vague buffer zone between them. It corresponds to <neutA> or Indeterminacy, as in Neutrosophy.

Consciousness, aconsciousness, and unconsciousness are the sources of positive, neutral (or blended), and negative emotions, thoughts, and behaviours throughout our lifespan.

In human behaviour, there exists a permanent interaction and discussion among conscious, unconscious, and aconscious. Sometimes people are mostly logical, sometimes they are mostly illogical, and others they are indifferent.

The triple (<A>, <neut A>, <antiA>) is there extended to the *discrete refined neutrosophic memory*, where ($<A>_1$, $<A>_2$,…,$<A>_l$; $<neutA>_1$, $<neutA>_2$,…,$<neutA>_m$; $<antiA>_1$, $<antiA>_2$, …,$<antiA>_n$) are defined based on the refined neutrosophy, see [7-9].

Smarandache in [7] cites Carl Jung who divides the unconsciousness into ([10]):

- Personal unconscious, which is specific to each individual, and comprises forgotten or suppressed conscious;
- Collective unconsciousness, which is characteristic to the whole human species, and comprises ancestral memories called "archetypes" (universal meaning images) and mental patterns as inherited psychic structures.

Smarandache adjoins the group unconscious, which is:

- Group unconsciousness, which is between the personal and collective unconsciousness. It is characteristic to a specific group that the individual belongs to, and has marked him/her mostly.

Equally, he extends the Jung's personal conscious and collective conscious to group conscious.

The aconsciousness, as an amalgam of consciousness and unconsciousness, is the indeterminate, ambiguous, vague zone where conscious and unconscious interfere. It is a transition space, or mediation between opposites.

The aconsciousness has a degree of conscious (c), and a degree of unconscious (u), where $c \in [0,1]$, and $0 \leq c + u \leq 2$.

In the neutrosophic psychology there is the following notation:

$$NL(\text{entity}) = (c,a,u) \quad (1)$$

Where c = degree of conscious (truth), a = degree of acounscious (indeterminacy): not sure if it is conscious or unconscious, or a blend of both, and u = degree of unconscious (falsehood), whereas, NL is the notation for

Neutrosophic Logic semantic.

NL(conscious) = (1, 0, 0); NL(acounscious) = (0, 1, 0); and NL(unconscious) = (0,a,1), where $a\in$ (0, 1], leaving room for indeterminacy (unknown, unclear).

Given U a universe of discourse, A, B, and C subsets, then the Neutrosophic Crisp Set of Type 2 satisfies the axioms: $A\cap B=\emptyset$, $B\cap C=\emptyset$, $C\cap A=\emptyset$, and $A\cup B\cup C=U$. Therefore, A, B, C form a disjoint partition of the universe of discourse U, see [11].

Refined Neutrosophic Crisp Set of Type 2 (and similarly for Types 1 and 3) is defined as: $A=A_1\cup A_2\cup\ldots\cup Ap$, $B=B_1\cup B_2\cup\ldots\cup B_r$, $C=C_1\cup C_2\cup\ldots\cup C_s$, with $A\cap B=B\cap C=C\cap A=\emptyset$, where p, r, s are integers ≥ 1, $p+r+s\geq 4$, and $A_i\cap A_j=\emptyset$ for $i,j\in\{1,2,\ldots,p\}$, $i\neq j$; $B_k\cap B_l=\emptyset$ for $k,l\in\{1,2,\ldots,r\}$, $k\neq l$; and $C_m\cap C_n=\emptyset$ for $m,n\in\{1,2,\ldots,s\}$, $m\neq n$.

The Neutrospsychic Crisp Personality considers a human person as a universe of discourse U, and three disjoint sets which are the following:

E = set of emotions of this person;

H = set of thoughts of this person;

B = set of behaviors of this person.

Therefore, $U=E\cup H\cup B$, with $E\cap H=\emptyset$, $H\cap B=\emptyset$, and $B\cap E=\emptyset$. Thus, $U=<E,H,B>$.

Also, a trait is measured by degrees of <trait> and degrees of <anti trait>, such that each person is classified in a range between these two opposites and it is dynamic. Additionally, he includes a middle position where there exists indeterminacy.

The most common pairs trait-anti trait, are the following:

- Extraversion – Introversion
- Conscientiousness – Unconscientiousness
- Perfectionism – Imperfectionism
- Sensitivism – Insensitivism
- Novator – Conservator
- Self Esteem – Self NonEsteem
- Agreeableness – Disagreeableness
- Openness to Intellect & Experience – Closeness to Intellect & Experience
- Inhibition – Disinhibition
- Flexibility – Rigidity
- Emotivism [Neuroticism (Hans Eysenck)] – Non-Emotivism
- Obsessionality – Nonobsessionality
- Cautiousness – Impulsivity
- Shyness – Boldness
- Honesty – Dishonesty
- Hostility [Psychoticism (Hans Eysenck)] – Nonhostility.

The *Neutrosophic Trait Operator* is the cumulative degree of individual x with respect to both the Trait and the antiTrait, and it is defined as:

$d_{Trait\ \&antiTrai}: S\rightarrow[-1, 1]$ (2)

Where, $d_{Trait\ \&antiTrait}(x)=d_{Trait}(x)+d_{antiTrait}(x)$.

To classify an individual as belonging to trait or anti trait, a threshold is defined and denoted by Thr for the trait, and antiThr for the anti trait, so that:

- If $d_{Trait\&antiTrait}(x)\geq$ +Thr, then the individual is categorized as definitively belonging to the Trait,
- If $d_{Trait\&antiTrait}(x)\leq$ -antiThr, then the individual is categorized as definitively belonging to the antiTrait.
- If $d_{Trait\&antiTrait}(x)\in(-\varepsilon,+\varepsilon)$, then the individual is categorized as been in a totally indeterminate state between the Trait and antiTrait.
- If $d_{Trait\&antiTrait}(x)\in(+\varepsilon,$ +Thr), then the individual is categorized as mostly belonging to the Trait.
- If $d_{Trait\&antiTrait}(x)\in$ (-antiThr, $-\varepsilon$), then the individual is categorized as mostly belonging to the antiTrait.

The way to use $d_{Trait\ \&\ antiTrait}$ is illustrated by Smarandache as follows:

"Assume a psychiatrist, after many sessions, neutrosophic questionnaires and observations measured with neutrosophic statistics, has gotten to the conclusion that George P.'s two temperament dimensions are estimated with a certain accuracy as:

- degree of stable (trait) is $d_{GP}(\text{stable})=0.2\in[0, 1]$,
- degree of unstable (antiTrait) is $d_{GP}(\text{unstable})=-0.5\in[-1, 0]$;and
- degree of extroverted (trait) is $d_{GP}(\text{extroverted})=0.9\in[0, 1]$,
- degree of introverted (antiTrait) is $d_{GP}(\text{introverted})=-0.3\in[-1, 0]$.

Then $d_{GD<stable>\&<unstable>}(x)=d_{GP}(\text{stable})+d_{GP}(\text{unstable})=0.2+(-0.5)=-0.3$, and $d_{GD<extroverted>\&<introverted>}(x)=d_{GP}(\text{extroverted})+d_{GP}(\text{introverted})=0.9+(-0.3)=+0.6$."

3 Method for measuring workplace stress

This section describes the design of the stress level measurement index in the work environment. First of all we establish the linguistic scale that we will use in the method, with its equivalent SVNN, see Table 1, according to the scale proposed in [12-13].

Linguistic term	SVNN
Extremely good (EG)	(1,0,0)
Very very good (VVG)	(0.9, 0.1, 0.1)
Very good (VG)	(0.8,0.15,0.20)
Good(G)	(0.70,0.25,0.30)
Medium good (MDG)	(0.60,0.35,0.40)
Medium(M)	(0.50,0.50,0.50)
Medium bad(MDB)	(0.40,0.65,0.60)
Bad (B)	(0.30,0.75,0.70)
Very bad (VB)	(0.20,0.85,0.80)
Very very bad (VVB)	(0.10,0.90,0.90)
Extremely bad (EB)	(0,1,1)

Table 1: Linguistic terms defined in [12-13] associated with a SVNN.

Let us remark that SVNNs are the simplest kinds of single-valued neutrosophic sets, therefore, the calculation based on them is the simplest one for classification, Most importantly, there exists scales which associate linguistic terms with SVNNs, see [12, 13], thus, the psychometrists can assess in the basis of the natural language, which is an advantage considering the difficulty to measuring in a numerical scale.

A scoring function $s\colon [0,1]^3 \to [0,3]$is defined in Formula 3, thus, a scoring function in [14] is used to sort the alternatives.

$$s(a_j) = 2 + T_j - F_j - I_j \quad (3)$$

Where a_j is an alternative evaluated with the SVNN (T_j, I_j, F_j).The definition of precision index is given in Equation 4.

$$a(a_j) = T_j - F_j \quad (4)$$

Let us note that $a\colon [0,1]^3 \to [-1,\ 1]$.

The first step of the index is to divide it into three different components, for each employee. The first component is based on the result of the Huber Stress Test applied to the worker, see [15].The possible test results are given below.

1. Stress level, given on the following scale:

1.1. Severe stress (B),

1.2. Moderate stress (M),

1.3. Acute stress (MDG),

To which we add,

1.4. Stress properly managed (VVG).

This test is evaluated according to the information provided by the subject on the physiological or psychological reactions he/she suffers. See that between parentheses we give the linguistic value in Table 1 associated with the Huber's Scale.

This part of the index will be called *Current State of Stress* (CSS) which is the state of stress the worker is currently in.

The second component of the index is called *Capacity to Overcome Stress Situations* (COSS), which consists in measuring the degree to which the individual has characteristics of his/her personality that will allow him/her to overcome a stress situation. These characteristics are:

2 Self-esteem, given on the following scale:

2.1. High self-esteem: it is equivalent to feeling confidently fit for life, feeling capable and valuable; or feel accepted as a person (G),

2.2. Low self-esteem: is when the person does not feel ready for life; feeling wrong as a person. (B),

2.3. Medium self-esteem: it is to oscillate between the two previous states, that is, to feel fit and useless, simultaneously right and wrong as a person, and to manifest these inconsistencies in behavior, act, sometimes sensibly, sometimes with thoughtlessness, thus reinforcing insecurity (M).

This measurement can be performed with the help of the Rosenberg test, see[16].

3 Assertiveness, given on the following scale:

3.1. Null or shyness (VVB),

3.2. Little or minimal assertiveness (B),
3.3. Regular or intermediate (M),
3.4. Assertiveness or security (G).
There are assertiveness tests such as the Behavioral Assertiveness Test (BAT), see [17].

4 Personality type test SEAPSI ([18-23]). The SEAPSI questionnaire consists of some phrases that identify the different types of personality where the individual must mark as they consider. The score observed according to the highest number of views will give us a pattern of the type of personality to which he/she corresponds. The personality types that are evaluated according to [6, 19] are:
4.1. With affective predominance (histrionic or cyclothymic) (M),
4.2. With cognitive predominance (paranoid or ananchastic) (G),
4.3. With behavioral predominance (impulsive or disocial) (M),
4.4. With interpersonal relationships deficit (schizoid, dependent, avoidant, schizotypal) (VB).
See that in these cases the evaluation was also included according to Table 1.
The third component of the index is related to the psycho-social environment.

5 Psychosocial Risk Card, which is given on the following scale, corresponds to the risks of suffering from environmental stress, let us call it *Environmental Psychosocial Stress Risk* (EPSR):
5.1. Work Stress (B),
5.2. Monotony (B),
5.3. Boredom (B),
5.4. Work fatigue (B),
5.5. . Comfort and work adequacy (G).

The method we propose in this paper is based on the Neutrosophical Psychology Theory, because stress is considered as the concept to be studied, it is considered that this is measured in a value located between two opposites denoted by <Eustress><Distress>. Additionally, the state in the medium of these opposites is considered and is here denoted by <NeutStress>, which is a transitional, intermediate, undefined form of stress; it is neither eustress nor distress.

We consider that each one of the elements that we have previously exposed and that have a G or better evaluation indicate a state of eustress, those evaluated by B or worse are indicators of existence of distress, while those evaluated as M indicate a state of <NeutStress>, they are those which also needs special attention, because that indicates there exists a transition towards a state either of distress or eustress.

If the worker is in the state of <NeutStress>, it could be predicted that he/she is going towards a state of eustress or reversible distress if the second and third components are favorable (valued as G or better), while the transition to distress would occur if the last two components are unfavorable (valued as B or worse).

Given these clarifications, below we describe the proposed method of measuring the stress level of a worker in a specific workplace:

1. The worker´s stress level is evaluated according to the CSS:
1.1. Its corresponding SVNN is set according to Table 1, and the crisp value of its index accuracy is associated.
2. The worker is evaluated according to his/her COSS, for this:
2.1. The Self-Esteem evaluation is carried out, its corresponding SVNN is set according to Table 1, and the crisp value of its index accuracy is associated.
2.2. The assertiveness evaluation is carried out, its corresponding SVNN is set according to Table 1, and the crisp value of its index accuracy is associated.
2.3. The SEAPSI Personality evaluation is obtained, its corresponding SVNN is set according to Table 1, and the crisp value of its index accuracy is associated.
2.4 It is calculated the mean of the crisp values obtained for the COSS.
3. The worker is evaluated according to his/her EPSR, the corresponding SVNN is set according to Table 1, and it is associated with the crisp value of the accuracy index.
4. The following criteria will be used to evaluate the worker:
4.1. The closer to 1 the value of CSS is, the better the worker´s stress condition is, or closer he/she is to the state of <Eustress>.
4.2. The closer to -1 the value of CSS is, the worse the worker´s stress condition is, or closer he/she is to the state of <Distress>.
4.3. The closer to 0 the value of CSS is, the more indeterminate the worker´s stress condition is, or closer he/she is to the state of <NeutStress>.
5. To predict the future possibility of getting out of a stress situation, in case the worker is in a stress situation at the present, or if the worker is in a state of <NeutStress>, we will have:
5.1. The closer to 1 the values of COSS and EPSR are, the worker is better able to tend to the state of <Eustress>.
5.2. The closer to -1 the values of COSS and EPSR are, the worker is better able to tend to the state of <Distress>.

5.3. The closer to 0 the values of COSS and EPSR are, the worker is in better potential conditions to tend to the state of <NeutSress>, which could be a state of great unpredictability.

The application of this index will be illustrated with an example, see Example 1.

Example 1:

Let us suppose we are interested to study the stress in worker X of Company Y. A psychologist of the enterprise apply to X the Huber Stress Test, the Self-esteem Test of Rosenberg, the Behavioral Assertiveness Test, the Personality type test SEAPSI, and the Psychosocial Risk Card.

The results are summarized in Table 2; see that the components of the index here proposed are also referred.

Index component	Test	Result	Evaluation according to Table 1
CSS	Huber Stress Test	Acute stress	MDG
COSS	Self-esteem Test of Rosenberg	Medium self-esteem	M
	Behavioral Assertiveness Test	Regular or intermediate	M
	Personality type test SEAPSI	Impulsive or dissocial	M
EPSR	Psychosocial Risk Card	Work fatigue	B

Table 2: Results of the test applied to worker X.

The equivalent SVNNs corresponding to the results in Table 2 are shown in Table 3, as well as the calculation of the accuracy index values, according to Equation 4, e.g., in accordance with the Huber Stress Test, X suffers of an 'Acute stress', which corresponds to the linguistic term MDG in the proposed method, and which is associated with the SVNN (0.60, 0.35, 0.40) in the Table 1, thus, applying the Equation 4 we have a(0.60, 0.35, 0.40) = 0.60-0.40 = 0.2. The other measures can be seen in Table 3.

Test	SVNN	a(Test result)
Huber Stress Test	(0.60,0.35,0.40)	0.2
Self-esteem Test of Rosenberg	(0.50,0.50,0.50)	0
Behavioral Assertiveness Test	(0.50,0.50,0.50)	0
Personality type test SEAPSI	(0.50,0.50,0.50)	0
Psychosocial Risk Card	(0.30,0.75,0.70)	-0.4

Table 3: SVNN and accuracy index values, according to psychological X´s evaluations.

The evaluation of the CSS is 0.2, which is closer to 0 than 1, thus X´s stress condition is closer to <NeutStress> than <Eustress>. COSS evaluation is the mean of {0, 0, 0}, which is 0, and EPSR is -0.4, which means psychosocial risks are favourable to the state <Distress>. Therefore, even though X's state is in a more or less comfortable stress situation, managers have to change the psychosocial risks, especially the causes of X's work fatigue. Mainly because inner X' conditions to overcome stress situations, evaluated as 0, are unpredictable.

Conclusion

This paper was dedicated to designing an index that measures the level of stress in the work environment by workers. The index is based on criteria of Personality-Focused Integrative Model and the Neutrosophical Psychology Theory. The index is divided into three components, the Current State of Stress, which measures the present state in terms of worker stress; Capacity to Overcome Stress Situations assesses the personality characteristics of the worker that would allow him/her to overcome a stress crisis in case of suffering of this, and finally the Environmental Psychosocial Stress Risk, which is the work situation external to the worker that are environmental generators of stress. The last two components allow predicting the behavior of the worker in a situation of workplace stress. This division of the index into three components allows establishing a more accurate idea of the current and future state of the worker in terms of stress. In addition, the indeterminacy, imprecise, or transitory state is explicitly taken into account, where the worker is not in either a state of eustress nor distress. In this intermediate case, the last two components would be those that would allow predicting, that the worker will either recover, or fall into a chronic distress or in an unpredictable state. The use of this index was illustrated with an example.

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A Neutrosophic Statistic Method to Predict Tax Time Series in Ecuador

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Abstract. Prediction of tax collection behavior is an essential tool for social planning by the State of any country. The tax is the State's mechanism for budget collection, which is necessary to accomplish public services that benefit the whole society. This paper firstly aims to propose a method of predicting time series where values can be given in form of intervals rather than numbers. This form permits to obtain more truthful results, but with a greater indeterminacy. Because statistical prediction methods are used, where data in form of intervals are included, we can classify this approach as a kind of Neutrosophic Statistics technique. Basically, the method converts a set of predicted numerical values into intervals. The second objective is to apply the method to predict the monthly income from taxes in Ecuador for the year 2019.

Keywords: time series, tax, prediction, neutrosophic statistic, autocorrelation, median average

1 Introduction

The tax is a kind of tribute regulated by the public law, see [1]. Taxes generally have the State as a creditor and aims to finance state expenditures. These are based on the principle that those who have more are those who must contribute more, in order to guarantee equity and social freedom.

People and companies must pay taxes on a mandatory basis, because this is the way to finance the operation of the State, otherwise it would collapse. This is the mechanism to guarantee the building of infrastructure such as roads, ports, airports, hydraulic and electrical installations, to provide public health, education, defense, social security services, as support for the unemployed, disability benefits or occupational accidents, the payment of pensions, among many other essential aspects of society.

Some kind of taxes are income taxes, capital gains and profits, social security contributions by workers, employers and freelancers, payroll taxes, taxes for the property, and goods and services taxes.

In this paper, the prediction of taxes in Ecuador is made for the year 2019. For this, we start from the monthly measurement of the sum of income taxes, consumption taxes and value-added taxes. Thus, we propose and apply a neutrosophic method of time series prediction, which differs from those appeared in [2-4]. Such a method uses a set of statistical techniques to obtain classical numeric values to form intervals that have as a limit the lowest and highest values of all the individual considered methods. So, predictions are based on intervals rather than numeric values.

The problem of predicting has a certain complexity; therefore there exist many methods to predict future values, see [5-12]. This quantity of tools is due to the fact that each of them is effective for a set of cases, while for others it is not. Moreover, the most elementary methods can guarantee better results than the more sophisticated ones. That is why the integration of the results of the methods can give more acceptable results than if each one is used separately.

Thus, we offer to increase the probability of obtaining a more truthful result, in exchange for increasing indeterminacy. This corresponds to the Theory of Neutrosophic Statistics, where models and parameters are applied over intervals instead of numerical values, see [13][1].

This method is applied to solve the tax prediction problem in Ecuador. This prediction is essential, because it allows social planning by the Ecuadorian State. It will be possible to estimate in advance the income that the State will have for taxes. This approach is based on the principle that the given information in form of intervals is useful for public administration in this way.

This paper is divided as follows; it begins with a section where the classic statistical concepts and methods of time series are explained, as well as the essential ideas of the theory of Neutrosophic Statistics. The proposed prediction method is next presented and applied to the tax prediction problem in Ecuador. We finish with the

section of conclusions.

2 Preliminaries

This section summarizes the theory of statistical methods of time series and neutrosophic statistic theory divided in two subsections.

2.1 Times Series

A *time series* is a gathering of observations made consecutively in time, see [14-17][2].

When observations are made continuously in time, time series is called *continuous*. Whereas, when the observations are taken only at specific moment of times it is called *discrete*, usually time variable are equally spaced. If time series can be predicted exactly it is called *deterministic*, however future values of most of time series can only be partially predicted by past values, and they are called *stochastic*.

Among the objectives to study time series, in this paper we select the *prediction* or *forecasting*, which is the calculus in advance of future values of the series since the past values.

Time series can have the following components:

a. *Seasonal effect* is manifested when time series fluctuates in short-term periods. In annual time series they correspond to changes in periods shorter than one year.
b. *Cyclic changes* occur when the time series oscillates with not fixed long-term periods. In annual time series these cycles correspond to oscillations in many years.
c. *Trend* is a long-run development. This component can be interpreted like the overall tendency of the series when oscillations are not considered.
d. A component that does not correspond to any of the previous ones, which is called *residual*.

Many fields of knowledge are used in time series forecasting, we select particularly a statistical approach.

A time series is called *strictly stationary* if the joint distribution of $X_{t_1}, X_{t_2}, \dots, X_{t_n}$ is the same as the joint distribution of $X_{t_1+q}, X_{t_2+q}, \dots, X_{t_n+q}$ for every $t_1, t_2, \dots, t_n, q$.

In the following we consider *normal stationary processes*, and we use the estimated coefficients and statistics of this kind of process. A *normal process* is such that the joint distribution of $X_{t_1}, X_{t_2}, \dots, X_{t_n}$ is a multivariate normal distribution.

Definition 1: Given $\{X_t\}$ a discrete time series and $q \in \mathbb{Z}_+^*$, elements of another time series $\{Y_t\}$ is defined by Equation 1.

$$Y_t = \frac{\sum_{r=0}^{q-1} X_{t+r}}{q} \qquad (1)$$

For t = 1, 2, …, n-q+1, and n is the number of elements in $\{X_t\}$.

$\{Y_t\}$ is called the time series of *Moving Averages* (MA).

The time series of MA is used to attenuate seasonal variations.

Definition 2: Given N observations $X_1, X_2, \dots, X_N$, on a discrete time series and $q \in \mathbb{Z}_+^*$, Equation 2 is the *Autocorrelation coefficient* (AR coefficient) of $X_1, X_2, \dots, X_N$, with *lag* q.

$$r_q = \frac{\sum_{t=1}^{N-q}(X_t - \bar{X})(X_{t+q} - \bar{X})}{\sum_{t=1}^{N}(X_t - \bar{X})^2} \qquad (2)$$

Where $\bar{X}$ is the mean of the time series.

In practice r_q is usually calculated since the autocovariance coefficients, $\{c_q\}$ with Equation 3 with the autocovariance coefficient with lag q.

$$c_q = \frac{1}{N}\sum_{t=1}^{N-q}(X_t - \bar{X})(X_{t+q} - \bar{X}) \qquad (3)$$

Then, $r_q = \frac{c_q}{c_0}$.

To estimate the autocovariance it is recommendable to take N > q+1, N≥50 and q≤N/4, see [17].

A *correlogram* is a graph that aids for interpreting the set of autocorrelation coefficients. It consists on a plot of lags q versus r_q.

A completely random time series, for a large N satisfies $r_q \approx 0$ for every q. This can be seen in the correlogram. Also, this kind of graph exhibits the presence of seasonal fluctuations in the original series when it has fluctuations as well.

The correlogram can contain the upper and lower bounds for autocorrelation with the significance level α, which is given by Equation 4:

$$B = \pm z_{1-\frac{\alpha}{2}} S(r_q) \qquad (4)$$

Where r_q is the estimated autocorrelation of lag q, $z_{1-\alpha/2}$ is the quantile of the normal distribution and $S(\cdot)$ is calculated as follows:

$$S(r_1) = \frac{1}{\sqrt{N}} \quad (5)$$

$$S(r_q) = \sqrt{\frac{1+2\sum_{i=1}^{q-1} r_i^2}{N}} \quad (6), \text{ for } q>1.$$

The trend is calculated by curve fitting of the time series observations, usually by means of a linear function and least square estimation.

MA and AR processes are used as models of time series. When they are combined or integrated they form the ARMA and ARIMA models, see [14, 17-18] for more details.

2.2 Neutrosophic Statistic

Neutrosophic Statistics is an extension of classical statistics where crisp numerical values are replaced by values in form of intervals, see [13][3]. This substitution can be applied to parameters, not only to random variables. The sample size can also be considered as indeterminate or inaccurate. In this theory the data can be ambiguous, vague, inaccurate, incomplete or indeterminate.

It is necessary to emphasize that there is a difference between the concepts of indeterminacy and randomness. Classical statistics deal with random variables, while in a neutrosophic framework they can also be indeterminate.

From this starting point, new concepts are defined from the classical ones, they are the following:

- *Neutrosophic Descriptive Statistics* "is comprised of all techniques to summarize and describe the neutrosophic numerical data characteristics."
- *Neustrosophic Inferential Statistics* "consists of methods that permit the generalization from a neutrosophic sampling to a population from which it was selected the sample."
- *Neutrosophic Data* "is the data that contains some indeterminacy."
- *Neutrosophic Frequency Distribution* "is a table displaying the categories, frequencies, and relative frequencies with some indeterminacy."
- *Neutrosophic Statistical Graphs* "are graphs that have indeterminate (unclear, vague, ambiguous, unknown) data or curves."

Other essential definitions are the following:

Neutrosophic Survey Results "are survey results that contain some indeterminacy. A Neutrosophic Population is a population not well determined at the level of membership (i.e. not sure if some individuals belong or do not belong to the population)."

A *simple random neutrosophic sample of size n* from a classical or neutrosophic population is a sample of n individuals such that at least one of them has some indeterminacy.

Neutrosophic Random Numbers can also be generated using, instead of only crisp numbers, a pool of sets.

A *Neutrosophic Normal Distribution* of a continuous variable X is a classical normal distribution of x, but such that its mean μ or its standard deviation σ (or variance σ^2), or both, are imprecise.

Other neutrosophic distributions are: neutrosophic standard normal distribution, neutrosophic bivariate normal distribution, neutrosophic uniform distribution, neutrosophic sampling distribution, neutrosophic geometric distribution, neutrosophic hypergeometric distribution, neutrosophic Poisson distribution, neutrosophic chi-squared distribution, neutrosophic exponential distribution, neutrosophic frequency distribution, neutrosophic Pareto distribution and neutrosophic t-distribution.

The *Neutrosophic Least-Squares Lines* that approximates the neutrosophic bivariate data (x_1,y_1), (x_2, y_2), …, (x_n, y_n) has the same formula as in classical statistics, i.e.,

$\hat{y} = a + by$, where the slope $b = \frac{\sum xy - [(\sum x)(\sum y)/n]}{\sum x^2 - [(\sum x)^2/n]}$ and the y-intercept $a = \bar{y} - b\bar{x}$, were $\bar{x}$ is the neutrosophic average of x, whereas $\bar{y}$ is the neutrosophic average of y.

The *Neutrosophic Residuals* are computed in the same way as in classical statistics:

$y_1 - \hat{y}_1, y_2 - \hat{y}_2, \ldots, y_n - \hat{y}_n$, where y_i are the real values of variable y, and $\hat{y}_i$ are respectively their predicted values.

It is worthy to explain the definition and operations with neutrosophic numbers:

The *neutrosophic numbers* has the form a+bI, where a and b are real numbers, and I = indeterminate.

Given $N_1 = a_1 + b_1 I$ and $N_2 = a_2 + b_2 I$ two neutrosophic numbers, some operations between them are defined as follows:

- $N_1 + N_2 = a_1 + a_1 + (b_1 + b_2)I$ (Addition);

- $N_1 - N_2 = a_1 - a_1 + (b_1 - b_2)I$ (Subtraction),
- $N_1 \times N_2 = a_1a_2 + (a_1b_2 + b_1a_2 + b_1b_2)I$ (Product),
- $\frac{N_1}{N_2} = \frac{a_1+b_1I}{a_2+b_2I} = \frac{a_1}{a_2} + \frac{a_2b_1-a_1b_2}{a_2(a_2+b_2)}I$ (Division).

Additionally, given $I_1 = [a_1, b_1]$ and $I_2 = [a_2, b_2]$ we have the following operations between them (see [19]):

- $I_1+I_2 = [a_1+a_2, b_1+ b_2]$ (Addition);
- $I_1-I_2 = [a_1-b_2, b_1- a_2]$ (Subtraction),
- $I_1 \cdot I_2 = [\min\{a_1 \cdot b_1, a_1 \cdot b_2, a_2 \cdot b_1, a_2 \cdot b_2\}, \max\{a_1 \cdot b_1, a_1 \cdot b_2, a_2 \cdot b_1, a_2 \cdot b_2\}]$ (Product),
- $I_1/I_2 = I_1 \cdot (1/I_2) = \{a/b: a \in I_1, b \in I_2\}$, always that $0 \notin I_2$ (Division).

3 Ecuadorian Tax Forecasting

Usually forecasting is referred to a unique value for every future time obtained from a unique model of prediction. However, the forecasted value is not necessarily accurate, in view that there not exists an ideal method of prediction. A very sophisticated method can yield to not sufficiently accurate results, while a simple one could be more accurate or vice versa.

In this paper we propose a method where the forecasted value is statistically obtained like an interval rather than a unique value. This predicted interval value is used to predict other value of the same kind and so on. Such a method is applied to forecast the Ecuadorian tax during 2019. It is based on the single-valued statistical forecasting methods which define an interval-valued one. We describe it below:

1. To graphically represent the time series and visually establish its properties of seasonal effect, cyclic changes and trend.
2. If $\{X_t\}$ for t = 1, 2, …, n are the values of the time series. Apply the correlogram to statistically establish the seasonal effect.
3. Let $M_1(\{X_t\}), M_2(\{X_t\}), \ldots, M_k(\{X_t\})$ be k forecasting methods conveniently selected according to some criteria of accuracy for this type of time series.
   Obtain $X_{in+1} = M_i(\{X_t\})$, for i = 1, 2, …, k; which are the forecasted values for every method at time t_{n+1}.
4. Form the intervals $I_{n+1}=[\min_i\{X_{in+1}\}, \max_i\{X_{in+1}\}]$. Now, we have new time series $\{X_t\}$ for t = 1, 2, …, n, n+1, where $X_{n+1} = I_{n+1}$.
5. Apply the Step 3 to the new $\{X_t\}$. In case that $\{X_t\}$ contains interval values, apply the prediction methods to both, the minimums and the maximums of the intervals and obtain a new value according to Step 3. In case that we have more than one interval instead of numeric values, we form the new interval that ranges from the minimum of every lower value to the maximum of every upper value of the input intervals.

   This Step is applied until we predict the future values we needs in advance.

Let us remark that the precedent method, which we shall denote as IM(S, n) for the time series S with n elements, allows predicting future values in form of intervals, i.e., we obtain S_{n+1} = IM(S, n) the predicted n+1 value which is an interval-valued solution. Moreover, some elements of S can be intervals. Therefore, this is a kind of Neutrosophic Statistic method.

If we want to obtain a representative single value since IM(S, n), we can calculate the following formula to interval $I_m = [a_1, a_2]$; see [20].

$$\lambda(I_m) = \frac{a_1+a_2}{2} \qquad (7)$$

The rationale of IM is the following, because every single-valued predicting method has its advantages and disadvantages over the other ones respect to accuracy, we cannot *a priori* establish which is the most appropriate method to solve the problem. But, if I_m is the interval that contains all these individual values obtained from the methods $M_1(\{X_t\}), M_2(\{X_t\}), \ldots, M_k(\{X_t\})$; denoting by x_{in+1} the predicted single valued number corresponding to the i^{th}-method and $v(n+1)$ the actual unknown value to predict, then we can assume that $probability(v(n+1) \in I_m) \geq \max_i\{probability(v(n+1) = x_{in+1})\}$. Nevertheless, the cost for assuming this principle is that we increase the indeterminacy when we accept intervals rather than numbers as the predicted value.

Let us calculate the prediction of the Ecuadorian tax applying the precedent method. We support our calculus on the R language software Version 2.11.1, see [21][4]. The time series is the monthly observation of the taxes paid in Ecuador in thousand of USD collected as the sum of the income tax, consumption tax and value-added tax, which is depicted in Figure 1.

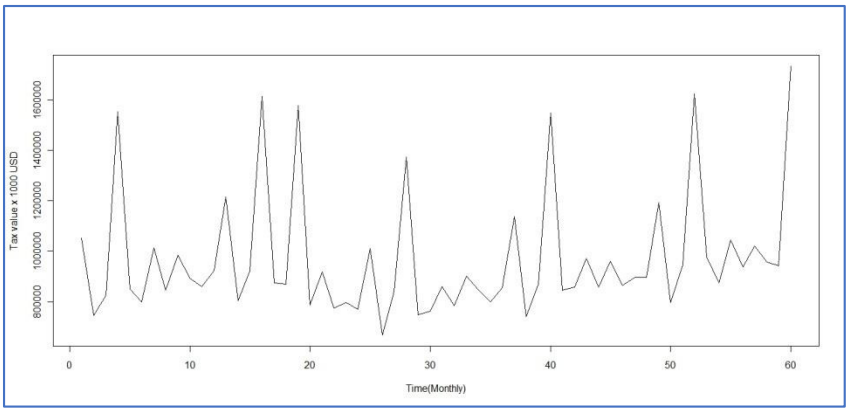

Figure 1: Depiction of the monthly time series of tax in Ecuador from 2014 to 2018.

For plotting we use the *plot* function of R. See that the series seems to have seasonal fluctuations, to determine this property we obtained the correlogram aided by the function *acf* of R, see Figure 2.

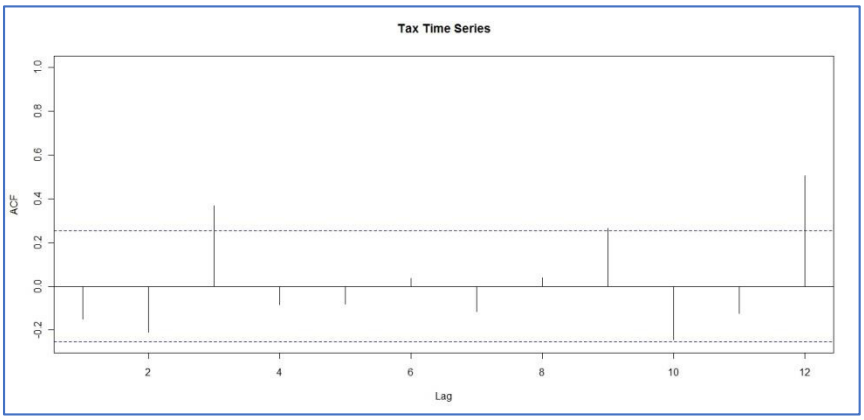

Figure 2: Depiction of the correlogram of the tax time series.

The dotted lines in Figure 2 bound the interval of randomness. We can appreciate that the seasonal effect is more evident yearly, although there also exists a quarterly one.

The linear trend can be calculated from least squares fit obtaining the function T(t) = 922349.3+1561.91*t, which is graphically represented with the solid line in Figure 3. We used *lsfit* function of R. Let us appreciate that the trend is slightly increasing.

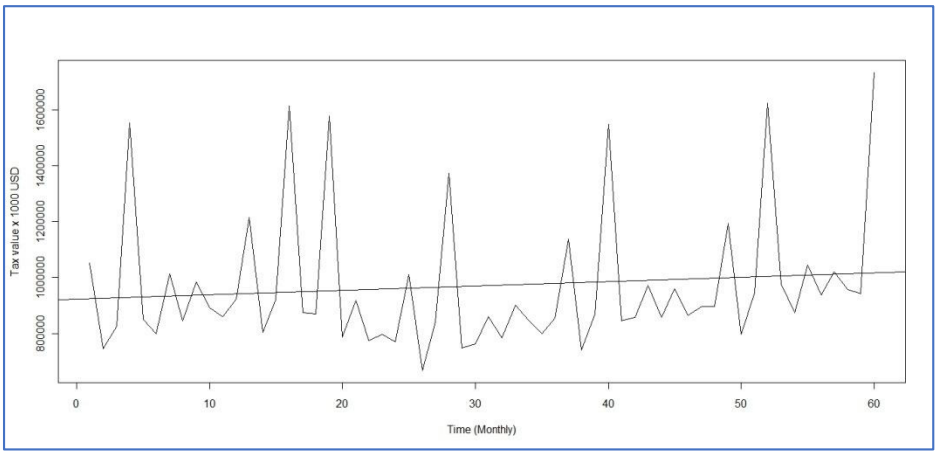

Figure 3: Tax time series with its linear trend.

For prediction we use the R functions *predict.ar*, *predict.Arima*, and *predict.StructTS*, which are based on

fitting methods using AR, ARIMA, and Maximum Likelihood respectively. We selected those methods because they are designed for time series prediction. The results are summarized in Table 1 and depicted in Figure 4.

Month	Lower prediction	Upper prediction	Middle prediction
January	887369.3	983527	935448.15
February	724684.8	970209.5	847447.15
March	964698.5	1311692	1138195.25
April	948233.3	1107685	1027959.15
May	813647	972354.5	893000.75
June	855445.6	972354.5	913900.05
July	965762.5	1140292	1053027.25
August	961802.7	1027133	994467.85
September	872498.3	1036670	954584.15
October	858309.4	992776.6	925543
November	940590.4	1086582	1013586.2
December	962525.2	1315634	1139079.6

Table 1: Predicted interval values for the year 2019 and the intermediate values x 1000 USD.

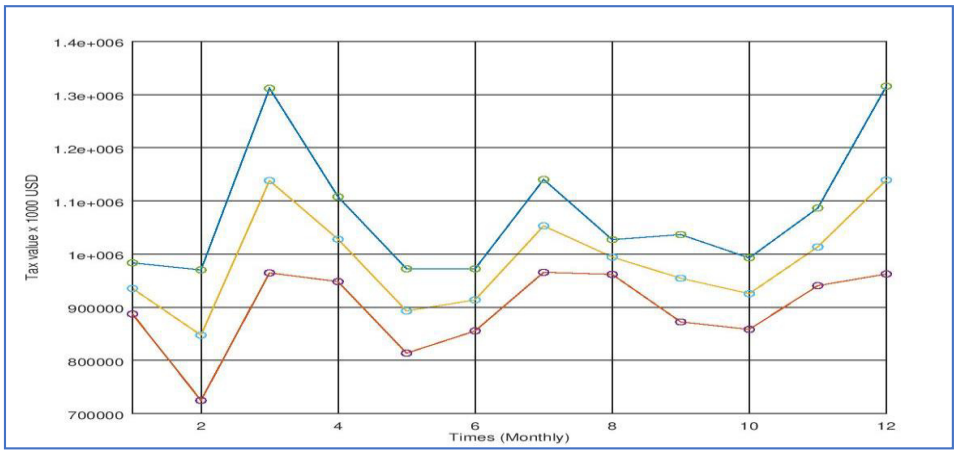

Figure 4: Depiction of the predicted interval values for the year 2019 and the intermediate values.

Let us note that in Figure 4 the upper line corresponds to the upper bound, the lower line corresponds to the lower bound and the intermediate line corresponds to the mean values, according to Equation 7.

Figure 5 contains the plotting of the degree of indeterminacy calculated according to Equation 8 given below.

Let $I_m = [a_1, a_2]$ be an interval, the indeterminacy of I_m is calculated as follows:

$$\gamma(I_m) = a_2 - a_1 \qquad (8)$$

Let us note that in Figure 5 the indeterminacy fluctuates over the time.

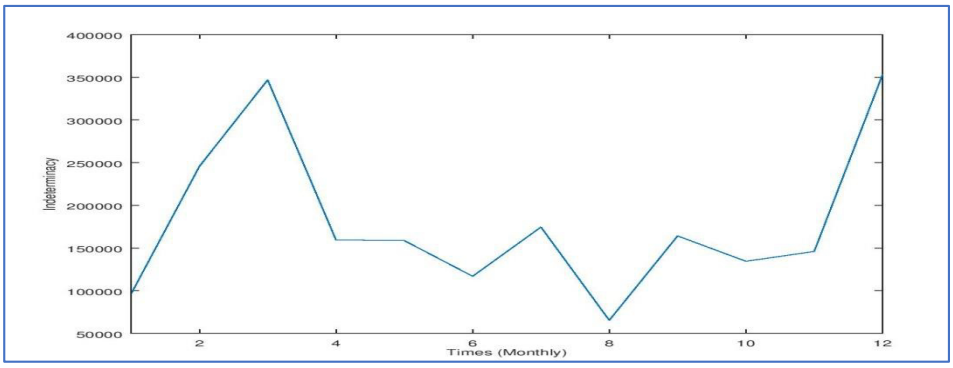

Figure 5: Depiction of the indeterminacy of predicted interval values.

Conclusion

This paper proposed a prediction method, where the future value is estimated in the form of an interval rather than in the form of a numeric value. Essentially, the method compiles the results of statistical prediction methods and converts them into a single value in form of an interval. This allows prediction of values with greater veracity, although with less precision. However, this is sufficiently useful to predict the behavior of taxes in Ecuador, in such a way that the monthly predictions of tax collection in Ecuador for the year 2019 are calculated.

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A neutrosophic model for the evaluation of the formative development of investigative competences

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Abstract. This paper presents a multicriteria method, solved by means of a method which is based on the ideal distance using neutrosophic numbers, which is convenient to evaluate the development of the investigative competencies of graduates in the UNIANDES Ibarra Law School, their competences and functions, for which we used theoretical samples that address the follow-up programs for higher education graduates, the analysis of their competencies and their impact on labor markets. The descriptive field research with a quantitative approach was applied. The sample covered a total of 122 Law professionals. The results obtained showed a similarity in the decisions obtained in practice.

Keywords: Law School graduates follow-up, competencies, multi-criteria selection, neutrosophic numbers.

1 Introduction

This investigation is the result of conducting an evaluation of the research competencies at the Regional Autonomous University of the Andes (UNIANDES), Ecuador, in the specificity of Law degree, and then, to extend its scope to the Ecuadorian and Latin American universities of this century applying TOPSIS [1] as a modern multicriteria decision method for a finite number of alternatives [2]. The selected alternative will have the farthest distance to the ideal negative solution and the shortest distance to the ideal positive solution [3]. During three years of hard work, theoretical inquiry, systematic interpretations and on-site actions, it is demonstrated the need to recognize formative research as a latent need to prepare professionals in their future skills.

The first history of monitoring higher education graduates began in the mid-19th century. Likewise, during the Second World War, in developed countries, the need to assess the competences of higher education graduates and its impact on labor markets was raised. During the second half of the 20th century, with the emergence of communication systems, the production and the administration, the relations between the countries and consequently their working interchanges were transformed (National University of Colombia, 2011).

From that moment, the repercussion of the graduate's performance in the business field became a topic of special interest, that's why the analysis in this regard began to be systematized and the universities had to take the forefront to investigate the research competitiveness of their graduates.

The current trend for the evaluation of multiple criteria requires a new science called Neutrosophy, which is the branch of philosophy that studies the origin, nature and scope of neutralities created by Professor Florentin Smarandache with multiple applications in the field of decision making [4].

Other authors introduce linguistic terms to be able to mathematically evaluate the assessment process when applying neutrosophic science [4, 5], which facilitates decision-making since it allows to know in detail the factors involved in it.

With regard to Ecuador, the review of educational quality required the implementation of mechanisms that would allow the activities, tasks, performance, positions, roles, and functions that graduates carry out to be followed up, also gave room for institutional self-evaluation. It worth mentioning that the University of Loja (UNL) is the one that officially began graduate studies in 2005 [6].

But it is the Organic Law of Higher Education [7], along with the Council of Evaluation, Accreditation and Quality Assurance of Higher Education (CEAACES), which allow the Regional Autonomous University of the Andes (UNIANDES) to have a graduates follow-up program, which allows them to maintain relationships with them through a Web page [8] where there is the possibility of accessing services, registering, finding employment options and accessing a portfolio of companies. This is complemented by an Annual Meeting of Graduates that summons graduates from each Extension to exchange experiences, where they can participate in conferences on innovative topics, plenary sessions and discussions at working groups. In addition, this interaction facilitates the collection of data on aspects related to job performance and inquires about the updating needs of graduates, among others.

UNIANDES Ibarra Extension, has the intentions to implement a reproducible method, even extensive to the rest of the training centers so that it can make an assessment of the competence of students under the precepts of Neutrosophy as a science, just like it is applied by Chakraborty [9] as an approach to current problems.

2 Materials and methods

In this paper, we propose a recommendation model based on the ideal distance using the single value neutrosophic number (SVN), specifically the TOPSIS method, but weighting will not use AHP (Analytical Hierarchy Process) but rather we will be using the aggregation operator WA (Weighted Average).

Decision making has historically been approached by multiple disciplines, from the classic ones such as philosophy, statistics, mathematics and economics, to more recent ones such as Artificial Intelligence. The theories and models developed point to rational support for complex decision making [10]. They include typical activities such as [11, 12], mathematical theory developed to deal with indeterminacy and complex decision making, such as:

• Defining the problem

• Identifying alternatives

• Evaluation criteria

• Selection of experts

• Evaluation of alternatives

• Order and selection of alternatives

• Decision.

Figure 2.1. Process for solving a decision-making problem [10].

In this paper, the highlighted activities will be addressed (Model, Collect information, assess alternatives)

Additionally, in order to obtain the expert evaluations in the evaluation models, the use of Single Value Neutrosophic Numbers (SVN) is proposed [13, 14].

Let X be a universe of discourse, a SVNS A over X, is an object with the following form.

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\}d \tag{2.1}$$

$Where\ u_A(x): X \to [0,1],\ r_A(x): X \to [0,1]\ y\ v_A(x): X \to [0,1]$
$with\ 0 \leq u_A(x) + r_A(x) + v_A(x): \leq 3\ for\ all\ x \in X$

For convenience, the SVN number will be expressed as A = (a, b, c), where a, *b*, *c* ∈ [0,1], and a + b + c ≤ 3 to determine the degree of association of membership and non-membership of the decision *a* over the proposal *x*

The method to be followed is then to collect the information from the entire set of decisions *Aj* of the discussion universe (data collected from the surveys, normalize their values), choose the best positive ideal vector B*i* by the experts, and then calculate the distances that the separates S*i*.

$$s_i = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(|a_{ij}-a_j^*|\right)^2+\left(|b_{ij}-b_j^*|\right)^2+\left(|c_{ij}-c_j^*|\right)^2\right\}\right)^{\frac{1}{2}}$$
$$(i = 1,2, \dots, m) \qquad (2.2)$$

In this document, linguistic variables are represented using single value neutrosophic numbers (SVN) to develop a decision support framework for evaluating the formative development of investigative skills.

As aggregation operators we will use a type of mathematical function to merge the information. These operators combine *n* values in a domain *D* and return a value in that same domain as treated by Torra and Narukawa [15].

The weighted average (WA) is one of the most mentioned aggregation operators in the literature. An operator WA has an associated vector of weights V, with V*i* ∈ [0, 1] sum Vi = 1 having the following form:

$$WA(a_1,..,a_n) = \sum_1^n v_i a_i \qquad (2.3)$$

Where *Vi* represents the importance/relevance of the data source *ai*

Table 1
Linguistic terms used

Linguistic term	ACRONYMS	SVN numbers
Extremely Good	(EG)	(1,0,0)
Very Very Good	(VVG)	(0.9, 0.1, 0.1)
Very Goog	(VG)	(0.8,0,15,0.20)
Good	(G)	(0.70,0.25,0.30)
Moderately Good	(MDG)	(0.60,0.35,0.40)
Medium	(M)	(0.50,0.50,0.50)
Moderately Bad mala	(MDB)	(0.40,0.65,0.60)
Bad	(B)	(0.30,0.75,0.70)
Very Bad	(VB)	(0.20,0.85,0.80)
Very Very Bad	(VVB)	(0.10,0.90,0.90)
Extremely Bad	(EB)	(0,1,1)

The results of the distances calculation allow us to sort the students according to the achievement of the competences.

The collection of the information is represented in the utility vector [16] and is expressed as follows:

$$P_j = \{p_{j1}, p_{j2}, \dots, p_{jk}\} \qquad (2.4)$$

Therefore the decisions for the evaluation of the formative development of investigative competences are provided by means of this valuation vector and the decision vij for each criterion Ci of each group of student Ej is expressed by means of the SVN number.

3 RESULTS AND DISCUSION

The objective of this phase was to evaluate the formative development of the competences at UNANDES Ibarra Law School, addressing the graduates' follow-up program. The sample covered a total of 122 Law professionals and the questionnaire was used as an instrument.

3.1 TOPSIS, Technique of Preference Sorted by Similarity to an Ideal Solution

TOPSIS technique has a totally intuitive approach, and is based on the fact that each of the alternatives can be represented in a Euclidean space, which also happens with the attributes that we're evaluating. The technique seeks to select an alternative that is as close as possible to a positive ideal alternative, but as far as possible from an alternative called negative ideal according to Chen [17]. The first one is integrated with the best nominal values that the attributes have, while the second is formed with the worst nominal values that are found in the attributes. Let be the alternatives $Ai,\ i = 1, 2, \ldots m$, the criteria $Cj,\ j = 1, 2, \ldots n$, the weights of the criteria wj and a decision matrix with $x\ ij\ = U\ j\ (A\ i\ ), \forall i, j$.. Where U is the utility function of the decision maker, operating on the basis that all the criteria are to be maximized/minimized according to whether profits or costs are being considered, respectively.

It is suggested that the direct method to carry out the multicriteria evaluation consists of choosing the alternative that has the shortest distance to the ideal alternative, in this way the chosen alternative would be very similar to the ideal solution, according to Srinivasan and Shocker [18]. Another way of choosing the alternative would be selecting the one that is furthest from the anti-ideal solution, according to Zeleny [19]. And this is the one that was used in the determination of the evaluation of the investigative competences of the students. TOPSIS is a technique that considers the distance to the ideal alternative and the distance to the anti-ideal alternative.

3.2 Identification of Alternatives:

In this phase the evaluation framework of the alternatives is made up by the experts' criteria evaluating three alternatives by neutrosophic methods based on the information aggregation model shown in Table 2

Table 2. *Alternatives for evaluating the formative development of competences*

ID	Acronym	Description	Questions
1	OMT	Occupational Market Trends	4
2	OD	Occupational Demand (employability)	5
3	TF	Training and Feedback	1

Each of these variables (OMT, OD, TF), called alternatives, have the statistical results of the 10 questions of the survey as values, and these will be weighted with the percentage of the students who answered. The following table shows the data taken from the population of 122 students graduated from UNANDES Ibarra.

Table 3, Survey results, each row adds up to 122

Acronyms	Question	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
OMT	1	60	61	1	0	0
	2	82	40	0	0	0
	3	61	44	17	0	0
	4	111	11	0	0	0
OD	5	104	11	7	0	0
	6	33	11	67	11	0
	7	17	78	5	11	11
	8	22	61	11	28	0
	9	66	39	17	0	0
TF	10	17	33	39	17	16

Possible values go from 0 no response, up to 122 the maximum number of the population, these data are normalized in values from 0 to 1 for the total population to match the numbers of the linguistic terms of the SVN so that we can plot them in the same curved surface of the triangular SVN number.

Linguistic term	Acronym	SVN numbers
Extremely good	(EG)	(1,0,0)
Very very good	(VVG)	(0.9, 0.1, 0.1)
Very good	(VG)	(0.8,0,15,0.20)
Good	(G)	(0.70,0.25,0.30)
Moderately good	(MDG)	(0.60,0.35,0.40)
Medium	(M)	(0.50,0.50,0.50)
Moderately bad	(MDB)	(0.40,0.65,0.60)
Bad	(B)	(0.30,0.75,0.70)
Very bad	(VB)	(0.20,0.85,0.80)
Very very bad	(VVB)	(0.10,0.90,0.90)
Extremely bad	(EB)	(0,1,1)

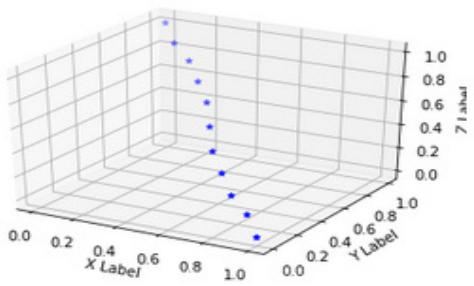
Table 3. Language terms used

3.4 Collection of information:

The collection of information is carried out automatically without the intervention of specialists, since knowing the value of each sample in percent of the population (0 and 1), it is easy to determine in linguistic terms for each of the three alternatives (OMT, OD, TF), since the region in the space occupied by the SNV neutrosophic number is known.

Figure 1, Decision surface for SNV terms (prepared by the author)

```
In [84]: from mpl_toolkits.mplot3d import Axes3D

         fig = plt.figure()
         ax = fig.add_subplot(111, projection='3d')

         x =[1,0.9,0.8,0.7,0.6,0.5,0.4,0.3,0.2,0.1,0]
         y =[0,0.1,0.15,0.25,0.35,0.50,0.65,0.75,0.85,0.90,1]
         z =[0,0.1,0.20,0.30,0.40,0.50,0.60,0.70,0.80,0.90,1]

         ax.scatter(x, y, z, c='b', marker='*')

         ax.set_xlabel('X Label')
         ax.set_ylabel('Y Label')
         ax.set_zlabel('Z Label')

         plt.show()
```



Decision makers' opinions are added using the SVNWA aggregation operator, the result is shown in table 4

Table 4, Collection of information

Acronym	Question	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
OMT	1	MDB	M	EB	EB	EB
	2	MDG	B	EB	EB	EB
	3	M	B	VVB	EB	EB
	4	VVG	VVG	EB	EB	EB
OD	5	VG	VVG	EB	EB	EB
	6	VB	VVG	M	VVB	EB
	7	VVB	MDG	EB	VVB	VVB
	8	VVB	M	EB	VB	EB
	9	M	B	VVB	EB	EB
TF	10	VVB	VB	B	VVB	VVB

3.4 Evaluation of Alternatives

From this information and with equation (3.1), (3.2) the ideal alternative for each student sample is selected.

$$A^{+} = \{(\max_{i=1}^{n}|j \in I^{+}|), (\min_{i=1}^{n}|j \in I^{-}|)\} = [v_1^{+}, v_2^{+}, \dots, v_n^{+}] \quad (3.1)$$

$$A^{-} = \{(\min_{i=1}^{n}|j \in I^{+}|), (\max_{i=1}^{n}|j \in I^{-}|)\} = [v_1^{-}, v_2^{-}, \dots, v_n^{-}] \quad (3.2)$$

The ideal alternative for expert judgment is:
A+ = (VVG, VVG, VVG, VG, MDG)
The alternatives are evaluated according to the Euclidean distance of all the vectors of set A. To order it, it was compared with the distance to the ideal vector A +. If the alternative Ai is closer than the measured distance A +. Then the calculated distance (closest Ai) is the best alternative, thus allowing establishing an order of priorities between them.

3.5 Selection of Alternatives

The distance of each alternative to the positive ideal solution, d^{+}, and to the negative ideal solution, d^{-}, is given by (3.3) and (3.4) respectively:

$$d_i^{+} = \sqrt{\Sigma_{j=1}^{m}(v_{ij} - v_j^{+})},\ i = 1, \dots, n \quad (3.3)$$

$$d_i^{-} = \sqrt{\Sigma_{j=1}^{m}(v_{ij} - v_j^{-})},\ i = 1, \dots, n \quad (3.4)$$

The relative proximity to the positive ideal solution will be calculated using expression (3.5): which is known as the coefficient of similarity C_i^{+} for each alternative.

$$C_i^{+} = \frac{d_i^{-}}{d_i^{+} + d_i^{-}} \quad i = 1, 2, \dots m \quad (3.5)$$

For the selection of the alternatives, the anti-ideal distance will be taken, starting with the one that is closest to the ideal solution (greater relative proximity).

Table 5, Calculation of distances.

Acronym	Question	Distance
OMT	1	0,73200
	2	1,00040
	3	0,74420
	4	1,35420
OD	5	1,26880
	6	0,40260
	7	0,20740
	8	0,26840
	9	0,80520
TF	10	0,20740

The results of the calculation of the distances in Table 5 allow us to sort what the competition alternatives should be according to the evaluations carried out on the students in their competitive achievements.

To carry out the evaluation of the formative development of investigative competences at UNIANDES Ibarra, we sorted the alternatives using the Euclidean distance between single-valued SVN neutrosophic numbers applying equation (2.1).

4 Conclusions

The evaluation of the variables: occupational market trends (OMT), occupational demand (OD) and Training and Feedback (TF), was validated from the calculation of the distances, obtaining the following results:

In accordance with the applied method, it indicates that areas such as Law (TMO 4 ----- 1,35420) will be a safe source of employment for Ecuadorians. It also evaluates that Law graduates should enroll in master's degree programs (DO 5 ----- 1,26880), thirdly, it evaluates the training received in the UNIANDES Law Shcool as Very Good (TMO 2 ----- 1,00040), fourthly, continuity of work is guaranteed.

One of the weakest points that the results show is that UNIANDES university graduates are not prepared to practice as a Manager or Executives (DO 7 ----- 0.20740)

To these results, we may add the reality, by saying that the majority of Law graduates entered the labor market in less than a year, once the degree was completed. They also suggest that given the quality of UNIANDES they would be willing to continue postgraduate studies under their auspices, as well as request training in very specific areas, this shows the importance for this group of updating knowledge in their field of specialization.

Another significant finding is that most of the interviewees affirmed that they had been in the last job for years, an indication that they have job stability and have correctly responded to job requirements in a world of strong competition and continuous evolution of knowledge.

Finally, it is essential that the information obtained from monitoring graduates becomes a support for the public academic offer, so this procedure must be integrated into the university culture so that it is carried out with rigorous criteria of formality, regulation and mandatory compliance.

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Neutrosophic Decision Map for critical success factors prioritization in a museum of religious Art

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Abstract: Visits to museums represent a way of keeping culture in memory of new generations. Getting to know the details that characterize each muse logical installation is a fundamental task for workers in the sector. That is why, depending on the knowledge that people have about the place, room recommendations are a problem of decision-making that are currently addressed. The present investigation proposes a method for the recommendation of museum rooms through the use of Neutrosophic Cognitive Map. A case study is applied where the proposal for the recommendation of rooms of the religious art museum of La Concepción in Riobamba is implemented.

Keywords: method; cognitive neutrophic map; museum; recommendations.

1 Introduction

Culture represents an important part that characterizes people. Museums allow you to recreate in a pleasant way the culture of the peoples [1]. Nowadays museums are the fundamental way of conserving historical heritage [2].

Introducing from young ages the curiosity of young people to know the elements that characterize the culture of the peoples is the essence to revive history. Latin America is the second most valued region in the world to visit its cultural heritage.

In Ecuador there are numerous museums that protect an incalculable cultural heritage [3]. In the province of Chimborazo we find several museums, in the city of Riobamba the museum that stands out is the Mothers Concepts museum considered one of the best museums of religious art for the quality and value of the works it has [4].

Knowing what route to take, what room to travel, with what elements to recreate, currently represents a problem of decision-making that visitors face. The problem described above is modeled through the set of previous knowledge that visitors have about the place, the expectations and learning needs they have, among other elements.

The present investigation proposes a method for the recommendation of museum rooms and bases its operation on Neutrosophic Cognitive Map to represent the causal knowledge.

2 Preliminaries

The investigation begins in this section with the main theoretical references on the problem that is addressed. The museums are presented and subsequently the Mothers Concepts museum in Riobamba is characterized. The Neutrosophical Cognitive Maps are characterized for research development. In addition, the theory of Neutrosophical numbers is presented as part of the development of the present investigation.

2.1 Museums

A museum is a permanent, non-profit institution, at the service of society and open to the public, which acquires, preserves, studies, exposes and disseminates the material and intangible heritage of humanity for the purpose of study, education and recreation.

There are numerous categories of museums with their corresponding subcategories, but these are the most common:

Anthropological: they are museums whose pieces and contents deal with the biological and social aspects of human beings, highlighting cultural diversity.

Archeological: they are museums dedicated to the dissemination of archeology and whose collection comes mostly from excavations. If the museum is next to the archaeological site of origin of its collection it is a site museum.

Of Architecture: they are museums whose contents are dedicated to study the constructive processes, their creators and the buildings designed by them. His exhibition is based on the exhibition of construction projects and materials that is models, plans and photographs.

Of Contemporary Art: they are museums whose works and contents have a chronology that includes from the end of the 19th century to the present.

Of Decorative Arts: they are museums whose works and contents are dedicated to those arts destined to produce functional and ornamental objects, such as goldsmithing, embroidery, glass, ceramics or furniture

Of Fine Arts: they are museums dedicated to the different artistic disciplines, and whose collections are formed mainly by painting and sculpture.

Natural Sciences: they are museums dedicated to the knowledge of the diversity of the natural world and among its collections are, among other things, samples of flora, fauna and geological.

Scientific-Technological: they are museums whose objects and contents serve as instruments of study and dissemination of science among society. They are usually quite intuitive and contain objects that can be manipulated and interactive installations.

Ethnographic: they are museums whose objects and contents deal with folklore and the popular uses and customs of a society.

Historical: they are museums whose contents are dedicated to spreading the general history of a specific city or territory to help understand the events that took place there.

Maritime and naval: they are museums whose objects and contents deal with navigation and everything related to the sea.

Military: they are museums whose objects and contents are associated with the army or military events.

Musical: they are museums whose objects and contents are associated with music and its historical evolution. Within this there are several typologies: museums of musical instruments, houses museums of composers, museums associated with opera houses, museums of popular music.

2.2 Characteristics of the Mothers Concepts museum in Riobamba

The religious art museum of the Conceptas de Riobamba, established in 1980 and remodeled in 1997, is one of the jewels of the culture, history and religious tradition of the old and new Riobamba.

It is composed of a set of rooms that are distributed as follows:

Living room 1: Angels: in this room the angels Gabriel, Rafael among others is exposed, being the symbol of evangelization in the 16th century.

Living room 2. Nativity: urns are exhibited with the birth of the child Jesus, demonstrating the great imagination and devotion of the people.

Living room. Pedro: normal size images that were used for processions are displayed and at the same time the denial to Pedro is shown.

Living room 4. Easter week: This room shows the customs and the great respect that people have for Easter or senior week.

Living room 5 and 6. Crucifixes: in this room different crucifixes made by a sculptor passionate about religion are exhibited.

Living room 7. Trinity: there are several pieces of sculpture some of them are covered with gold and silver.

Living room 8. Mary: Here are paintings from the colonial era that still exist today.

Living room 9. Coronation: there are several representations about the transition of the virgin.

Living room 10. Mass and Holiness: In this room we will find several models of oil paintings on canvas, wooden sculptures, polychrome and with silver.

Living room 11. Furniture: Here are objects made with leather, figures with relief, the special thing about this room are the locals.

Living room 12. Daily life: This room is a vivid representation of how cloister nuns usually live.

Living room 13. Wood and ceramic: there are decorated and carved objects that only preserved wealthy people.

Living room 14. Treasures: In this room the most outstanding custodians of the 17th and 18th century is exposed.

2.3 Neutrosophic Cognitive Map

The causative models: there are different kinds of causality which are expressed in forms of graphics, where each causative model that is represented by a graphic is representations of the causality among concepts. The causative models allow modeling the cause or effect of any determined event [5], [6], [7],[8].

The original definition of truth value in neutrosophical logic is shown as referred to as N {(T,I,F):$T,I,F \subseteq$ [0,1]} n, in which:

T: represents the degree of belonging,
I: the degree of undefined,
F: the falsehood.

What represents a neutrosophics valuation, considered as a mapping of a group of propositional formulas to N, and for each sentence p to obtain the result by equation 1 [9], [10], [11].

$$v(p) = (T, I, F) \tag{1}$$

The Cognitive neutrosophics Map: is a technique which allows the representations of the causative relations of different concepts as an extension of mental models using extended values or numbers in a interval of [-1,1] [12], [13], [14], [15]. The MCN are presented by extended model with feedback to show causality.

There are three possible kinds of causative relations among concepts in the MCN [16], [17]:

$W_{ij} > 0$: It refers a positive causality among concepts. It means, the increasing or decreasing in the value of C_i, It goes on increasing or decreasing in the value of C_j.

$W_{ij} < 0$: It refers a negative causality among concepts in the value of C_i, which takes to a decreasing or increasing of the value of C_j.

$W_{ij} = 0$: It refers to no existence of the relations among concepts C_i and C_j.

2 Method for critical success factors prioritization in a museum

The method is structured to support the process of recommending museum rooms. It bases its operation through a multi-expert multicriteria approach where room recommendations are modeled based on the set of criteria. The causative models are used in the inference as a way of representing the knowledge, beginning by the artificial technique of the Cognitive Neutrosophic Map.

The figure 1 shows the schema of the suggested method. The system is designed by an architecture of three layers for modeling the suggested business entries, processing and exits.

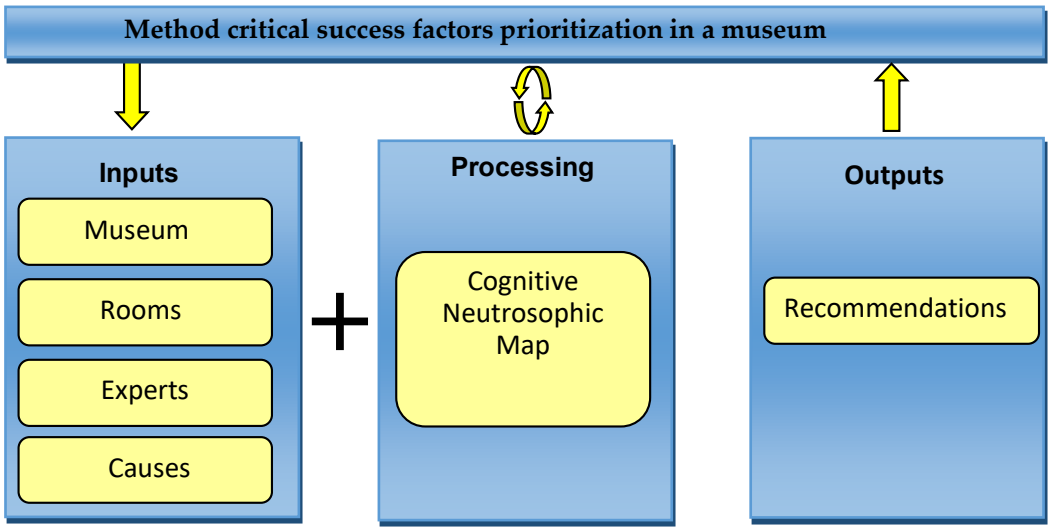

Figure 1. Method critical success factors prioritization in a museum

The outputs of the system: they represent the results of the processing where the recommendations associated with the decision-making problem are obtained.

The process is made by means of the flow of works which are the five activities of the core of the proposed method. The figure 2 shows the schema with the method workflow.

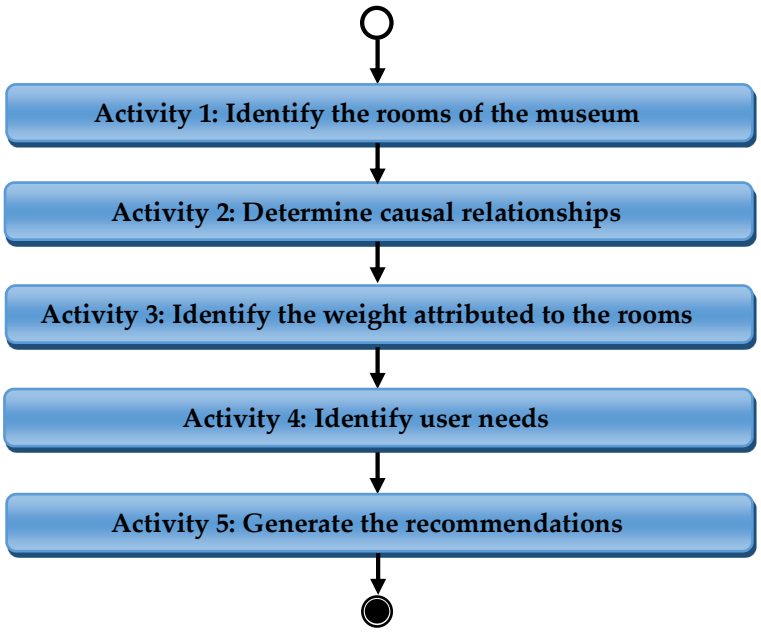

Figura 2. Scheme with the method workflow.

The method for the recommendation of museum rooms is made up of five activities as expressed in figure 2. A description of each of the proposed activities is given below.

Activity 1: Identification of museum rooms.

The identification of the museum rooms represents the activity in which the general set of criteria that represent the basis of the inference are determined. A multicriteria approach is used, thus identifying the greatest possible criteria attributed to each room.

Activity 2. Determination of causal relationships:

Activity 2 Bringing about the causative relations by means of a multiple-expert criteria`s view. It guarantees the causative knowledge of criteria. The activity consists in extracting the knowledge that experts have about the rooms. The causative relations are expressed by means of a group of values which represent the relations of direct

or inverse implications. It is used the scale suggested by Perez shown in the table 1[18].

Table 1. The group of values to express causality

Number of value	Impact
1	(NMF) negatively greatest strongly
-0,75	(NF) negatively strong
-0,50	(NM) negatively medium
-0,25	(ND) negatively weak
0	without importance
0,25	(PD) positively weak
0,50	(PM) positively médium
0,75	(PF) positively strong
1	(PMF) positively strongest

During the determination of the causative relations is made a process of adding where the results is called adjacent matrix which represent the values assigned to the arches[19], [20]. So:

$$M = \begin{bmatrix} \cdot\cdot & \cdot\cdot & \cdot\cdot \\ \cdot\cdot & W_{ij} & \cdot\cdot \\ \cdot\cdot & \cdot\cdot & \cdot\cdot \\ \cdot\cdot & \cdot\cdot & \cdot\cdot \end{bmatrix}$$

The adjacent matrix $M = M(C_i C_j)$ represent the causative value of the arch function, the node C_i which is C_j increases. Causatively C_j if $M_{ij} = -1$, and when the node C is not C if $M_{ij} = 0$.

Activity 3: Identification of the weights attributed to the rooms.

Beginning by getting the adjacent matrix from the activity 2, the added value emited by the group of expert are all together the relations with the weight of the nodes in which are generated the cognitive neutrosophic map as result [21], [22], [23],[24].

By means of a static analysis of the result of the value gotten in the adjacent matrix can be calculated the grade of exit using the equation 1 where are the attributed weight for each manifestation.

$$id_i = \sum_{i=1}^{n} \left\| I_{ji} \right\| \tag{1}$$

Activity 4: Identification of user needs.

The identification of the needs of the users consists in determining which elements they wish to recreate during the visit.

Table 2. The group of values to express preference

Number of value	Impacto impact
0	No knowledge about the room
0,25	Light knowledge about the room
0,5	Low knowledge of the room
0,75	Adequate knowledge about the room
1	High knowledge about the room

Activity 5: Generation of room recommendations.

It is the process based in the simulation of the scene suggested by Glykas, the new values of the concepts express the influence of the concepts interconnected to the specific concept and it is calculated by means the following equation 2

$$A_i^{(K+1)} = f\left(A_i^{(K)} \sum_{i=1;j\neq i}^{n} A_i^{(K)} * W_{ji}\right) \quad (2)$$

Where:

$A_i^{(K+1)}$: it is the value of the concept C_i in the step k+1 of simulation.

$A_i^{(K)}$: it is the value of the concept C_j in the step K of the simulation.

W_{ji}: It is the weight of the connection which goes from the concept C_j to the concept C_i and f (x) is the activated function [25], [26].

3 Application of the proposed method in critical success factors prioritization in a museum religious Art

From the case analysis it is possible to determine the behavior of the different alternatives based on possible recommendations. For the proposed method, a system for the recommendation of museum rooms is implemented. The implementation of the proposal on a case study is carried out in the religious arts museum of Las Madres Conceptas in Riobamba.
Below, it is described the results of the studies:

Activity 1. Identification of museum rooms:

The identification of museum rooms is conditioned by the case under analysis. A total of 7 rooms are specifically identified. Table 3 presents the rooms used in the decision making problem.

Table 3. Proposal of rooms used.

Node	Concept
C_1	Living room 1: Angels, Nativity
C_2	Living room 2: Pedro, Easter week
C_3	Living room 3: Crucifixes
C_4	Living room 4: Trinity, Mary
C_5	Living room 5 : Coronation, Mass and Holiness
C_6	Living room 6: Furniture, Daily life
C_7	Living room 7: Wood and ceramic, Treasures

Activity 2: Determination of causal relationships.

The scale proposed in Table 1 was used to determine the causal relationships. Three experts from the area of knowledge under study were involved. The 3 aggregating Neutrosophic Cognitive Maps were obtained, containing the answers in a single result.

Table 4 shows the adjacency matrix obtained as a result of the process.

Table 4. The adjacent matrix as the result of the process

	C1T, I, F	C2 T, I, F	C3 T, I, F	C4 T, I, F	C5 T, I, F	C6 T, I, F	C7 T, I, F
C1 T, I, F	[0, 0,0]	[0.75, 0.5,0.25]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.25, 0,0]
C2 T, I, F	[0.75, 0.5,0.25]	[0, 0,0]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]
C3 T, I, F	[0.5, 0.25,0]	[0.75, 0.5,0.25]	[0, 0,0]	[0.5, 0.25,0]	[0.75, 0.5,0.25]	[0.5, 0.25,0]	[0.5, 0.25,0]
C4 T, I, F	[0.75, 0.5,0.25]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0, 0,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]
C5 T, I, F	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0, 0,0]	[0.5, 0.25,0]	[0.5, 0.25,0]
C6 T, I, F	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0, 0,0]	[0.5, 0.25,0]

	C1T, I, F	C2 T, I, F	C3 T, I, F	C4 T, I, F	C5 T, I, F	C6 T, I, F	C7 T, I, F
C7 T, I, F	[0.25, 0,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0, 0,0]

Activity 3: Identification of the weights attributed to the romos.

For the identification of the weights, the knowledge base stored in the adjacency matrix, Table 4, is taken into account, applying the function (1), the behavior of the weight attributed to the manifestations is obtained. Table 5 shows the resulting weights.

Table 5. Weights attributed to each room.

Node	Concept	Weight
C_1	Living room 1: Angels, Nativity	0,12
C_2	Living room 2: Pedro, Easter week	0,15
C_3	Living room 3: Crucifixes	0,14
C_4	Living room 4: Trinity, Mary	0,13
C_5	Living room 5 : Coronation, Mass and Holiness	0,13
C_6	Living room 6: Furniture, Daily life	0,12
C_7	Living room 7: Wood and ceramic, Treasures	0,12

Activity 4. Identification of user needs:

From the visitor interview, the degree of preference that people have over their knowledge needs was determined through self-assessment. The study was conducted to recommend a visitor under study. Table 6 shows the resulting values. The values are used as activation vectors in the later stage for the recommendation process.

Table 6. Attributed preference to the visiting.

Visitor	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	[0.75]	[0.25]	[0.25]	[0.75]	[1]	[1]	[0.75]

Activity 5: Generation of room recommendations.

From the behavior of the weights attributed to the alternatives, the degree of belonging of a room is determined by an aggregation process. Table 7 shows the result of the calculation performed.

Table 7. The attributed weight to the Living room.

Visitor A1	Weights	Preferences	Adding
C_1	0,12	0.75	0,13
C_2	0,15	0.25	0,11
C_3	0,14	0.25	0,14
C_4	0,13	0.75	0,10
C_5	0,13	1	0,09
C_6	0,12	1	0,13
C_7	0,12	0.75	0,09
Index			1,61

Beginning from the simulated process of the scene was obtained the predictions of the behaviour on the visiting

by means of the equation 2.

The prediction models the causal relationships of the rooms and foresees the evolution of these in the visitors.

Figure 3 presents the simulation result showing the different alternatives and their behavior evaluation. From the simulation process, the decision-making problem is solved.

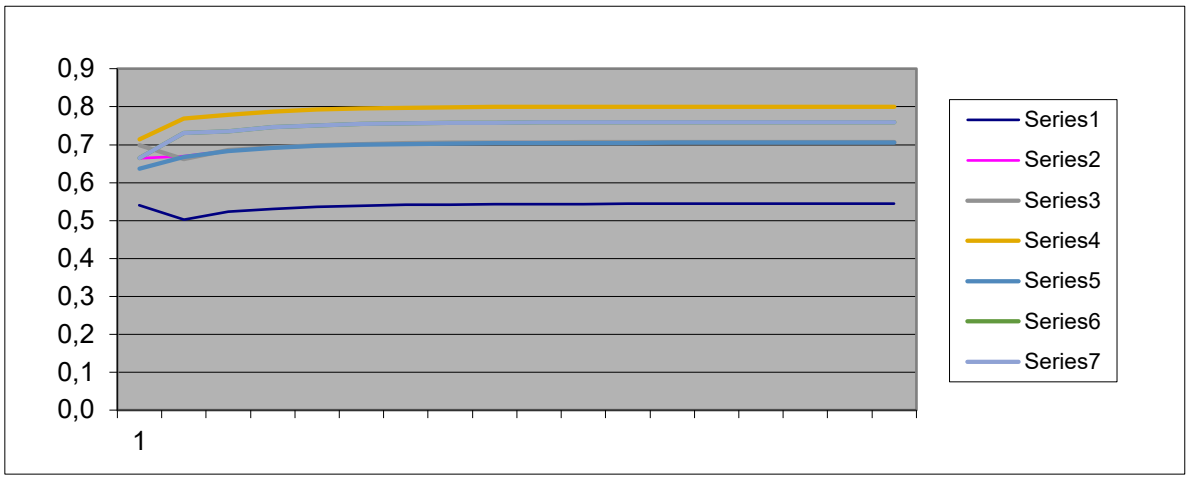

Figure 3. Result of the simulation of scenarios.

In the case of the analyzed study, an order of the alternatives for the recommendations is obtained as follows:

$$R_4 \succ R_7 \succ R_3 \succ R_2 \succ R_5 \succ R_6 \succ R_1$$

From which it is determined that the recommendation issued by the method is:

$$R_4$$

4 Conclusions

From the development of the proposed research, a method was obtained to support decision making on the recommendation of museum rooms. The proposed method is based on a multi-expert multicriteria approach. The inference process is model by neutrosophics numbers.

The implementation of the method made it possible to obtain the added Neutrosophics Cognitive Map with the representation of the causal relationships on the museum rooms under study by identifying the degree of relevance of the visitors.

From the application of the system proposed in the case study it was possible to demonstrate the applicability of the method allowing the recommendation of museum rooms based on the set of criteria that are visitors' preferences.

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Critical success factors modelling in operational management and the recovery of overdue portfolio of the Babahoyo GAD in The Municipal Market May 4

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Abstract. This paper aims to study the situation of the recovery of the overdue portfolio of the Babahoyo Municipal Decentralized Autonomous Government (MDAG) in the municipal market "4 de Mayo". The problem consists in the difficulties arose in tax collection by the municipal government´s employees to this market. In the present investigation neutrosophic cognitive maps are applied to assess the relationship between every pair of causes of this problem. For the evaluation, we count on five experts' criteria. Because there exist some pairs of causes whose relationship are unknown, neutrosophic cognitive maps are used instead of the fuzzy ones, where symbol I denotes indeterminate relationships among them. Additionally, the Ishikawa Diagram is applied, which is a simple graphical way to represent the causes and effects of problems.

Keywords: neutrosophic cognitive map, recovery of overdue portfolio, neutrosophic graph, neutrosophic number, Ishikawa diagram.

1 Introduction

All Decentralized Autonomous Governments obtain liquidity from two ways of income, firstly by the collection of direct taxes and secondly by budgetary appropriation from the State. Thus, at the moment that the MDAG has a high index of past due portfolio of taxes, either for property, for occupancy rates of the municipal markets modules, or for different concepts collected by the municipality, its liquidity decreases and also falls into dependence on the State to make payments for current expenses such as remuneration.

Municipality is an institution that is in charge of meeting the requirements that come from the community, and the collection of public resources aims to sponsor the continuous improvement in order to meet the needs of citizens. Its attention focuses on the timely collection of municipal taxes, carried out by the Municipal Treasury Department.

The municipal tax collection procedure is directly responsible for the compilation of public resources that will be invested for the community works benefit. It is essential that the collection process for the modules of the municipal market "4 de Mayo", which the Treasury Department of the Babahoyo MDAG is in charge, made some optimal and strategic changes.

Therefore, the level of municipality's commitment to address central problems that are related to the community and promote the development of Ecuador is highly compromising because they depend on the community's welfare in all its aspects.

Also, this project was aligned with the National Development Plan of Ecuador, since it is the direct duty of the municipalities to reorder the territory and redistribute the power, the money to solve the population's essential problems, as well as the merchants whom they sell their products in the different municipal markets, for which the municipality must have the necessary tools to chronologically describe all the processes for the modules collection of the municipal markets and thus avoid increasing the value of the past due portfolio value.

The recovery of the State, because of it acts in accordance with the general interests of the population, allows us to deepen the improvement in quality and warmth in the provision of public services. This improvement must be the result of a transparent, participatory, inclusive public management that articulates its management with the non-state, private and community public sphere. At present, the country has an institutionalized State with roles and competences assigned to each government level, whose public management during the last ten years has

contributed to the structural transformations in favour of the society. There exist considerable achievements in management, which must be strengthened, but there is always space to improve and, in some cases, amend courses of action taken.

This intervention includes, among others, the following actions:

• Efficient and effective public resources administration.
• Transparency of information and accountability.
• Decentralized management.
• Quality of public services from supply and demand.
• Provision of services with warmth.

Therefore, the collection procedures of the municipal markets should be improved, taking into account this emblematic intervention to renew these processes and thus provide a warmth service to the merchants when they immediately approach to cancel their securities due with the municipality, then these values will be used in the improvement of the municipal market.

The Babahoyo MDAG is in charge of executing the different steps for local development together with the State to improve the living conditions of the community including the merchants, for this end, it must collect the market tax values of 4 de Mayo's in a timely manner, to invest them in works to improve such market.

Given the fundamental need of the Babahoyo municipality to improve the processes that are carried out in the treasury area for the collection of the modules of the municipal market "4 de Mayo", the need arises to implement an operational management that details the processes to follow at the time of making the collection to the merchants of such market, which will reduce the level of overdue portfolio for this concept.

Briefly, our goal is to increase the level of recovery of the past due portfolio of the Babahoyo MDAG related to the municipal market "4 de Mayo". For this, we realize a study based on the Serrano's Bachelor thesis, see [1]. This kind of difficulties has aroused the interest of several researchers in Ecuador; see [2-7].

The technique used in this paper is the Neutrosophic Cognitive Maps. Cognitive maps were introduced by Axelrod, consisting in a directed graph; where each vertex represents a concept and every edge represents the causal relationship between two concepts, see [8][1]. Additionally, the edges are weighted with a value in the set {-1, 0, 1}, where 0 means there is not any relationship between the concepts; whereas, -1 represents that there exists an inverse relationship between them, and +1 that the relationship between them is direct. Later Kosko introduced the notion of Fuzzy Cognitive Maps, see [9], where the three precedent values of the weights are extended to the interval [-1, 1], to model the strength of the causal relationships.

The most recent approach to this subject are the Neutrosophic Cognitive Maps, which basically are fuzzy cognitive maps where symbol I is added to denote the representation of indeterminate relationships between the concepts, see [10-12]. Because experts cannot establish a relationship between some pair of concepts related to the studied problem, then, neutrosophic cognitive maps are used instead of fuzzy cognitive maps. The uncertainty is modeled aided by the values in [-1, 1].

We also include an Ishikawa Diagram, which is a simple graphical representation of the causes and the effect in the studied problem; see [13-15][2].

This paper is divided as follows; first the section of Materials and Methods contains the concepts of Neutrosophic Cognitive Maps and Ishikawa Diagram. The Results section is devoted to expose the solution of the problem here posed. Finally, we draw the Conclusions.

2 Materials and Methods

This section contains the main theories and methods used in this paper. The first subsection is dedicated to the Neutrosophic Cognitive Maps, whereas the second subsection is devoted to expose the definition of the Ishikawa Diagrams.

2.1 Neutrosophic Cognitive Maps

Neutrosophic logic extends the notion of fuzzy logic, where the semantic of a proposition P is described by a three-tuple <T, I, F>, each element representing truthfulness, indeterminacy and falseness, respectively.

A neutrosophic matrix is a matrix $A = (a_{ij})$, whose elements have been replaced by elements in $<R \cup I>$, where $<R \cup I>$ is the neutrosophic integer ring, i.e., the usual integer ring where it is added the symbol I and operations with it, see [16-17][3].

On the other hand, a neutrosophic graph is a graph in which at least one edge or one vertex is neutrosophic. If indeterminacy is introduced in cognitive mapping it is called a Neutrosophic Cognitive Map (NCM).

NCM are based on neutrosophic logic to represent uncertainty and indeterminacy in cognitive maps. A NCM is a directed graph in which at least one edge is an indeterminacy denoted by dotted lines. The static analysis methods in NCM can be read in [12]. The static analysis of NCM is based on neutrosopic numbers, see [16-17], where neutrosophic numbers has the form a+bI, where a and b are real numbers, and I = indeterminate.

A de-neutrosophication process was introduced by Salmeron and Smarandache in [18], where a neutrosophic number is associated with a real number. In the following we summarize the main measures used in the NCM adjacency matrix:

1. Outdegree ($od(v_i)$): is the row sum of absolute values of a variable in the neutrosophic adjacency matrix. It shows the cumulative strengths of connections (a_{ij}) exiting the variable.

2. Indegree ($id(v_i)$) is the column sum of absolute values of a variable. It shows the cumulative strength of variables entering the variable.

3. The centrality or total degree ($td(v_i)$), of a variable is the summation of its indegree (in-arrows) and outdegree (out-arrows), see Equation 1.

$$td(v_i) = od(v_i) + id(v_i) \quad (1)$$

The variables can be classified according to their values of Outdegree, Indegree and Total degree, as it is shown:

a) Transmitter variables have a positive or indeterminacy outdegree $od(v_i)$, and zero indegree $id(v_i)$.

b) Receiver variables have a positive indegree or indeterminacy $id(v_i)$, and zero outdegree $od(v_i)$.

c) Ordinary variables have both a nonzero indegree and outdegree. Ordinary variables can be more or less receiver or transmitter variables, based on the ratio of their indegrees and outdegrees.

A de-neutrosophication process gives an interval number for centrality. Finally the nodes are ordered.

The contribution of a variable in a cognitive map can be calculated by its degree of centrality, which shows how connected the variable is to other variables and what the cumulative strength of these connections are. The median of the extreme values is used, see Equation 2:

$$\lambda([a_1, a_2]) = \frac{a_1+a_2}{2} \quad (2)$$

We can rank the variables by the using Equation 3.

$$\text{Then } A \succ B \Leftrightarrow \frac{a_1+a_2}{2} > \frac{b_1+b_2}{2} \quad (3)$$

2.2 Ishikawa Diagrams

Ishikawa diagrams are due to the Japanese Professor Kaoru Ishikawa, and they were created as part of a group of techniques used to measure quality, see [13][4]. This graphic is also known fishbone diagram because of its shape. This diagram is still used in many fields to graphically represent an effect, its causes and their sub-causes.

Ishikawa diagram consists in a central line, divided in two sections. On the right the problem or the effect is represented, whereas, on the left, some transversal line point to the central line, each of them contains horizontal lines where a cause of the problem is written. At the same time, others lines can point to the line of causes representing sub-causes and so on.

This diagram permits a schematic visual representation of cause-effect representation. It is used in fields like to assist memory and retrieval of relevant medical cases from the medical literature, or for reducing radiator rejection, and in general to represent causes which produce a negative problem, see [14-15][5].

3 Results

To study the causes of the present problem we applied a poll to the population of 40 members of the staff of the Municipal Decentralized Autonomous Government of Babahoyo. Then, we identified the causes of the recovery of overdue portfolio, which are summarized in Table 1.

Cause			Effect
Internal and Financial	Internal and Managerial	External	Low level of recovery of Past Due Portfolio in the municipal market "4 de Mayo"
1. Inefficiency of the collection process.	4. Lack of documentation control.	9. Disagreement of merchants for operational management.	
2. Receipts collected and not discounted in the collection system.	5. Lack of collection policies.	10. Merchants do not go to the treasury department to update their data if required.	
3. Late accounts receivable.	6. Lack of procedures.	11. Little interest on the part of the merchants for the fulfillment of the payment obligations of the modules of the municipal market "4 de Mayo" of Babahoyo.	

	7. Lack of merchant classification. 8. They do not have an Operational Management that adequately performs the approval process for municipal market "4 de Mayo" of Babahoyo, amnesties, incentives.	

Table 1: Causes and effect in the recovery of overdue portfolio of the Municipal Decentralized Autonomous Government of Babahoyo in the market "4 de Mayo".

In Table 1, on the left we can see the causes classified in viz., "Internal and Financial", "Internal and Managerial" and External. The "Internal and Financial" factors consist in the causes related to internal deficiencies of the government having a financial nature, whereas the "Internal and Managerial" are also internal associated with organizational deficiencies. The External ones are negatives effects coming from the workers of the market "4 de Mayo", which is not directly controlled by the government. See that every cause is numbered from 1 to 11 and we use this numeration in the Ishikawa Diagram of Figure 1.

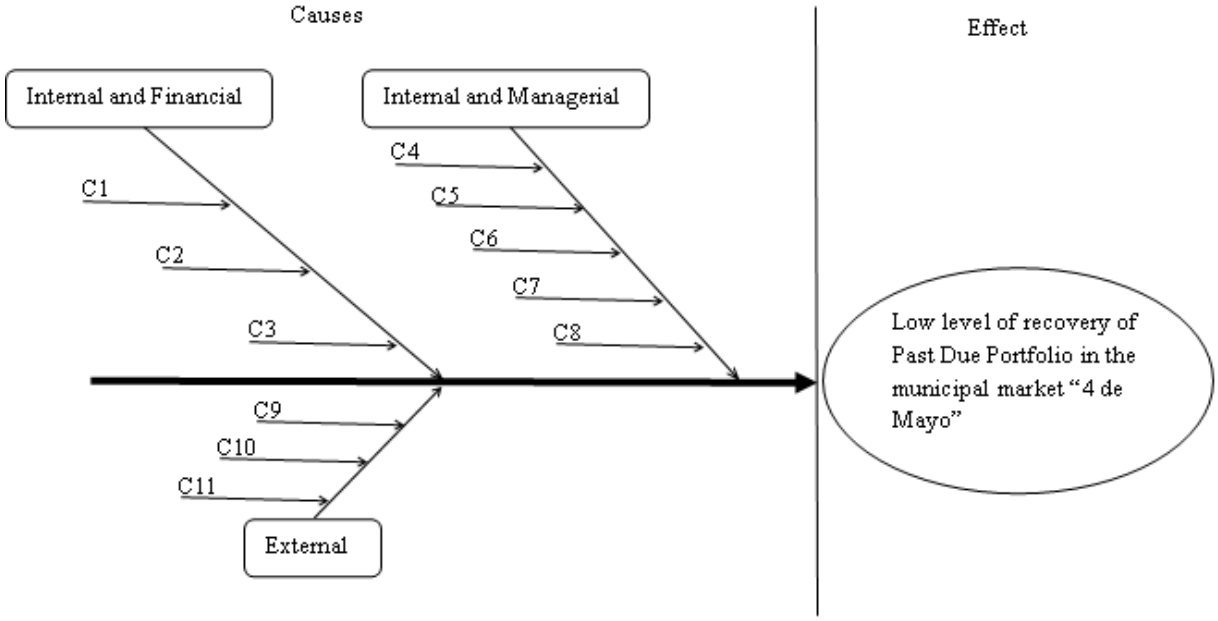

Figure 1: Ishikawa Diagram of the recovery of overdue portfolio of the Municipal Decentralized Autonomous Government of Babahoyo in the market "4 de Mayo". The number of the represented cause is taken from Table 1.

We considered that the Ishikawa Diagram is not sufficient to determine the nature of the problem. Thus, we studied the relationship among the causes by using Neutrosophic Cognitive Maps. For this, we count on five experts' assessment on the causal relationships for every pair of causes. In the following we detail the criteria of that assessment:

1. To establish a scale from 0 to 10 to assess the causal relationship between C_i and C_j, b_{ij}= 0 when "C_i does not implies C_j at all", b_{ij}= 10 when "C_i implies C_j for sure", and the others values in 1, 2,…, 9 represents intermediate degrees of causal relationships. Also, b_{ij}= I symbolizes that the causal relationship is indeterminate.
2. Every expert emits his (her) criterion for every C_iC_j edge, according to the scale described in point 1.
3. For every b_{ij}, we calculate the median of them respect to the five experts. When at least one expert evaluates b_{ij}= I, then the obtained median is substituted by I.
4. For every median obtained in the point 3, we calculate $a_{ij} = b_{ij}/10$. Moreover, a_{ij} = I if b_{ij} = I.

The results for applying the precedent algorithm can be seen in Table 2, where the adjacency matrix of the obtained neutrosophic cognitive map is summarized.

Vertex (v_i)	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
C_1	0	0	0	0	0	0	0	0	0.7	0	0
C_2	0.6	0	0	0	0	0	0	0	0	0	0
C_3	0.7	I	0	0	0	0	0	0	0	0	0
C_4	0.3	0.6	I	0	0	0	0.8	0	0	0	0
C_5	0.9	0.9	0.9	0.6	0	0	0	0	0.6	0	0
C_6	0.1	0.9	0.9	0.6	0.8	0	0	0	0.6	0.6	0
C_7	0.4	0.9	0.6	0	0.6	0.8	0	0	0.6	0	0
C_8	I	0	I	I	0	0.6	0	0	0.8	I	0
C_9	0	0	0	I	0	0	0	0	0	0.6	0
C_{10}	0.6	0	0.8	0	0.8	0	0.6	0	0	0	0
C_{11}	0.7	0	0.8	0	0.8	I	0	0	0	I	0

Table 2: Adjacency matrix of the Neutrosophic Cognitive Map.

The indegree, outdegree, total degree indexes, and also $\lambda(td(v_i))$ are calculated and they can be seen in Table 3. Additionally, the rank of every one the causes are situated in the last column.

Cause	$id(v_i)$	$od(v_i)$	$td(v_i)$	$\lambda(td(v_i))$	Ranking
C_1	0.7	4.3+ I	5.0+I	5.5	4
C_2	0.6	3.3+ I	3.9+I	4.4	7
C_3	0.7+I	4.0+2.0I	4.7+ 3.0I	6.2	3
C_4	1.7+I	1.2+ 2.0I	2.9+3.0I	4.4	7
C_5	3.9	3.0	6.9	6.9	1
C_6	4.5	1.4+I	5.9+I	6.4	2
C_7	3.9	1.4	5.3	5.3	5
C_8	1.4+4.0I	0.0	1.4+4.0I	3.4	10
C_9	0.6+I	3.3	3.9+I	4.4	7
C_{10}	2.8	1.2+2.0I	4.0+2.0I	5.0	6
C_{11}	2.3+2.0I	0.0	2.3+ 2.0I	3.3	11

Table 3: Indegree, Outdgree, Total Degree and Ranking results of every cause.

According to Table 3, variables 8 and 11, representing “They do not have an Operational Management that adequately performs the approval process for municipal market ‘4 de Mayo’ of Babahoyo, amnesties, incentives” and “Little interest on the part of the merchants for the fulfillment of the payment obligations of the modules of the municipal market ‘4 de Mayo’ of Babahoyo” respectively, are receivers, i.e., they are inferred from the other causes and they do not infer others. The rest of the variables are ordinary.

On the other hand, according to the ranking, C_5, C_6 and C_3 are the three most influential variables in this order, thus, the most important strategy to follow is to improve the procedures and collection methods by the functionaries of the municipal government.

Conclusion

The present investigation was dedicated to the study of the problems of collection by the municipal government of Babahoyo on the taxes coming from the municipal market “4 de Mayo”. For this end, the Ishikawa Diagram of causes-effect was obtained. The technique of neutrosophic cognitive maps was also applied to determine the variables that most influence the problem. We yielded that the three variables to which more attention should be paid are: “Lack of collection policies”, “Lack of procedures” and “Late payment of accounts receivable”, in that order. The authorities were informed about these results so that they can take the appropriate measures.

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Proposal of a neutrosophic index to evaluate the management of internal control

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Abstract. Corporate auditing is part of the necessary mechanisms to evaluate and monitor the practices being carried out in enterprises. It also allows for the timely correction of future trends that will damage the company. Internal control is part of these audits, where the company is internally analyzed, and is a highly recommended practice for both state and private companies. Evaluation of internal control presents some challenges, such as the presence of incomplete or contradictory information, as well as the importance of properly understanding and communicating what it is wished to study. This is why in this paper we propose an index to evaluate the internal control of a company, based on Single-Valued Neutrosophic Numbers (SVNN) and natural language. The advantage of this tool is that linguistic terms can be more easily used for assessing and better understood by the evaluated; also the indeterminacy that exists in any evaluation can be incorporated. To illustrate the use of this index, a case study is carried out in the internal control of the municipal public water company of Tulcán, Ecuador.

Keywords: Internal control, audit, neutrosophy, Single-Valued Neutrosophic Number.

1 Introduction

The audit is a monitoring and control tool that contributes to the creation of a culture of discipline in the organization and allows discovering failures in the existing structures or vulnerabilities in the organization. The audit is the evolution or upper stage of accounting that is practiced by public accountants and is defined as a systematic process to obtain and evaluate evidence objectively with respect to claims regarding acts or facts to determine the degree of compliance and to communicate the results to interested third parties, see [1].

Audit activity must be effective and efficient to generate added value to the organization in order to meet the risk hedging objectives to which that review is exposed, see [2].

The importance of having a good internal control system in organizations has increased in recent years, due to it is a practice where efficiency and productivity are measured at the time of planting them; especially if it focuses on the basic activities that are carried out, because it depends on maintaining reliable accounting, see [3].

Government internal control for public sector entities, recommended by the Ecuadorian governing body, is based on the integrated internal control framework issued by the Committee of Organizations Sponsored by the Treadway Commission (COSO), which sets out five interrelated and integrated components of the administration process, with the aim of helping entities achieving their objectives, see [4][1].

Internal control is a key factor in the achievement of the objectives of public or private organizations, whose responsibility in its application goes from the highest authority and it is related to all human talent. Internal control system, as quoted by Rivas in the paper "contemporary models of internal control" by Mantilla and Blanco, states that there are three generators ([5]): the first one is based on empirical actions of trial and error procedures; the second one is it has a legal bias that imposes structures and practices of internal control, especially in the public sector, there exists a distortion because it operates in the line compliance (formal) and far from the levels of quality (technical); the third is the current one that focuses efforts on the quality derived from positioning at the highest strategic and managerial levels, as a requirement that guarantees the efficiency of internal control ([5]).

Internal control is a useful tool by which the administration manages to ensure the orderly and efficient management of the company's activities, see [6]. It is important to note that the audit carried out by an auditor must be performed on the basis of selective tests and random sampling of the accounting and documentation records supporting those records, as well as of the important decisions (in his or her opinion) taken by management. The

extent and scope of such tests shall be determined by the nature of the process and by the strength or weakness of the internal control system, see [7].

This paper aims to propose an index to measure internal control. To do this we select the Single-Valued Neutrosophic Number (SVNN) as measurement tools, because of three characteristics of neutrosophy ([8-9]), the first ones is the modeling of the uncertainty, which it shares with other theories such as fuzzy sets of Zadeh ([10]), the second one is the explicit inclusion of the indeterminacy, and thirdly the possibility that provides for modeling with linguistic terms. The internal control measurement is performed by auditors who do not necessarily manage well numeric evaluation terms, however the use of linguistic terms would allow them to evaluate more easily, in addition they will better be understood by the evaluated personnel. Moreover, each evaluation has a certain degree of indeterminacy that is inevitable, due to contradictions, ignorance, inconsistencies among other characteristics; therefore the use of neutrosophic tools is justified in this research.

The paper has the following structure, a section where some criteria of internal control and the basic concepts of neutrosophy, which are used throughout this document are explained, as well as the proposed index is defined. The next section illustrates with a Case Study the application of this index in the internal control to the Municipal Public Water Company of Tulcán, Ecuador. The last section is devoted to conclusions.

2 Basic Concepts

This section describes the main concepts needed in this article. Subsection 2.1 contains the basic elements on internal control. Subsection 2.2 contains the definitions of Single-Valued Neutrosophic Numbers, the proposed index to measure internal control, among others.

2.1 Internal Control

Audit has three stages, viz., firstly the information collection phase, secondly, the analysis phase, and thirdly the decision-making phase ([11]). The Ecuadorian Government Auditing Standards set out three phases, namely, (1) planning, which has two processes, preliminary planning, which aims to determine the strategy to be followed based on the knowledge of the process that was audited, also that obtained from the audited department, its obligations and responsibility assigned by the management of the company in its statutes, and (2) the specific planning that is to define the strategy by determining the procedures to be carried out in (3) the execution phase of the audit., where, on the basis of compliance and substantive tests, evidence can be obtained that will be the basis of findings that are reported in the reporting and audit results phase.

The author in [12][2, 3] lists the responsibilities of the internal controls of the administration and the auditor. The administration is responsible for establishing and maintaining the internal controls that the entity requires and that the administration publicly reports on the effectiveness of the operation of those controls. In contrast, the auditor is responsible for understanding and verifying the effectiveness and efficiency of the internal control system, and the auditor should therefore prepare an audit report on the evaluation of the internal controls of the administration, including the auditor's opinion on the operational effectiveness of those controls.

The internal control audit under the management audit makes it possible to analyze efficiency and effectiveness, and in the investigated case is to determine compliance with previous recommendations and to assess how these were implemented in order to give a professional judgment to the enterprise departments as its own management.

The internal control audit before expressing an opinion must comply with the planning, control tests and results communication phases; where the planning consists of understanding the audited entity or process, its environment; the control components are necessary to investigate the administration, its procedures to observe and inspect and logically follow up the recommendations resulting from previous audits; the control tests must identify the procedures applicable in the circumstances to form an opinion and obtain sufficient and competent evidence regarding the controls that were operating during the audit period; and finally, the communication of results, which is the third phase that the auditor should report to manage any weaknesses detected in the internal control, in addition, to ensure that those responsible for this management are properly informed of the weaknesses found, the main goal of that report is to induce the entity to take necessary measures for the correction of the deficiencies and strengthen internal control.

The main criteria that should be evaluated in the internal control, according to COSO, are the following five:

1. Control Environment,
2. Risk Assessment,
3. Control Activities,
4. Information and Communication,
5. Monitoring Controls.

These criteria are defined as follows:

Control Environment: these are the criteria that set the pattern of the organization's functioning and its sensitivity to control.

Risk Assessment: processes developed by the company to identify, measure and manage the risks related to achieving the objectives.

Control Activities: policies, procedures, and control mechanisms aimed at the fulfillment of the objectives.

Information and Communication: these are the mechanisms that make it possible to have the appropriate information, in time and form, for the development of the responsibilities of the managers.

Monitoring Controls: it is the process of evaluating the quality of the internal control system by means of the evaluation monitoring activities.

It is appropriate to break down these five criteria into sub-criteria to be measured, because the evaluation is easier to perform, in this paper we propose the following sub-criteria ([13]):

1. Control Environment.
   - 1.1. Integrity and ethical values,
   - 1.2. Commitment to competition,
   - 1.3. Board of directors or audit committee,
   - 1.4. Philosophy and operating style of management,
   - 1.5. Organizational structure,
   - 1.6. Allocation of authority and responsibilities,
   - 1.7. Human resources policies and procedures.
2. Risk Assessment.
   - 2.1 Mission, objectives and policies,
   - 2.2. Process or activity level objectives,
   - 2.3. Risk identification,
   - 2.4. Risk estimation,
   - 2.5. Change management.
3. Control Activities.
   - 3.1. Identification of control procedures,
   - 3.2. Opposition of interests,
   - 3.3. Coordination of areas,
   - 3.4. Documentation,
   - 3.5. Defined levels of authorization,
   - 3.6. Adequate recording of transactions,
   - 3.7. Restricted access to resources, assets and records,
   - 3.8. Staff relationship in sensitive areas,
   - 3.9. Control of the information system,
   - 3.10. Information Technology Control,
   - 3.11. Performance indicators,
   - 3.12. Manual of procedures.
4. Information and Communication.
   - 4.1. Information and responsibility,
   - 4.2. Information flow,
   - 4.3. Integrated Information Systems,
   - 4.4. Flexibility to change,
   - 4.5. Commitment of the higher authority,
   - 4.6. Communication channels.
5. Monitoring Controls.
   - 5.1. Evaluation of the internal control system,
   - 5.2. Effectiveness of the internal control system,
   - 5.3. Validation of assumptions,
   - 5.4. Deficiencies detected.

2.2 Neutrosophic Approach

Definition 1. ([8-9, 14]) Let U be a space of points (objects), with a generic element in U denoted by x. A *neutrosophic set* A in U is characterized by a truth-membership function T_A, an indeterminacy-membership function I_A and a falsity-membership function F_A. $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard or nonstandard subsets of $]^-0, 1^+[$. It can be written as $A = \{< x, (T_A(x), I_A(x), F_A(x)) >: x \in U; T_A(x), I_A(x), F_A(x) \subseteq]^-0, 1^+[\}$. There is no restriction on the sum of $T_A(x)$, $I_A(x)$ and $F_A(x)$, thus, $^-0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3^+$.

Neutrosophic sets are useful in their nonstandard form only in philosophy, but not in technical applications, thus the *Single-Valued Neutrosophic Sets* are defined.

Definition 2. ([8-9, 14][4]) Let U be a space of points (objects), with a generic element in U denoted by x. A *Single-Valued Neutrosophic Set* (SVNS) A in U is characterized by a truth-membership function T_A, an indeterminacy-membership function I_A and a falsity-membership function F_A. $T_A(x)$, $I_A(x)$ and $F_A(x) \in [0,1]$. It can be written as $A = \{< x, (T_A(x), I_A(x), F_A(x)) >: x \in U; T_A(x), I_A(x), F_A(x) \in [0, 1]\}$.

There is no restriction on the sum of $T_A(x)$, $I_A(x)$ and $F_A(x)$, thus, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.
For convenience, a *Single-Valued Neutrosophic Number* (SVNN) is represented by (a, b, c), where a, b, c ∈ [0, 1] and $0 \leq a + b + c \leq 3$.

A linguistic scale can be associated with SVNN, here we propose the scale summarized in Table 1.

Linguistic term	SVNN
Extremely good (EG)	(1,0,0)
Very very good (VVG)	(0.9, 0.1, 0.1)
Very good (VG)	(0.8,0.15,0.20)
Good(G)	(0.70,0.25,0.30)
Medium good (MDG)	(0.60,0.35,0.40)
Medium(M)	(0.50,0.50,0.50)
Medium bad (MDB)	(0.40,0.65,0.60)
Bad (B)	(0.30,0.75,0.70)
Very bad (VB)	(0.20,0.85,0.80)
Very very bad (VVB)	(0.10,0.90,0.90)
Extremely bad (EB)	(0,1,1)

Table 1: Linguistic terms proposed in [9, 15] associated with SVNNs.

Definition 3. Let U be a universe of discourse, a space of points (objects) and *x* denotes a generic element of U. ***A*** is a *Single Valued Neutrosophic Aggregation Operator* (SVNAO) if it is a mapping $\boldsymbol{A}$: $\cup_{n \in \mathbb{N}} ([0,1]^3)^n \rightarrow [0,1]^3$.

One example of SVNAO is the *Weighted Average* operator (WA), see [16-17], which is shown in Equation 1.

$$WA(a_1, a_2, \cdots, a_n) = \sum_{i=1}^{n} w_i a_i \quad (1)$$

Where, $a_i = (T_i, I_i, F_i)$ are SVNNs and $w_i \in [0, 1]$ for every i = 1, 2, …, n; which satisfy the condition $\sum_{i=1}^{n} w_i = 1$. The a_is are the values obtained for the i^{th} alternative assessment, and w_i denotes the weight which represents the importance given to the alternative a_i or the expertise level who evaluates the alternative.

The index we propose here is based on a combination between WA and the evaluators ' assessment on the linguistic scale shown in Table 1, as detailed below:

1. The managers of the company, trained to carry out the evaluation are selected for each one of the five criteria. Let us denote them by $K = \{k_{11}, k_{12},\ldots,k_{1m1}; k_{21}, k_{22},\ldots,k_{2m2}; k_{31}, k_{32},\ldots,k_{3m3}; k_{41}, k_{42},\ldots,k_{4m4}; k_{51}, k_{52},\ldots,k_{5m5}\}$, where k_{ij} denotes the evaluator selected to evaluate the i-th criterion (i = 1, 2, …, 5) and the j-th rater (j = 1, 2, …, m_i). Two different notations can denote the same evaluator, when a specialist evaluates two different criteria for which he or she is trained.
2. It is denoted by $W = \{w_{11}, w_{12},\ldots, w_{1m1}; w_{21}, w_{22},\ldots, w_{2m2}; w_{31}, w_{32},\ldots,w_{3m3}; w_{41}, w_{42},\ldots,w_{4m4}; w_{51}, w_{52},\ldots, w_{5m5}\}$ the set of weights that are assigned to each evaluator with respect to each criterion, so that $\sum_{j=1}^{m_i} w_{ij} = 1$, for i = 1, 2, …, 5.
3. Each evaluator in K evaluates the internal control criterion assigned to him or her using the linguistic terms in Table 1. The procedure is the following:
   - If the i-th criterion is assigned to the j-th evaluator, he (she) evaluates each of the sub-criteria corresponding to i. Next, he (she) aggregates his (her) evaluations according to Equation 1, using identical weights for every sub-criterion. This will be the final evaluation of criterion i by the evaluator j.
   - The total assessment of criterion i is obtained by aggregating, using Formula 1 and weights w_{i1}, $w_{i2},\ldots, w_{imi}$ of all evaluations obtained for i in the previous point. This evaluation allows determining the state of the i-th criterion and itself is useful for internal control.
4. The final index is obtained by aggregating the indices calculated in the previous point and constitutes the final evaluation of internal control of the company. Again Equation 1 is used for this.
5. Each of the previous assessments are compared with the SVNNs in Table 1 by using Formula 2 as follows ([18]):

$$d(a,b) = \sqrt{\frac{1}{3}((T_a - T_b)^2 + (I_a - I_b)^2 + (F_a - F_b)^2)} \quad (2)$$

Where $a = <T_a, I_a, F_a>$ and $b = <T_b, I_b, F_b>$ are two SVNNs.

The linguistic term associated with the SVNN having the minimum distance in formula 2 is selected as the natural language evaluation of the criterion.

In case there is a tie between two values of Table 1, the worst of the two possible linguistic values in the table is selected.

3 Case Study

This research was carried out in the Company, Public Municipal Water and Sewer utilities of the city of Tulcán, Ecuador, in order to verify the compliance of the internal control standards that are of mandatory compliance in the public sector of Ecuador, norm 100-01 of the State General Controllership 2009 ([4]). It defines an integral process applied by the highest authority, management and personnel that provides reasonable security for the achievement of institutional objectives and the protection of public resources. It is oriented to comply with the legal, technical and administrative order, promote efficiency and effectiveness of the operations of the entity and guarantees the reliability and timeliness of the information, for this, it is essential to evaluate the reliability of internal control.

One evaluator per criterion was selected to evaluate the internal control. Thus, we have $K = \{k_{11}; k_{21}; k_{31}; k_{41}; k_{51}\}$ and $W = \{w_{11}; w_{21}; w_{31}; w_{41}; w_{51}\}$, where $w_{i1} = 1$, for i = 1, 2, 3, 4, and 5.

The obtained results of evaluation by every one of experts respect to every sub-criterion is summarized in Table 2, see that we denote the sub-criterion with the number used in the previous subsection, also, it can be seen the linguistic term and its associated SVNN, according to Table 1. Let us observe that the evaluation of the criteria are obtained aggregating the SVNNs of sub-criteria, according to Equation 1, whereas its associated linguistic term is selected with the criterion proposed in the fifth point of the method.

Sub-Criterion	Evaluation in form of linguistic term	Associated SVNN
1. Control Environment	**MDG** (dist = 0.02369)	**(0.58571,0.38571,0.41429)**
1.1.	MDG	(0.60,0.35,0.40)
1.2	MDG	(0.60,0.35,0.40)
1.3	M	(0.50,0.50,0.50)
1.4	M	(0.50,0.50,0.50)
1.5	G	(0.70,0.25,0.30)
1.6	G	(0.70,0.25,0.30)
1.7	M	(0.50,0.50,0.50)
2. Risk Assessment	**M** (dist = 0.028284)	**(0.48,0.54,0.52)**
2.1.	VVG	(0.9, 0.1, 0.1)
2.2	G	(0.70,0.25,0.30)
2.3	B	(0.30,0.75,0.70)
2.4	B	(0.30,0.75,0.70)
2.5	VB	(0.20,0.85,0.80)
3. Control Activities.	**MDB** (dist = 0.035358)	**(0.35833,0.66667,0.64167)**
3.1.	VB	(0.20,0.85,0.80)
3.2	VB	(0.20,0.85,0.80)
3.3	VB	(0.20,0.85,0.80)
3.4	VB	(0.20,0.85,0.80)
3.5	G	(0.70,0.25,0.30)
3.6.	G	(0.70,0.25,0.30)
3.7	B	(0.30,0.75,0.70)
3.8	G	(0.70,0.25,0.30)
3.9	B	(0.30,0.75,0.70)
3.10	B	(0.30,0.75,0.70)
3.11	B	(0.30,0.75,0.70)
3.12	VB	(0.20,0.85,0.80)
4. Information and	**G** (dist = 0.028868)	**(0.7,0.3,0.3)**

	Communication		
	4.1.	VVG	(0.9, 0.1, 0.1)
	4.2	VVG	(0.9, 0.1, 0.1)
	4.3	G	(0.70,0.25,0.30)
	4.4	B	(0.30,0.75,0.70)
	4.5	M	(0.50,0.50,0.50)
	4.6.	VVG	(0.9, 0.1, 0.1)
5.	Monitoring Controls.	**M** (dist = 0.059512)	**(0.55,0.425,0.45)**
	5.1.	G	(0.70,0.25,0.30)
	5.2	G	(0.70,0.25,0.30)
	5.3	MDG	(0.60,0.35,0.40)
	5.4	VB	(0.20,0.85,0.80)

Table 2: Experts' evaluation of the criteria and sub-criteria, using linguistic terms and SVNNs, *dist* represents the minimum distance between SVNN of the criteria and the SVNN associated with the linguistic terms in Table 1.

The final index of the internal control is obtained by means of Equation 1, aggregating the indexes of the five criteria; it is (0.53481, 0.46348, 0.46519). Thus, the internal control is evaluated as Medium (M) with dist = 0.035389.

Conclusion

This paper was dedicated to define a new neutrosophic index to measure the internal control of an enterprise. Moreover, we proposed a group decision method for Internal Control assessment. The advantage of the index is that inputs and outputs are linguistic terms, which is the most convenient way to measure by human beings, and also it is more comprehensible for the evaluated directives, thus, the reception of the evaluation is more natural. Additionally, to use the neutrosophy permits joining the indeterminacy that is typical in decision making. We illustrated the application of the index in the case study of the Company, Public Municipal Water and Sewer utilities of the city of Tulcán, Ecuador. We propose to code this method for being applied in real life internal controls.

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PESTEL analysis of environment state responsibility in Ecuador

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Abstract: The care and conservation of the environment is currently a task to ensure human survival. Various are the negative environmental impacts to which the planet is subjected. Quantifying the adverse events that the planet faces constitutes an activity little addressed by science. The present investigation describes a solution to the problem posed from the development of a method for environmental evaluation. It uses a multicriteria approach and models its inference by means of Neutrosophics Cognitive Maps.

Keywords: Method; Environmental evaluation; Neutrosophics Cognitive Maps.

1 Introduction

Environmental problems affect sustainable and ecologically sustainable development. These problems occupy the center of concerns in today's world. This is largely due to the fact that the environmental deterioration has reached very high levels. Currently it is necessary to think about the search for solutions, to help reduce the impacts caused by man in his nature-society relationship. The protection of the environment is one of the most important responsibilities of the society that works in entities, companies and in the community in general [1], [2], [3].

Environmental problems have changed the way we relate to the environment and society, making it clear those human beings is essential elements in the composition of the environment. Law as instrumental social science cannot afford to be oblivious to this problem that affects humanity to the point of compromising its existence in a mediated future.

The knowledge of environmental problems promotes individual and collective responsibility to face the ecological and social deterioration manifested in many underdeveloped countries. The search for sustainable development for all must be a worldwide government priority [4], [5], [6].

Ecuador is a country with 278,000 square km of surface and has 50 areas within the National System of Protected Areas. The biological diversity of Ecuador places it among the most important countries on the planet.

Ecuador has a privileged geographical location in the geotropic. Its varied relief and influence of sea currents converge to build the context of the most varied life forms of flora and fauna. The 49 existing protected areas comprise 19.1 million Hectares, which represents 19% of the total area of the country. It has 11 national parks, 9 ecological reserves, 6 biological reserves, 1 geobotanical reserve, 4 wildlife production reserves and 10 wildlife refuges [8], [9], [10].

Ecuador maintains an important interest in preserving the natural spaces that place it as one of the most diverse countries on the planet. The reasons are based on the fact that it is the first mega diverse country in the world, second in diversity of endemic vertebrates, third country in diversity of amphibians, fourth in diversity of birds and fifth in diversity of papillonic butterflies [11], [12], [13]. As an important part of social services, environmental protection constitutes a political interest in Ecuador to reduce the adverse effects listed above.

In Ecuador, the Constitution of the Republic, in its article 397 No. 4, provides that in order to guarantee the right of the population to live in a healthy and ecologically balanced environment, the state undertakes to ensure

the intangibility of protected natural areas , in such a way that the conservation of biodiversity and the maintenance of the ecological functions of ecosystems are guaranteed [14], [15], [16].

2 Preliminaries

This section of the research describes the set of elements that facilitates the understanding of the proposal from the theoretical point of view. It starts by addressing the environmental issue. The negative effects on the environment that climate change fosters are introduced. The Neutrosophical Cognitive Maps are characterized as an element of inference for the development of the present investigation. In addition, the theory of neutrosophics numbers is introduced.

2.1 Medio Environment

The environment is defined as a system of abiotic, biotic and social elements with which man interacts, while adapting to it, transforming it and using it to meet his needs. It must be conceived in its entirety, being part of it; the built, the personal and the collective; the economic, the social, the cultural, the technological, the ecological, the aesthetic, which demonstrates the integrality and what this term represents [17], [18].

Concern for environmental problems became evident in the mid-twentieth century, as a result of pollution caused by accelerated industrial development. The prevailing economic growth model had direct implications for environmental degradation and the impact of natural resources [19].

Preventing the environment from being mistreated implies ensuring its recomposition, repairing the effects caused and eliminating the causes that have caused its deterioration. This implies a high level of civil responsibility, which displays the legal treatment of environmental damage [17], [20]. In general, environmental damage is irreversible.

In the field of environment and ecosystem prevention is the starting point for environmental protection and a need for study and development, being considered as a guiding principle [21], [22]. The process that governs the implementation of activities aimed at preserving the environment and the quality of life of society is called environmental management [23].

Environmental management is a continuous process of actions that generates the definition of environmental sustainability policy, planning, action, review and improvement of the performance of a company. Environmental damages are mainly caused by the overexploitation of natural resources and the environmental degradation to which ecosystems are subjected.

2.2 Climate change

Climate change is considered as the biggest problem to be confronted by humanity. The United Nations framework convention on climate change to Paris defined climate change as the climate change that is directly or indirectly attributed to human activity that alters the composition of the world atmosphere and adds to the natural variability of the climate observed during periods of comparable time [24], [25].

Among the most analyzed consequences of climate change is the increase in greenhouse gases [26], [27], [28], the increase of the temperature, the decrease of the water resources, deterioration of the biodiversity, alterations in the agriculture and the vegetal cover and the contamination of the oceanic environments [29], [30]. Figure 1 shows an image that illustrates the negative effect of climate change on the environment.

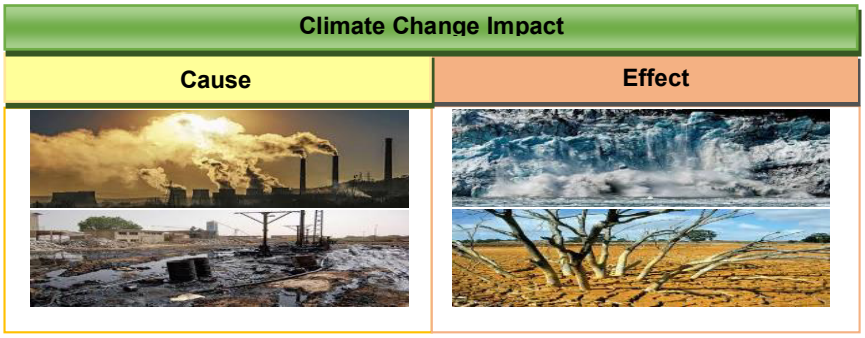

Figure 1. Negative effects of climate change on the environment

2.3 Fuzzy Cognitive Map

Causal modeling is useful for understanding the decision making process. Causality is generally seen as a precise relationship: the same cause always causes the same effect. But in the everyday world, the links between cause and effect are often imprecise or imperfect by nature [31], [32].

In many problems it is impossible to express the probabilities accurately to represent causation. One option in this scenario is to represent the degree of influence between one concept and another through diffuse logic using the Diffuse Cognitive Map (MCD) [33, 34].

DCMs are diffuse models with feedback to represent caution, they combine the theoretical tools of cognitive maps, fuzzy logic, neural networks, semantic networks, expert systems and nonlinear dynamic same line [35].

This technique allows modeling the system with feedback. In the diagram, each node represents a fuzzy set or event that occurs to some degree. With the use of this technique, the benefits of visual modeling, simulation and prediction are also obtained.

A DCM can be represented through a directed graph in which nodes represent concepts and arcs indicate causal relationship. The intensity of the causal relationship is represented by diffuse values. An adjacency matrix is used to represent the connectivity between nodes [36 , 37].

Scenario analysis contributes to the identification of different alternatives to reach a future state. It is a flexible strategic planning method frequently used in technology management [38, 39].

2.4 Neutrosophic Cognitive Map

Neutrosophy was proposed by Florentín Smarandache for the treatment of neutralities [40]. This has formed the basis for a series of mathematical theories that generalizes classical and fuzzy theories such as neutrosophical sets and neutrosophical logic. The original definition of truth value in neutrosophical logic is shown as:

N {(T,I,F):$T,I,F \subseteq [0,1]$}, in which: T, represents the degree of belonging. I, the degree of undefined. F, the falsehood.

What represents a neutrosophical evaluation, considered as a mapping of a group of propositional formulas to N, and for each sentence p to obtain the result through equation 1.

$$v(p) = (T, I, F) \quad (1)$$

Mathematically a Neutrosophic Cognitive Map (NCM) can be defined using a 4-tuple (C, W, A, f)

Where:

$C = \{C_1, C_2, C_3, \dots, C_N\}$ represents the set of graph concepts,

W: $(Ci\ , Cj\ ) \rightarrow wij$ is a function that associates a causal value wij with each pair of neurons $(Ci\ , Cj)$.

The values wij denote the direction and intensity of the edge that connects the concept Ci with the neuron Cj where the matrix of weights W defines the behavior of the system.

A: $(Ci\ ) \rightarrow Ai$ is a function that associates a degree of activation $Ai \in \mathbb{R}$ every concept Ci of the system, during the time t (t = 1,2, … , T). In addition, the map uses a function f: $\mathbb{R} \rightarrow [0,1]$ to maintain the degree of activation of each concept in the appropriate range.

3 Method for environmental assessment state responsibility

This section describes the method for environmental assessment. It bases its operation by Neutrosophic Cognitive Map. It nourishes its processing by means of static analysis with the objective of determining the most important nodes of the graph. This is achieved from the application of graph theory, specifically of centrality metrics.

While traditional relationships are appropriate to describe relationships such as inheritance. Diffuse sets are better at capturing relationships in which there are different degrees of belonging such as neighborhood. Figure 2 shows a general scheme with the operation of the proposed method.

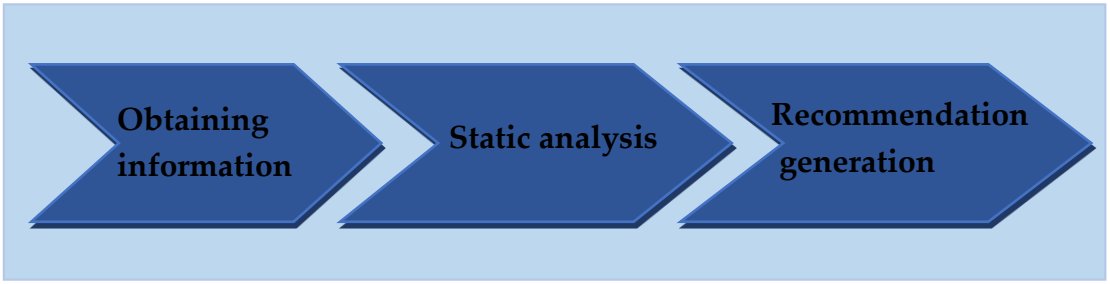

Figure 2. Scheme of the operation of the proposed method.

The proposed method is structured in three fundamental stages: Stage 1 obtaining information, Stage 2 implementation of static analysis, Stage 3 generation of recommendations. A description of the steps of the proposed method is given below.

Stage 1. Obtaining information:

The stage of obtaining the information consists in determining the environmental indicators that are evaluated. From which the assessment criteria on which the inference of the method is based are identified.

You must ensure that:

The criteria identified meet the condition expressed in equation (2).

$$C = \{C_1 ... C_n\} (n \geq 2) \tag{2}$$

The criteria domain C is finite.

Once the evaluation criteria have been determined, the causal relationships expressed on the evaluation criteria are determined. The causal relationships are expressed in the adjacency matrix representing the basis for the operation of the next stage of the method.

Stage 2 2. Static analysis:

The static analysis allows obtaining the causal conceptual centrality of the Neutrosophic Cognitive Map; it is obtained from the relationships expressed in the adjacency matrix. The modeled parameters are degree of output od, degree of input id and centrality C [41]. Using the equations (3, 4 and 5) the modeled parameters are obtained.

Degree of output obtained by the equation (3)

$$od_i = \sum_{i=1}^{n} \left\| I_{ij} \right\| \tag{3}$$

Degree of input obtained through the equation (4)

$$id_i = \sum_{i=1}^{n} \left\| I_{ji} \right\| \tag{4}$$

Centrality obtained through the equation (5)

$$C_i = od_i + id_i \tag{5}$$

Stage 3. Generation of recommendations:

Without losing generality, the inference process in an NCM can be defined mathematically using two components: a status vector $A_{1\times N}$ which represents the degree of activation of the map concepts, and a matrix of causal weights $W_{N\times N}$ which defines the interaction between neurons.

The following equation (6) summarizes this process, which consists in calculating the state vector A over time, for an initial condition A_0. Similarly to other neuronal systems, the activation of C_i the neurons that directly affect the concept will depend on the activation C_i and of the causal weights associated with said concept [22], [23].

$$A_i^{(t+1)} = f\left(\sum_{i=1;\, j\neq i}^{n} W_{ji} A_i^{(t)}\right) \tag{6}$$

Where:

$A_i^{(t+1)}$: it is the value of the concept C_i in the step t+1 of simulation.

$A_i^{(t)}$: it is the value of the concept C_j in the step t of the simulation.

W_{ji}: it is the weight of the connection which goes from the concept C_j to the concept C_i and f (x) is the activated function.

4 Method implementation through a case study in Ecuador

The proposal has been implemented in the social context in the Quevedo city of Ecuador. The environmental situation of the Quevedo Canton is not exceptional in terms of the deterioration exhibited by the remaining small cantons in the country. The main elements of the implemented method are described below.

Stage 1: Obtaining information.

During the process of obtaining information, scientific research methods were used from which environmental assessments were identified. Table 1 shows the criteria obtained.

Table 1. Evaluation criteria.

Criteria	Description
C_1	Natural resources with degradation
C_2	Deforestation by logging of primary forests
C_3	Biodiversity loss
C_4	Loss of water quality
C_5	Imbalance in the food chain - ecological
C_6	Soil erosion - sedimentation
C_7	Fragmentation - isolation of populations
C_8	Pollution (soil, air, water)
C_9	Species migration

With the use of a multi-expert approach, the causal relationships of the criteria presented are determined. For the process, three experts were consulted who issued their ratings. As a final result, the aggregate adjacency matrix shown in Table 2 was obtained.

Table 2. Adjacency matrix added.

	C_1T, I, F	**C_2 T, I, F**	**C_3 T, I, F**	**C_4 T, I, F**	**C_5 T, I, F**	**C_6 T, I, F**	**C_7 T, I, F**	**C_8 T, I, F**
C_1 T, I, F	[0, 0,0]	[0.25, 0.5,0.75]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.25, 0.25,0]	[0.5, 0.25,0]	[0.25, 0,0]	[0.25, 0,0]
C_2 T, I, F	[0.50, 0.25,0.75]	[0, 0,0]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]	[0.25, 0.25,0]	[0.75, 0.5,0.25]
C_3 T, I, F	[0.5, 0.25,0]	[0.50, 0.25,0.75]	[0, 0,0]	[0.5, 0.25,0]	[0.75, 0.5,0.25]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.25, 0.25,0]
C_4 T, I, F	[0.75, 0.5,0.25]	[0.25, 0.5,0.75]	[0.50, 0.25,0.75]	[0, 0,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]
C_5 T, I, F	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.50, 0.25,0.75]	[0, 0,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.25, 0.25,0]
C_6 T, I, F	[0.25, 0.25,0]	[0.5, 0.25,0]	[0.25, 0.5,0.75]	[0.5, 0.25,0]	[0.50, 0.25,0.75]	[0, 0,0]	[0.5, 0.25,0]	[0.5, 0.25,0]
C_7 T, I, F	[0.25, 0,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0.50, 0.25,0.75]	[0, 0,0]	[0.25, 0.5,0.75]
C_8 T, I, F	[0.5, 0.25,0]	[0.25, 0.5,0.75]	[0.25, 0.25,0]	[0.25, 0.25,0]	[0.25, 0.5,0.75]	[0.50, 0.25,0.75]	[0.25, 0.5,0.75]	[0, 0,0]

Stage 2: Static analysis implementation.

From the processing carried out of the adjacency matrix, the values of the static criteria Od, Id, C are obtained. Table 3 presents the result of the values obtained.

Table 3. Behavior of static analysis

Criteria	Description	id	od	c
C_1	Natural resources with degradation	3,00	2,50	5,50
C_2	Deforestation by logging of primary forests	1,75	3,75	5,50
C_3	Biodiversity loss	3,00	3,25	6,25
C_4	Loss of water quality	3,25	2,75	6,00
C_5	Imbalance in the food chain - ecological	3,25	2,50	5,75

C_6	Soil erosion - sedimentation	3,25	2,50	5,75
C_7	Fragmentation - isolation of populations	2,50	2,75	5,25
C_8	Species migration	2,50	2,25	4,75

The essential knowledge of the static analysis carried out of the evaluation criteria, expresses that the most preferred indicators are: Deforestation by logging of primary forests and y Biodiversity loss.

Stage 3: Generation of recommendations.

The stage obtains the values attributed to the weights of the criteria that represents the normalization of the values of the degree of output. Subsequently, the preferences on the case study being analyzed are obtained. This part of the process consists in determining the level of presence possessing the evaluative criteria in the Quevedo city of Ecuador. Once the values of the weights and preferences have been obtained, the process of aggregation of information is carried out.

The information aggregation process is carried out by means of the information aggregation operator (Ordered Weighted Averaging) OWA as expressed in equation (7).

$$F(a_1, a_2 .. a_n) = W^t B \tag{7}$$

Where:

W: it is the weight OWA vector associated with aggregation.

B: it is the ordered aggregate vector, where the jth largest component of B is b_j being this the jth largest of the a_i. Table 4 shows the result.

Table 4. The attributed weight to criteria.

Criteria	Weights	Preferences	Adding
C_1	0,1123	1	0,1685
C_2	0,1685	1	0,1460
C_3	0,1460	0.75	0,1235
C_4	0,1235	0.75	0,1235
C_5	0,1123	1	0,0842
C_6	0,1123	1	0,0842
C_7	0,1235	0.75	0,0842
C_8	0,1011	0.25	0,0252
Index			0.8394

From the above mentioned analysis of the data in Table 4, an incidence index of the environmental variables of a 0.83 can be identified, representing a high index of environmental deterioration over the exposed indicators.

Once the scenario simulation has been applied using equation (6), the results are presented in Figure 3.

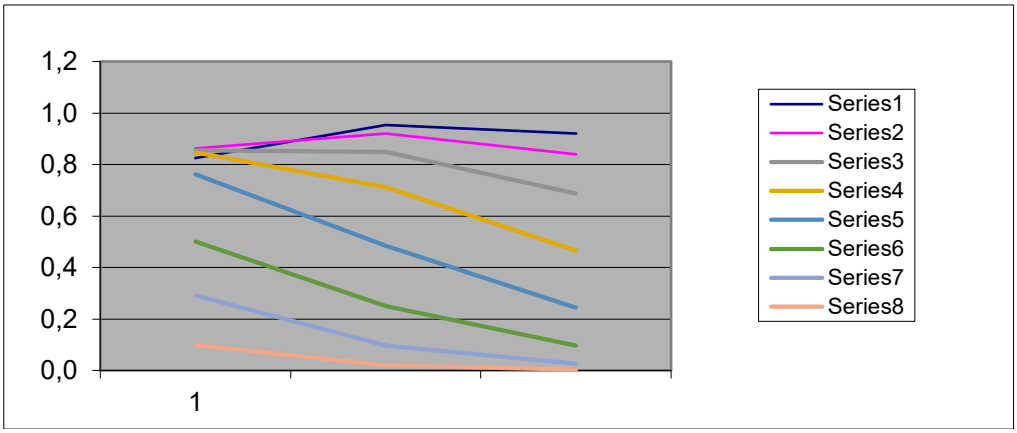

Figure 3. Result of the simulation of scenarios.

From the simulation result, a set of behaviors such as:

There is an increase in indicators over time. However, based on the strategies implemented, a recovery of different criteria is expected over time.

5 Conclusions

This research presented a method for the evaluation of environmental variables. The method used as an inference process the Neurosophical Congnitive Maps through a multicriteria approach. The proposed method obtained the set of causal relationships that relate the environmental variables from which the inference process of the proposed solution was generated. The proposal was implemented as a case study in the Quevedo city of Ecuador, from which an incidence index of the environmental variables of 0.83 was obtained according to the method considered high according to international standards.

Future work will concentrate on extending the model to group decision making allowing to taking into account multiples stakeholder point of views. Another area of work is in developing and integration to the of a consensus process to make decision making more reliable.

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Evaluating the acceptance level of the papillomavirus vaccine using a neutrosophic linguistic model

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Abstract. Human Papilloma Virus is a health problem for paying attention to. This is due to the consequences it can bring to infected peoples and the society. Thus, it is a privilege to have the vaccine that prevents children to get such disease. Particularly we propose in this paper to carry out a study of the approval level of the Human Papilloma Virus vaccine in the fiscal school "Bolívar" sited in Tulcán city, Ecuador. To achieve greater accuracy in this study it is applied the method of 2-tuples linguistic neutrosophic model, which is part of the Computing with Words. This tool allows obtaining results from the evaluation of the satisfaction of the respondents by means of linguistic terms, which is the most natural way of evaluation compared with the numerical one. There is also a numeric element that measures the accuracy of the result. The incorporation of neutrosophy allows the explicit inclusion of indeterminacy within what is evaluated, that results in a greater accuracy in the model with respect to the 2-tuples linguistic fuzzy method.

Keywords: Human Papilloma Virus, 2-tuple linguistic neutrosophic number, Computing with Words, linguistic model.

1 Introduction

According to the World Health Organization (WHO) the Human Papilloma Virus (HPV) is one of the most important causes of human morbidity and mortality, and is associated with sexual activity. HPV causes cervical cancer, ranks fourth among the most common cancers affecting women, with an estimated 266,000 deaths and some 528,000 new cases in 2012. The vast majority (about 85%) of these deaths occurred in the less developed regions, where it accounts for nearly 12% of all female cancers. Some countries have begun to vaccinate children, as the vaccine prevents different types of genital cancer in both men and women; in addition, one of the two available vaccines also prevents genital warts in both sexes. WHO recommends that girls between the ages of 9 and 13 be vaccinated, as this is the most cost-effective public health measure against this kind of disease, see [1-2].

MINSA-Peru, the Peruvian Ministry of Health ([3]) in the study report "Summary of Experience and Evaluation of the HPV Vaccine Test Project in Peru" evaluated acceptability through case studies to determine the conditions and contexts surrounding the decision to vaccinate and the determinants of HPV vaccine approval. The decision-making processes of parents and girls regarding HPV vaccination were diverse and complex in the cases studied during the program evaluation. The cases suggest that decision-making is not necessarily a linear process, but rather a process that varies in response to concerns and doubts about the effects and objectives of the HPV vaccine.

The case studies highlighted two stages in the decision regarding HPV vaccination. Parents refuse HPV vaccination because of concerns regarding the signed authorization requirement and adverse effects on girls. Educational efforts by teachers and health personnel, and information independently collected by parents and girls, resulted in most parents and girls accepting HPV vaccination.

Some studies have been found that the acceptability of the vaccine varies in relation to the socio-cultural and educational context, and promoting the vaccine to prevent a sexually transmitted infection in very young girls (<12 years) may create obstacles to its acceptability, it is recommended that it be promoted for the prevention of cervical cancer.

The purpose of this investigation is to identify the level of approval of the HPV vaccine by the parents of girls between 9 and 11 years old in the fiscal school "Bolívar" of the Tulcán city in Ecuador, and to generate information that will contribute to orient actions to achieve a greater coverage of vaccination and to protect through immunization a greater population against this disease and consequently to contribute to improve the conditions of health of the population.

This paper deal with decision support models based on neutrosophy ([4-6]), providing linguistic results that are easily interpretable. To this end, it is proposed that information be represented with linguistic values and operated on a 2-tuples linguistic model [7-10]. Thus, the mental models obtained are closer to the way of thinking of decision-makers.

Computing with words (CWW) is a methodology that permits a computation and reasoning process using words belonging to the language instead of numbers. This methodology allows creating and enriching decision models in which vague and imprecise information is represented by linguistic variables using words belonging to a natural language instead of numbers, see [11-15].

These processes have been carried out in fuzzy decision making using different models:

Semantic Model: operations are performed using fuzzy or fuzzy arithmetic.

Symbolic Model: the operations are carried out on the indexes of the linguistic labels.

Model based on the linguistic 2-tuple: it operates in a domain of linguistic expression, treating it as a continuous universe, gaining precision in the results. The use of the model based on 2-tuples has made possible to tackle Decision Making problems defined in complex contexts that the classical models could not, due to their limitations.

A classic statistical method could be used to determine the degree of acceptance of this vaccine, however, the final result would be given in the form of the percentage of respondents who give a specific answer to each question. Although this method is the most widely used for conducting surveys, it lacks the interpretability of the linguistic scale. Statistics can be very suitable for health specialists, who must finally interpret the results so that educators express it to the students in the form of linguistic terms, which is a more effective way of explaining this health situation.

On the other hand, Neutrosophic Statistics is a generalization of classical statistics ([16-18]), where for example the distributions that depend on numerical parameters are replaced by interval of parameters, the population or sample sizes are considered in an indeterminate interval, and so on. However, this generalization also lacks of interpretability.

Other concepts that combine statistics in decision-making in the neutrosophic environment are probability multi-valued neutrosophic sets (PMVNSs) ([19]), which are designed to solve problems of Multi-criteria group decision-making, where multi-valued neutrosophic sets ([20]) are combined with multi-criteria decision methods, as in [19]. In [21] the Frank operator is studied to solve problems of Multi-criteria group decision-making from Normal Neutrosophic Sets, where the three membership functions of neutrosophic sets correspond to functions of normal distribution, which provide to it statistical properties.

In [22] measures on the Probabilistic Neutrosophic Hesitant Fuzzy Sets are studied, which reduce unnecessary evaluation processes in decision-making.

Other concepts are based on linguistic calculations, especially those which use the Linguistic Neutrosophic Numbers ([23, 24]).

With the proposed method, linguistic interpretation is carried out directly and automatically. Another advantage that can be highlighted is the possibility of converting this method into a standard method for carrying out this type of study, which can be automated by means of friendly software, where only linguistic terms are entered as data and linguistic conclusions are also obtained.

This method is more accurate in two ways. In one sense the processed 2-tuples contain both, a linguistic term and a numerical value that reflects the accuracy of this linguistic term, this advantage is inherited from the original fuzzy method. On the other hand, the neutrosophic 2-tuples overcome the fuzzy ones in that not only one linguistic term, but three are taken into account, which makes the reached conclusion more accurate.

This paper have the following structure, section 2 contains the concepts and definitions essential to understand the results of this research. Section 3 presents the results obtained in the research. The last section is devoted to conclusions.

2 Basic Concepts

This section explains the main concepts related to 2-tuples linguistic models.

The 2-tuple linguistic representation model allows computation processes with words without loss of information, based on the concept of symbolic translation.

Let $S = \{s_0, s_1, \dots, s_g\}$ be a set of linguistic terms and $\beta \epsilon [0, g]$ a value in the granularity interval of S.

Definition 1. ([7-9]) The Symbolic Translation of a linguistic $terms_i$ is a number valued in the interval [-0.5, 0.5) which expresses the difference of information between a quantity of information expressed by the value $\beta \epsilon$ [0,g], obtained in a symbolic operation and the nearest integer value, $i \in \{0, \dots, g\}$ which indicates the index of the

nearest linguistic label (s_i) in S.

Based on this concept, a new model for the representation of linguistic information was developed, which makes use of a pair of values or 2-tuples. This representation model defines a set of functions that facilitate operations on 2-tuples.

Definition 2. ([7-9]) 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:

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

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

Where s_i is such that $i = \text{round}(\beta)$ and $\alpha = \beta - i, \quad \alpha \in [-0.5, 0.5)$ 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 numeric value in $[0, g]$.

In [10] the concept of 2-Tuple Linguistic Neutrosophic Number (2TLNN) is proposed to solve problems based on Single-Valued Neutrosophic Sets and 2-tuples linguistic sets (2TLSs).

A 2TLNN is defined as follows [10]:

Suppose that $S = \{s_0, \dots, s_g\}$ is a 2TLSs with odd cardinality t+1. It is defined for $(s_T, a), (s_I, b), (s_F, c) \in L$ and a, b, c $\in$[0, t], where $(s_T, a), (s_I, b), (s_F, c) \in L$ independently express the degree of truthfulness, indeterminacy, and falsehood by 2TLSs, then 2TLNN is defined as follows:

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

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

The scoring and accuracy functions allow us to rank 2TLNN [10].

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:

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

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

Definition 3. Given a 2TLNN, $l_j = \langle\left(s_{T_j}, a_j\right), \left(s_{I_j}, b_j\right), \left(s_{F_j}, c_j\right)\rangle$ (j = 1, 2,…, n) with vector of weights $w_i = (w_1, w_2, \dots, w_n)^T$ which satisfies the conditions $w_i \in [0, 1]$ and $\sum_{i=1}^{n} w_i = 1$, then the following two aggregation operators are defined, which are the Linguistic Neutrosophic Number-weighted arithmetic averaging (LNNWAA) and the Linguistic Neutrosophic Number-weighted geometric averaging (LNNWGA), respectively, [25]:

$$\text{LNNWAA}(l_1, l_2, \dots, l_n) = \sum_{j=1}^{n} w_j l_j = \langle s_{t - t\prod_{j=1}^{n}\left(1 - \frac{T_j}{t}\right)^{w_j}}, s_{t\prod_{j=1}^{n}\left(\frac{I_j}{t}\right)^{w_j}}, s_{t\prod_{j=1}^{n}\left(\frac{F_j}{t}\right)^{w_j}}\rangle \quad (5)$$

$$\text{LNNWGA}(l_1, l_2, \dots, l_n) = \prod_{j=1}^{n} l_j^{w_j} = \langle s_{t\prod_{j=1}^{n}\left(\frac{T_j}{t}\right)^{w_j}}, s_{t - t\prod_{j=1}^{n}\left(1 - \frac{F_j}{t}\right)^{w_j}}, s_{t - t\prod_{j=1}^{n}\left(1 - \frac{F_j}{t}\right)^{w_j}}\rangle \quad (6)$$

Decision-making is a discipline that has been approached from different perspectives, from the most classical such as philosophy, statistics, mathematics and economics, to the most recent ones such as artificial intelligence. The solution to a decision-making problem consists in the following steps:

- Defining the problem of decision making.
- Analyze the problem and identify the solution alternatives: $X = \{x_1, x_2, \dots, x_n\}$(n≥2).
- Establish the evaluation criteria.
- Select experts.
- Evaluate alternatives.
- Sort and select the best alternative.
- Implement and follow up.

When the number of criteria satisfies $C = \{c_1, c_2, \dots, c_m\}$ $(m \ge 2)$, it is considered a multi-criteria decision-making problem. When the number of experts is such that $K = \{k_1, k_1, \dots, k_n\}$ (n≥2) it is considered a group decision problem.

In this paper we propose a method to measure the acceptance of the papilloma virus vaccine. This is basically a multicriteria decision making solution to process linguistically the responses of the interviewed. In the following we describe what are the steps forming the proposed method.

Step 1. The respondents will be selected to conduct the assessment of their satisfaction with respect to the human papilloma virus vaccine. They are denoted by: $K = \{k_1, k_1, \dots, k_n\}$ $(n \geq 2)$. It is recommendable they are selected statistically, were a random sampling is used.

Step 2. Specify the scale of linguistic terms that will be used for evaluation. Every scale depends on the kind of answer. It is important that the set of possible answers have an odd cardinality, and we recommend including an indeterminate response, like "I don't know", "I don't care" or "Indifference". Specifically, here we propose the following questionnaire and linguistic scales:

- Q_1: Do you know about HPV infection?

Measured with the linguistic scale $S_1 = \{s_{10} =$ "Nothing", $s_{11} =$ "Very little", $s_{12} =$ "Little", $s_{13} =$ "More or less", $s_{14} =$ "Much"$\}$.

- Q_2: Do you know what the HPV vaccine protects against?

Measured with the linguistic scale $S_2 = \{s_{20} =$ "Nothing", $s_{21} =$ "Very little", $s_{22} =$ "Little", $s_{23} =$ "More or less", $s_{24} =$ "Very much"$\}$.

- Q_3: Do you know if HPV is related to cervical cancer?

Measured with the linguistic scale $S_3 = \{s_{30} =$ "No", $s_{31} =$ "Not sure", $s_{42} =$ "Yes"$\}$.

- Q_4: Education level of the interviewed

Measured with the linguistic scale $S_4 = \{s_{40} =$ "Low", $s_{41} =$ "Middle", $s_{42} =$ "High"$\}$.

- Q_5: Do you authorize the administration of the HPV vaccine to your daughter or tutored?

Measured with the linguistic scale $S_5 = \{s_{50} =$ "No", $s_{51} =$ "Not sure", $s_{52} =$ "Yes"$\}$.

Step 3. Aggregate the result for each criterion and all respondents, using Equation 7 with weights allotted equal to 1/n. This weight could vary if the sample is partitioned and some interviewed responses are considered more important than the others, nevertheless, in this research we judge everybody have the same weight.

$$WAO(l_1, l_2, \dots, l_n) = \langle s_{\sum_{j=1}^{n} w_j T_j}, s_{\sum_{j=1}^{n} w_j I_j}, s_{\sum_{j=1}^{n} w_j F_j} \rangle \quad (7)$$

This operator corresponds to the arithmetic mean ([7]). We used WAO instead of LNNWAA or LNNWGA, because this is associated with the statistic mean, taking into account we are calculating the result of review of a random sampling.

Step 4. Either the scoring or the accuracy functions are applied to evaluate the results, obtaining a unique 2-tuple value.

3 Results

This section summarizes the results of applying the survey to the parents of girls respect to the approval level of the HPV vaccine. We substituted the classical statistical analysis by a decision making approach where a linguistic terms scale is used.

With this investigation we prefer obtaining linguistic results from linguistic input values rather than numeric ones because natural language is more effective to express person's opinions. Additionally, neutrosophy permits more accurate calculations.

The questionnaire was applied to the parents of girls in the fiscal school "Bolívar" according to the details given in Table 1.

Respondent	Quantity	Percent
Mother	70	81
Father	12	14
Others	4	5
Total	86	100

Table 1: Respondents to the questionnaire.

The questionnaire to measure the criteria is the following:

Let us note that second indexes of every S_i elements are those used for calculation. We asked for the truthfulness, indeterminacy, and falseness of the answers in form of linguistic terms.

The final results are summarized in Tables 2-6.

Linguistic term	Number of answers for the first component	Number of answers for the second component	Number of answers for the third component
s_{10}	62	0	5
s_{11}	8	60	9
s_{12}	2	12	0
s_{13}	10	3	53

s_{14}	4	11	19

Table 2: Responses to the questionnaire for Q_1.

Linguistic term	Number of answers for the first component	Number of answers for the second component	Number of answers for the third component
s_{20}	72	0	3
s_{21}	0	72	11
s_{22}	0	0	0
s_{23}	10	4	72
s_{24}	4	10	0

Table 3: Responses to the questionnaire for Q_2.

Linguistic term	Number of answers for the first component	Number of answers for the second component	Number of answers for the third component
s_{30}	68	0	18
s_{31}	0	0	0
s_{22}	18	0	68

Table 4: Responses to the questionnaire for Q_3.

Linguistic term	Number of individuals	Percent
s_{40}	36	42
s_{41}	42	49
s_{42}	8	9

Table 5: Responses to the questionnaire for Q_4.

Linguistic term	Number of answers for the first component	Number of answers for the second component	Number of answers for the third component
s_{30}	74	11	10
s_{31}	3	0	0
s_{22}	9	75	76

Table 6: Responses to the questionnaire for Q_5.

Table 7 summarizes the result to aggregate the person's opinions for questions 1, 2, 3, and 5, using formula 75.

Question	Aggregated 2 –tuples corresponding to the first component	Aggregated 2 –tuples corresponding to the second component	Aggregated 2 –tuples corresponding to the third component
Q_1	(s_{11}, -0.32558)	(s_{12}, -0.40698)	(s_{13}, -0.16279)
Q_2	(s_{21}, -0.46512)	(s_{21}, 0.44186)	(s_{23}, -0.36047)
Q_3	(s_{30}, 0.11111)	-	(s_{32}, -0.41860)
Q_5	(s_{50}, 0.24419)	(s_{52}, -0.25581)	(s_{52}, -0.23256)

Table 7: Results of aggregating opinion's for questions 1, 2, 3, and 5.

Let us remark that in the proposed method, the arithmetic mean is used as an aggregation operator ([7]), which is an unbiased statistic used in classical statistics. In this investigation, a survey is carried out on 100% of the population of parents or guardians of the Fiscal Educational Unit "Bolívar" of the city of Tulcán, therefore it is sufficient to process the data within the descriptive statistics. For this reason, the arithmetic mean is used as the linguistic aggregation operator, instead of the LNNWAA and LNNWGA ([25]).

Table 8 contains the results for applying formula 3 to the components obtained in Q_1, Q_2, and Q_5, whereas formula 4 is applied to Q_3. The last column contains the name of the linguistic terms associated with the symbols on the left.

Question	Results of applying the score function or accuracy function	Linguistic term
Q_1	(s_{11}, 0.41473)	"Very Little"
Q_2	(s_{21}, 0.15116)	"Very Little"
Q_3	(s_{30}, -0.15676)	"No"
Q_5	(s_{50}, 0.24419)	"No"

Table 8: Results for applying the score function in Questions 1, 2, 3, and 5.

Thus, the majority of the inquired persons are mothers, they know very little about HPV infection, know very little what the HPV vaccine protects against, do not know if HPV is related to cervical cancer, the educational level is low or medium, and do not authorize the administration of the HPV vaccine to their daughters.

Conclusion

This paper was dedicated to study the evaluation of the parents and tutors' opinions about the use of the HPV vaccine to girls in the fiscal school "Bolívar" of the city of Tulcán in Ecuador. We used the 2-tuple linguistic neutrosophic model, hence, the input and output of the survey is evaluated on scales based on linguistic terms. Five questions were asked to 86 parents or tutors, most of them mothers. We can conclude that the results are negative, in general the parents and tutors consider not appropriate to vaccinate their girls, they do not know many important aspects of the HPV disease, and few of them have a high educational degree. We recommend increasing the educational work by the health personnel and teachers, [26, 27]. In future works we will take into account other operators described in the literature to carry out this type of study. However, with the proposed method, the main problem at hand was solved, which has a humanitarian and educational nature.

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Neutrosophic Iadov tecnique for assessing the proposal of standardization of the beef cutting for roasting in Patate canton, Ecuador

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Abstract. Meat is an important food for human consumption. Its consumption is associated with economic development, so that the more meat consumed, the higher the level of quality of life or index of wealth attributed to a population. This consideration has led, during the second half of the 20th century, to a greater consumption of meat. To prepare different dishes requires an adequate knowledge of cutting meat, so ignoring this aspect would be contradictory with gastronomy. In Ecuador, and particularly in the Patate canton, there is a lack of knowledge about the types of cuts that can be made with meat, in order to obtain favorable, appealing results and, in turn, make culinary art an art of excellence and quality. The objective of this work is to analyze the real situation of the knowledge of cutting meat, for a gastronomy of excellence and quality. To validate the results of the analysis that is carried out, the Iadov technique is used, and in particular the Neutrosophical Iadov is used, a technique that when using Neutrosophy provides accurate results and contributes to a greater interpretability of qualitative information, and in particular of linguistic terms, useful for decision-making support. Conclusions are presented that indicate how knowledge of cutting meat behaves, in the Patate canton of Ecuador and where emphasis should be placed to obtain a gastronomy of excellence and quality.

Keywords: beef cutting, beef quality, neutrosophic Iadov technique, single-valued neutrosophic number.

1 Introduction

In Ecuador, there is a high rate of meat consumption, gastronomic establishments and the population demand this product, however the difficulty is perceived, in restaurants, that the cuts of meat are mixed, which affects the quality of the final product To the consumer, in the Canton Patate, this situation is frequently and specifically evident with regard to the culinary, since when adequate cuts of meat are not established, they are not cooked properly, feeling their hardness when subjected to the cooking, which affects the profitability of the suppliers of these gastronomic sites.

The waste of meat due to its inadequate handling has a significant impact on the gastronomic economy and on the culinary art itself. In Cantón Patate, people do not know the types of cuts that can be made in meats, nor do they have sufficient knowledge of the temperature and terms necessary for their cooking, this ignorance affects the offers that are offered to customers in different gastronomic centers and affects that meat substitute products overshadow roasts.

Based on the aforementioned, in the present work it is emphasized in the cuts of beef, specifically, because in the Canton Patate, livestock is varied and its products are not sufficiently used, due to the existing ignorance of the cuts of beef from cattle. He reports [1] that in the Patate canton, the consumption rate of beef is high, as is the consumption of others. Gastronomic establishments and the population demand these products.

There is difficulty in the restaurants that offer roasts, which is accentuated in the cuts of meat that are not standardized and they do it in a mixed way, which affects the quality of meat products, causing confusion for consumers. In the Patate canton, the situation is exacerbated, due to the chef's inability to apply adequate cooking terms to meats with bad cuts, which causes a hard texture when cooked and its quality is affected.

"Quality is the set of characteristics of a product or service that satisfies the explicit or implicit wishes of the consumer" ([1]), in this regard the quality of the meat in the gastronomic centers of the Patate canton is expressed

in the tenderness of meat and its juiciness, which are considered important attributes that influence its sensory quality and consumer acceptability. Other factors such as the organoleptic and aesthetic physical conditions may also influence the degree of maturation, the attributes of the container and its ability to preserve the product.

The nutritional contribution, the freshness of the cut and the viability of the preparation, are reasons why it is important to study how to make high quality cuts of meat, so that they contribute to the acceptance and satisfaction of customers when they consume roasted preparations of meats. Other quality aspects to take into account are the age of the animal, sex, breed, food, the area where the piece comes from and the cut made are factors that affect the flavor of the meat, which sometimes It is varied, in the texture that affects the rating given to the meat.

On the other hand, the meat is classified, depending on the age, this can be veal, craving, ox, cow and bull and in some cases they are differentiated with some not excessively clear names, such as fattened and grazing calf, among others, [2]. Studies in this regard are evidenced by [3-5] [1].

Due to the existing problems in Canton Patate, the standardization of cuts of meat from cattle and other meats was recommended. Standardization according to [4], means specifying quantity, quality and procedure of the meat to achieve a suitable product.

The standardization of selected cuts of meat from beef cattle for roasts is carried out to ensure that establishments that distribute this type of cut have an adequate and quality procedure to ensure that they are the correct size and shape for distribution to different types of restaurants. and that they make a correct preparation when serving consumer preparations.

Once the standardization process was carried out, the satisfaction level of the suppliers of different gastronomic sites in the Canton Patate was evaluated, in order to analyze whether the proposed standardization of meat cuts is feasible and profitable for the gastronomic centers of the aforementioned Canton. The Neutrosophical Iadov technique is used to assess the level of satisfaction.

The Neutrosophical Iadov technique arises from the Iadov technique, which owes its name to its creator V. A. Iadov. Researchers have used it in different studies to study the level of user satisfaction in various contexts. Its extension to Neutrosophy has been used in different studies such as, for example, the studies of [6], [7], [10-15]

The fundamental basis of the technique consists of three closed questions interspersed in a questionnaire and whose relationship the respondent does not know and two open questions. Its objective is the assessment of the level of satisfaction according to what is known as the "Iadov logical table." The answer to these questions allows locating, according to the logical table, on a satisfaction scale, and then calculates the Group Satisfaction Index (ISG).

In the present investigation, it is used as a Neutrosophical Iadov, to analyze the level of satisfaction of the suppliers of different gastronomic sites in the Canton of Patate, in order to analyze whether the proposed standardization of cuts of meat is feasible and profitable for gastronomic centers. of said Canton. For this purpose, a questionnaire was designed with a specific internal structure that the interviewee does not know, [6-7].

The designed questionnaire was adapted to analyze the satisfaction of the suppliers of different gastronomic sites in the Canton Patate, in order to analyze whether the proposed standardization of cuts of meat is feasible and profitable for the gastronomic centers of the aforementioned Canton Patate. The internal structure of the questionnaire follows a relationship between three closed questions, the relationship between the closed questions is established through the so-called "Iadov Logic Graph".

The authors [8-12] and [2], use the Neutrosophical Iadov technique and incorporate indeterminacy which is treated by Neutrosophy, its main advantage lies in the possibility of responding with linguistic terms, instead of useful numerical values for obtain greater interpretability of qualitative information, and in particular linguistic terms, in order to obtain accurate results to support decision-making regarding the standardization of meat cuts and that suppliers obtain higher quality and profitability in gastronomic centers.

2 Neutrosophic Iadov technique

This section is dedicated to exposing the main definitions and procedures of the Neutrosophical Iadov technique. Iadov's technique is based on the processing of a survey designed to investigate the causes of a certain social phenomenon.

The designed survey has three closed questions and the answers are analyzed according to the satisfaction level assessment according to what is known as the "Iadov logical table." The interviewees do not know the relationship between the three questions, for the analysis of the present indeterminacy, (not defined) (I), some open questions are provided that are analyzed through a process of de-neutrosoficación as proposed by Salmerona and Smarandache [16-18]. In this case, I [-1,1].

Definition 1 ([13-14]) Let X be a universe of discourse, a space of points (objects) and x denotes a generic element of X. A *neutrosophic set* A in X is characterized by a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$, and a falsity-membership function $F_A(x)$. Where, $T_A(x)$, $I_A(x)$, $F_A(x) \subseteq]^-0, 1^+[$, i.e., they

are real standard or nonstandard subsets of the interval $]^{-}0, 1^{+}[$. These functions do not satisfy any restriction, that is to say, the following inequalities hold:

$$^{-}0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^{+}.$$

Definition 2 ([15-16]) Let X be a universe of discourse, a space of points (objects) and x denotes a generic element of X. A *Single Valued Neutrosophic Set* (SVNS) A in X is characterized by a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$, and a falsity-membership function $F_A(x)$. Where, $T_A(x)$, $I_A(x)$, $F_A(x)$: $X \rightarrow [0, 1]$ such that: $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$. A *single valued neutrosophic number* (SVNN) is symbolized by <T,I,F> for convenience, where T, I, F $\in [0, 1]$ and $0 \leq$ T+ I+ F≤ 3.

Therefore, $A = \{\langle x, T_A(x), I_A(x), F_A(x)\rangle : x \in X\}$ or more straightforwardly $A = \langle T_A(x), I_A(x), F_A(x)\rangle$, for every x$\in$X.

Let A and B be two SVNSs, the following operations are defined:

1. $A \subseteq B$ if and only if $T_A(x) \leq T_B(x)$, $I_A(x) \geq I_B(x)$ and $F_A(x) \geq F_B(x)$. Particularly, $A = B$ if and only if $A \subseteq B$ and $B \subseteq A$.
2. $A \cup B = \langle \max(T_A(x), T_B(x)), \min(I_A(x), I_B(x)), \min(F_A(x), F_B(x))\rangle$, for every x$\in$X.
3. $A \cap B = \langle \min(T_A(x), T_B(x)), \max(I_A(x), I_B(x)), \max(F_A(x), F_B(x))\rangle$, for every x$\in$X.

A scoring function $s: [0,1]^3 \rightarrow [0,3]$ is defined in Formula 1, thus, an adapted scoring function in [9] is used to sort the alternatives.

$$s(a_j) = 2 + T_j - F_j - I_j \quad (1)$$

Where a_j is an alternative evaluated with the SVNN (T_j, I_j, F_j).
The definition of precision index is given in Equation 2.

$$a(a_j) = T_j - F_j \quad (2)$$

Where $a: [0,1]^3 \rightarrow [-1,\ 1]$.
We prefer to score the options according to precision with Equation 2.

Definition 3. The *Neutrosophic Logic* (NL) is the generalization of the fuzzy logic, where a logical proposition P is characterized by three components:

NL(P) = (T,I,F) (3)

Where the neutrosophic component T is the degree of truthfulness, F is the degree of falsehood, and I is the degree of indeterminacy ([17]).

Based on the aforementioned concepts, the individual satisfaction scale shown in Table 1 was used to measure the individual satisfaction of each respondent associated with a linguistic term. Observe that the scores are those used in [9].

Number	Expression	SVNN	Score (Precision function)
1	Clear satisfaction	(1, 0, 0)	1
2	More satisfied than dissatisfied	(1, 0.25, 0.25)	0.75
3	Not defined	(0.5, 0.5, 0.5)	0
4	More dissatisfied than satisfied	(0.25, 0.25, 1)	-0.75
5	Clear dissatisfaction	(0,0,1)	-1
6	Contradictory	(1,0,1)	0

Table 1: Individual satisfaction scale.

Fuzzy aggregation operators are used to solve group decision problems; this concept can be extended to the neutrosophical framework. Neutrosophical aggregation operators are formally defined in definition 4 they are used in the present work to analyze the results of open questions and in particular when using the De-neutrosofication process to treat indeterminacy.

Definition 4 Let X be a universe of discourse, a space of points (objects) and x denotes a generic element of X. $\boldsymbol{A}$ is a *Single Valued Neutrosophic Aggregation Operator* (SVNAO) if it is a mapping
$\boldsymbol{A}$: $\cup_{n \in \mathbb{N}} ([0,1]^3)^n \rightarrow [0,1]^3$.

One example of SVNAO is the *Weighted Average* operator (WA), which is shown in Equation 4.

$$WA(a_1, a_2, \cdots, a_n) = \sum_{i=1}^{n} w_i a_i \quad (4)$$

Where, $a_i = (T_i, I_i, F_i)$ are SVNNs and $w_i \in [0, 1]$ for every i = 1, 2, …, n; which satisfy the condition $\sum_{i=1}^{n} w_i = 1$. The a_is are the values obtained for the i^{th} alternative assessment, and w_i denote the weight which represents the importance given to the alternative a_i.

The Weighted Average operator was used in [8] like an index of agreement, it was called Group Satisfaction Index (GSI).

Briefly, the proposed neutrosophic Iadov technique consists in the following steps:

1. Each interviewed person says his or her criterion for every of the three closed questions, according to Table 1. The only three possible answers for questions 1 and 2 are either, "Yes", "I don't know" or "No". The third question has six possible answers, namely, "Very satisfied", "Partially satisfied", "I don't care", "More unsatisfied than satisfied", "Not at all satisfied", and "I don't know what to say".
2. For each triplet of answers given by each interviewed, one answer per question, a number in Table 1 is taken from the intersection cell, with values ranged from 1 to 6.
3. The number obtained in the previous step is selected in the first column of Table 1. It is associated to its corresponding SVNN, in the second column of the table.
4. Every person's opinion is associated with an importance weight, $w_i \in [0, 1]$ for every i = 1, 2, …, n; which satisfy the condition $\sum_{i=1}^{n} w_i = 1$. This step is necessary when the opinion is given by experts and the expertise level will be taking into account. Otherwise, it is recommendable to assume $w_i = \frac{1}{n}$ for every i = 1, …, n.
5. The person's opinions are aggregated using the Weighted Average operator defined in Equation 4, it is the GSI.
6. Calculate *a*(GSI).
7. Calculate the closest score to *a*(GSI) from those appeared in the last column of Table 1. When *a*(GSI) is equally closest to two different values, the selection is made by means of the score function given in Equation 1.
8. In case that the final score is 0, which means not defined or contradiction, the final criterion is obtained from the answers given to the open questions.

The questionnaire is supported in the "Iadov Logic Chart" represented in Table 2.

	1. Question 1								
	No			I don't know			Yes		
3. Question 3	2. Question 2								
	Yes	I don't know	No	Yes	I don't know	No	Yes	I don't know	No
Very satisfied.	1	2	6	2	2	6	6	6	6
Partially satisfied.	2	2	3	2	3	3	6	3	6
I don't care.	3	3	3	3	3	3	3	3	3
More unsatisfied than satisfied.	6	3	6	3	4	4	3	4	4
Not at all satisfied.	6	6	6	6	4	4	6	4	5
I don't know what to say.	2	3	6	3	3	3	6	3	4

Table 2: A generic logic table by V.A. Iadov to measure the relationship among the three closed questions.

3 Results

This section is devoted to show the results of applying the neutrosophic Iadov technique to analyse the problem of standardization of the beef cutting for roasting in Patate canton. For this, 53 owners and chefs of roast restaurants, and culinary specialists were asked about the quality of the roast beef cutting in the restaurants of the canton. The questions were the three following:

1. Do you consider that there is a good training in the restaurants of meats or barbecues that offer different types of fine cuts on your menu?
2. Do you think that the elaboration and socialization of the standardization sheet of fine cuts - which includes weight, temperature, dishes in which the different cuts are used - will be effective for leveling in all places and to establish the proper way to offer them?
3. How do you assess your satisfaction about the quality of dishes with fine cuts in roast restaurants and barbecues in Patate canton?

Additionally, we applied a survey from the viewpoint of the customers. The sample consisted in 373 citizens of the Patate canton, aged form 17 to 55 years old. The three questions were the following:

1. Do you know the different kinds of beef cuttings?
2. Do you have visited restaurants with a menu containing roasted beef in Patate canton?
3. How do you assess your satisfaction respect to the service in the visited restaurants about the roasted beef?

Tables 3 and 4 are the Iadov's logic tables for the specialists and customers' opinions, respectively:

	1. Do you consider that there is a good training in the restaurants of meats or barbecues that offer different types of fine cuts on your menu?								
	Yes			I don't know			No		
3. How do you assess your satisfaction about the quality of dishes with fine cuts in roast restaurants and barbecues in Patate canton?	2. Do you think that the elaboration and socialization of the standardization sheet of fine cuts - which includes weight, temperature, dishes in which the different cuts are used - will be effective for leveling in all places and to establish the proper way to offer them?								
	Yes	I don't know	No	Yes	I don't know	No	Yes	I don't know	No
Very satisfied.	1(1)	2(1)	6	2	2	6	6	6	6
Partially satisfied.	2(7)	2(3)	3	2(3)	3	3	6(8)	3	6
I don't care.	3	3	3	3	3	3	3	3	3
More unsatisfied than satisfied.	6(4)	3	6	3(2)	4	4	3	4	4(6)
Not at all satisfied.	6(2)	6	6	6(9)	4	4	6	4(3)	5(4)
I don't know what to say.	2	3	6	3	3	3	6	3	4

Table 3: Iadov's logic table on the questionnaire applied to the specialists.

	1. Do you know the different kinds of beef cuttings?			
	Yes		No	
3. How do you assess your satisfaction respect to the service in the visited restaurants about the roasted beef?	2. Do you have visited restaurants with a menu containing roasted beef in Patate canton?			
	Yes	No	Yes	No
Very satisfied.	1(9)	6	6(2)	6
Partially satisfied.	2(67)	3	6(108)	6
I don't care.	3	3	3(2)	3
More unsatisfied than satisfied.	6(34)	6	3(51)	4
Not at all satisfied.	6(3)	6	6(8)	5
I don't know what to say.	2(12)	6(21)	6	4(56)

Table 4: Iadov's logic table on the questionnaire applied to the customers.

Let us observe that the numbers in parenthesis in Tables 3 and 4 correspond to the number of interviewed who answered to the corresponding responses. Let us note that Table 4 does not contain the term "I don't know" because it does not proceed according to the questions. Tables 5 and 6 summarize the results of service satisfactions given by specialists and customers, respectively.

Expression	Total	Percent
Very satisfied.	2	3.77%

Partially satisfied.	21	39.62%
I don't care.	0	0%
More unsatisfied than satisfied.	12	22.65%
Not at all satisfied.	18	33.96%
I don't know what to say.	0	0%

Table 5: Summary of the survey results applied to the specialists.

Expression	Total	Percent
Very satisfied.	11	2.95%
Partially satisfied.	175	46.92%
I don't care.	2	0.54%
More unsatisfied than satisfied.	85	22.78%
Not at all satisfied.	11	2.95%
I don't know what to say.	89	23.86%

Table 6: Summary of the survey results applied to the customers.

Thus, for the specialists along with Table 3 we obtain $a(\text{GSI}) = 0.014151$, whereas for the customers we calculated $a(\text{GSI}) = 0.070375$. Both results are slightly positive, in the interval (-0.5, 0.5). Let us classify these results by comparing with the scale in Figure 1, see [8],[3, 4] thus, they are contradictory or indeterminate. Nevertheless, experts consider these results are not good because there not exist negligible deficiencies in the quality of this kind of service, and to apply an open question survey is not necessary.

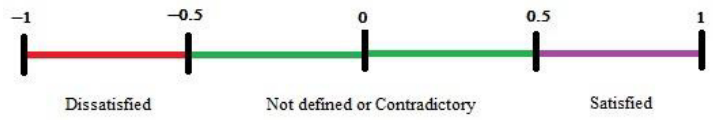

Figure 1: Scale of group satisfaction of the Iadov's technique.

Conclusion

In the article a study is made of the real situation of the knowledge of the cut of the meat, for a gastronomy of excellence and quality in the canton Patate of Ecuador, because the meat by its characteristics is an important food in the diet of the being human, its consumption allows economic development; Reason that for gastronomic ventures have good yields and excellent customer satisfaction, they must take into account the cuts of meat, when purchasing it and then offer them. The standardization of meat cuts is a useful tool that gastronomic entrepreneurs must know.

To analyze the satisfaction level of standardization of cuts of meat, in order to obtain greater profitability in gastronomic centers, the Iadov Neutrosófico technique was used, the results obtained are not considered good enough in terms of satisfaction of site providers of gastronomy of the Canton Patate, since the proposal of standardization of cuts of meat is unknown and, in turn, such ignorance affects the profitability of the gastronomic centers of the aforementioned Canton.

These conclusions were reported to restaurant owners and others related to this business with the aim of applying the necessary measures to improve the aforementioned situation. We propose to repeat this investigation once the necessary measures have been taken, to calculate the degree of evolution in this aspect of restaurants, barbecues and the rest of the gastronomic centers of the Patate canton of Ecuador.

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Neutrosophic causal modeling for analyzing the diffusion of the institutional culture: the case UNIANDES

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Abstract: The dissemination of culture is an activity assumed by teaching institutions. Knowing the cultural elements that characterize each nation allows to preserve the cultural heritage. However, quantifying this result represents a complex task to perform. This research proposes a solution to the problem posed with the design of a multicriteria method for the evaluation of cultural diffusion. The method uses neutrosophical numbers to model uncertainty. The proposal introduced the results in UNIANDES, Ibarra and it was found that it has a high rate of cultural diffusion.

Keywords: Diffusion of the culture; neutrosophic numbers; evaluation; multi-criteria.

1 Introduction

The culture encompasses all the contexts in which the life of an individual develops. For this reason, the institutional framework does not escape this fact. It is imperative, for the human species, to preserve and spread their culture. This allows transcending time to preserve roots and authenticity [1], [2].

Cultural diffusion is one of the three elements that make up heritage management (Research, Conservation / Restoration and Dissemination). Dissemination is a cultural Mediation Management between Heritage and Society [3].

There are several ways to transmit and preserve the culture. Attending to its versatility, immediacy, diversity and level of insertion in society; Information Technology and Communications (ICTs) is considered an ideal means for cultural dissemination [4], [5]. Under the guidance of the previous thought the investigation is developed [6], [7].

Knowing the level of cultural dissemination achieved by organizations represents a task little addressed by science. Based on the problem described above, it is proposed as the objective of the present investigation to develop a causal neutrosophic model for the analysis of cultural diffusion.

2 Preliminaries

This section describes the set of theoretical references necessary to facilitate the understanding of the proposal. ICTs are described in the context of cultural diffusion. Multicriteria methods are introduced in the context of the investigation. The Neutrosophic Cognitive Maps are characterized as an element of inference for the development of the present investigation. In addition, the theory of Neutrosophic numbers is introduced.

2.1 ICTs in the dissemination of culture

Currently, Information Technology and Communications (ICTs) are present in all areas of knowledge. That is why culture has also been an area in which its use has been introduced.

In the cultural context it is convenient to place the introduction of the concept of e-culture, which in principle is still one of many neologisms related to the new digital and technological paradigm that made fortune in a probably transitory way. Without intending to establish a canonical definition, it can be proposed that this concept applies to all cultural processes that are developed in studies through the network, in part or in its entirety.

Among the most used media to spread the culture are computers, televisions, portable players, radio, video games and Smartphone.

The computer: the contribution of this technology is practically unlimited. It reflects the trajectory of an institution. It can include the development of multimedia programs or educational games and the creation of computer tools such as web pages or wikis. The computer can also house digital documents, videos and images.

The television: allows the insertion of allegorical advertising spots to dates, events or relevant news of the institution that can be a way of spreading its culture. Using televisions in specific areas within the building occupied by the institution, a sequence of images, text and sound can be uninterruptedly projected for informational, advertising or dissemination purposes of specific aspects of the institution's internal life.

The portable player: contributes to the dissemination of informative audios, which can communicate a synthesis of the historical trajectory of the institution. It is useful in the history room or in spaces where elements of the entity's culture stand out, allow the results to be disseminated and that visitors or interested parties access that knowledge. In addition, it can help eliminate the language barrier by including audios in different languages.

The radio: represents one of the ideal ways to reach homes and thus raise awareness of relevant aspects about the institution, its achievements and its culture. In the same way, advertising spots related to dates, events or highlights of the institution can be used.

The game console: although it is a device used primarily by children and adolescents, it has the potential for cultural dissemination. Creativity and commitment could result in the development of educational games in which aspects of the institution's culture are discussed.

The Smartphone: a technology that has revolutionized the means of telephone communication. It provides almost all the functions of a computer, in a compact, agile and portable way. It is very present in the lives of individuals today. Its versatility allows it to be a synthesis of the previous technologies and incorporates them to a high degree. You can recreate the environment and scope of each of the above elements.

ICTs represent an important source for disseminating the cultural heritage of an institution representing an element to be measured by the institutions.

2.2 Diffuse Cognitive Map

The theory of Cognitive Maps allows to obtain a structure based on the most understandable knowledge. A cognitive map is characterized from a group of concepts and causal relationships between its nodes.The concepts represent variables that describe the system that is modeled in a specific domain.

Causal relationships denote connections between concepts. Each relationship has an associated sign that determines causal directionality. It is true that:

- If the sign of the connection is positive, then a variation in the concept of cause (initial concept) will cause a variation in the concept of effect in the same direction.
- • If the sign of the relationship is negative, then a variation in the concept of cause will cause a variation in the concept of effect in the opposite direction.

2.3 Neutrosophic classification

The neutrosophic groups are a blurred group generated. It let's being U an universe of speech, and M a group included in U[8], [9], [10].An element x of U is noted in respect of the set M as x(T, I, F). With the purpose of facilitating the application of a problem for making decisions and engineering is performed the proposal of the neutrosophic number of unique value (SVN)[11], [12], [13].

If **X** is a universe of speech. A SVN over X is an object of the way.

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\}d \quad (1)$$

Where $u_A(x): X \rightarrow [0,1]$, $r_A(x), : X \rightarrow [0,1]$ y $v_A(x): X \rightarrow [0,1]$ $with$ $0 \leq u_A(x) + r_A(x) + v_A(x) :\leq 3$ for everything $x \in X$.

The interval $u_A(x), r_A(x)$ y $v_A(x)$ denote the membership on true, I do not know and false of X in A, respectively. Number SVN will express as A= (a,b,c), where a, b, $c \in [0,1]$, y + b + $c \leq 3$.

2.4 Neutrosophic Cognitive Map

A Neutrosophic Cognitive Map (NCM) is defined using a 3-tuple for each node (T, I, F) for each concept$C = \{C1, C2, C3, \dots, CN\}$ that represents the set of graph concepts [14], [15], [16].

Where

W: $(Ci, Cj) \rightarrow wij$It is a function that associates a causal value wij with each pair of neurons(Ci, Cj). This value wij denotes the direction and intensity of the edge that connects the concept Ci with the neuron Cj where the matrix of weights W defines the behavior of the system [16], [17], [18].

From the algebraic point of view the propagation phase of a stimulus is reduced to successive multiplications of the state vector by the weight matrix, until a stop criterion is reached [19]. Therefore, a variation in a concept can directly or indirectly affect the entire map.

NCMs do not exploit the advantages of Fuzzy Logic in the information propagation process, rather these principles are used during the construction of the map. In this way the concepts and relationships of the map are represented by diffuse variables expressed as linguistic terms [20],[21], [22].

Given its recurring nature, the system modeled by an NCM will evolve over time, where the activation of each neuron will depend on the degree of activation of its background in the previous iteration. Normally this process is repeated until the system stabilizes or reaches a maximum number of iterations [23].

Equation (2) summarizes this simulation process, which consists in calculating the state vector A over time, for an initial conditionA_0. Similarly to other neuronal systems, the activation of Ci will depend on the activation of neurons that directly affect the concept Ci and the causal weights associated with that concept.

$$A_i^{(t+1)} = f\left(\sum_{i=1;\, j\neq i}^{n} W_{ji} A_i^{(t)}\right) \qquad (2)$$

3 Proposed model to assess cultural dissemination

The proposed model consists of three fundamental activities: Selection of dissemination profiles, evaluation of alternatives and generation of recommendations based on the selection of the knowledge base of the cultural diffusion similarity profile. The figure 1 shows a schema with the general performance of the suggested method.

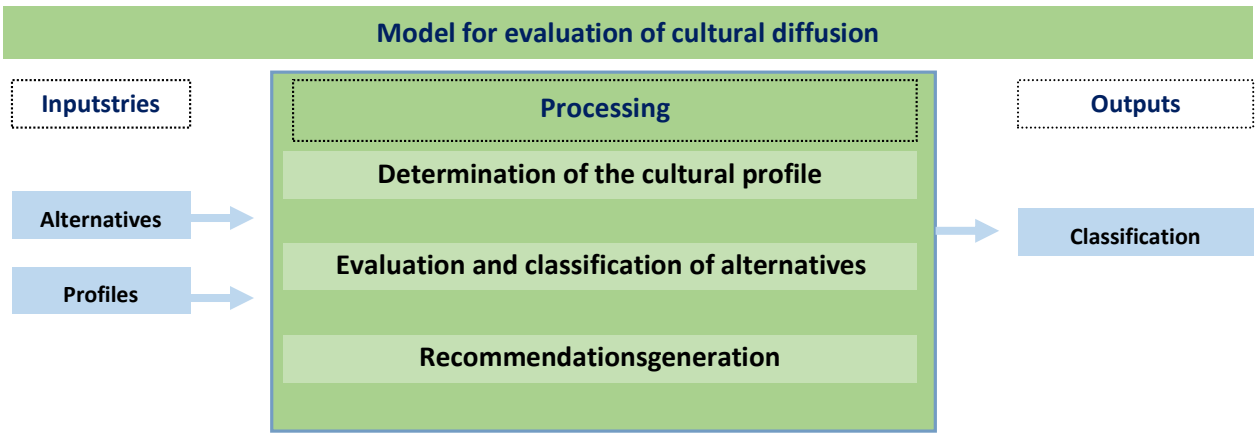

Figure 1. Main schema for performing the method.

In the following, it is presented the flow of works.

It is mainly based on the Cordon proposal as a recommendation`s system based on the knowledge, allowing to represent the linguistic terms and the indetermination by means of SVN numbers. The detailed description of each activity and the math model that support the proposal is presented below.

Activity 1. Determination of the cultural profile:

The creation of cultural profiles is expressed from the knowledge that institutions reflect on the object of study. Each alternative$a_i$will be described by a set of characteristics that will shape the cultural profile. As expressed in equation (3).

$$C = \{c_1, \dots, c_k, \dots, c_l\} \tag{3}$$

Once the evaluation criteria have been identified, the causal relationships between the manifestations are determined using a domain of values between [-1; 1], where 3 experts participated, the 3 Cognitive Neutrosophical Maps were obtained by adding the answers in a single result. Table 1 shows the adjacency matrix obtained as a result of the process.

Table 1: Resulting adjacency matrix

	$C_{1\,T,I,F}$	$C_{2\,T,I,F}$	$C_{3\,T,I,F}$	$C_{4\,T,I,F}$
$C_{1\,T,I,F}$	[0, 0,0]	[0.75, 0.5,0.25]	[0.5, 0.25,0]	[0.5, 0.25,0]
$C_{2\,T,I,F}$	[0.75, 0.5,0.25]	[0, 0,0]	[0.75, 0.5,0.25]	[0.75, 0.5,0.25]
$C_{3\,T,I,F}$	[0.5, 0.25,0]	[0.75, 0.5,0.25]	[0, 0,0]	[0.5, 0.25,0]
$C_{4\,T,I,F}$	[0.75, 0.5,0.25]	[0.5, 0.25,0]	[0.5, 0.25,0]	[0, 0,0]

From the behavior of the weights attributed to the alternatives and the development of the manifestations, the degree of belonging to a disease is determined through an aggregation process. Table 2 shows the result of the calculation performed.

Table 2: Weight attributed to the criteria.

Criteria	Weights of the nodes
C_1	0,1226
C_2	0,1515
C_3	0,1411
C_4	0,1351

This profile can be obtained in a direct way, beginning with the computing algorithms used to capture the institutions. Equation 4 describes the process of obtaining.

$$F_{a_j} = \{v_1^j, \dots, v_k^j, \dots v_l^j\}, j = 1, \dots n \tag{4}$$

The criteria of the institutions, a_i will be expressed using he linguistic scale S, $v_k^j \in S$ where:$S = \{s_1, \dots, s_g\}$, is a group of linguistic terms defined to evaluate the features C_k using the SVN numbers. For this, the linguistic terms to use, are defined. Equation 5 describes the process.

$$A = \{a_1, \dots, a_j, \dots, a_n\} \tag{5}$$

The profiles are saved in a database for the future recovering.

Activity 2. Evaluation and classification of alternatives:

In this activity is determined the information about institutions over the preference which are saved in the profile, such as:

$$P_e = \{p_1^e, \dots, p_k^e, \dots, p_l^e\} \tag{6}$$

The profile will be integrated by a group of attributes that caracterize the institutions:

$$C^e = \{c_1^e, \dots, c_k^e, \dots, c_l^e\} \tag{7}$$

Where:

$$c_k^e \in S \tag{8}$$

This one can be obtained by means of an example or the well- called conversational view and other examples that can be adapted.

Activity 3. Generation of recommendations:

In this activity, institutions are filtered according to the saved profile to find what or which are more appropriated according to the recent features.

With this purpose, it is calculated the similarity among institutions feature, P_e and each available profile aj registered in the database.

For calculating the whole similarities, it is used the following expression:

$$S_i = 1 - \left(\left(\frac{1}{3} \sum_{j=1}^{n} \left\{ \left(\left| a_{ij} - a_j^* \right| \right)^2 + \left(\left| b_{ij} - b_j^* \right| \right)^2 + \left(\left| c_{ij} - c_j^* \right| \right)^2 \right\} \right)^{\frac{1}{2}} \right) \quad (9)$$

The function S calculates the similarity among attributed values of the institutions profile and saved ones, ai.

Once, it is calculated the similarity among the institutions profile and saved ones in the database, each profile are organized according to the similarity obtained, representing by the following similarity vector.

$$D = (d_1, \dots, d_n) \quad (10)$$

The best recommendation will be ones that satisfy the needs of the institutions profile, that`s to say, which present more similarities.

4 Model implementation in a case study in UNIANDES, Ibarra

This section describes the implementation of the proposed method to evaluate cultural diffusion. For the application of the proposal, it is based on the set of data stored in the database on the behavior of the diffusion indicators of different institutions. The stored institutions have a set of patterns that are classified according to their level of diffusion. The classification on the stored data allows to determine the level of diffusion that the institutions possess.

A case study is applied in UNIANDES, Ibarra with the objective of determining the evaluation of cultural diffusion. Below is the demonstrative example used as a study house. It starts from the database it owns and executes the proposed method.

$$A = \{a_1, a_2, a_3, a_4, a_5\}5$$

Described by the group of attributes

$$C = \{c_1, c_2, c_3, c_{4,}, c_5\}$$

The attributes are valued in the following linguistic scale (table 3)

This valuation is saved to nurture the database.

Table 3. Linguistic terms used [24].

Linguistic terms	SVN number
(EB) Extremely good	(1,0,0)
(MMB) Excellent	(0.9, 0.1, 0.1)
(MB) Verygood	(0.8,0,15,0.20)
(B) Good	(0.70,0.25,0.30)
(MDB) So-so	(0.60,0.35,0.40)
(M) Media	(0.50,0.50,0.50)
(MDM) Awful	(0.40,0.65,0.60)
(MA) Bad	(0.30,0.75,0.70)
(MM) Very bad	(0.20,0.85,0.80)
(MMM) Very very bad	(0.10,0.90,0.90)
(EM)Extremely bad	(0,1,1)

The table 4 shows a view with the data used in the example.

Table 4. The database of the institutions profile.

	c_1	c_2	c_3	c_4
a_1	MMB	M	B	B
a_2	MB	B	MD	M
a_3	M	MMB	M	B
a_4	MB	B	MDB	B
a_5	MMB	MDB	M	B

If a institutions up wishes getting the recommendations of the system should provide information about his.

In Thais case:

$$P_e = \{\text{MB}, \text{B}, \text{MDB}, \text{M}\}$$

The following step in the example is calculating the similarity among the institutions profile and the saved ones in the database.

Table 5. Similarity among the institutions profile and saved profiles.

a_1	a_2	a_3	a_4	a_5
0.28	0.65	0.26	0.75	0.25

In the recommendation`s phase will be suggested such profile that match more with the institutions profile. An organization of the profile based on the comparison will be the following one.

$$\{a_4, a_2, a_1, a_3, a_5\}$$

In the case that the system suggests two closest institutions, these ones will be the recommendations:

$$a_4, a_2$$

The performance of the recommendations will provide the closest result to the comparative profile for such example and it is:

$$a_4$$

Beginning with the demonstration made, it is seen the usefulness of the proposal.

Specifically, thea_4, institution is valued based on compliance with cultural dissemination indicators as an institution of high level of dissemination.

5. Conclusions

The present work developed a method for the evaluation of cultural diffusion. It based its operation on a multi-criteria approach with the use of neutrosophic numbers.

The proposed method is applied in a case study with the objective of assessing its applicability. The case was implemented in UNIANDES, Ibarra. It was obtained as a result from the fulfillment of the indicators of cultural diffusion as an institution of high level of diffusion.

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NSS
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Prioritization internal factors in the emergency service of the “Luis Gabriel Dávila” Hospital that cause the re-entry of patients within 48 hours, based on neutrosophic DEMATEL

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Abstract. A high incidence of patient readmission in a hospital is a public health problem to consider. This investigation aims to address this problem at the "Luis Gabriel Dávila" hospital in the Province of Carchi, Ecuador, in its emergency area, where readmission incidence is considered in a time span of 48 hours. For this end, Neutrosophic DEMATEL method was used as the technique that studies the cause-effect relationships to allow decision-making in the problems solution of this type. Neutrosophic DEMATEL includes the modeling of indeterminacy due to the lack of information, or contradictory, paradoxical or inconsistent information. This paper uses a scale of linguistic terms, which is an advantage for experts to emit their criteria. A team of three experts is selected, who evaluated twelve factors related to this topic.

Keywords: patient readmission, Neutrosophic DEMATEL, single-valued trapezoidal neutrosophic number, single-valued triangular neutrosophic number.

1 Introduction

The present study was carried out in the Province of Carchi, Canton Tulcán, in the Hospital "Luis Gabriel Dávila" emergency area, where the high incidence of patient readmissions related to the complication and progression of the disease was evidenced. There is considered as objective, to implement intervention strategies on internal factors in the emergency service, thus contributing to risk factors reduction that occur at the time of admission to a hospital unit. When analyzing different investigations, it was confirmed that the personnel who works within the service believes that knowledge about the causes of patient readmission is limited, which creates a problem for their care; see [1].

Hospital readmissions represent a public health problem, given that they are due to complex relationships between health status and functionality, in-hospital care and management, interactions between the patient, his (her) family environment and the community; see [2-3].

It is very important to know that when analyzing readmissions, there is a need to have valid information on the quality of care, since this has led to the monitoring of various clinical indicators in other investigations that allow detecting failures in health systems related to hospital readmissions. In hospital emergency services, it has been proposed to use the ‘emergency return rate’ as an indicator of quality, along with others such as ‘voluntary discharge’, ‘mortality’ or ‘claims’.

When reviewing some current research, it is identified that the results were shown in proportion to the fact that hospital readmissions are frequent, potentially preventable, costly events associated with high morbidity and mortality. There exist few papers that have investigated the causes of hospital readmissions; the most classical is the publication in 1990 by Pierce et al., see [4][1], which classified its causes into 4 groups, viz.,

'related to the patient', 'the doctor', 'the health system' and 'the disease'.

Other authors have used a classification in three groups of causes: 'related to the patient', 'the doctor' and 'the disease'. Over the years, research on hospital readmissions has changed its approach and opened the way to new information; according to Caballero et al., see [5][2], they have described new factors associated with hospital readmissions, such as: hospital stay, severity of the disease, co-morbidities, number of pre-emergency or hospitalizations, male sex, being over 65 years and deficiencies in care.

In analyzing a research conducted in the United States, readmission policies, as well as clinical interventions to reduce them, have focused mainly on health plans, to improve the quality of care and solve the potential problems of patients, and others are increasingly committed to broad population-based strategies that will optimize the transitions of care and health of all people, regardless of their age.

According to the National Development Plan A Lifetime in Ecuador, Objective 1 indicates guaranteeing a dignified life with equal opportunities for all people. On the other hand, it mentions that health "is constituted as a fundamental component of a dignified life, since it has such a repercussion at the individual level and in the collective as well. The absence of it can bring inter-generational effects. This integral vision of health and its determinants urges to provide the conditions for the enjoyment of health in an integral manner, which includes not only physical but also mental health. The people's mental health requires significant attention to face growing problems, such as disorders related to depression and anxiety, which limit and condition the potential of a society for its development", see [6].

In Ecuador there exist few readmission publications and the impact they generate on resources and the provision of health services. This study aims to establish the main causes of hospital readmission, internal factors in the provision of services and improve the quality of care provided by health personnel within the emergency service. Integrating information from clinical-administrative databases of hospital care improves the ability to identify factors associated with an increased risk of patient readmission that could be used to propose strategies and a possible solution to the problem.

The mathematical model utilized to solve this problem is Neutrosophic DEMATEL. DEMATEL is a method consisting in a cause-effect matrix among a set of factors, containing the level of influence of each other, see [7-11]. A final matrix is obtained indicating the importance of every one of these factors, and also a causal diagram can be depicted to represent the weight of them. Neutrosophic DEMATEL is the neutrosophic approach to this method, where the indeterminacy is including for modelling by means of the single-valued trapezoidal neutrosophic number; see [12]. The single-valued trapezoidal neutrosophic number contains three membership functions, one representing truthfulness, a second one representing indeterminacy and a third one representing falseness, all of them having a trapezoidal shape, see [13][3].

In this paper we use a linguistic neutrosophic scale to measure the degree of influence of every pair of factors. This is an advantage, because natural language is more comprehensible for experts than a numeric one. Moreover, neutrosophic numbers are more accurate than fuzzy or fuzzy intuitionistic ones.

The present paper is divided as follows; the first section is devoted to expose the main concepts and the Neutrosophic DEMATEL method. Next, a section of Results shows the calculations we made to solve the problem, and finally, last section contains the conclusions.

2 Preliminaries

This section exposes the main definitions and the Neutrosophic DEMATEL method itself. The point of depart in the DEMATEL method is a cause-effect matrix containing the degree of influence of every factor over the others, provided by an experts' group. Particularly, Neutrosophic DEMATEL uses calculus based on single-valued trapezoidal neutrosophic numbers, see Definition 1.

Definition 1. ([13-15]) Suppose $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0,1]$ and $a_1, a_2, a_3, a_4 \in \mathbb{R}$, where $a_1 \leq a_2 \leq a_3 \leq a_4$.Then, a single-valued trapezoidal neutrosophic number $a = (a_1,a_2,a_3,a_4)$; $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}$ is a special neutrosophic set on the real line set $\mathbb{R}$, whose truth-membership, indeterminacy-membership and falsity-membership functions are defined as:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_4-x}{a_4-a_3}\right), & a_3 \leq x \leq a_4 \\ 0, \text{ otherwise} \end{cases} \quad (1)$$

$$I_{\tilde{a}}(x)=\begin{cases}\frac{(a_2-x+\beta_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1\le x\le a_2\\ \beta_{\tilde{a}}, & a_2\le x\le a_3\\ \frac{(x-a_2+\beta_{\tilde{a}}(a_4-x))}{a_4-a_3}, & a_3\le x\le a_4\\ 1, & \text{otherwise}\end{cases} \quad (2)$$

$$F_{\tilde{a}}(x)=\begin{cases}\frac{(a_2-x+\gamma_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1\le x\le a_2\\ \gamma_{\tilde{a}}, & a_2\le x\le a_3\\ \frac{(x-a_3+\gamma_{\tilde{a}}(a_4-x))}{a_4-a_3}, & a_3\le x\le a_4\\ 1, & \text{otherwise}\end{cases} \quad (3)$$

Where $\alpha_{\tilde{a}},\beta_{\tilde{a}},\gamma_{\tilde{a}}$ typify the maximum truth-membership degree, the minimum indeterminacy-membership degree and the minimum falsity-membership degree, respectively. A single-valued trapezoidal neutrosophic number $a=(a_1,a_2,a_3,a_4)$; $\alpha_{\tilde{a}},\beta_{\tilde{a}},\gamma_{\tilde{a}}$ may express an imprecise quantity of the range, which it approximately equals to the interval $[a_2, a_3]$.

Definition 2. ([13-15]) Let $\tilde{a}=\langle(a_1,a_2,a_3);\alpha_{\tilde{a}},\beta_{\tilde{a}},\gamma_{\tilde{a}}\rangle$; $\alpha_{\tilde{a}},\beta_{\tilde{a}},\gamma_{\tilde{a}}$ and $\tilde{b}=\langle(b_1,b_2,b_3);\alpha_{\tilde{b}},\beta_{\tilde{b}},\gamma_{\tilde{b}}\rangle$; $\alpha_{\tilde{a}},\beta_{\tilde{a}},\gamma_{\tilde{a}}$ be two single-valued trapezoidal neutrosophic numbers, and λ be any real number. Then we have the following operations:

1. Addition of two trapezoidal neutrosophic numbers:

$$\tilde{a}+\tilde{b}=\langle(a_1+b_1,a_2+b_2,a_3+b_3,a_4+b_4);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\rangle$$

2. Subtraction of two trapezoidal neutrosophic numbers:

$$\tilde{a}-\tilde{b}=\langle(a_1-b_4,a_2-b_3,a_3-b_2,a_4-b_1);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\rangle$$

3. Inverse of trapezoidal neutrosophic numbers:

$\tilde{a}^{-1}=\langle({a_4}^{-1},{a_3}^{-1},{a_2}^{-1},{a_1}^{-1});\alpha_{\tilde{a}},\beta_{\tilde{a}},\gamma_{\tilde{a}}\rangle$, where $a_1,a_2,a_3,a_4\neq 0$.

4. Multiplication of trapezoidal neutrosophic numbers by a constant value:

$$\lambda\tilde{a}=\begin{cases}\langle(\lambda a_1,\lambda a_2,\lambda a_3,\lambda a_4);\alpha_{\tilde{a}},\beta_{\tilde{a}},\gamma_{\tilde{a}}\rangle, & \lambda>0\\ \langle(\lambda a_4,\lambda a_3,\lambda a_2,\lambda a_1);\alpha_{\tilde{a}},\beta_{\tilde{a}},\gamma_{\tilde{a}}\rangle, & \lambda<0\end{cases}$$

5. Division of two trapezoidal neutrosophic numbers:

$$\frac{\tilde{a}}{\tilde{b}}=\begin{cases}\langle\left(\frac{a_1}{b_4},\frac{a_2}{b_3},\frac{a_3}{b_2},\frac{a_4}{b_1}\right);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\rangle, a_4>0 \text{ and } b_4>0\\ \langle\left(\frac{a_4}{b_4},\frac{a_3}{b_3},\frac{a_2}{b_2},\frac{a_1}{b_1}\right);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\rangle, a_4<0 \text{ and } b_4>0\\ \langle\left(\frac{a_4}{b_1},\frac{a_3}{b_2},\frac{a_2}{b_3},\frac{a_1}{b_4}\right);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\rangle, a_4<0 \text{ and } b_4<0\end{cases}$$

6. Multiplication of trapezoidal neutrosophic numbers:

$$\tilde{a}\tilde{b}=\begin{cases}\langle(a_1b_1,a_2b_2,a_3b_3,a_4b_4);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\rangle, & a_4>0 \text{ and } b_4>0\\ \langle(a_1b_4,a_2b_3,a_3b_2,a_4b_1);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\rangle, & a_4<0 \text{ and } b_4>0\\ \langle(a_4b_4,a_3b_3,a_2b_2,a_1b_1);\alpha_{\tilde{a}}\wedge\alpha_{\tilde{b}},\beta_{\tilde{a}}\vee\beta_{\tilde{b}},\gamma_{\tilde{a}}\vee\gamma_{\tilde{b}}\rangle, & a_4<0 \text{ and } b_4<0\end{cases}$$

The Neutrosophic DEMATEL analysis is explained as follows, see [12]:

Step1. Identifying decision goals: collecting relevant information presenting the problem.

1. Selection of experts and decision makers that have experience in the field.

2. Identifying the relevant criteria to the problem.

Step 2. Pair-wise comparison matrices between relevant criteria.

1. Identify the criteria, Criteria = (F_1, F_2, F_3,…, F_n).

2. Experts make pair-wise comparisons matrices between criteria.

a. Interpret each value for each criterion compared to other one in a trapezoidal neutrosophic number (l_{jk},m_{jkl},m_{jku},u_{jk}), j,k = {1,2,…,n}.

b. Make comparisons between criteria by each expert as shown in Table 1.

c. Focuses only on (n−1) consensus judgments using a scale from 0 to 1.

3. Experts should determine the maximum truth-membership degree (α), the minimum indeterminacy-membership degree (β) and the minimum falsity-membership degree (γ) of single-valued neutrosophic numbers as shown in Table 2.

4. Determine the crisp value of each opinion as shown in Table 3, using Equations 4 or 5:

Criteria	F_1	F_2	…	F_n
F_1	(l_{11},m_{11l},m_{11u},u_{11})	(l_{12},m_{12l},m_{12u},u_{12})	…	(l_{1n},m_{1nl},m_{1nu},u_{1n})
F_2	(l_{21},m_{21l},m_{21u},u_{21})	(l_{22},m_{22l},m_{22u},u_{22})	…	(l_{2n},m_{2nl},m_{2nu},u_{2n})
…	…	…	…	…
F_n	(l_{n1},m_{n1l},m_{n1u},u_{n1})	(l_{n2},m_{n2l},m_{n2u},u_{n2})	…	(l_{nn},m_{nnl},m_{nnu},u_{nn})

Table 1: The pair-wise comparison matrix between criteria.

Criteria	F_1	F_2	…	F_n
F_1	(l_{11},m_{11l},m_{11u},u_{11}; α_{11},β_{11},γ_{11})	(l_{12},m_{12l},m_{12u},u_{12}; α_{12},β_{12},γ_{12})	…	(l_{1n},m_{1nl},m_{1nu},u_{1n}; α_{1n},β_{1n},γ_{1n})
F_2	(l_{21},m_{21l},m_{21u},u_{21}; α_{21},β_{21},γ_{21})	(l_{22},m_{22l},m_{22u},u_{22}; α_{22},β_{22},γ_{22})	…	(l_{2n},m_{2nl},m_{2nu},u_{2n}; α_{2n},β_{2n},γ_{2n})
…	…	…	…	…
F_n	(l_{n1},m_{n1l},m_{n1u},u_{n1}; α_{n1},β_{n1},γ_{n1})	(l_{n2},m_{n2l},m_{n2u},u_{n2}; α_{n2},β_{n2},γ_{n2})	…	(l_{nn},m_{nnl},m_{nnu},u_{nn}; α_{nn},β_{nn},γ_{nn})

Table 2: The pair-wise comparison matrix between criteria with the α, β and γ degree.

Criteria	F_1	F_2	…	F_n
F_1	CV_{11}	CV_{12}	…	CV_{1n}
F_2	CV_{21}	CV_{22}	…	CV_{2n}
…	…	…	…	…
F_n	CV_{n1}	CV_{n2}	…	CV_{nn}

Table 3: The crisp values of comparison matrix.

Criteria	F_1	F_2	…	F_n
F_1	$\overline{CV}_{11}$	$\overline{CV}_{12}$	…	$\overline{CV}_{1n}$
F_2	$\overline{CV}_{21}$	$\overline{CV}_{22}$	…	$\overline{CV}_{2n}$
…	…	…	…	…
F_n	$\overline{CV}_{n1}$	$\overline{CV}_{n2}$	…	$\overline{CV}_{nn}$

Table 4: Integration of the average opinions of all experts.

$$S(\tilde{a}_{ij}) = \frac{1}{16}[a_1 + b_1 + c_1 + d_1](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \quad (4)$$

$$A(\tilde{a}_{ij}) = \frac{1}{16}[a_1 + b_1 + c_1 + d_1](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (5)$$

Step 3. Integration of matrices. All opinions of experts need to be integrated into one matrix presenting the average opinions of all experts about each criterion, as shown in Table 4 using Equation 6.

$$\overline{CV}_{lm} = \frac{\sum_{j=1}^{k} CV_{lmi}}{k} \quad (6)$$

Where k is the number of experts and CV_{lmi} is the crisp value in Table 3 corresponding to expert i. We

obtain the average for all values as in the matrix in Table 4.

Step 4. Generating the direct relation matrix.

This matrix is obtained from previous Step 3, i.e. the integrating of all averaged opinions of experts. An initial direct relation matrix A is a n×n matrix obtained by pair-wise comparisons, $S = [s_{ij}]_{n\times n}$. S_{ij} denotes the degree to which the criterion i affects the criterion j.

Step 5. Normalizing the direct relation matrix.

The normalized direct relation matrix can be obtained using the Equation 7 and 8:

$$K = \frac{1}{\max_{1\le i\le n}\sum_{j=1}^{n} a_{ij}} \qquad (7)$$

$$S = K \times A \qquad (8)$$

Step 6. Attaining the total relation matrix. The total relation matrix is acquired using the formula 9 from the generalized direct relation matrix S. A total relation matrix (T), in which 'I' denotes the identity matrix, is shown as follows:

$$T = S(I - S)^{-1} \qquad (9)$$

Step 7. Obtaining the sum of rows and columns.

The sum of rows of T is denoted by D, and the sum of columns is denoted by R. Calculate R+D and D-R. Calculate T, where $T= [a_{ij}]_{n\times n}$, i, j=1, 2… n.

$$D = \left[\sum_{i=1}^{n} a_{ij}\right]_{1\times n} = \left[a_j\right]_{n\times 1} \qquad (10)$$

$$R = \left[\sum_{j=1}^{n} a_{ij}\right]_{1\times n} = \left[a_i\right]_{n\times 1} \qquad (11)$$

Step 8. Drawing cause and effect diagram

The causal diagram is obtained by the horizontal axes is presented by (D+R) and the vertical axes (D−R) which is a degree of relation and it depicts the steps of proposed model.

Remark 1. Let us observe that we can reduce the complexity of the calculus if the single-valued trapezoidal neutrosophic numbers are converted to single-valued triangular neutrosophic numbers, where $a_2 = a_3$ in Equations 1, 2 and 3, see [16].

Additionally, we use the neutrosophic linguistic scale summarized in Table 5 to assess the criteria.

Linguistic Term	Single-valued triangular neutrosophic number
No influence (NI)	$\tilde{0} = \langle(0,0,0);0.50,0.50,0.50\rangle$
Very low influence (VLI)	$\tilde{1} = \langle(0,1,2);0.30,0.75,0.70\rangle$
Low influence (LI)	$\tilde{2} = \langle(1,2,3);0.80,0.15,0.20\rangle$
High influence (HI)	$\tilde{3} = \langle(2,3,4);0.90,0.10,0.10\rangle$
Very high influence (VHI)	$\tilde{4} = \langle(4,4,4);1.00,0.00,0.00\rangle$

Table 5: Linguistic terms used to measure influences and their corresponding Single-valued triangular neutrosophic number.

3 Results

In this section Neutrosophic DEMATEL is applied to the problem on the emergency service of the "Luis Gabriel Dávila" hospital that causes the readmission of patients within 48 hours. We start identifying the main factors that affect this phenomenon; they are summarized in Table 6, see [1][4].

Causes related to the patient	F_1: Therapeutic breach
	F_2:Psychiatric disorder
	F_3:Volunteer registration or fugue without being seen by a doctor
	F_4:Regular use of Hospital Urgency System for non-urgent problems
	F_5:Anxiety
Causes related to professionals	F_6:Error in diagnosis or treatment error
	F_7:Initialy patient must have entered in emergency
	F_8:Instructions to return or patient was called to return
Causes related to system	F_9:No specialist available
Causes related to the disease	F_{10}:Disease progression and disease recurrence

	F_{11}:Complication
	F_{12}:New problem

Table 6: The most important factors that cause the readmission problem.

Three experts were selected to form the cause-effect matrix based on the linguistic scale in Table 6. Tables 7, 8 and 9 contain their assessments.

Factor	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}
F_1	$\tilde{0}$	$\tilde{1}$	$\tilde{3}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{3}$	$\tilde{4}$	$\tilde{4}$	$\tilde{3}$
F_2	$\tilde{3}$	$\tilde{0}$	$\tilde{3}$	$\tilde{3}$	$\tilde{3}$	$\tilde{0}$	$\tilde{1}$	$\tilde{0}$	$\tilde{0}$	$\tilde{2}$	$\tilde{2}$	$\tilde{2}$
F_3	$\tilde{1}$	$\tilde{0}$	$\tilde{2}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{3}$	$\tilde{1}$	$\tilde{3}$	$\tilde{3}$	$\tilde{3}$
F_4	$\tilde{3}$	$\tilde{0}$	$\tilde{2}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{4}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$
F_5	$\tilde{3}$	$\tilde{1}$	$\tilde{4}$	$\tilde{3}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{1}$
F_6	$\tilde{0}$	$\tilde{0}$	$\tilde{2}$	$\tilde{0}$	$\tilde{3}$	$\tilde{0}$	$\tilde{3}$	$\tilde{3}$	$\tilde{0}$	$\tilde{3}$	$\tilde{3}$	$\tilde{3}$
F_7	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{3}$	$\tilde{0}$	$\tilde{0}$	$\tilde{3}$	$\tilde{0}$	$\tilde{3}$	$\tilde{3}$	$\tilde{3}$
F_8	$\tilde{3}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{2}$	$\tilde{0}$	$\tilde{1}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$
F_9	$\tilde{3}$	$\tilde{0}$	$\tilde{3}$	$\tilde{3}$	$\tilde{3}$	$\tilde{4}$	$\tilde{3}$	$\tilde{3}$	$\tilde{0}$	$\tilde{3}$	$\tilde{3}$	$\tilde{3}$
F_{10}	$\tilde{2}$	$\tilde{0}$	$\tilde{0}$	$\tilde{2}$	$\tilde{3}$	$\tilde{0}$	$\tilde{0}$	$\tilde{3}$	$\tilde{0}$	$\tilde{0}$	$\tilde{4}$	$\tilde{3}$
F_{11}	$\tilde{3}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{3}$	$\tilde{0}$	$\tilde{0}$	$\tilde{3}$	$\tilde{0}$	$\tilde{3}$	$\tilde{0}$	$\tilde{3}$
F_{12}	$\tilde{3}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{3}$	$\tilde{0}$	$\tilde{0}$	$\tilde{3}$	$\tilde{0}$	$\tilde{3}$	$\tilde{3}$	$\tilde{0}$

Table 7: The pair-wise comparison matrix between criteria corresponding to Expert 1.

Factor	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}
F_1	$\tilde{0}$	$\tilde{0}$	$\tilde{2}$	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{0}$	$\tilde{4}$	$\tilde{4}$	$\tilde{4}$	$\tilde{4}$
F_2	$\tilde{3}$	$\tilde{0}$	$\tilde{4}$	$\tilde{2}$	$\tilde{2}$	$\tilde{0}$	$\tilde{2}$	$\tilde{1}$	$\tilde{1}$	$\tilde{3}$	$\tilde{1}$	$\tilde{1}$
F_3	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{1}$	$\tilde{0}$	$\tilde{0}$	$\tilde{4}$	$\tilde{0}$	$\tilde{4}$	$\tilde{2}$	$\tilde{4}$
F_4	$\tilde{4}$	$\tilde{0}$	$\tilde{1}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{1}$	$\tilde{3}$	$\tilde{1}$	$\tilde{1}$	$\tilde{0}$
F_5	$\tilde{2}$	$\tilde{2}$	$\tilde{4}$	$\tilde{2}$	$\tilde{0}$	$\tilde{1}$	$\tilde{1}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{1}$	$\tilde{0}$
F_6	$\tilde{0}$	$\tilde{1}$	$\tilde{1}$	$\tilde{0}$	$\tilde{2}$	$\tilde{0}$	$\tilde{2}$	$\tilde{4}$	$\tilde{0}$	$\tilde{2}$	$\tilde{2}$	$\tilde{4}$
F_7	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{4}$	$\tilde{1}$	$\tilde{0}$	$\tilde{4}$	$\tilde{1}$	$\tilde{2}$	$\tilde{3}$	$\tilde{2}$
F_8	$\tilde{2}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{0}$	$\tilde{0}$	$\tilde{1}$	$\tilde{0}$	$\tilde{1}$
F_9	$\tilde{2}$	$\tilde{0}$	$\tilde{2}$	$\tilde{2}$	$\tilde{3}$	$\tilde{3}$	$\tilde{4}$	$\tilde{4}$	$\tilde{0}$	$\tilde{2}$	$\tilde{2}$	$\tilde{2}$
F_{10}	$\tilde{3}$	$\tilde{0}$	$\tilde{0}$	$\tilde{2}$	$\tilde{2}$	$\tilde{1}$	$\tilde{1}$	$\tilde{4}$	$\tilde{0}$	$\tilde{0}$	$\tilde{3}$	$\tilde{4}$
F_{11}	$\tilde{2}$	$\tilde{1}$	$\tilde{0}$	$\tilde{0}$	$\tilde{4}$	$\tilde{0}$	$\tilde{0}$	$\tilde{2}$	$\tilde{1}$	$\tilde{4}$	$\tilde{0}$	$\tilde{4}$
F_{12}	$\tilde{4}$	$\tilde{1}$	$\tilde{1}$	$\tilde{0}$	$\tilde{2}$	$\tilde{0}$	$\tilde{1}$	$\tilde{2}$	$\tilde{0}$	$\tilde{2}$	$\tilde{2}$	$\tilde{0}$

Table 8: The pair-wise comparison matrix between criteria corresponding to Expert 2.

Factor	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}
F_1	$\tilde{0}$	$\tilde{0}$	$\tilde{2}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{1}$	$\tilde{1}$	$\tilde{4}$	$\tilde{3}$	$\tilde{3}$	$\tilde{4}$
F_2	$\tilde{2}$	$\tilde{0}$	$\tilde{2}$	$\tilde{3}$	$\tilde{4}$	$\tilde{1}$	$\tilde{2}$	$\tilde{0}$	$\tilde{0}$	$\tilde{1}$	$\tilde{3}$	$\tilde{1}$
F_3	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{1}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{2}$	$\tilde{0}$	$\tilde{2}$	$\tilde{2}$	$\tilde{2}$
F_4	$\tilde{2}$	$\tilde{1}$	$\tilde{1}$	$\tilde{0}$	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{3}$	$\tilde{1}$	$\tilde{0}$	$\tilde{0}$
F_5	$\tilde{2}$	$\tilde{2}$	$\tilde{3}$	$\tilde{4}$	$\tilde{0}$	$\tilde{1}$	$\tilde{1}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{2}$
F_6	$\tilde{0}$	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{2}$	$\tilde{0}$	$\tilde{2}$	$\tilde{2}$	$\tilde{1}$	$\tilde{2}$	$\tilde{3}$	$\tilde{2}$
F_7	$\tilde{0}$	$\tilde{1}$	$\tilde{0}$	$\tilde{1}$	$\tilde{4}$	$\tilde{0}$	$\tilde{0}$	$\tilde{4}$	$\tilde{0}$	$\tilde{2}$	$\tilde{4}$	$\tilde{3}$
F_8	$\tilde{2}$	$\tilde{0}$	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$	$\tilde{0}$	$\tilde{2}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$
F_9	$\tilde{4}$	$\tilde{0}$	$\tilde{2}$	$\tilde{2}$	$\tilde{2}$	$\tilde{3}$	$\tilde{4}$	$\tilde{4}$	$\tilde{0}$	$\tilde{2}$	$\tilde{2}$	$\tilde{2}$
F_{10}	$\tilde{3}$	$\tilde{0}$	$\tilde{0}$	$\tilde{1}$	$\tilde{2}$	$\tilde{1}$	$\tilde{0}$	$\tilde{4}$	$\tilde{0}$	$\tilde{0}$	$\tilde{3}$	$\tilde{4}$
F_{11}	$\tilde{3}$	$\tilde{0}$	$\tilde{1}$	$\tilde{0}$	$\tilde{2}$	$\tilde{0}$	$\tilde{0}$	$\tilde{2}$	$\tilde{0}$	$\tilde{4}$	$\tilde{0}$	$\tilde{4}$
F_{12}	$\tilde{4}$	$\tilde{0}$	$\tilde{0}$	$\tilde{0}$	$\tilde{4}$	$\tilde{0}$	$\tilde{0}$	$\tilde{2}$	$\tilde{1}$	$\tilde{4}$	$\tilde{2}$	$\tilde{0}$

Table 9: The pair-wise comparison matrix between criteria corresponding to Expert 3.

Table 10, 11 and 12 contain the crisp values of comparison matrices for Experts 1, 2 and 3 respectively,

using Equation 12, which is based on Equation 5 for single-valued triangular neutrosophic numbers.

$$A(\tilde{a}_{ij}) = \frac{1}{8}[a_1 + b_1 + c_1](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (12)$$

For calculation we use the free software Octave 4.2.1, see [17].

Factor	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}
F_1	0	0.84	3.26	0	0	0	0	0	3.26	4.5	4.5	3.26
F_2	3.26	0	3.26	3.26	3.26	0	0.84	0	0	2.14	2.14	2.14
F_3	0.84	0	0	0	0	0	0	3.26	0.84	3.26	3.26	3.26
F_4	3.26	0	2.14	0	0	0	0	0	4.5	0	0	0
F_5	3.26	0.84	4.5	3.26	0	0	0	0	0	0	0	0.84
F_6	0	0	2.14	0	3.26	0	3.26	3,26	0	3.26	3.26	3.26
F_7	0	0	0	0	3.26	0	0	3.26	0	3.26	3.26	3.26
F_8	3.26	0	0	0	2.14	0	0.84	0	0	0	0	0
F_9	3.26	0	3.26	3.26	3.26	4.5	3.26	3.26	0	3.26	3.26	3.26
F_{10}	2.14	0	0	2.14	3.26	0	0	3.26	0	0	4.5	3.26
F_{11}	3.26	0	0	0	3.26	0	0	3.26	0	3.26	0	3.26
F_{12}	3.26	0	0	0	3.26	0	0	3.26	0	3.26	3.26	0

Table 10: Crisp values of comparison matrix for Expert 1.

Factor	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}
F_1	0	0	2.14	0.84	0.84	0.84	0.84	0	4.5	4.5	4.5	4.5
F_2	3.26	0	4.5	2.14	2.14	0	2.14	0.84	0.84	3.26	0.84	0.84
F_3	0	0	0	0	0.84	0	0	4.5	0	4.5	2.14	4.5
F_4	4.5	0	0.84	0	0	0	0	0.84	3.26	0.84	0.84	0
F_5	2.14	2.14	4.5	2.14	0	0.84	0.84	0	0	0	0.84	0
F_6	0	0.84	0.84	0	2.14	0	2.14	4.5	0	2.14	2.14	4.5
F_7	0	0	0	0	4.5	0.84	0	4.5	0.84	2.14	3.26	2.14
F_8	2.14	0	0	0	0.84	0.84	0.84	0	0	0.84	0	0.84
F_9	2.14	0	2.14	2.14	3.26	3.26	4.5	4.5	0	2.14	2.14	2.14
F_{10}	3.26	0	0	2.14	2.14	0.84	0.84	4.5	0	0	3.26	4.5
F_{11}	2.14	0.84	0	0	4.5	0	0	2.14	0.84	4.5	0	4.5
F_{12}	4.5	0.84	0.84	0	2.14	0	0.84	2.14	0	2.14	2.14	0

Table 11: Crisp values of comparison matrix for Expert 2.

Factor	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}
F_1	0	0	2.14	0	0	0	0.84	0.84	4.5	3.26	3.26	4.5
F_2	2.14	0	2.14	3.26	4.5	0.84	2.14	0	0	0.84	3.26	0.84
F_3	0	0	0	0.84	0	0	0	2.14	0	2.14	2.14	2.14
F_4	2.14	0.84	0.84	0	0.84	0.84	0.84	0.84	3.26	0.84	0	0
F_5	2.14	2.14	3.26	4.5	0	0.84	0.84	0	0	0	0	2.14
F_6	0	0.84	0.84	0.84	2.14	0	2.14	2.14	0.84	2.14	3.26	2.14
F_7	0	0.84	0	0.84	4.5	0	0	4.5	0	2.14	4.5	3.26
F_8	2.14	0	0.84	0.84	0.84	0	2.14	0	0	0	0	0
F_9	4.5	0	2.14	2.14	2.14	3.26	4.5	4.5	0	2.14	2.14	2.14
F_{10}	3.26	0	0	0.84	2.14	0.84	0	4.5	0	0	3.26	4.5
F_{11}	3.26	0	0.84	0	2.14	0	0	2.14	0	4.5	0	4.5
F_{12}	4.5	0	0	0	4.5	0	0	2.14	0.84	4.5	2.14	0

Table 12: Crisp values of comparison matrix for Expert 3.

Table 13 is the matrix of the three experts' averaged evaluations; see Equation 6.

Factor	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}
F_1	0	0.28	2.51	0.28	0.28	0.28	0.56	0.28	4.09	4.09	4.09	4.09
F_2	2.89	0	3.3	2.89	3.3	0.28	1.71	0.28	0.28	2.08	2.08	1.27
F_3	0.28	0	0	0.28	0.28	0	0	3.3	0.28	3.3	2.51	3.3
F_4	3.3	0.28	1.27	0	0.28	0.28	0.28	0.56	3.67	0.56	0.28	0
F_5	2.51	1.71	4.09	3.3	0	0.56	0.56	0	0	0	0.28	0.99
F_6	0	0.56	1.27	0.28	2.51	0	2.51	3.3	0.28	2.51	2.89	3.3
F_7	0	0.28	0	0.28	4.09	0.28	0	4.09	0.28	2.51	3.67	2.89
F_8	2.51	0	0.28	0.28	1.27	0.28	1.27	0	0	0.28	0	0.28
F_9	3.3	0	2.51	2.51	2.89	3.67	4.09	4.09	0	2.51	2.51	2.51
F_{10}	2.89	0	0	1.71	2.51	0.56	0.28	4.09	0	0	3.67	4.09
F_{11}	2.89	0.28	0.28	0	3.3	0	0	2.51	0.28	4.09	0	4.09
F_{12}	4.09	0.28	0.28	0	3.3	0	0.28	2.51	0.28	3.3	2.51	0

Table 13: Averaged crisp values of comparison matrices for the three experts.

Applying Equation 7 we have K = 0.03268 and we obtained matrix S according to Equation 8, and T according to Equation 9. Thus, vectors D and R are obtained applying Equations 10 and 11, respectively, see Table 14. See also the depicted cause and effect diagram in Figure 1.

Factor	D	R	D+R	D-R
F_1	1.89	1.62	3.51	0.27
F_2	0.29	1.44	1.73	-1.16
F_3	1.08	0.93	2.01	0.16
F_4	0.81	0.91	1.72	-0.10
F_5	1.67	0.99	2.66	0.68
F_6	0.40	1.32	1.72	-0.92
F_7	0.70	1.23	1.93	-0.53
F_8	1.75	0.49	2.24	1.26
F_9	0.71	2.12	2.84	-1.41
F_{10}	1.84	1.35	3.18	0.49
F_{11}	1.75	1.26	3.01	0.49
F_{12}	1.98	1.21	3.19	0.76

Table 14: Vectors D, R, D+R and D-R.

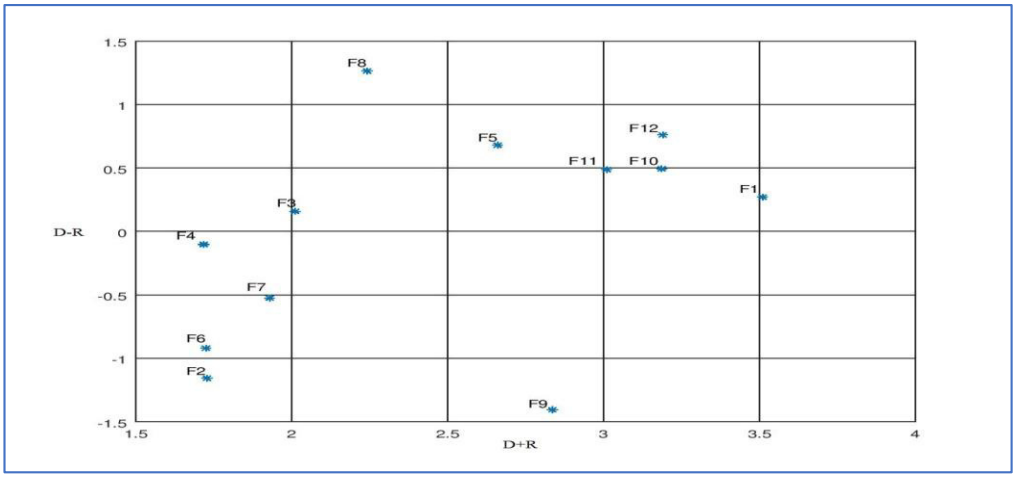

Figure 1: Cause and effect diagram.

According to the results in Table 14 and the diagram in Figure 1, we have that the most important factor in the entire system is F_1, followed by F_{12}, F_{10} and F_{11} in that order, because they have the biggest D+R index. Additionally, the net causes are F_1, F_3, F_5, F_8, F_{10}, F_{11}, F_{12}, while F_2, F_4, F_6, F_7, F_9 are the receivers; because factors in the first group have positive D-R values and those in the second group have negative values.

Therefore the "Therapeutic breach" is the most important cause and authorities in the hospital should pay attention to this factor. Additionally, we have that the causes related to the disease are the second more important.

Conclusion

This article was devoted to studying the problem of readmission in a time span of 48 hours in the hospital "Luis Gabriel Dávila" placed in Carchi province, Ecuador. Three experts evaluated the cause-effect relationship between twelve factors by using a scale based on linguistic terms. The Neutrosophic DEMATEL method was applied and it was concluded that "Therapeutic breach" is the most important cause to pay more attention to, while the causes related to the disease are the second most important.

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Neutrosophic interrelationship of Key Performance Indicators in an accounting process

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Abstract. This paper is an investigation on the interrelationship among some financial performance indicators of the company "Zambrano Loor Naira Narcisa" located in the city of Santo Domingo, Ecuador. The study is conducted because this company presents some difficulties in this regard. In order to guarantee the profundity of the analysis, we apply the technique of dynamic study of Neutrosophic Cognitive Maps, where the cause-effect relationship among the indicators is described and established; in addition it is provided the causal connecting weights between each pair of indicators. Four experts have made the evaluations. The advantage of neutrosophic cognitive maps over fuzzy cognitive maps is that the former maintains the modeling of the uncertainty of the latter, and also offers the possibility of incorporating indetermination, thus constituting a more realistic source to assess cause-effect relationships.

Keywords: Key Performance Indicator, financial accounting, neutrosophic cognitive map, neutrosophic number.

1 Introduction

The company "Zambrano Loor Naira Narcisa" is located in the city of Santo Domingo, Ecuador. It is dedicated to the wholesale and retail sale of lubricants and refrigerants for all types of motor vehicles. In an interview with its manager, he alleged that they are obliged to keep accounts according to the Ecuadorian categorization. This investigation aims to achieve an adequate accounting process, due to they do not have appropriate financial information for decision making according to the needs of the company, see [1].

The accounting is essential because it provides financial information of the company, to people or entities interested in knowing the results on the profitability and solvency of the business. The users can be internal or external; the most important external user is the State, which is interested in the collection of income taxes. The internal users are the owners of the companies that we call shareholders, the administrators and the employees; see [2-6].

The objective of this paper is to study the key financial performance indicators of the company "Zambrano Loor Naira Narcisa". Similar studies can be found in [7, 8]. For this purpose, Neutrosophic Cognitive Maps are applied; see [9-11]. Cognitive maps are basically directed graphs, where their nodes represent concepts and their edges represent causal relationships among these concepts, see [12]. Additionally, each edge is associated with a weight that can be null, which means that there is no relationship between the concepts; if it is a positive value it means that if one concept increases (decreases) its value the other will also tend to increase (decrease); while if it is negative it means that if one concept tends to increase (decrease), the other will tend to decrease (increase).

Both, fuzzy cognitive maps ([13, 14]) and neutrosophic cognitive maps incorporate uncertainty in causal relationships, and the latter ones are based on Neutrosophy. Neutrosophy is the branch of philosophy that deals with the phenomena of neutrality, see [15]. Neutralities are the consequence of contradictions, ignorance, paradoxes, inconsistencies, among other reasons. Neutrosophic sets generalize fuzzy, intuitionist fuzzy, interval-valued fuzzy sets, among others. Neutrosophic sets include for the first time a membership function of indeterminacy, aside from the membership function and the non-membership function.

Another generalization is that these three membership functions are independent each other, unlike the

intuitionistic fuzzy sets. On the other hand, neutrosophic sets are defined in subsets of the non-standard interval $]^{-}0,1^{+}[$.

The definition of neutrosophic sets is only of philosophical interest, that is why the interval-valued neutrosophic sets and the simplest single-valued neutrosophic sets are defined, which are subsets or elements of the interval [0, 1], respectively. For convenience, single-valued neutrosophic numbers are defined, which is the simplest form of single-valued neutrosophic sets.

It is worth noting that neutrosophy has opened a large number of practical applications within dissimilar fields ([16]) as decision-making ([17-19]), digital image processing ([20-23]), time series forecasting ([24-26]), artificial intelligence ([27]), game theory ([28]), recommender systems ([29]), learning management systems ([30]), biomedical diagnosis ([31]), among others.

Additionally, rings can be defined where the main element is the symbol "I" of indeterminacy, and where the neutrosophic number is divided into a determinate part "d" and an indeterminate part "I", while the neutrosophic number is defined as the sum of these two elements, which is convenient for defining operations between elements of neutrosophic cognitive maps. Therefore, neutrosophic cognitive maps include the possible weights of fuzzy cognitive maps, and also a symbolic value denoted by I representing the indetermination.

In this article a dynamic study of the causal relationship among the different financial indicators is carried out. For this, we incorporate the complexity of cause-effect relations, where two-way relations can exist, that is to say, a concept can be cause and at the same time effect of another one.

Accounting processes are usually viewed objectively, based on financial measures. This makes that the managers and decision makers lose the holistic view of these indicators, which depends on both economic and social variables such as the satisfaction of the company's customers or the education level of the employees, among others. On the other hand, up to the authors' knowledge, the tool known as dynamic study of neutrosophic cognitive maps has been applied in exclusively social phenomena such as the problem of a minority who are the Hijras in India or the migrant workers sick with HIV, see [9, 10]. The most important purpose of this paper is to study the key financial performance indicators of the company "Zambrano Loor Naira Narcisa", which will contribute to solving a major problem for this company.

The main contribution of this paper is the demonstration through this real case, that it is possible to use the dynamic study of neutrosophic cognitive maps to measure a financial situation of a company, where subjective criteria based on objective measures of accounting are associated with subjective measures like the customer's satisfaction. Additionally, mathematical modeling based on neutrosophic logic instead of fuzzy logic, allows a more accurate study, since the relationship between some variables can be unknown. Thus, it is possible to model the indeterminacy existing between them, which is not possible by using fuzzy set theory or intuitionistic fuzzy set theory.

The paper is divided in the following sections. Section 2 contains a summary of the main concepts of the Neutrosophic Cognitive Maps method. Section 3 contains the results of applying NCMs for the analysis of the performance of key indicators in the company "Zambrano Loor Naira Narcisa". The last section contains the conclusions.

2 A summary on Neutrosophic Cognitive Maps

To begin this section we have the following basic definitions regarding neutrosophy:

Definition 1. ([15]) Let X be a universe of discourse. A *Neutrosophic Set* (NS) is characterized by three membership functions, $u_A(x), r_A(x), v_A(x) : X \rightarrow]^{-}0, 1^{+}[$, which satisfy the condition $^{-}0 \leq \inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3^{+}$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ are the membership functions of truthfulness, indeterminacy and falseness of x in A, respectively, and their images are standard or non-standard subsets of $]^{-}0, 1^{+}[$.

Definition 2. ([15]) Let X be a universe of discourse. A *Single-Valued Neutrosophic Set* (SVNS) A on X is a set of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \quad (1)$$

Where $u_A, r_A, v_A : X \rightarrow [0,1]$, satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denote the membership functions of truthfulness, indeterminate and falseness of x in A, respectively. For convenience a *Single-Valued Neutrosophic Number* (SVNN) will be expressed as A = (a, b, c), which a, b, c $\in [0,1]$ and satisfy $0 \leq a + b + c \leq 3$.

Other important definitions are related to the graphs. See [9-11, 15].

Definition 3. A *neutrosophic graph* is a graph containing at least one indeterminate edge, which is represented by dotted lines.

Definition 4. A *neutrosophic directed graph* is a directed graph containing at least one indeterminate edge, which is represented by dotted lines.

Definition 5. A *Neutrosophic Cognitive Map* (NCM) is a neutrosophic directed graph, whose nodes represent concepts and whose edges represent causal relationships among the edges.

If $C_1, C_2, \ldots, C_k$ are k nodes, each of the C_j (i = 1, 2, …, k) can be represented by a vector $(x_1, x_2, \ldots, x_k)$

where $x_i \in \{0, 1, I\}$. $x_i = 0$ means that the node C_i is in an activated state, $x_i = 1$ means that the node C_i is in a deactivated state and $x_i = I$ means that the node C_i is in an indeterminate state, in a specific time or in a specific situation.

If C_m and C_n are two nodes of the NCM, an edge directed from C_m to C_n is called a *connection* and represents the causality from C_m to C_n. Each node in the NCM is associated with a weight within the set {-1, 0, 1, I}. If α_{mn} denotes the weight of the edge C_mC_n, $\alpha_{mn} \in \{-1, 0, 1, I\}$ then we have the following:

$\alpha_{mn} = 0$ if C_m has no effect on C_n,

$\alpha_{mn} = 1$ if an increase (decrease) in C_m produces an increase (decrease) in C_n,

$\alpha_{mn} = -1$ if an increase (decrease) in C_m produces a decrease (increase) in C_n,

$\alpha_{mn} = I$ if the effect of C_m on C_n is indeterminate.

Definition 6. A NCM having edges with weights in {-1, 0, 1, I} is called *Simple Neutrosophic Cognitive Map*.

Definition 7. If $C_1, C_2, \ldots, C_k$ are the nodes of a NCM. The *neutrosophic matrix* N(E) is defined as $N(E) = (\alpha_{mn})$, where α_{mn} denotes the weight of the directed edge C_mC_n, such that $\alpha_{mn} \in \{-1, 0, 1, I\}$. N(E) is called the *neutrosophic adjacency matrix* of the NCM.

Definition 8. Let $C_1, C_2, \ldots, C_k$ be the nodes of a NCM. Let $A = (a_1, a_2, \ldots, a_k)$, where $a_m \in \{-1, 0, 1, I\}$. A is called *instantaneous state neutrosophic vector* and means a position of on-off-indeterminate state of the node in a given instant.

$a_m = 0$ if C_m is deactivated (has no effect),

$a_m = 1$ if C_m is activated (has an effect),

$a_m = I$ if C_m is indeterminate (its effect cannot be determined).

Definition 9. Let $C_1, C_2, \ldots, C_k$ be the nodes of a NCM. Let $\overrightarrow{C_1C_2}, \overrightarrow{C_2C_3}, \overrightarrow{C_3C_4}, \ldots, \overrightarrow{C_mC_n}$ be the edges of the NCM, then the edges constitute a *directed cycle*.

The NCM is called *cyclic* if it has a directed cycle. It is said *acyclic* if it has not a directed cycle.

Definition 10. A NCM containing cycles is said to have *feedback*. When there is feedback in the NCM, it is said that it is a *dynamic system*.

Definition 11. Let $\overrightarrow{C_1C_2}, \overrightarrow{C_2C_3}, \overrightarrow{C_3C_4}, \ldots, \overrightarrow{C_{k-1}C_k}$ be a cycle. When C_m is activated and its causality flows through the edges of the cycle and then it is the cause of C_m itself, then the dynamic system circulates. This is fulfilled for each node C_m with m = 1, 2,…, k. The equilibrium state for this dynamic system is called the *hidden pattern*.

Definition 12. If the equilibrium state of a dynamic system is a single state, then it is called a *fixed point*.

An example of a fixed point is when a dynamic system starts by being activated by C_1. If it is assumed that the NCM sits on C_1 and C_k, i.e. the state remains as (1, 0,..., 0, 1), then this vector of neutrosophic state is called *fixed point*.

Definition 13. If the NCM is established with a neutrosophic state-vector that repeats itself in the form:

$A_1 \to A_2 \to \cdots \to A_m \to A_1$, then the equilibrium is called a *limit cycle* of the NCM.

Method for Determining the Hidden Patterns

Let $C_1, C_2, \ldots, C_k$ be the nodes of the NCM with feedback. Assume that E is the associated adjacency matrix. A hidden pattern is found when C_1 is activated and a vector input $A_1 = (1, 0, 0, \ldots, 0)$ is given. The data must pass through the neutrosophic matrix N(E), which is obtained by multiplying A_1 by the matrix N(E).

Let $A_1N(E) = (\alpha_1, \alpha_2, \ldots, \alpha_k)$ with the threshold operation of replacing m by 1 if $\alpha_m > p$ and α_m by 0 if $\alpha_m < p$ (p is a suitable positive integer) and α_m is replaced by I if this is not an integer. The resulting concept is updated; vector C_1 is included in the updated vector by transforming the first coordinate of the resulting vector into 1.

If $A_1N(E) \to A_2$ is assumed then $A_2N(E)$ is considered and the same procedure is repeated. This procedure is repeated until a limit cycle or fixed point is reached.

Definition 14. A *neutrosophic number* N is defined as a number as follows, see [15, 32-34]:

$$N = d + I \qquad (2)$$

Where d is called *determinate part* and I is called *indeterminate part*.

Given $N_1 = a_1 + b_1I$ and $N_2 = a_2 + b_2I$ two neutrosophic numbers, some operations between them are defined as follows:

$N_1 + N_2 = a_1 + a_1 + (b_1 + b_2)I$ (Addition);

$N_1 - N_2 = a_1 - a_1 + (b_1 - b_2)I$ (Difference),

$N_1 \times N_2 = a_1a_2 + (a_1b_2 + b_1a_2 + b_1b_2)I$ (Product),

$\frac{N_1}{N_2} = \frac{a_1+b_1I}{a_2+b_2I} = \frac{a_1}{a_2} + \frac{a_2b_1-a_1b_2}{a_2(a_2+b_2)}I$ (Division).

3 Results

First of all, we describe the selected key performance indicators of the financial accounting:

I_1. *Liquidity*: This indicator reflects the relationship between the financial resources that a company has in the short-term to face the payment obligations contracted in the same period, which makes it possible to determine whether it has sufficient resources to cover its commitments. The greater the result of the current ratio, the greater the possibility that liabilities will be paid, since there are sufficient assets that can be converted into cash when required.

I_2. *Efficiency*: It measures the effectiveness with which the company's resources are being used, measuring the degree of efficiency with which the assets are used in its operations, and their speed of recovery, expressing the result by index or number of times.

I_3. *Indebtedness*: It aims to measure the extent to which and how creditors participate in the financing of the company. In the same way, it tries to establish the risk that such creditors run, the risk of the owners and the convenience or inconvenience of a certain level of indebtedness of the company.

I_4. *Return on equity*: This indicator measures the return on net investment, i.e. stockholders' equity. It relates the net profit that an organization has earned during a period and compares it with the investment that corresponds to the shareholders. Return on stockholders' equity is a key indicator of the extent to which a company has generated a return on the resources that shareholders have entrusted to manage.

I_5. *Leverage*: is the relationship between credit and equity invested in a financial transaction. The higher the credit, the higher the leverage and the lower the equity investment. In other words, leverage is simply using debt to finance an operation. By reducing the initial capital that needs to be provided, there is an increase in the return obtained. Increased leverage also increases the risks of the operation, as it results in less flexibility or greater exposure to insolvency or inability to meet payments.

I_6. *Customer satisfaction*: It is a measure of how products and services provided by a company meet or exceed customer expectations.

Let us note that I_6 is not precisely a financial indicator, however, it is a key factor to study the good performance of the enterprise, and thus we decided to include it.

Another important aspect to remark is that experts' evaluations depend on the context of company "Zambrano Loor Naira Narcisa" in the year 2017, i.e., they are not only generic. Thus, first experts studied the financial situation of this company and later they evaluated the relationship among the indicators.

For group evaluation, each expert evaluates according to a value in the set {-1, 0, 1, I}, next the median per causal-effect weight is calculated. In case that one expert evaluates with I, then the aggregated results of this causal-effect weight is taken as I.

Figure 1 is the graphical representation of the NCM tree corresponding to the company, where the dotted red lines symbolize the indeterminate weights.

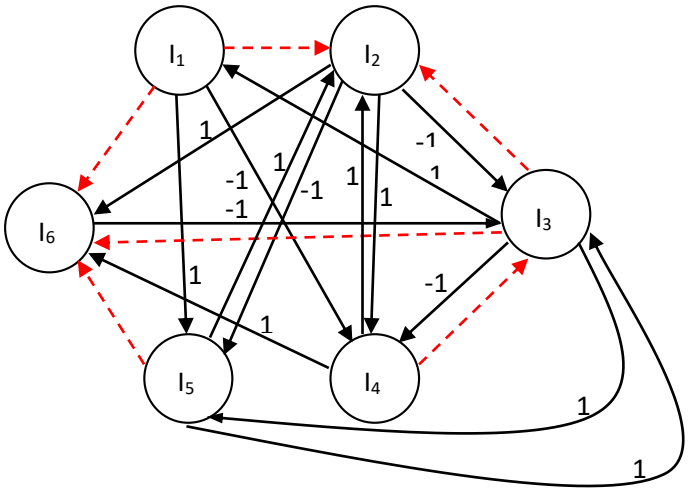

Figure 1: Graphical representation of the tree of NCM.

Accordingly, the matrix N(E) corresponding to the NCM shown in Figure 1 is the following:

$$\begin{pmatrix} 0 & I & 0 & -1 & 1 & I \\ 0 & 0 & -1 & 1 & -1 & 1 \\ 1 & I & 0 & -1 & 1 & I \\ 0 & 1 & I & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 & 0 & I \\ 0 & 0 & -1 & 0 & 0 & 0 \end{pmatrix}$$

When the method for determining hidden patterns is applied, if $I_2$is activated with the vector $A_1 = (0\ 1\ 0\ 0\ 0\ 0)$ the following results are obtained:
$A_1N(E) = (0\ \ 0\ \ -1\ \ 1\ \ -1\ \ 1) \rightarrow (0\ \ 1\ \ 0\ \ 1\ \ 0\ \ 1) = A_2$,
$A_2N(E) = (0\ \ 1\ \ -2\ \ 1\ \ -1\ \ 2) \rightarrow (0\ \ 1\ \ 0\ \ 1\ \ 0\ \ 1) = A_2$,
We support the calculations on the software Octave 4.2.1, see [35].

If $I_3$is activated with the vector $B_1 = (0\ 0\ 1\ 0\ 0\ 0)$ the following results are obtained:
$B_1N(E) = (1\ \ I\ \ 0\ \ -1\ \ 1\ \ I) \rightarrow (1\ \ I\ \ 1\ \ 0\ \ 1\ \ I) = B_2$,
$B_2N(E) = (1\ \ 1+2I\ \ 1+2I\ \ -2+I\ \ 2+I\ \ 4I) \rightarrow (1\ \ 1\ \ 1\ \ 0\ \ 1\ \ I) = B_3$,
$B_3N(E) = (1\ \ 1+2I\ \ I\ \ -1\ \ 1\ \ 1+3I) \rightarrow (1\ \ 1\ \ 1\ \ 0\ \ 1\ \ 1) = B_4$,
$B_4N(E) = (1\ \ 1+2I\ \ -1\ \ -1\ \ 1\ \ 1+3I) \rightarrow (1\ \ 1\ \ 1\ \ 0\ \ 1\ \ 1) = B_4$.

If $I_6$is activated with the vector $D_1 = (0\ 0\ 0\ 0\ 0\ 1)$ the following results are obtained:
$D_1N(E) = (0\ \ 0\ \ -1\ \ 0\ \ 0\ \ 0) \rightarrow (0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 1) = D_2$,
$D_2N(E) = (0\ \ 0\ \ -1\ \ 0\ \ 0\ \ 0) \rightarrow (0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 1) = D_2$.

The other indicators have not fixed points when the algorithm was applied.

Thus, the conclusion is that when “efficiency” state is activated then “Return on equity” and “Customer satisfaction” states are also activated. Whereas, when “indebtedness” state is activated, then, the other indicators except “Return on equity” are activated. Let us note that the state corresponding to “Customer satisfaction” is a non influential fixed point over the other indicators.

These results show which are the fundamental aspects that must be strengthened in the company. Firstly, efficiency is considered a key financial performance indicator of the company. To improve this indicator in a company dedicated to sales, it is necessary to strengthen some weak points that the company has, and not all of them are purely financial. For example, it is essential to have a sufficiently trained and motivated staff to increase sales, so that without changing the products to sale and their quality, the number of sales would increase, which is why the company must try to put their more talented salespeople in the most important places of the enterprise, and that will increase the number of customers loyal to the company.

On the other hand, the control of the indebtedness indicator is of vital importance, because it is necessary to find the precise balance between the debt that should be contracted so that it is sufficient to perform the business and also it should be payable in a reasonable amount and term, without ruining the business. This will also lead to customer satisfaction. That is to say, a sufficiently reasonable risk of the creditors towards the company will produce positive results for the quality of the service.

Additionally, it is shown that an improvement in any of the financial indicators of the company will produce greater customer satisfaction, which is logical. Therefore it will increase quality, and in turn this will increase the number of customers loyal to the company, which will contribute to improving the indicators, making this a loop with positive feedback.

Conclusion

This paper was dedicated to study the causal-effect relationship among the key performance indicators in the accounting process of the company "Zambrano Loor Naira Narcisa" located in the city of Santo Domingo, Ecuador. This is because the company has been shown some difficulties in its financial performance. Thus, we applied the neutrosophic cognitive map technique and our conclusion is that it is necessary to improve the company´s efficiency and to correctly deal with the indebtedness, consequently, these two aspects shall contribute to the progress of the enterprise.

In this paper we solved an accounting problem of a company supported by the dynamic analysis of neutrosophic cognitive maps, which is unusual, considering that the analysis of accounting is fundamentally based on objective measures, see [36, 37]. The use of this tool allowed the objective variables to be associated with a subjective aspect of the company such as “customer satisfaction”, which cannot be directly measured as an accounting variable.

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Neutrosophic Iadov for measuring of user satisfaction in a virtual learning environment at UNIANDES Puyo

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Abstract. In present, the university education promoted by the Regional Autonomous University of Los Andes, Ecuador, is supported by a Virtual Learning Environment. This is the fundamental reason that originated this research, for knowing if the use of the Virtual Learning Environment has either a positive or negative effect on the teaching-learning process in this university, especially in the Puyo campus. To carry out this work we consider the academic cycle April-August 2018. A survey was conducted in a unique environment and was applied to teachers and students, such that their opinion on the use of this tool is investigated. The processing of data of the survey was based on the neutrophic Iadov technique. Iadov technique consists of a set of three closed questions, and in addition an undetermined number of open questions that are processed by a logical tree that combines every triple of possible answers with a number that serves to logically evaluate such a combination. Neutrosophic Iadov generalizes the Iadov technique in order to take into account the indeterminacy that is typical of any evaluation. Therefore, this method is more accurate than its precedent.

Keywords: Virtual Learning Environment, higher education, neutrosophic Iadov technique, computer assisted instruction.

1 Introduction

The social, political, economic and cultural conditions that characterize 21st century societies have permitted, among other things, the emergence of the so-called culture of the digital society, see [1]. Ecuadorian society and the world in general have experienced profound changes in the way of working, relating and learning, largely due to the influence of technology in daily life. All these changes are even reflected in the smallest aspect of our life and one of the most important places is university, since it is the institution that is responsible for training the new professionals required by the working world.

According to Cano's criteria ([2]) in order to improve the quality of university education, we have to profoundly transform the procedures focused on student learning with the aim of providing them, throughout their time at the institution, with a complete as possible training and, of course, to favor its professional insertion in the workplace from the platform of an organizational model of university orientation, and formally institutional tutorial action. In this context, the teaching practice of every teacher is the closest level to the student, from a multidimensional perspective, as it is shown in Figure 1.

According to Fados ([3]), teaching cannot be understood as a simple transmission of information, but as a more complex process that concerns on how to provoke personal development in an intentional and organized context. While learning is understood as a process by which an organism changes its behavior as a result of experience. Thus, maturation and development cannot be considered learning.

In the "Diagnosis of Virtual Higher Education in Ecuador" carried out by UNESCO in 2002, it was established that 72% of Ecuadorian universities already offered distance and semi-full-time programs with increasing tendency, which leads us to deduce that all this offer of vocational training will necessarily have to rely on some virtual learning platform to meet student demand, see [4].

The impact of communication networks on training and education is one of the biggest changes that have taken place in Educational Institutions, in this new training context, terms such as "virtual training", "virtual classroom" or "virtual training environments" begin to emerge, see [4].

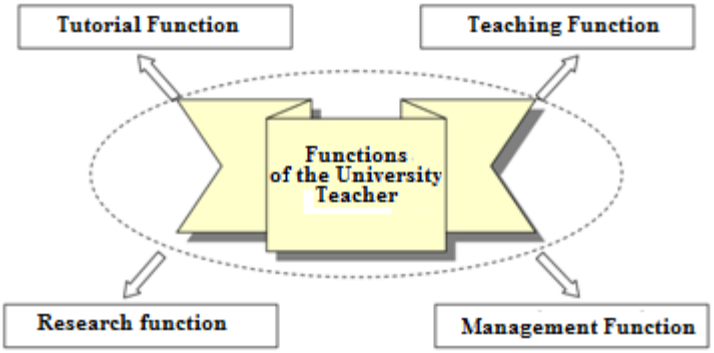

Figure 1: Functions of the university teacher. Source [2].

According to Colina et. al. ([5]) ICTs offer excellent possibilities to overcome the limitations of space and time, where students interact with the teacher, establishing their own style that allows them to generate cognitive learning strategies in new spaces such as virtual environments of learning and if we add to this that nowadays university students are skilled about using new technologies, together with their great capacity for learning and the modern teacher is receptive to its usage, we have the ideal scenario to implement a Virtual Learning Environment in UNIANDES Puyo.

For Toala Dueñas et al. ([4]) in educational institutions and moreover in universities, the use of ICTs is being offered as means of study, in addition, in the full-time modality, several teachers incorporate virtual platforms for the reception of chores. UNIANDES Puyo is not far from this reality and in the semi-full-time and full-time modalities a considerable percentage of their teachers largely use this tool in their classes since several years ago.

In 1988, UNESCO, in its world report on education, points out that virtual learning environments constitute a totally new form of educational technology and offers a complex series of opportunities and tasks to educational institutions around the world; see [6][1].

According to Estrada in [6], among the characteristics of virtual learning environments we can mention:

- It promotes various ways of accessing and producing knowledge,
- It offers a new learning, communicational and work scenario so that the school is no longer the exclusive environment for training,
- It takes time, discipline, and perseverance to work in Virtual Learning Environment,
- Communication skills and autonomous learning are needed,
- Reflective thinking is favored.
- Provides new possibilities for interaction between teachers and students and between students.
- Facilitates the distribution and management of information.

The use of ICTs in the training of higher education provides multiple advantages in improving teacher quality, which is materialized in aspects such as access from remote areas, flexibility in time and space for the development of teaching or learning activities. Also, the possibility of interacting with the information by the different agents involved in these activities ([7][2]), so we can highlight:

- Breakage of space-time barriers in teaching and learning activities,
- Open and flexible training processes,
- Improves communication between the different agents of the teaching-learning process,
- More personalized teaching,
- Quick access to information,
- Possibility to interact with the information,
- Raises the interest and motivation of students,
- Improvement of educational effectiveness,

- Allow the teacher to have more time for other tasks,
- Complementary activities to support learning.

The set of knowledge and skills that today's professional needs to develop are very broad, and time is short. UNIANDES is aware of this reality and provides technological tools including the Virtual Learning Environment, which support and facilitate student work. But are students and teachers aware of the benefits obtained by using the Virtual Learning Environment? In response to this question, this paper seeks to know the positive or negative impact of the use of the Virtual Learning Environment in the teaching-learning process at UNIANDES Puyo in the last academic period, that is, April-August 2018. For this, we applied the neutrosophic Iadov technique.

The Iadov technique was created by its author to establish the level of satisfaction for the profession of pedagogical careers. Then, some authors including González ([8]) applied it to assess the satisfaction of pedagogical professional training. In [9] a modification of this technique is made and it is proposed as an alternative for the diagnosis of professional motivation in physical education teachers[3].

The Iadov technique constitutes an indirect way for the study of satisfaction when performing certain activities is based on the analysis of a questionnaire that has a specific internal structure unknown to the interviewee, [8-10][4]. Closed questions are established through the so-called "Iadov Logic Chart". The original proposal of the Iadov method does not allow an adequate management of the indeterminacy nor the management of the importance of the users. The introduction of the neutrosophic estimation seeks to solve the problems of indeterminacy that appear universally in the evaluations of the surveys and other instruments, by taking advantage of not only the opposing positions but also the neutral or ambiguous ones, see [11-14][5, 6]. Under the principle that every idea <A> tends to be neutralized, diminished, balanced by other ideas, in clear rupture with binary doctrines in the explanation and understanding of phenomena.

The purpose of this paper is to study student satisfaction at the Regional Autonomous University of Los Andes in Puyo, Ecuador on Virtual Learning Environment usage, for this end, the neutrosophic Iadov technique is applied. We use this technique because in addition to having the advantages offered by the classic Iadov technique, we also take into account the indeterminacy of the measurements, when modelling with Neutrosophy.

This paper is divided with the following structure; Section 2 describes the fundamental concepts that will be used for this study. Section 3 presents the results obtained from applying the neutrosophic Iadov technique for the study we are interested in carrying out. The last section contains the conclusions of the paper.

2 Basic Concepts

Throughout this section we describe the main definitions necessaries to apply the neutrosophic Iadov technique, which basically consists in processing a survey containing three closed questions. The results are assessed according to the "Iadov Logic Chart", where a number is given for every possible triple of responses. The interviewed does not know the interrelationship among the three questions. Finally, in case of doubt about the meaning of the answers, or simply to collect more information, many open questions can be asked as well. See in the following the formal definitions.

Definition 1. Let X be a universe of discourse, a space of points (objects) and x denotes a generic element of X. A *neutrosophic set A* in X is characterized by a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$, and a falsity-membership function $F_A(x)$. Where, $T_A(x)$, $I_A(x)$, $F_A(x) \subseteq]^-0, 1^+[$, i.e., they are real standard or nonstandard subsets of the interval $]^-0, 1^+[$. These functions do not satisfy any restriction, i.e., the following inequalities hold:

$^-0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$.

Definition 2. Let X be a universe of discourse, a space of points (objects) and x denotes a generic element of X. A *Single Valued Neutrosophic Set* (SVNS) A in X is characterized by a truth-membership function $T_A(x)$, an indeterminacy-membership function $I_A(x)$, and a falsity-membership function $F_A(x)$. Where, $T_A(x)$, $I_A(x)$, $F_A(x)$: $X \to [0, 1]$ such that: $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$. A *single valued neutrosophic number* (SVNN) is symbolized by <T,I,F> for convenience, where T, I, F $\in$ [0, 1] and $0 \leq T + I + F \leq 3$.

Therefore, $A = \{\langle x, T_A(x), I_A(x), F_A(x)\rangle : x \in X\}$ or what is the same $A = \langle T_A(x), I_A(x), F_A(x)\rangle$, for every $x \in X$.

Let A and B be two SVNSs, the following operations are defined:

4. $A \subseteq B$ if and only if $T_A(x) \leq T_B(x)$, $I_A(x) \geq I_B(x)$ and $F_A(x) \geq F_B(x)$. And, $A = B$ if and only if $A \subseteq B$ and $B \subseteq A$.

5. $A \cup B = \langle \max(T_A(x), T_B(x)), \min(I_A(x), I_B(x)), \min(F_A(x), F_B(x)) \rangle$, for every x∈X.

6. $A \cap B = \langle \min(T_A(x), T_B(x)), \max(I_A(x), I_B(x)), \max(F_A(x), F_B(x)) \rangle$, for every x∈X.

A scoring function $s: [0,1]^3 \rightarrow [0,3]$ can be read in Formula 1. Here we apply an adapted scoring function which is defined for sorting alternatives in Decision Making, see [15].

$$s(a_j) = 2 + T_j - F_j - I_j \quad (1)$$

Where a_j is an alternative evaluated with the SVNN (T_j, I_j, F_j).
Additionally, the definition of precision index $a: [0,1]^3 \rightarrow [-1, 1]$, which is given in Equation 2.

$$a(a_j) = T_j - F_j \quad (2)$$

Here we shall utilize Equation 2 for calculations.

Definition 3. The *Neutrosophic Logic* (NL) is the generalization of the fuzzy logic, where a logical proposition P is characterized by three components:

NL(P) = (T,I,F) (3)

Where the neutrosophic component T is the degree of truthfulness, F is the degree of falsehood, and I is the degree of indeterminacy ([15-16]).

Table 1 summarizes a scale of satisfaction that associates a number with a linguistic expression, a SVNN and a score obtained by calculating Equation 2. Therefore, we have the elements sufficient to measure the satisfaction of the interviewed. The scores are slightly different of those used in [11][7].

Number	Expression	SVNN	Score (Precision function)
1	Clear satisfaction	(1, 0, 0)	1
2	More satisfied than dissatisfied	(1, 0.25, 0.25)	0.75
3	Not defined	(0.5, 0.5, 0.5)	0
4	More dissatisfied than satisfied	(0.25, 0.25, 1)	-0.75
5	Clear dissatisfaction	(0,0,1)	-1
6	Contradictory	(1,0,1)	0

Table 1: Individual satisfaction scale.

An essential element for applying this technique is the "Iadov Logic Chart" represented in Table 2.

	1. Question 1								
	Yes			I don't know			No		
4. Question 3	2. Question 2								
	Yes	I don't know	No	Yes	I don't know	No	Yes	I don't know	No
Very satisfied.	1	2	6	2	2	6	6	6	6
Partially satisfied.	2	2	3	2	3	3	6	3	6
I don't care.	3	3	3	3	3	3	3	3	3
More unsatisfied than satisfied.	6	3	6	3	4	4	3	4	4
Not at all satisfied.	6	6	6	6	4	4	6	4	5
I don't know what to say.	2	3	6	3	3	3	6	3	4

Table 2: A generic logic table by V.A. Iadov to measure the relationship among the three closed questions.

One example of aggregation operator used for aggregate SVNNs is the *Weighted Average* operator (WA),

which is shown in Equation 4, see [17][8].

$$WA(a_1, a_2, \cdots, a_n) = \sum_{i=1}^{n} w_i a_i \quad (4)$$

Where, $a_i = (T_i, I_i, F_i)$ are SVNNs representing the evaluation of the alternatives, and $w_i \in [0, 1]$ for every i = 1, 2, …, n; which satisfy the condition $\sum_{i=1}^{n} w_i = 1$. The w_is represent the importance or weight of every alternative.

For measuring the group agreement, it is defined the Group Satisfaction Index (GSI) in [8], which is calculated as the Weighted Average operator.

In the following we describe the algorithm to use the neutrosophic Iadov technique:

9. The interviewed person is asked on his/her opinion, and he/she gives the answers for the three closed questions.
10. Thus, for each triplet of responses given by the interviewed person, we shall have a number from 1 to 6, which is selected of the Iadov Logic chart, see Table 2.
11. The selected number is the final evaluation of the person's opinion, which can be associated with its corresponding SVNN, in the third column of Table 1. However, we use the corresponding score in the last column of Table 1 for calculations.
12. Equation 4 is applied to aggregate the scores obtained of every person. Here we assume $w_i = \frac{1}{n}$ for all i.

    This is the so-called GSI.
13. To interpret the obtained GSI, we select from Table 1, the linguistic term having a closest score to GSI. When GSI is equally closest to two different values, the selection is made by means of the score function given in Equation 1.
14. In case that the final score is 0, we have to resort to the answers to the open questions.

3 Results

In this section we present the results of applying the neutrosophic Iadov technique to study the acceptance of Virtual Learning Environment. For this, we applied a survey to the participants in to 25 teachers and 261 students of UNIANDES Puyo, for both cases we did not distinguish the modality of studies because we want to know the level of satisfaction of using the Virtual Learning Environment in the teaching-learning process and the suggestions teachers and students have to improve this service.

The applied survey has two models according to the role of action: teachers and students. The selected teachers worked during the academic period April - August 2018. In total 25 teachers answered the questions, which teach different subjects in the modality of full-time and semi-full-time studies, which have access to the Virtual Learning Environment. On the other hand, the students considered for the study, belong to all the studies that are offered in the extension of Puyo. 261 students answered the questions, who regularly attend classes in the full-time courses, semi-full-time courses, and who have user account s in the Virtual Learning Environment.

The materials used in the research are, Office 365 forms and the Virtual Learning Environment implanted in UNIANDES Puyo to which all teachers and students have access. Teachers have access to virtual classrooms with the role of tutor teacher. In this way they have their own spaces where they can generate the contents of their subjects independently, with the requirement to comply with the structure of the virtual classroom established in the "Regulations for teachers in the use of virtual learning environment".

To carry out the research, it was necessary to design two survey models, one for teachers and one for students, in both cases we seek to know the degree of satisfaction of using the Virtual Learning Environment through answers to closed questions.

Both, teachers and students were notified and invited to participate in the survey using an electronic message

from the Virtual Learning Environment itself, they conducted the questionnaire anonymously electronically using Office 365 forms, in which they answered questions regarding the degree of satisfaction with the Virtual Learning Environment usage. Each type of questionnaire was analyzed individually, generating a global result by form model, with this analysis the positive or negative impact of the use of the Virtual Learning Environment in UNIANDES Puyo during the academic period April-August 2018 is measured.

The closed questions applied to teachers were the following:

1. Do you frequently use the Virtual Learning Environment to teach your classes?
2. Do you think the Virtual Learning Environment is useful for your classes?
3. How do you feel about the result of the Virtual Learning Environment regarding the independent work of students?

The closed questions to the students were the following:

1. Do you frequently receive classes supported by the Virtual Learning Environment?
2. Do you think that the use of the Virtual Learning Environment is useful for your independent study?
3. How do you feel about the management of the Virtual Learning Environment?

The possible answers for questions 1, 2, and 3 respectively were, (Yes, No), (Yes, I don't know, No), and (Very satisfied, Partially satisfied, I don't care, More unsatisfied than satisfied, Not at all satisfied, I don't know what to say).

The open questions asked to teachers and students were the following:

1. Tell and explain what are the difficulties encountered in using the Virtual Learning Environment.
2. Suggest some improvements that you would apply to using the Virtual Learning Environment.

The neutrosophic Iadov technique was applied. Scale shown in Figure 2 was considered for the interpretation of the final result.

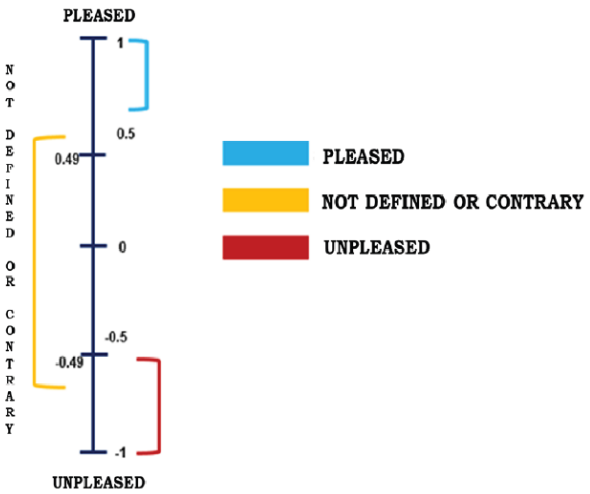

Figure 2: Scale of Group Satisfaction Index, according to [4].

Table 3 contains the results of the survey for the teachers, whereas Table 4 contains the results for the students. Let us note the number of the obtained answers per triple is enclosed between parentheses.

	1. Do you frequently use the Virtual Learning Environment to teach your classes?	
	Yes	No
3.How do you feel about the result of the Virtual Learning Environment	2.Do you think the Virtual Learning Environment is useful for your classes?	

regarding the independent work of students?	Yes	I don't know	No	Yes	I don't know	No
Very satisfied.	1 (14)	2	6	6	6	6
Partially satisfied.	2 (6)	2	3	6	3	6
I don't care.	3	3	3	3	3	3 (1)
More unsatisfied than satisfied.	6	3 (1)	6	3	4	4
Not at all satisfied.	6	6	6 (1)	6	4	5
I don't know what to say.	2	3	6	6	3 (2)	4

Table 3: Logical picture of Iadov for the interviewed teachers.

Thus, we obtained GSI = 0.77083 which signifies teachers are more satisfied than dissatisfied.

	1.Do you frequently receive classes supported by the Virtual Learning Environment?					
	Yes			No		
3.How do you feel about the management of the Virtual Learning Environment?	2.Do you think that the use of the Virtual Learning Environment is useful for your independent study?					
	Yes	I don't know	No	Yes	I don't know	No
Very satisfied.	1 (84)	2	6	6	6	6
Partially satisfied.	2 (157)	2	3	6	3	6
I don't care.	3	3	3	3	3 (3)	3 (2)
More unsatisfied than satisfied.	6	3	6	3	4	4
Not at all satisfied.	6	6	6 (1)	6	4	5 (2)
I don't know what to say.	2	3 (2)	6	6	3 (9)	4 (1)

Table 4: Logical picture of Iadov for the interviewed students.

Then, we have GSI = 0.76245 and therefore students are more satisfied than dissatisfied, as well.

According to the scale in Figure 2, the interviewed students and teachers are pleased with the method.

The open questions in general confirmed the acceptance of the method. Some interesting results obtained from the answers to the open questions were the following:

Teachers and students indicate that lack of time is the main reason why they have not used the Virtual Learning Environment, followed by ignorance of its operation.

On the other hand, students have the feeling of being constantly working, this is because some teachers occupy the virtual classroom with homework and delivery times are very short. To solve this problem, they request a better dosage of tasks and their delivery times, including adding new add-ons to the Virtual Learning Environment so that there is a better communication between teachers and their students.

From the students' perspective, using a Virtual Learning Environment in academic training creates more flexible learning environments that facilitate lifelong learning, improves independent learning and self-learning, as well as collaborative and group learning of students. These criteria match with teachers' responses.

On the part of the teaching staff, the main suggestion to improve the Virtual Learning Environment has to do with more training in the use of the available tools. They also suggest creating virtual classrooms in advance.

Another aspect mentioned to improve, which has no direct relationship with the Virtual Learning Environment, but it is worth mentioning has to do with the quality of Internet service on the university campus of UNIANDES Puyo.

From the students' point of view, the Virtual Learning Environment facilitates its work within the teaching-

learning process, but the quantity of subjects and tasks to accomplish, together with the short delivery times, gives them the feeling of not resting.

Another aspect that students request is the quality of internet service, although this limitation is not dependent on the Virtual Learning Environment.

Conclusion

This paper was dedicated to the study of the acceptance of the Virtual Learning Environment at the Regional Autonomous University of Los Andes, Puyo extension in Ecuador. 25 teachers and 261 students from this study center were surveyed, who were asked three closed questions about their use and satisfaction with the Virtual Learning Environment. The study relied on the technique of neutrosophic Iadov, where it was shown that respondents are more satisfied than dissatisfied with this learning supplement. The advantage to using neutrosophic Iadov is that it takes into account contradictions and indeterminacies in the answers to the three closed questions. Additionally, the two open questions asked to students and teachers, allowed to determine the changes that are needed to improve the use of the Virtual Learning Environment, which is mainly related to the necessity of a previous training for using the Virtual Learning Environment.

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Evaluation of actions to implement quality management and institutional projects in UNIANDES-Quevedo University a neutrosophic approach

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Abstract: The processes of quality management and human vocational training constitute an important element to be measured in higher education organizations. Quantifying its impact makes it possible to project the organization to improve this indicator. However, consolidating the processes of quality management and institutional development for the achievement of professional human development of excellence at the UNIANDES-Quevedo University represents an unresolved task. The present investigation proposes a solution to the problem posed from the development of a method to measure the implementation of quality management in institutional projects. The method bases its operation by neutrosophic numbers and uses a multicriteria approach. The proposal is applied as a case study at the UNIANDES-Quevedo University, from which it was possible to quantify its implementation rate.

Keywords: Method; neutrosophic; multicriteria; quality management

1Introduction

The institutional training management in universities has been framed in a strong theoretical and methodological debate that can cover different issues. Given the various epistemological and methodological positions that exist today in this field, a cultural, political and institutional debate arises. The above leads to recognize in the discussion environments about university reality, the issues associated with university social responsibility [1], [2], [3], university management processes, quality systems, final academic achievements and the scope of quality indices in graduates [4], [5], [6].

As part of the strategy to improve higher education in Ecuador, the consolidation of quality management processes and institutional development represents a line of work for the achievement of professional human development of excellence [7], [8]. At the University of UNIANDES-Quevedo in recent years, the subject has been given vital importance.

Based on the aforementioned analysis, the objective of this research is to develop a method to measure the implementation of quality management in institutional projects.

During the investigation diverse methods of science were used, among them the synthetic analytical, the logical historical, the one of the modeling and the systemic one. This allowed: to carry out a conceptual historical analysis, on quality management and its impact on training in universities, as well as structuring ideas on how to model the training of professionals as managers of culture in the 21st century, in the recognition of human and professional development as guiding categories thereof. Through interviews and observation guides, the investigated problem was corroborated.

From the theoretical references used for the development of this research, there was no evidence of the existence of a method to measure the implementation of project quality management. The fundamental contribution of the research developed is specified in the realization of a comprehensive institutional

management project that enables work with various institutional projects perfected for the various substantive functions carried out at the UNIANDES-Quevedo University.

2 Preliminaries

This section introduces the main elements that help to understand the proposed solution. Quality management is described for the context of the present investigation. The problem regarding the management of university institutional quality is presented and finally the use of Neutrosophics Cognitive Maps is described as a proposal for the evaluation of quality management.

2.1 Quality management

In order to implement an integrated institutional management system in any university, it is necessary to recognize concepts such as: quality, systems, quality systems, processes and results; This coincides with the pretense of considering the training of true competent professionals committed to their being, their knowledge, their work and living together, in the context of a transformative and socially relevant university[9], [10]. Therefore, the assessment of aspects such as career evaluation, accreditation and development rates achieved[11], [12]. These are criteria to take into account in this field, because universities need an academic evaluation and accreditation system [13], [14].

The process of university quality and excellence is important within the functions of higher education institutions, with an Academic, Research, Extensionist and management perspective. Highlighting ontological elements that have a preponderance in these processes as [11], [15] :

1. Governance, degree of effectiveness and legitimacy in the exercise of the function of university government; capacity of direction and coordination of the development between the personnel and organizational units, of whose contribution and synergy the institutional efficiency will depend.

2. The normative regulation set of legal instruments to establish the obligations, processes and procedures that the members of the university community must fulfill to exercise a right or benefit. Culture of planning and programming of financial resources, level of modernization of the legal framework that regulates programming and financing linked to the Institutional Development Plan and the Annual Operational Plans of the higher education institution.

3. The responsible University Autonomy, legal capacity to carry out its purposes with the widest freedom and organize its own government. Decentralized management, action to empower the University Centers so that they can execute the training, research, cultural dissemination and extension of services, which favor the development of their environment.

4. Rationality of expenditure, establishment of practices and lines of conduct of austerity and rationalization of operational and administrative expenses, as well as the compaction of occupational structures of campuses, centers, institutes and university units.

5. Technological systemic assurance, adoption of an operation model with a systemic and automated approach, of which all the actors of the university community that contribute to the execution of institutional expenditure are oriented to specific results and goals.

2.2 Issue around quality management

In the management and training dynamics of UNIANDES University, Quevedo Extension, practices are observed in the framework of institutional management and academic, research, extensionist and support processes, which do not make it possible to achieve the aspirations that senior management has raised, from the mission and vision that this university has; These practices constitute weaknesses at the systemic level, and encompass both students, managers, teachers and support staff or services involved in institutional life[1], [2].

When assessing the institutional reality in relation to the quality standards in university management that are established in the country and internationally, it is important to consider as in the context of this university, logic of an extension prevails, as it does not have a fully existing existence autonomous since many essential processes need the control, evaluation and addressing of the matrix, or headquarters [1], [2]. The preliminary studies carried out, which relied on triangulation as a method of determining factual manifestations of the problem, were developed from the analysis of the results of institutional evaluations, the observation of

university processes and the application of instruments to measure the satisfaction of the members of the university community, throwing the following elements [1], [2]:

a) The university community of UNIANDES-Quevedo University is unaware of the theories and practices of university institutional excellence recognized in the world. This is expressed in the fact that in the university community of UNIANDES-Quevedo there is a generalized practice of process management from the operational logic, but not of a process management that leads to institutional excellence, highlights the fact that teachers do not participate in the logic or paradigms of university excellence recorded by international organizations.

b) The existing capacities, both of infrastructure, as well as technological or human, are moderately used in the socio-educational context of the UNIANDES-Quevedo University; In this sense, managers, teachers and administrative staff do not have an awareness of management and institutional excellence.

c) Students in training do not achieve excellence in their integral and professional development; because the same in the process of vocational training do not recognize institutional excellence, as they do not handle terms such as relevance, institutional significance in society, quality and impact of graduates.

d) The institutional climate is favorable but fails to be optimal. Institutional communication processes can still be directed to perfect the institutional climate. There is no communication program for students in vocational training that prepares them to understand institutional excellence.

2.3 Neutrosophic Cognitive Map for quality assessment

Causal models: there are different types of causality that are expressed in the form of graphs, where each causal model that can be represented by a graph is a representation of causality between concepts. Causal models allow modeling the cause or effect of a given event [16], [17], [18]. Figure 1 shows a scheme with the different causal relationships.

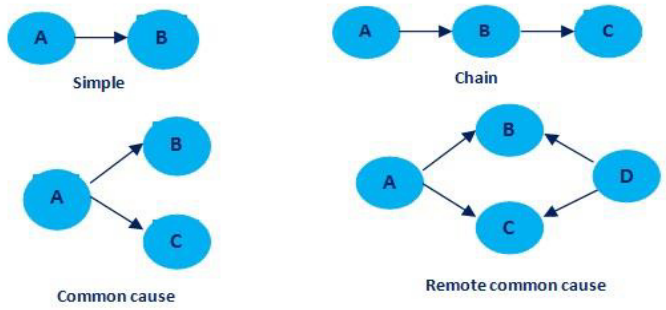

Figure 1: Example of causal graphs.

Neutrophic numbers are defined as: be $N = \{(T, I, F) : T, I, F \subseteq [0, 1]1n$, a neutrosophic valuation is a mapping of a group of formulas proportional to N, this is that for every sentence p have:

$$v\,(p) = (T, I, F) \tag{1}$$

With the purpose of facilitating the practical application to decision-making and engineering problems, the proposal of the Single Valued Neutrosophic Numbers was made (SVN) [19], [20], [21] which allow the use of linguistic variables [22], [23], [24] which increases the way of interpreting the recommendation models and the use of indeterminacy.

Let X be a universe of speech. An SVN over X is an object of the form.

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\}d \tag{2}$$

Neutrosophic Cognitive Map (NCM): it is a technique that allows the representation of the causal relationships of different concepts[25], [26], [23]. It is an extension of mental models using diffuse values in a range of [-1,1] [27],[28], [29]. NCM are represented by diffuse models with feedback to represent causality[30, 31].

In general terms, a cognitive map can be characterized by a set of concepts and causal relationships between nodes[32], [33]. The concepts represent variables, entities or states that usually describe the system

that is intended to be modeled in a given domain. On the other hand, causal relationships denote connections between concepts. Each relationship has an associated sign to express the direction of causation. More explicitly, it is true that[34,35:

- If the sign of the connection is positive, then a variation in the concept of cause (initial concept) will cause a variation in the concept of effect in the same direction.
- If the sign of the relationship is negative, then a variation in the concept of cause will cause a variation in the concept of effect in the opposite direction.

3 Design of the method to measure the implementation of quality management in institutional projects

This section describes the operation of the method to measure the implementation of quality management in institutional projects through the Neutrosophics Cognitive Map. The fundamental elements that characterize the proposal are presented to facilitate its understanding.

The method designed to infer the quality management implementation rate is expressed through three basic activities: input, inference and results. Figure 2 shows a general scheme of the proposed method.

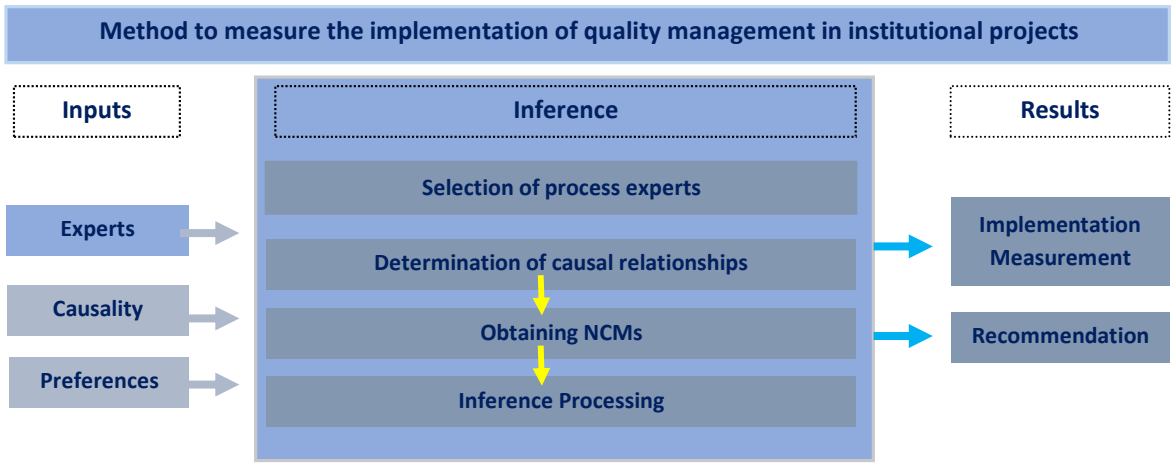

Figure 2: Structure of the proposed method.

The proposed method is structured to support workflow management on the implementation of quality in institutional projects. It employs a multi-expert multicriteria approach. It uses a set of evaluative indicators that represent the basis on which the method makes the inference. The inference process describes the reasoning from the implementation of the Neutrosophics Cognitive Map technique. Figure 3 shows the activities that describe the workflow of the method.

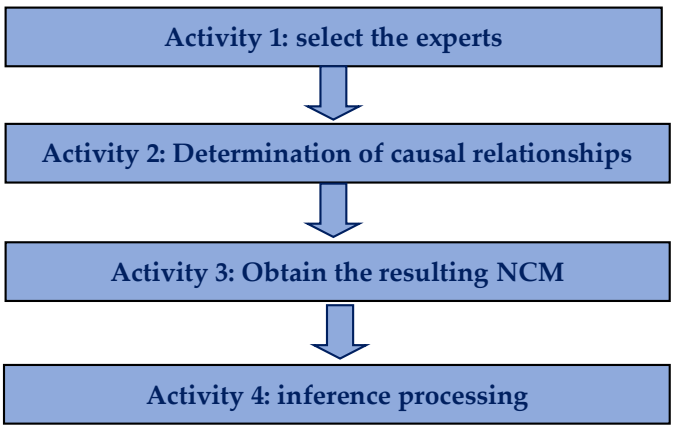

Figure 3: Workflow activities of the method.

A description of the proposed activities follows:

Activity 1 select the experts and determine the indicators:

The activity consists in determining the group of experts involved in the process. A multi-expert approach is used so that:

The number of experts involved in the process $E = \{e_1, \dots e_m\},\ m \geq 2,$

The number of process evaluation indicators $I = \{i_1, \dots i_n\},\ n \geq 2,$

Activity 2 determinations of causal relationships:

The determination of the causal relationships consists in establishing the relation of the map concepts. They are represented by diffuse variables expressed as linguistic terms. More explicitly, during the knowledge engineering stage each expert expresses the relationship between each pair of concepts C_i yC_j of the map. Then, for each causal relationship, K rules are obtained with the following structure: If C_i is A THEN C_j is B and weight W_{ij} is C.

The Centroid method and the Mamdani inference mechanism are then used to add the k rules, and the defuzified value is the value of the relationship. Figure 4 shows the membership functions used for the domain.

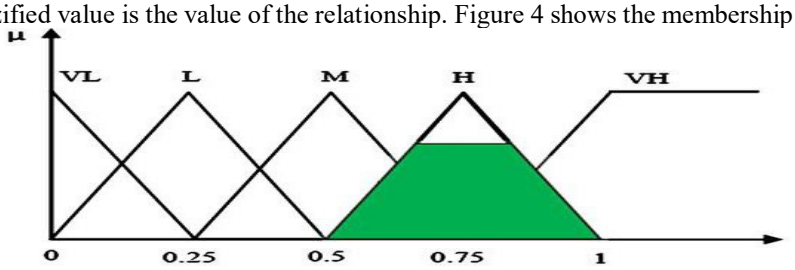

Figure 4: Membership function.

Activity 3 obtaining the resulting NCM:

From the results of activity 2 where the causal relationships are obtained, they are expressed by the adjacency matrix [34]. The aggregate values issued by the grouped experts, make up the relationships with the weights of the nodes, through which the resulting Neutrosophics Cognitive Map is generated [35]. By means of a static analysis of the result of the values obtained in the adjacency matrix, the degree of output can be calculated using equation (3) where the weights attributed to each manifestation are obtained [36].

$$id_i = \sum_{i=1}^{n} \left\| I_{ji} \right\| \tag{3}$$

Activity 4 inference processing:

The degree of activation of a neuron is an indicator of the level of presence of the concept in the system[37]. This feature is a key aspect in the interpretability and usability of NCMs, especially if the threshold function is continuous. Figure 5 shows the appearance of an NCM and the semantics in the activation of a neuron.

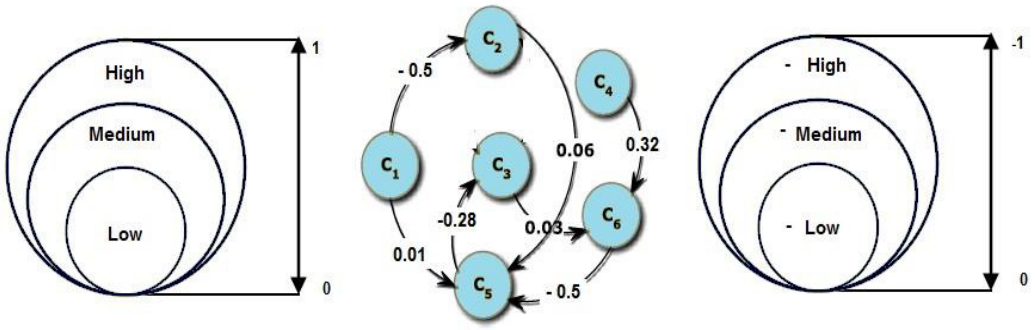

Figure 5: Level of activation of a concept.

From equation (4) the processing is carried out, which consists in calculating the state vector A over time, for an initial condition A^0. Similarly to other neuronal systems, the activation of$C_i$the neurons that directly affect the concept will depend on the activation$C_i$and of the causal weights associated with said concept [38, 39, 40].

$$A_i^{(K+1)} = f\left(A_i^{(K)} \sum_{i=1;\, j\neq i}^{n} A_i^{(K)} * W_{ji}\right) \tag{4}$$

Where:

$A_i^{(K+1)}$: is the value of the concept C_i in step k+1 of the simulation,

$A_i^{(K)}$: is the value of the concept C_j in step k of the simulation,

W_{ji}: is the weight of the connection that goes from the concept C_j to the concept C_i y f (x) It is the activation function.

4. Introduction of the method to measure the implementation of quality management

This section describes the implementation of the proposed method. A case study is carried out where it is possible to determine the behavior of the different alternatives based on determining the implementation of quality management in institutional projects.

For the proposed method, a support system for decision-making is implemented that allows the quality implementation to be measured through quality indicators. The proposal used the institutional projects at the UNIANDES-Quevedo University as the implementation scenario. The results of the study are described below:

Activity 1 select the experts and determine the indicators:

For the development of the study, 3 experts were consulted who represented the basis for the identification of causal relationships. The knowledge about the generation of the Project of innovation in the socio-institutional university management of the UNIANDES-Quevedo University was taken into account. The interactive circular and spiral logical structure. The dynamic generation in responses to institutional evaluation indicators.

From the work with the experts, 6 evaluation indicators were identified, which are related in Table 1.

Number.	Indicator
1	Management dynamics of Technical-Economic Cultural Reproduction
2	Dynamics of Creative Interpretation - Transgressive of Professional Human Development
3	Formation Dynamics of Integrative Human Capabilities
4	Orientation Dynamics of Professional Intentionality
5	Elective Freedom Dynamics responsible for Vocational training
6	Management dynamics Contextual Praxis Professional Partner

Table 1: Evaluative indicators.

Activity 2 determine causal relationships:

For the process of identifying causal relationships, 3 adjacency matrices were obtained corresponding to the 3 experts involved in the process for which they were added in the resulting matrix. Table 2 shows the adjacency matrix resulting from the process.

	$C_{1\,T,I,F}$	$C_{2\,T,I,F}$	$C_{3\,T,I,F}$	$C_{4\,T,I,F}$	$C_{5\,T,I,F}$	$C_{6\,T,I,F}$
$C_{1\,T,I,F}$	[0, 0,0]	[0.7, 0.5,0.2]	[0.5, 0.25,0]	[0.5, 0.2,0]	[0.5, 0.2,0]	[0.5, 0.2,0]
$C_{2\,T,I,F}$	[0.7, 0.5,0.2]	[0, 0,0]	[0.7, 0.5,0.2]	[0.7, 0.5,0.2]	[0.7, 0.5,0.2]	[0, 0,0]
$C_{3\,T,I,F}$	[0, 0,0]	[0.7, 0.5,0.2]	[0, 0,0]	[0.5, 0.2,0]	[0, 0,0]	[0.5, 0.2,0]
$C_{4\,T,I,F}$	[0.7, 0.5,0.2]	[0.5, 0.25,0]	[0.5, 0.2,0]	[0, 0,0]	[0.5, 0.2,0]	[0, 0,0]
$C_{5\,T,I,F}$	[0.5, 0.2,0]	[0.5, 0.25,0]	[0.5, 0.2,0]	[0.5, 0.2,0]	[0, 0,0]	[0.5, 0.2,0]
$C_{6\,T,I,F}$	[0.5, 0.2,0]	[0.5, 0.25,0]	[0.5, 0.2,0]	[0.5, 0.2,0]	[0.5, 0.25,0]	[0, 0,0]

Table 2: Adjacency matrix evaluative indicators.

Activity 3 results of the resulting NCM:

From the resulting adjacency matrix, the Neutrosophic Cognitive Map of the method to measure the implementation of quality management is obtained. Figure 6 shows the resulting Neutrosophic Cognitive Map.

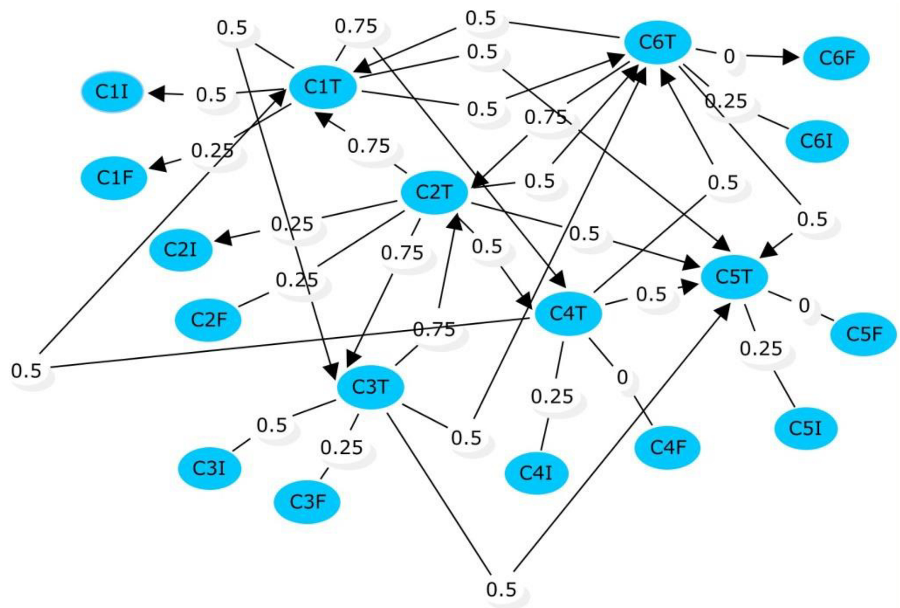

Figure 6: Neutrosophic Cognitive Map resulting.

Activity 4 inference processing:

From the adjacency matrix, the weights attributed to the evaluation indicators were identified by solving equation (3). Table 3 shows the results obtained from the weights.

Number	Evaluative Indicators	Peso
C_1	Management dynamics of Technical-Economic Cultural Reproduction	0,1875
C_2	Dynamics of Creative Interpretation - Transgressive of Professional Human Development	0,1944
C_3	Formation Dynamics of Integrative Human Capabilities	0,1181
C_4	Orientation Dynamics of Professional Intentionality	0,1528
C_5	Elective Freedom Dynamics responsible for Vocational training	0,1736
C_6	Management dynamics Contextual Praxis Professional Partner	0,1736

Table 3: Weight attributed to the evaluation indicators.

Based on the behavior of the weights attributed to the indicators and the behavior in the organization of the evaluation indicators, an information aggregation process is carried out with the objective of estimating the implementation rate. Table 4 shows the result of the calculation performed.

Criteria	Weights	Preferences	Aggregation
C_1	0,1875	0,75	0,140625
C_2	0,1944	1	0,1944
C_3	0,1181	1	0,1181
C_4	0,1528	0,5	0,0764
C_5	0,1736	0,75	0,1302
C_6	0,1736	0,75	0,1302
Index			0,79

Table 4: Weight and preferences attributed to the development of the method.

Once the implementation index is obtained, an analysis of the value obtained is performed where an index of quality management implementation of an I = 79 is evidenced. From the determined value, it can be concluded that the project quality management Institutions at Universidad UNIANDES-Quevedo is at an appropriate level.

Conclusions

From the development of the proposed research, a method is obtained to determine the implementation rate of quality in institutional projects. The proposed method based its operation through a multi-expert multicriteria approach.

From the implementation of the method, the aggregated Neutrosophic Cognitve Map is obtained with the representation of the causal relationships in the evaluation criteria. This element represents the basis for the inference of the operation of the proposed method. A limitation to be address in future work in the inclusion of machine learning mechanism to improve the dynamic behavior con NCM.

From the application of the method in the case study, it is possible to demonstrate the applicability of the method that allowed measuring the quality management implementation index based on the set of evaluation criteria.

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Analysis of the Venezuelan migratory impact on the economic development of Santo Domingo city, a neutrosophic cognitive map approach

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Abstract. In the most recent years, there has been a massive Venezuelan emigration to Santo Domingo city in Ecuador. This phenomenon has affected the local economy as well as the society of the city. This paper aims to study the economic impact of Venezuelan emigration to the city of Santo Domingo since a Neutrosophic Cognitive Map (NCM) approach. The advantage of using NCMs is that the causal relationships between the variables that influence the phenomenon under study are established and ranked in order of their importance. This allows determining which are the elements related to the Venezuelan migration to the Ecuadorian city of Santo Domingo that most impact the city economically, and if this impact is positive or negative for citizens and migrants. Finally, decision-makers will be provided with valuable information to take the necessary measures, where those favorable trends are reinforced and the unfavorable ones are reversed, always that humanitarian policies were dictated.

Keywords: Migration, local economy, employment, cognitive maps, neutrosophic cognitive maps.

1 Introduction

Ecuador has not been characterized as a country with an immigrant tradition compared to other countries of the American continent such as Mexico or Brazil. However, in the last decade, Ecuador has gone from being a country of emigrants to one that receives immigrants. The number of migrants in Ecuadorian territory has increased since the principle of universal citizenship recognized in the Constitution of Montecristi in 2008. According to the 1990 census, there were 65147 foreigners in Ecuador, in 2001 the number increased to 104130, while in 2010 the number was 325356.

Although there are no exact figures for the number of Venezuelans living in the country, according to data from the Civil Organization of Venezuelans in Ecuador, there exist approximately 28347 Venezuelans in the nation who mainly live in the cities of Quito, Guayaquil, Cuenca, and Ibarra.

In the press conference held at the Palais des Nations in Geneva, William Splinder, the spokesperson of United Nations High Commissioner for Refugees (UNHCR) said that many Venezuelans are moving on foot in a journey for days and even weeks in precarious conditions. Many of them are left without resources to continue their journey and are forced to live in difficult conditions in public parks, resorting to begging and other harmful mechanisms to meet their daily needs. It has been identified that about 20 percent of newcomers show specific protection needs and other vulnerabilities, including women and children at risk, single-parent families or persons with disabilities, who need urgent assistance. Women and girls account for 40 percent of newcomers and face serious risks of sexual violence, including survival and trafficking sex. Xenophobic reactions to the exodus have been observed in some sectors; see [1-4].

Emigration should be analyzed from two points of view, the social one linked to human rights, because with the sustenance of their work they intend to "help" the relatives who stayed in Venezuela, which leads to an increase

in the human tragedy that these aspects are linked to, and secondly the benefits obtained to the economic perspective in Ecuador when there exist labor sectors that are not of the pleasure of Ecuadorians, but that the presence of Venezuelan emigrants, mainly young people, helps to generate benefits for the company's owners who decide to rely on their services since their costs are minimized, especially if they are informally hired.

The purpose of this investigation is to analyze the impact of the massive migration of Venezuelans in Ecuador over the last two years, especially the economic impact in the city of Santo Domingo. We must recognize that the study we are doing would be superficial if other variables, such as political and social, were not included. In particular, we propose to carry out this analysis through the application of neutrosophic cognitive maps where the causal relationships between different characteristics related to Venezuelan migration are linked. We select the use of neutrosophy to incorporate some causal relationships among aspects that may be indeterminate, mainly since at the moment of the research there was no certainty of the degree of relationship between them, although they are essential for this study.

The neutrosophic logic theory is based on Neutrosophy and generalizes fuzzy sets and fuzzy logic theory; see [5-7]. A Neutrosophic Cognitive Map (NCM) is a Cognitive Map where indeterminacy is explicitly included in causal relations evaluations, see [8]. NCMs are based on neutrosophic logic to represent uncertainty and indeterminacy in cognitive maps([9]), thus, it extends Fuzzy Cognitive Maps ([10]). An NCM is a directed graph such that at least one edge is indeterminate and it is depicted by using dotted lines, see [11]. This kind of representation allows dealing with indeterminacy. In this paper, we apply the static tools of NCM for the study.

There exist different approaches to mathematically model the migratory flow between countries. Usually, these are dynamic models, since migratory flows change over time. Among those models there are Markov chains, for example in [12] the migration process is modeled using the multistage network equilibrium model of human migration. In [13] a model called "Discrete-time model for a substance motion in a channel of a network" is developed, which among its proposed applications is the modeling of human migratory processes, especially the interaction between migrants and the native population.

In [14, 15] a review of human migration models is made. Among the mathematical models, in addition to those based on the Markov chain, there are others based on natural and social phenomena, such as the Gravity Model based on the Newtonian theory of universal gravitation, migration modeling based on adaptation to climate change, model of agent migration adaptation to rainfall change, economic models, as well as statistical models based on time-series and multiple regression analysis. In [16] a multiclass human migration network equilibrium model is designed and a calculation algorithm is proposed. None of the aforementioned models explicitly considers indeterminacy as part of them. An interesting exception appears in [17], where the Iadov technique is used to study the migratory phenomenon in Ecuador. On the other hand, we intend to specifically study the migration impact on the local economic situation and not the behavior of the migratory flow.

On the other hand, there is extensive experience in the application of FCM to study sociological phenomena. In [18] the FCM is applied to incorporate social science scenarios in integrated assessment models. Khan and Quaddus [19] use the FCM to study causal relationships among relevant domain concepts. In [20] the situation of the social and personal life of employees of private companies is analyzed. On the other hand, Tsadiras in [21] compares the inference capacity of FCM based on binary, trivalent and sigmoid functions. An interesting generalization would be to replace the FCM by NCM, once the indeterminacy is included, to obtain more accurate models.

Also, some NCM-based models are used for modeling social phenomena. In [22] the criminal situation in Nigeria and the factors related to this phenomenon are studied, with the support of NCMs. In [23] the reasons for suicide are studied using this tool. Mondal and Pramanik ([24]) use it to study the social situation of a discriminated minority in India, the hijras group, in [25] the problem of construction workers in a region of India is studied using NCM, and Vasantha-Kandasamy and Smarandache ([26]) study through this tool the social situation of migrant workers who are carriers of HIV/AIDS. These constitute the most recent approaches to study social phenomena by NCM. In particular, NCMs allow us to model not only uncertainty, as Markov chains or FCMs do, but also incorporate the indeterminacy of decision-making, and it does so through the subjective assessment of experts, which makes the difference of tools based on classical statistics. The methods used above are based on the dynamic study of the variables, which reach an equilibrium point. In this paper, the static analysis is performed, which is algorithmically simpler.

As we have previously pointed out, Venezuelan migration in Ecuador has had an impact on the local population, including the economically. This study is motivated by the need to measure appropriately, which is intuitively known by the opinion issued by the Ecuadorian citizens, which is the rejection of Venezuelan emigrants, and the humanitarian situation in which they find themselves. For this reason, the authors of the paper consider that the main contribution of this investigation is that it determines what the true humanitarian situation of these migrants is and how they influence the local economy. Therefore in some way, it will reverse any circumstance

that it is not following humanism or that damages the prosperity of the citizens, to designing effective public policies ([27-30]). NCMs have the advantage that they are tools that model the causal relationships between the variables that are measured, in addition to incorporating the indeterminacy because of the relationships between two or more variables are unknown.

We should point out that other more general neutrosophic theories have proven are effective in solving decision-making problems, such as plithogenic sets, that could be considered to replace classic neutrosophic sets in a possible future investigation similar to this, see [31].

This paper is divided into the following sections; Section Preliminaries contains the basic concepts related to Neutrosophic Cognitive Maps. Section Results summarizes the results of the investigation on the economic impact of the Venezuelan migration to Santo Domingo city. The paper finishes with the section of Conclusions.

2 Preliminaries

This section summarizes the most important definitions and techniques associated with NCM. Concepts like neutrosophic logic, neutrosophic numbers, neutrosophic cognitive maps and static indices of NCM are described.

Definition 1. ([6-7]) Let X be a universe of discourse. A *Neutrosophic Set* (NS) is characterized by three membership functions, $u_A(x), r_A(x), v_A(x) : X \to \,]^-0, 1^+[$, which satisfy the condition $^-0 \leq \inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3^+$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denote the membership functions of truthfulness, indetermination, and falseness of x in A, respectively, and their images are standard or non-standard subsets of $]^-0, 1^+[$.

The *Single-Valued Neutrosophic Set*, which is defined below, was created to apply NS to real problems.

Definition 2. ([6-7]) Let X be a universe of discourse. A *Single-Valued Neutrosophic Set* (SVNS) A on X is an object of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \quad (1)$$

Where $u_A, r_A, v_A : X \to [0,1]$, satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denote the membership functions of truthfulness, indetermination, and falseness of x in A, respectively. For convenience a *Single-Valued Neutrosophic Number* (SVNN) will be expressed as A = (a, b, c), where a, b, c $\in [0,1]$ and satisfies $0 \leq a + b + c \leq 3$.

Neutrosophic Logic (NL), extends fuzzy logic, in such a way that given a logical proposition P, it is characterized by three components; see [5]:

$$NL(P) = (T, I, F) \quad (2)$$

Where component T is the degree of truthfulness, F is the degree of falsity and I is the degree of indetermination. The degree of indeterminacy is considered an independent component.

The results of the static analyses in NCMs are given in form of neutrosophic numbers, which are numbers with the algebraic structure a+bI, where I = indetermination; see Definitions 3 and 4.

Definition 3. ([32-36]) Let R be a ring. The *neutrosophic ring* $\langle R \cup I\rangle$ is also a ring, generated by R and I under the operation of R, where I is a neutrosophic element that satisfies the property $I^2 = I$. Given an integer n, then, n+I and nI are neutrosophic elements of $\langle R \cup I\rangle$ and in addition $0 \cdot I = 0$. Also, the inverse of I I^{-1} is not defined.

For example, a neutrosophic ring is $\langle \mathbb{R} \cup I\rangle$ generated by the ring $\mathbb{R}$.

An operation over $\langle R \cup I\rangle$, especially with I is the following:

I+I+...+I = nI.

Definition 4. A *neutrosophic number* N is defined as a number as follows ([37, 38]):

$$N = d + I \quad (3)$$

Where d is the *determined part* and I is the *indeterminate part* of N.

Let $N_1 = a_1 + b_1 I$ and $N_2 = a_2 + b_2 I$ be two neutrosophic numbers, then some operations between them are defined as follows:

1. $N_1 + N_2 = a_1 + a_1 + (b_1 + b_2)I$ (Addition),
2. $N_1 - N_2 = a_1 - a_1 + (b_1 - b_2)I$ (Difference),
3. $N_1 \times N_2 = a_1 a_2 + (a_1 b_2 + b_1 a_2 + b_1 b_2)I$ (Product),
4. $\frac{N_1}{N_2} = \frac{a_1 + b_1 I}{a_2 + b_2 I} = \frac{a_1}{a_2} + \frac{a_2 b_1 - a_1 b_2}{a_2(a_2 + b_2)} I$ (Division).

A *neutrosophic matrix* is a matrix whose components are elements of $\langle R \cup I\rangle$.

Since this, it is possible to generalize the operations between vectors and matrices on R to the ring $\langle R \cup I\rangle$.

A *neutrosophic graph* is a graph with at least one neutrosophic edge linking two nodes, i.e. an edge where there is indetermination on the connection of two nodes, see [39-41].

A *neutrosophic cognitive map* (NCM) is a neutrosophic graph used to represent causal reasoning, see [7, 37, 38].

Neutrosophic Cognitive Maps extend cognitive maps and fuzzy cognitive maps since it includes the possibility of indetermination. See for instance Figure 1, where the connections of nodes v_4 to v_2, v_5 to v_2 and v_1 to v_5 are represented by dashed lines, which means that there is indeterminacy in these connections.

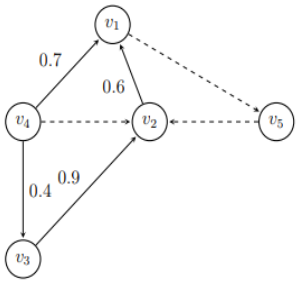

Figure 1. Example of Neutrosophic Cognitive Map.

To build an NCM we have to collect the evaluations of k experts. The *collective adjacency matrix* of the experts is calculated as follows ([7]):

$$E = \mu(E_1, E_2, \dots, E_k) \quad (4)$$

Where μ is an aggregation operator, usually the arithmetic mean.

Centrality measures are calculated as neutrosophic numbers obtained from the adjacency matrix of the NCM. These measures are:

Outdegree, denoted by $od(v_i)$, is calculated as the sum by rows of the absolute values of a variable in the neutrosophic adjacency matrix. It measures the degree of accumulated force of the existing connections of the variable. See Equation 5:

$$od(v_i) = \sum_{j=1}^{N} |c_{ij}| \quad (5)$$

Indegree, denoted by $id(v_i)$, is calculated as the sum by columns of the absolute values of a variable in the neutrosophic adjacency matrix. It measures the degree of accumulated force of the variables that arrive at the given variable. See Equation 6:

$$id(v_i) = \sum_{j=1}^{N} |c_{ji}| \quad (6)$$

The *Total Degree*, which is denoted by $td(v_i)$, is calculated by the sum of indegree and outdegree. See Equation 7:

$$td(v_i) = od(v_i) + id(v_i) \quad (7)$$

A de-neutrosophication process was proposed by Salmeron and Smarandache ([42]) and can be applied to give a final order. This process provides a range of numbers for centrality using as a base the maximum and minimum values of $I = [a_1, a_2] \subseteq [0, 1]$, based on Equation 8, see [7, 42]:

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \quad (8)$$

The next step when the previous indices are calculated is to establish an order of preference among the variables. Thus, given $A = [a_1, a_2]$ and $B = [b_1, b_2]$, the preference is defined as follows:

$$A \succ B \Leftrightarrow \lambda(A) > \lambda(B) \quad (9)$$

That is to say, A is preferred over B if and only if $\lambda(A) > \lambda(B)$.

The nodes are classified according to the following rules:

- Transmitting variables: They have positive or indeterminate outdegree and null indegree.
- The receiving variables: They have an indeterminate or positive indegree, and null outdegree.
- Ordinary variables: They have both non-null indegree and non-null outdegree.

3 Results

This section exposes the results of applying NCMs to study the economic impact of the Venezuelan migration to Santo Domingo city. NCMs are proven tools for social studies, in this research, we will use static analysis of NCMs. Additionally, the classification rules for the nodes given above allow determining the dynamic relationships between the studied variables, since the variables that influence the others or those that are influenced by the others are identified, also the degree of such influence is given.

The variables we study are the following:

V_1: Immigrant's labor experience.
V_2: Immigrant's kind of job.
V_3: Immigrant's time of residence in Ecuador.
V_4: Immigrant has a family in Venezuela.
V_5: Immigrant has suffered from discrimination.
V_6: Immigrant's motive for migrating.
V_7: Local Economy of Santo Domingo.

We based our analysis in experts' opinions, a survey applied to Venezuelan's migrants, the interviews made to the main Santo Domingo's political authorities, among others. The last punctuations were made by three experts, who assessed the current situation of the Venezuelan' immigrant. Figure 2 shows the neutrosophic graph of the NCM after the relationships among these variables were evaluated, whereas the adjacency matrix can be seen in Table 1.

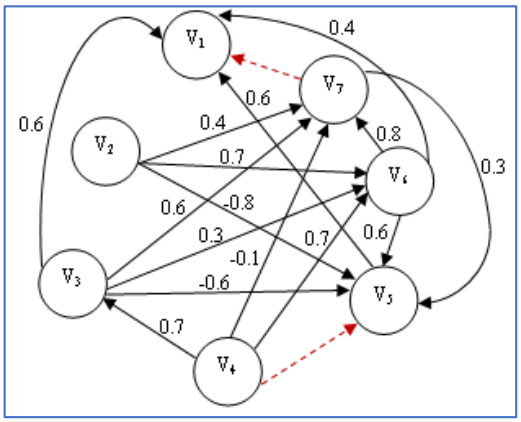

Figure 2: Pictorial representation of the NCM. Red and dashed lines represent indeterminate relationships.

Variable	V_1	V_2	V_3	V_4	V_5	V_6	V_7
V_1	0	0	0	0	0	0	0
V_2	0	0	0	0	-0.8	0.7	0.4
V_3	0.6	0	0	0	-0.6	0.3	0.6
V_4	0	0	0.7	0	I	0.7	-0.1
V_5	0.6	0	0	0	0	0	0
V_6	0.4	0	0	0	0.6	0	0.8
V_7	I	0	0	0	0.3	0	0

Table 1: Adjacency matrix of the causal relationships among every pair of variables.

From Table 1, we can calculate the static indexes of the NCM, i.e., outdegree, indegree, and the total degree of the neutrosophic adjacency matrix, according to formulas 5, 6 and 7, respectively; see Table 2.

Variable	*outdegree*	*indegree*	*Total degree*
V_1	0	1.6+I	1.6+I
V_2	1.9	0	1.9
V_3	2.1	0.7	2.8

V_4	1.5+I	0	1.5+I
V_5	0.6	2.3+I	2.9+I
V_6	1.8	1.7	3.5
V_7	0.3+I	1.9	2.2+I

Table 2: Indegree, outdegree, and the total degree of the neutrosophic adjacency matrix.

Results in Table 2 are converted to intervals in case the value contains symbol I, next to the de-neutrosophication function λ is applied according to Equation 8, and finally an order of preference among the variables is established, see Equation 9.

Variable	Final Value	$\lambda(V_i)$	Order of preference
V_1	[1.6, 2.6]	2.1	5
V_2	1.9	1.9	7
V_3	2.8	2.8	3
V_4	[1.5, 2.5]	2	6
V_5	[2.9, 3.9]	3.4	2
V_6	3.5	3.5	1
V_7	[2.2, 3.2]	2.7	4

Table 3: Total degree, de-neutrosophicated and ordinal number of every variable.

Table 3 indicates that the order of preference of the variables is the following:
$V_6 \succ V_5 \succ V_3 \succ V_7 \succ V_1 \succ V_4 \succ V_2$.

As can be seen, the variables corresponding to "Immigrant's motive for migrating" (V_6), "Immigrant's suffered from discrimination" (V_5) and "Immigrant's time of residence in Ecuador" (V_3), are the ones with the most impact on the city's economy. On the other hand, the variables "Immigrant's kind of job" (V_2) and "Immigrant has a family in Venezuela" (V_4) are classified as transmitters; therefore although they are the least important, they influence the other variables. Finally, the variable "Immigrant's labor experience" (V_1) is influenced by the others as it is a receiving variable. In the next section, the results and the measures to be taken will be explained in more detail.

Conclusion

This paper was dedicated to studying the local economic impact of the Venezuelan migration to Santo Domingo city in Ecuador. We used Neutrosophic Cognitive Maps as the method to study this impact. Three experts, a survey to the immigrants, official data, among others, served as the source for the evaluation based on seven socio-economic variables, viz., "immigrant's labor experience", "immigrant's kind of job", "immigrant's time of residence in Ecuador", "immigrant has a family in Venezuela", "immigrant has suffered from discrimination", "immigrant's motive for migrating", and "local economy of Santo Domingo". The most influential factor is "immigrant's motive for migrating", later we have "immigrant has suffered from discrimination", "immigrant's time of residence in Ecuador", and "local economy of Santo Domingo". Thus, the motif for migrating is a powerful cause to take into account for studying the situation of those people. Because the main motif of them is the economic situation, then, it is frequent they suffer from discrimination by the native citizens, the time of residence in Ecuador of most of them is less than two years and the local economy has been impacted by these variables. The influence on the economy is positive in the sense that Venezuelans immigrants have jobs not wanted by the Ecuadorian citizens; however, the negative impact is that many of them have not jobbed, thus, they become a social problem. We recommend to Santo Domingo's political authorities they consider helping those people, mainly in placing them in jobs or giving them social assistance.

The authors think that because of the importance of this phenomenon future studies deserve to be developed in that delve even deeper into the variables that influence the local economic impact of Venezuelan migration. It is proposed to repeat the study after a sufficient time of having applied the measures by the city government about this phenomenon. In such a case, we could use again the static analysis of the NCMs, or the dynamic analysis as in [24, 25]. This study of the situation could be combined with Venezuelan migration forecast models, which would allow predicting future behaviors of the economic situation of the city. An interesting approach would be to apply plithogenic decision methods that make it possible to better capture the complex nature of the phenomenon.

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The transformational leadership, sustainable key for the development of ecuadorian companies. A neutrosophic psychology approach

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Abstract. The study of leadership is a fairly recurring topic in the scientific literature in recent years. Some approaches concern with the relationship between leadership and some personality traits of leaders. One field where leadership is of great importance is the business world, where leaders are needed to direct the company's progress because they inspire the other members of the organization. This paper aims to propose a mathematical method for measuring the transformational leadership degree in the company. Transformational leadership is the most complete of leaderships; the transformational leader is versatile, charismatic, communicative, empathic, and produces positive changes in the company. The method is based on the opinion of colleagues and subordinates of the leader about its leadership capacity, rather than on the study of its own personality. For the method to be easily usable, it is based on a graphic representation of both, the individual evaluations and the final results. The method is derived from the neutrosophical psychology theory, since it is considered not only the concepts of <leadership> or <anti-leadership>, but for the first time the <a-leadership> is defined to classify those people who exist in the organization that neither direct, nor restrain the development of the company, moreover, the a-leadership can be a component of any leader's personality.

Keywords: Transformational leadership, neutrosophy, neutrosophical psychology theory, neutrosophic crisp personality.

1 Introduction

Historically, leadership has been thought of as a myth, there are those who say that leaders must be born, others mention that they are also made daily, the truth is that today there have been great leaders with positive transcendence. and others in a negative way, and have left a legacy to society in general, in this document we will make it clear that leaders are people who have developed their skills and abilities to become people who motivate, guide and transform large masses of people All they want is to comply with philosophies that cover everyone with the same umbrella, that is, they are united by the same objectives.

Ecuadorian companies have been led to an empirical administration, however, due to the economic and political demands of the country, they have changed from knowledge to the application of knowledge, so that companies can remain in the market, evolve over time, changing its structure and improving the direction.

Management experts have conducted multiple studies in recent years to different business groups and institutions around the world, in which they have been able to determine that the most successful and outstanding companies are those that are managed by effective managers or directors, with skills and highly developed managerial skills, [1].

Globalization affects the interpersonal and managerial skills of leaders, so they must be prepared to work effectively in disagreements and understand the culture of the company. To improve productivity, organizations are betting on updating their human, technological and knowledge resources, and to establish a culture of excellence, to generate structural change due to the institution's need to adapt to the environment, [2], [1].

One of the most acclaimed leadership models today is precisely transformational leadership, which has the characteristic of promoting significant and sustainable changes in people and companies. To achieve high levels of leadership, it is essential to have the correct preparation to face the current challenges, find leaders who meet the company's objectives and inspire employees to train staff to achieve the expected results, it is essential to achieve transformational leadership.

This type of leadership requires changes and, fundamentally, changes necessary to execute administration processes, for the analysis of the necessary changes in order to obtain efficient leadership, Neutrosophy is used and specifically, the theory of neutrosophical psychology is used. This theory considers not only the concepts of <leadership> or <anti leadership>, but defines <leadership> to classify the people who exist in organizations, who do not direct or restrict the development of the company, but contribute to better profitability and efficient support for decision making.

1.1. Liderazgo empresarial

For an entrepreneurial leadership, an ideal transformative leader is important, this leader is the one who elevates his group to a higher level of commitment, in which each worker is responsible for the strategy that is being carried out, empowering him or her of their functions. and making him feel proud at work. In this regard, Cardona in [6], states that "transformational leadership is attractive and motivates people.

The referred author values the leader as a nonconformist visionary, capable of holistically appreciating the process, with a broad vision of his life goals, with a positive attitude and mainly a strategist, flexible, enterprising and innovative. The leader is in charge of the transformation, both of the state of affairs in the company, and the same aspirations and ideals of the followers ", this theory suggests that the leader inspires his followers and manages to transcend his personal interests related to the objectives of the organization, being able to have a profound and extraordinary effect on its subordinates, see [7].

In this regard [7], he points out that transformational leaders are always encouraging the creativity of their followers, searching and exploring new ways of doing things, such as new and innovative opportunities to learn. Transformational leadership offers an individual approach, since it directly supports followers, where communication is a fundamental element that influences the flow of different ideas, useful for making special recognitions to the people who contribute the most to the value of generating better returns. and ideas.

The aforementioned constitutes the basis for a leader to have followers, if leaders do not have followers, the results will not be as expected, because the leader fosters a long-term vision capable of articulating his followers, this is where the magic that few leaders generate is generated. They realize the possibility of transmitting all that energy to others to generate passion and motivation to achieve their goals.

A characteristic that distinguishes leaders, and particularly transformational leaders, is that they do not work in the short term, they always have a long-term vision, their task is to promote lasting and transcendental changes, these changes are cross-cutting where they take into account all the organization structure to achieve the objectives, that is, the leader does not look for momentary or temporary solutions of inconsistency, he always looks for lasting solutions for the benefit of all. For a company to be competitive, it must be efficient in all functional areas, for this it is essential to have active, competent and highly motivated employees.

A company with a pleasant working environment is no longer a luxury, it is a must in the organization, and this is because the working environment is nowadays considered a determining factor in the productivity and success of companies [8]. This is the reason why leadership and job satisfaction are important, not only because there is a relationship between job satisfaction and some factors that affect the economic success of an organization, but also because there are currently growing humanitarian concerns about some type of psychological experiences that people have during their lives, especially during their working life [9].

Chiavenato, as cited in [10], defines the organizational state of mind as the quality of the psychological environment of an organization, which is achieved with the level of motivation that people maintain. The organizational state of mind is an appreciation of the work environment enjoyed by the workers of a company.

A transformative leader helps improve the state of mind of the organization through his ability to activate the human group he is in charge of, so that they are committed to the organization and can meet the proposed goals and objectives. This type of leader must generate confidence and motivation in the employees, so that they are an example to follow, with this a better efficiency in the performance of work will be achieved.

It is important for a leader to know the different types of leadership and put into practice the most complete one. To do this, Table 1 shows the types of business leaders with their respective characteristics. Useful to choose the most suitable and obtain greater advantages.

LEADERSHIP	CONCEPT
NATURAL	They are those leaders who do not have a managerial position, and who displace their leadership on a daily basis, regardless of their position.
PARTICIPATORY	They are those leaders, who are decision-makers and take into account the other collaborators to give their opinions about their ideas, encouraging teamwork.
AUTOCRATIC	It is that leader who makes decisions on his/her own, and that is limited to taking ideas from the other participants, this leadership is good in times of crisis, when it is necessary to take firm positions.

BUREAUCRATIC	This leader is not very open to changes, is not very interested in the personality of his/her collaborators, and is limited to generating motivation for his/her entire team, in this leadership exceptional decisions prevail.
CHARISMATIC	This type of leadership is characterized by having a magnetism towards people, is an optimistic, energetic leader, who generates a lot of passion when exposing his/her ideas, what he/she has as a disadvantage is that he/she usually thinks that even when a project is not present, it will work.
TRANSACTIONAL	These leaders are concerned with maintaining the normal flow of operations in the company, they use the disciplinary issue a lot to align the employees, they only motivate under a style of rewards, which means that it is not sustainable, and this leader only cares to let everything flow normally.
TRANSFORMATIONAL	This leadership is the most complete, since its characteristics are to be versatile, charismatic and decisive, its interest is for people, he/she made its decisions backed by its followers, it is a specialist in motivating people, he/she has an open communication with all the members of the organization, is extremely proactive in directing its actions.

Table 1: Types of leaderships in enterprises.

Table 2, shows intrapersonal skills have to do with the inner development of the human being, this type of skill is acquired, and the leader must know how to manage his/her internal emotions, he/she must know how to separate the personal sphere from the work.

SKILL	CONCEPT
PERSONAL DEVELOPMENT	Adopt new ideas; it is a process of transformation of the person to improve their lifestyle.
EMOTIONAL INTELLIGENCE	The leader must know how to intelligently use his/her emotions to make them work for him/her and the result would be to clearly and calmly manipulate his/her behavior.
ASERTIVITY	The leader must express directly and adequately his/her views respectfully and without offenses, to establish a good dialogue for a better relationship with his/her collaborators.

Table 2: Intrapersonal skills necessary for a good leadership.

The good management of interpersonal skills helps the leader to effectively interact with their collaborators as it promotes good communication management, supports the fulfillment of group or individual goals, cares about their needs, motivates them and encourages them. They are divided into items in Table 3.

SKILL	CONCEPT
ORGANIZATIONAL BEHAVIOR	Provides compliance with the organization's strategy through effective behavior, whether individual or jointly.
ORGANIZATIONAL COMMUNICATION	It is the set of communication tools which channel the transfer of information from the organization in a secure way without leaks for better decision making.
TIME MANAGEMENT	It is to know how to plan time, prioritize the important activities over the urgent ones, since when using our time effectively it automatically becomes production and profitability.
CONFLICT MANAGEMENT	The manager, leader or collaborator must learn to handle conflicts with serenity and elegance since the human being in constant competition is prone to enter a conflictive environment, the challenge is to know how to take them, since in certain cases a conflict produces true solutions.
NEGOTIATION	It is the interaction between two or more people who need to meet an individual or group need, the purpose of the negotiation is to win or simply reach an agreement, which benefits both parties and manages to comply with the target set.
TRANSFORMING LEADERSHIP	Transformational leadership is the best type of leadership because it motivates, inspires its collaborators by fulfilling the objectives, strategy of the company based on humility and continuous strength.
COACHING	The leader who executes the coaching tool accompanies, guides,

	instructs, trains a person or collaborator, in a specific activity, has as a goal a greater personal and labor growth, therefore, a greater growth in the profitability of the business.
TRAINING OF WORK TEAMS	Effective teamwork leads to greater growth of the organization, even more so if personnel works in a leadership environment the objectives are easier to achieve since it creates an environment of commitment, dynamism, trust, innovation, productivity, humility giving greater value to the organization.
FACULATION OR EMPOWERMENT	Empowerment is a strategic process based on generating a relationship of partners between the company and its employees, granting them authority, power and autonomy, always in a leadership environment.

Table 3: Interpersonal skills necessary for a good leadership.

Some abilities give the solution to problems, internal or external, complicated that the company or organization has, each action taken in a leadership environment will have an optimal result. They are divided into the items in Table 4.

SKILL	CONCEPT
STRATEGIC THOUGHT	It is the action proposed by a leader, person, collaborators or organization to reach an end, analyzes the resources available, channels them, always executes them, optimizing time and cost.
INNOVATION	It is the implementation of a creative idea always in order to generate a differentiating value to competition or service.
DECISION MAKING	Process by which the leader must always take an action based on qualitative or quantitative data in order to obtain a favorable result for an individual or organization.
MANAGEMENT TO CHANGE	The leader must manage the strategy to change since it is necessary to generate an environment of trust, taking into account the contributions of employees indicating that this change will not affect their jobs will simply help the company grow and get to meet their goals with greater effectiveness and quality.

Table 4: Skills that the leader of the company must have to handle complex situations.

Based on the study carried out, Neutrosophical psychology is used to select the ideal leader for a company, a business or a new venture. In the next session some fundamental elements that the theory of neutrosophical psychology follows.

2 Neutrosophic psychology approach to business leadership

This section describes the main concepts and theories necessary to understand the study carried out in this document. It is divided into two subsections, the first dedicated to summarizing the main concepts related to leadership in companies, and the second contains some ideas of neutrosophical psychology.

2.2 Neutrosophic psychology

Sigmund Freud divides memory into three parts: conscious, preconscious, and unconscious, see [5]. Additionally, in the framework of the neutrosophic psychology it is defined the "aconscious", which means: to be ignorant, impassive, indifferent, senseless, and unfeeling. Thus, according to this theory we have: conscious, aconscious, and unconscious.Memory is divided into three main parts. It is a symmetric triad of the form $(< A >, < neutA >, < antiA >)$ as in neutrosophy:

1) Conscious, meaning things that we are currently aware of, it corresponds to $< A >$.
2) Unconscious, which comprises things that we are not aware of; they are hard to access because they are deep inside our mind. It is the opposite of conscious, corresponding to $< antiA >$.
3) Aconscious, which etymologically means away from conscious and unconscious, or neither conscious nor

unconscious, but in between, or a mixture of conscious and unconscious, a vague buffer zone between them. It corresponds to $< neutA >$ or Indeterminacy, as in Neutrosophy.

Thus, the consciousness, aconsciousness, and unconsciousness are the sources of positive, neutral (or blended), and negative emotions, thoughts, and behaviours throughout our lifespan. In human behaviour, there exists a permanent interaction and discussion among conscious, unconscious, and aconscious.

Sometimes people are mostly rational, sometimes they are mostly irrational, and others they are indifferent. This notion can be extended to the *discrete refined neutrosophic memory*, where the triad (<A>, <neutA>, <antiA>) is extended to the most general scheme $(< A > 1, < A > 2, \dots, < A > l;\ < neutA > 1, < neutA > 2, \dots, < neutA > m;\ < antiA > 1, < antiA > 2, \dots, < antiA > n)$ as in refined neutrosophy, see [5, 11-12]. Carl Jung has divided the unconscious (consciousness) into ([13]):

- personal unconscious, which is specific to each individual, and comprises forgotten or suppressed conscious;
- collective unconscious (consciousness), which is characteristic to the whole human species, and comprises ancestral memories called "archetypes" (universal meaning images) and mental patterns as inherited psychic structures.
- In [5] it is defined the group unconscious (consciousness), which is between the personal and collective unconsciousness. It is characteristic to a specific group that the individual belongs to, and has marked him/her mostly.

The aconsciousness, as an amalgam of consciousness and unconsciousness, is the indeterminate, ambiguous, vague zone where conscious and unconscious interfere. It is a transition space, or a mediation between opposites. In [5][2] it is defined $SL \in \{preconscious, subconscious, semiconscious = semiunconscious, subunconscious, and\ preunconscious\}$ of the aconsciousness into:

a) personal aconsciousness at sublevel SL, specific to each individual, and comprising particular things that only the individual is confused (indeterminate) about;
b) collective aconsciousness at sublevel SL, characteristic to whole human species, and comprising general things that all people are confused (indeterminate) about.
c) group aconsciousness at sublevel SL, characteristic to a specific group, and comprising group things (customs, traditions, believes) that all group members are confused about.

According to [5], the aconsciousness has a degree of conscious (c), and a degree of unconscious (u), where $c \in [0,1], and\ 0 \leq c + u \leq 2$. In the neutrosophic psychology there is the following notation:

$$NL(entity) = (c, a, u) \qquad (1)$$

Where;

c = degree of conscious (truth), a = degree of acounscious (indeterminacy): not sure if it's conscious or unconscious, or a blend of both, and u = degree of unconscious (falsehood).

$NL(conscious) = (1,0,0)$; $NL(acounscious) = (0,1,0)$; and $NL(unconscious) = (0,a,1)$; where; $a \in [(0,1]$, leaving room for indeterminacy (unknown, unclear).

The Neutrospsychic Crisp Personality considers a human person as a universe of discourse U, and three disjoint sets which are the following ([14][3]).

E = set of emotions of this person
H = set of thoughts of this person
B = set of behaviors of this person

Therefore, $U = E \cup H \cup B$, with $E \cap H = \emptyset, H \cap B = \emptyset$, and $B \cap E = \emptyset$. Thus, $U =< E, H, B >$.

Also, in [5] the trait is measured by degrees of <trait> and degrees of <anti trait>, such that each person is classified in a range between these two opposites and it is dynamic. Additionally, they include a middle position where there exists indeterminacy. In [5] it is enumerated the most common pair trait-anti trait, as follows:

- Extraversion – Introversion
- Conscientiousness – Unconscientiousness
- Perfectionism – Imperfectionism
- Sensitivism – Insensitivism
- Novator – Conservator

- Self Esteem – Self NonEsteem
- Agreeableness – Disagreeableness
- Openness to Intellect & Experience – Closeness to Intellect & Experience
- Inhibition – Disinhibition
- Flexibility – Rigidity
- Emotivism [Neuroticism (Hans Eysenck)] – Non-Emotivism
- Obsessionality – Nonobsessionality
- Cautiousness – Impulsivity
- Shyness – Boldness
- Honesty – Dishonesty
- Hostility [Psychoticism (Hans Eysenck)] – Nonhostility.

The Neutrosophic Trait Operator is the cumulative degree of individual x with respect to both the Trait and the antiTrait, and it is defined as:

$$dTrait\ \&\ antiTrai: S \rightarrow [-1,1] \quad (2)$$

Where; $dTrait\ \&\ antiTrai(x) = dTrait(x) + dantiTrait(x)$.

To classify an individual as belonging to trait or anti trait, a threshold is defined and denoted by Thr for the trait, and antiThr for the antitrait, so that:

- If $dTrait\ \&\ antiTrait(x) \geq +Thr$, then the individual is categorized as definitively belonging to the Trait,
- If $dTrait\ \&\ antiTrait(x) \leq -antiThr$, then the individual is categorized as definitively belonging to the antiTrait.
- If $dTrait\ \&\ antiTrait(x) \in (-\varepsilon, +\varepsilon)$, then the individual is categorized as been in a totally indeterminate state between the Trait and antiTrait.
- If $dTrait\ \&\ antiTrait(x) \in (\varepsilon, Thr)$, then the individual is categorized as mostly belonging to the Trait.
- If $dTrait\ \&\ antiTrait(x) \in (-antiThr, -\varepsilon)$, then the individual is categorized as mostly belonging to the antiTrait.

The way to deal with $dTrait\ \&\ antiTrait$ is illustrated in [5][4] as follows:

"Assume a psychiatrist, after many sessions, neutrosophic questionnaires and observations measured with neutrosophic statistics, has gotten to the conclusion that George P.'s two temperament dimensions are estimated with a certain accuracy as:

- degree of stable (trait) is $dGP(stable) = 0.2 \in [0,1]$;
- degree of unstable (antiTrait) is $dGP(unstable) = -0.5 \in [-1,0]$; and
- degree of extroverted (trait) is $dGP(extroverted) = 0.9 \in [0,1]$,
- degree of introverted (antiTrait) is $dGP(introverted) = -0.3 \in [-1,0]$.

Then $dGD < stable > \ \&\ < unstable > (x) = dGP(stable) + dGP(unstable) = 0.2 + (-0.5) = -0.3$, and $dGD < extroverted > \ \&\ < introverted > (x) = dGP(extroverted) + dGP(introverted) = 0.9 + (-0.3) = +0.6$."

3 Method to measure managerial transformational leadership

In this section we introduce a graphical assessment method to evaluate the managerial transformational leadership of an enterprise's manager. A pictorial rather than a linguistic or numeric evaluation is a very simple, easy way to measure leadership. Also, here we prefer to avoid identifying the degree of leadership or "anti leadership" by means of traits ([15-16][5]), because it is an indirect way to detect this kind of person (here we denote it by x). Thus, we selected that employees give their opinions about one possible leader by asking them about the degree of leadership and "anti leadership" by mean of some questions, which are the following:

1. Mark a square in the figure below on what degree you consider x is inspiring for the teamwork, to what extent his/her influences to meet the company's goals. The darkest square means "nothing," the lighter one "total."

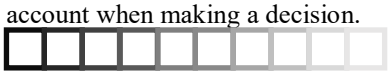
2. Mark a square in the figure below on what degree you consider x prevents the teamwork's environment from meeting the company's goals satisfactorily. The darkest square means "total," the lightest one "nothing."

3. Mark a square of the figures below on what degree you consider x meets the following shown characteristics, remembering that the darkest square means "nothing "and the lightest one "total":
   3.1. He/she adapts quickly and easily to different roles.

   3.2. He/she has a charm that attracts the staff of the company that knows him/her.

   3.3. He/she makes positive decisions for the company with firmness and determination.

   3.4. He/she concerns about meeting the people around him/her, listens and takes their opinions into account when making a decision.



   3.5. He/she is communicative, kind, gentle with the other workers.

Let us remark that each square represents an approximately 10% of agree about the criterion, and it is additive respect to the number of square on the left, e.g., if the third square is selected, that means the interviewed is approximately 30% agreed with the proposition. This survey should be applied to the majority of workers having a job relationship with *x*.

Questions 1 and 2 evaluate the degree of leadership (question 1) and the degree of anti-leadership (question 2) of x. To determine the total degree of leadership we only have to count the number of squares on the left of the selected square in question 1 including it (let us denote it by ps), next we count the number of squares on the left of the selected square in question 2 including it (let us denote it by ns), and finally we calculate the x's degree of leadership by formula 3:

$$dl = (ps - ns) + sign(ps - ns) \quad (3)$$

On the other hand, question 3 is concerned to measure the degree of transformational leader x is. In this case, a transformational leader must satisfy all the asked qualities, thus, we use formula 4 to assess this aspect.

$$dtl = min(s1, s2, s3, s4, s5) \quad (4)$$

Where; si $(i = 1, 2, 3, 4, 5)$ is the number of squares on the left of the marked squares including them for questions 3.1, 3.2, 3.3, 3.4, and 3.5, respectively.

Figure 1, is the discrete 2D pictorial coordinate system representation of the leadership degree of x from the viewpoint of one of his/her colleagues. See that we coined the term "a leadership" to represent no leadership nor anti leadership. The filled squares represent the coordinates. The abscissa represents dl of Equation 3, where respect to the center (labeled as "a leadership" and marked with a red line in figure 1), we have to count $abs(dl)$ squares, either to the left $if\ sign(dl) < 0$ or to the right $if\ sign(dl) > 0$, or we situate it in the middle where $abs(dl) = 0$.

The ordinate represents the degree that x is a transformational leader. Figure 1 shows a darkest zone, representing a non-leader, because he/she is an anti-leader. Whereas a brightest zone represents the leadership quality of x, and a central grayer zone represents "a leadership". Upper and righter x is situated; more leader's qualities he/she has.

To calculate the aggregated value of transformational leadership index we have to calculate de median of dl by every partner of x, and also the median of dtl for every one of them, and these values can be represented in a coordinate system like this shown in figure 1. When the median is not an integer, we approximate it to the nearer lower integer respect to the median.

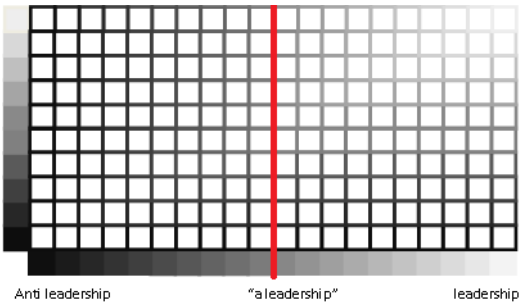


Figure 1: 2D coordinate system to represent leadership.

Let DL be the aggregation of dl respect to every interviewed and similarly let DTL be the aggregation of dtl respect to every interviewed, then, a numeric index of transformational leadership of x can be calculated as follows:

$$ITL(x) = DL * DTL \quad (5)$$

See that $ITL \in [-100, 100]$. $If\ ITL \leq -\varepsilon$, then x is not a good transformational leader, $if\ ITL \geq \varepsilon$, then x is not a good transformational leader, and $if\ ITL \in (-\varepsilon, \varepsilon)$, then he/she is an a-leader. In the following we illustrate the method with an example.

Example 1.

For simplicity we suppose that a survey was made to only three employees denoted by $E1$, $E2$, and $E3$, about the transformational leadership of x, who is a member of the company, the results were the following:

E_1 answered:

Question 1:

Question 2:

Question 3.1:

Question 3.2:

Question 3.3:

Question 3.4:

Question 3.5:

E_2 answered:

Question 1:

Question 2:

Question 3.1:

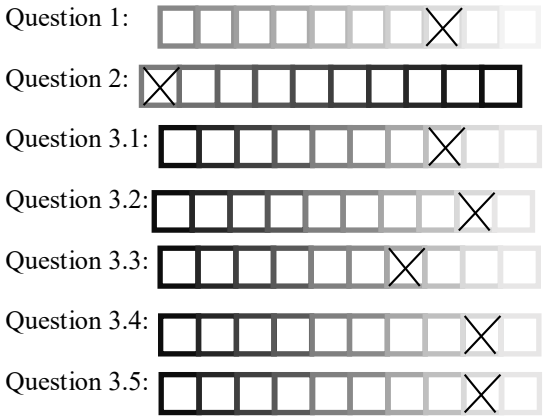
Question 3.2:

Question 3.3:

Question 3.4:

Question 3.5:

And E_3 answered:



Thus, $dl(x) = 6-2+sign(6-2) = 4+1 = 5, dl(x) = 5-2+sign(5-2) = 3+1 = 4, and\ dl(x) = 8-1+sign(8-1) = 7+1 = 8$; according to $E1$, $E2$, and $E3$'s criteria, respectively. Additionally, $dtl(x) = min(6,7,7,6,8) = 6, dtl(x) = min(5,5,6,6,5) = 5, and\ dtl(x) = min(8,9,7,9,9) = 7$. Thus, $DL = median(5,4,8) = 5$; $DTL = median(6,5,7) = 6$.

Representing these evaluations in the coordinate system of Figure 1, we obtain the graphic in Figure 2.

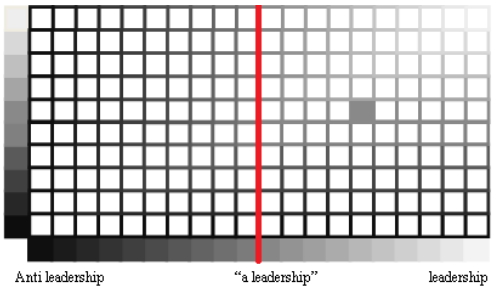


Figure 2: Graphical representation of the transformational leadership degree of x, represented by the filled square, coordinate 5 on the right of the leadership label, and six of height.

Therefore a graphical representation of the transformational leadership of x is approximately medium. According to Equation 5, a numeric measure of this is $ITL = 5 * 6 = 30$.

ITL corresponds to the area limited by the origin of the coordinate system and the point represented in Figure 2, see Figure 3.

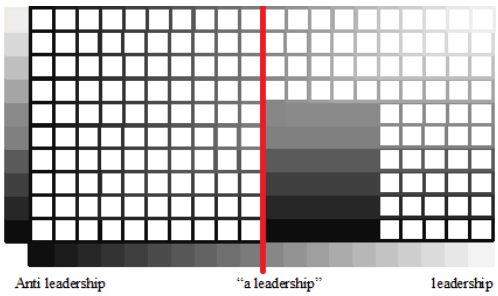


Figure 3: Area in the coordinate system representing ITL with filled squares.

Conclusion

This paper was dedicated to design a new method to assess transformational leadership in any company. The method starts from the evaluation of the leadership of a member of the company according to their peers and subordinates. The advantage of the method is its simplicity and that it can be easily automated. In addition, the way of representing opinions and the final evaluation is entirely graphic, therefore the result can be visualized by all, which in our opinion improves the understanding of what is measured, rather than if numerical measurements

were used. For the first time, the term "a-leadership", inspired by the neutrosophic psychology, is coined to mean the part of the individual's behavior that does not correspond to either leadership nor anti leadership. The use of the method was illustrated by one example.

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Prioritization of non-functional requirements in a mobile application for panic button system using neutrosophic decision maps

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Abstract. Several countries around the world have implemented systems to preserve public safety. Taking advantage of technological advances that are available to all citizens, in Ecuador it has been implemented a system called panic button, which consists of a cell phone network with geo-location, which can assist every citizen who needs to ask for help and the authorities will respond efficiently. This research proposes to improve this system in order to increase its efficiency and effectiveness. This requires the use of prioritization of non-functional requirements. In this paper we use the static analysis of Neutrosophic Cognitive Maps to determine, evaluate, and compare non-functional requirements. Neutrosophic Cognitive Maps allow establishing causal relationships among different criteria, with the objective of determining an order of preference. In this investigation we have three experts who provided the evaluations.

Keywords: Non-functional requirements, requirement engineering, neutrosophic logic, neutrosophic cognitive maps.

1 Introduction

Article 23 of the Public Security and State Law in Ecuador refers to citizen security and justice, through which some institutions such as the National Police among others, seek to guarantee citizens' security by the implementation of infrastructure, as well as the necessary equipment within the linked institutions.

Several countries have implemented measures aimed at preventing the safety of citizens, such as the ERSOS application that has been developed in Chile, using the technological resources currently available, in this case by means of geo-location, which seeks to provide alternatives that facilitate interaction between control authorities and citizens in case of inconveniences or emergencies that threaten their integrity.

In conjunction with the National Police and the Ministry of the Interior, the country has developed an alarm system that operates since the Community Police Units (CPU), which uses the panic button, a security strategy implemented by the National Police. This is based on an alert generated from the user's cellular network, having as its main reference the address to the home that has been registered, to which the aid personnel are directed in the event of an emergency, see [1].

The project in [1] is significant because it proposes the development of an option that allows for a better response to citizen emergencies, trying to find new technological alternatives that will improve the response time for responding to emergency calls in the CPU of the National Police.

The objective of such project was to develop a mobile application that would optimize the panic button system supported by geo-location to achieve a better response time in the CPU of the National Police, as a prototype in the parish of Caranqui, taking advantage of the great usefulness of technological resources currently available.

This paper aims to order by importance the quality criteria of the software applications that will be used in the system. Thus, our purpose is to analyse the prioritization of non-functional requirements of the software applied

in the cell-phone applications and computer servers.

In order to determine the prioritization of non-functional requirements to implement such a system, the Neutrosophic Cognitive Maps technique is used, see [2]. Non-functional requirement (NFR) refers to global properties and frequently to quality of functional requirements. This is an important and complex part of the requirement engineering process. It is essential for studying the quality of software, and constitutes a critical problem; see [3-10]. Non-functional requirements are difficult to evaluate, particularly because they are subjective, relative and interdependent.

To analyze NFR, uncertainty arises, making desirable to compute with qualitative information. In software development projects analyst must identify and specify relationships between NFR. Current approaches differentiate three types of relationships: negative (-), positive (+) or null (no contribution). The opportunity to evaluate NFR depends on the type of these relationships. Softgoal Interdependency Graphs ([6]) is a technique used for modeling non-functional requirements and interdependencies among them. Bendjenna in [3] proposed the use of fuzzy cognitive maps (FCM) relationships among NFRs and the weight of these relationships expressed with fuzzy weights in the range 0 to 1; see [11] [1]for Cognitive Maps and [12][2] for FCM. This model lacks additional techniques for analyzing the resulting FCM.

Neutrosophic logic generalizes fuzzy logic and is based on neutrosophy, see [13-14]. When indeterminacy is introduced in cognitive map it is called Neutrosophic Cognitive Map (NCM), see [2, 15]. NCMs are based on neutrosophic logic to represent uncertainty and indeterminacy in cognitive maps ([11]) extending FCM ([12]). A NCM is a directed graph in which at least one edge is indeterminate and is denoted by dotted lines. To utilize a NCM permits dealing with indeterminacy, making easy the elicitation of interdependencies among NFR.

This paper is divided in the following sections; Section 2 contains the definitions and theories that will be applied to solve the proposed problem. Section 3 consists in the exposition of the results of the problem solution. The last section contains the conclusions.

2 Basic Concepts

This section contains the main definitions of neutrosophic logic, in addition of neutrosophic numbers, neutrosophic cognitive maps and their static indices. All these are theories, methods and techniques that will serve to solve the problem addressed in this article.

Definition 1. ([13, 15]) Let X be a universe of discourse. A *Neutrosophic Set* (NS) is characterized by three membership functions, $u_A(x), r_A(x), v_A(x) : X \to \,]^-0, 1^+[$, which satisfy the condition $^-0 \leq \inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3^+$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denote the membership functions of truthfulness, indetermination and falseness of x in A, respectively, and their images are standard or non-standard subsets of $]^-0, 1^+[$.

The *Single-Valued Neutrosophic Set*, which is defined below, was created to apply NS to real problems.

Definition 2. ([13, 15]) Let X be a universe of discourse. A *Single-Valued Neutrosophic Set* (SVNS) A on X is an object of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \quad (1)$$

Where $u_A, r_A, v_A : X \to [0,1]$, satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all $x \in X$. $u_A(x), r_A(x)$ and $v_A(x)$ denote the membership functions of truthfulness, indetermination and falseness of x in A, respectively. For convenience a *Single-Valued Neutrosophic Number* (SVNN) will be expressed as A = (a, b, c), where a, b, c $\in [0,1]$ and satisfies $0 \leq a + b + c \leq 3$.

Neutrosophic Logic (NL), was proposed in 1995 by Florentin Smarandache, and is a generalization of fuzzy logic. According to this theory, a proposition P is characterized by three components; see [13-14][3]:

$$NL(P) = (T,I,F) \quad (2)$$

Where component T is the degree of truthfulness, F is the degree of falsity and I is the degree of indetermination. This degree of indeterminacy is proposed for the first time as an independent component.

The results of the static analyses in neutrosophic theory are given in the form of neutrosophic numbers, which are numbers with the algebraic structure a+bI, where I = indetermination. The formal definitions of these concepts are given below.

Definition 3. Let R be a ring. The *neutrosophic ring* $\langle R \cup I\rangle$ is also a ring, generated by R and I under the operation of R, where I is a neutrosophic element that satisfies the property $I^2 = I$. Given an integer n, then, n+I and nI are neutrosophic elements of $\langle R \cup I\rangle$ and in addition $0 \cdot I = 0$. Also, I^{-1}, the inverse of I is not defined.

An example of a neutrosophic ring is $\langle \mathbb{R} \cup I\rangle$ generated by $\mathbb{R}$.

Other operations on I are the following:

I+I = 2I and in general I+I+...+I = nI.

Definition 4. A *neutrosophic number* N is defined as a number as follows ([16-18][4]):

$$N = d + I \quad (3)$$

Where d is the *determined part* and I is the *indeterminate part* of N.

Example 1. N = 4.7+I, has 4.7 as the determined part and I as the indeterminate part, such that if I = [0, 1] then, N = [4.7, 5.7].

Let $N_1 = a_1 + b_1 I$ and $N_2 = a_2 + b_2 I$ be two neutrosophic numbers, then some operations between them are defined as follows:

5. $N_1 + N_2 = a_1 + a_1 + (b_1 + b_2)I$ (Addition),
6. $N_1 - N_2 = a_1 - a_1 + (b_1 - b_2)I$ (Difference),
7. $N_1 \times N_2 = a_1 a_2 + (a_1 b_2 + b_1 a_2 + b_1 b_2)I$ (Product),
8. $\frac{N_1}{N_2} = \frac{a_1 + b_1 I}{a_2 + b_2 I} = \frac{a_1}{a_2} + \frac{a_2 b_1 - a_1 b_2}{a_2(a_2 + b_2)} I$ (Division).

A *neutrosophic matrix* is a matrix whose components are elements of $\langle R \cup I \rangle$.

From this, it is possible to generalize the operations between vectors and matrices on R to the ring $\langle R \cup I \rangle$.

An example is the following:

Example 2. Given two matrices, $A = \begin{pmatrix} -1 & 2 & -I \\ 3 & I & 0 \end{pmatrix}$ and $B = \begin{pmatrix} I & 1 & 2 & 4 \\ 1 & I & 0 & 2 \\ 5 & -2 & 3I & -I \end{pmatrix}$, $AB = \begin{pmatrix} -6I + 2 & -1 + 4I & -2 - 3I & I \\ 4I & 3 + I & 6 & 12 + 2I \end{pmatrix}$.

A *neutrosophic graph* is a graph with at least one neutrosophic edge linking two nodes, i.e. an edge where there is indetermination about its connection of two nodes.

A *neutrosophic cognitive map* (NCM) is a neutrosophic graph used to represent causal reasoning.

This is a generalization of cognitive maps and fuzzy cognitive maps, since it includes the possibility of indetermination. See an example in Figure 1, where the connections of nodes v_4 to v_2, v_5 to v_2 and v_1 to v_5 are represented by dashed lines, which mean that there is an indeterminacy in these connections.

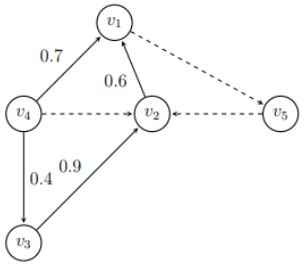

Figure 1. Example of Neutrosophic Cognitive Map.

To build a NCM we have to gather the evaluations of k experts. The *collective adjacency matrix* of the experts is calculated as follows:

$$E = \mu(E_1, E_2, \dots, E_k) \quad (4)$$

Where μ is an aggregation operator, usually the arithmetic mean.

Centrality measures are calculated as neutrosophic numbers obtained from the adjacency matrix of the NCM. These measures are:

Outdegree, denoted by $od(v_i)$, is calculated as the sum by rows of the absolute values of a variable in the neutrosophic adjacency matrix. It measures the degree of accumulated force of the existing connections of the variable. See Equation 5:

$$od(v_i) = \sum |c_{ij}| \quad (5)$$

Indegree, denoted by $id(v_i)$, is calculated as the sum by columns of the absolute values of a variable in the neutrosophic adjacency matrix. It measures the degree of accumulated force of the variables that arrive at the given variable. See Equation 6:

$$id(v_i) = \sum |c_{ji}| \quad (6)$$

The *Total Degree*, which is denoted by $td(v_i)$, is calculated by the sum of indegree and outdegree. See Equation 7:

$$td(v_i) = od(v_i) + id(v_i) \quad (7)$$

A de-neutrosophication process was proposed by Salmeron and Smarandache ([19]) and can be applied to give a final order. This process provides a range of numbers for centrality using as a base the maximum and mini mum

values of I = [a_1, a_2] ⊆ [0, 1], based on Equation 8, see [19]:

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \quad (8)$$

Once the previous numeric value is calculated, an order can be established between A = [a_1, a_2] and B = [b_1, b_2], as it is shown below:

$$A \succ B \Leftrightarrow \lambda(A) > \lambda(B) \quad (9)$$

In other words, A is preferred over B if and only if λ(A)>λ(B).

3 Results

This section is devoted to describe the calculus for applying NCM to determine and sort the main attributes to consider in the mobile application for the panic button system. The study is carried out respect to the software application necessary to install in the cell phones, as well as the software of data store in the computer servers. For this end, we begin with the non-functional requirements attributes selected by three experts, which are the following:

A_1. Portability,
A_2. Reliability,
A_3. Efficiency,
A_4. Security,
A_5. Initial and Life-cycle cost,
A_6. Usability by users' community,
A_7. Stability,
A_8. Extensibility, or capacity to incorporate new additives to the system,
A_9: Maintainability,
A_{10}: Response time,
A_{11}: Data integrity.

The three experts evaluated the strength of the causal relationships between every pair of attributes using a scale of integers in 0-10. We established this scale because it is more understandable for them, than a continuous scale in [0, 1]. Here, 0 means that there is not any causal relationship, 10 means the strength is total and 5, it is medium. We informed to experts that they can use symbol I to indicate indetermination. Additionally, we asked them to settle on if every relationship is direct or inverse.

These evaluations were processed as follows:

1. The strength of the assessed causalities are aggregated over the set of the three experts, using the median, if they are numeric. In case that at least one of experts assesses with symbol I, then I is the final aggregation value and the steps below do not proceed.
2. These aggregated evaluations are divided by 10 and it is the numeric strength of the relationships.
3. If the majority of the three experts consider the relationship is direct, then, we associate sign + to the obtained strength in step 2, otherwise we associate sign -.

Table 1 contains the calculations obtained by experts' evaluations. Let us note we use the notation A_1, A_2, …, A_{11} to represent the attributes associated with these notations.

Attribute	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}
A_1	0	I	0.7	I	-0.4	0.9	-0.3	0.4	-0.6	I	I
A_2	0	0	0.1	0.8	-0.5	0.4	0.6	0	0	0	0.8
A_3	0	0	0	I	0.7	0.6	I	0.6	I	0.9	0.4
A_4	0	0	0	0	0.3	0.4	0	-0.3	0	-0.2	0.8
A_5	0	0	0	0	0	0.5	0.6	I	0.6	0.4	0.3
A_6	0	0	0	0	0	0	0	0	0	0	0
A_7	0	0	0	0.4	0	0.5	0	0	0	-0.3	I
A_8	0	-0.4	0	0	0	0.6	-0.5	0	-0.3	-0.3	-0.3
A_9	0	0.5	0	0	0	0.3	0.5	0	0	0	0
A_{10}	0	0.5	0	0	0	0.8	0	0	0	0	I
A_{11}	0	0	0	0	0	0.1	0	0	0.3	0	0

Table 1: Obtained aggregated relationships between every pair of attributes.

We supported our calculations by using Octave 4.2.1, see [20]. Table 2 summarizes the results of indegree, outdegree and total degree corresponding to Table 1. Whereas Table 3 contains the interval-valued total degree, the de-neutrosophicated values and order number of the attributes.

Attribute	$id(A_i)$	$od(A_i)$	$td(A_i)$
A_1	0	3.3+4I	3.3+4I
A_2	1.4+I	3.2	4.6+I
A_3	0.8	3.2+3I	4+3I
A_4	1.2+2I	2	3.2+2I
A_5	1.9	2.4+I	4.3+I
A_6	5.1	0	5.1
A_7	2.5+I	1.2+I	3.7+2I
A_8	1.3+I	2.4	3.7+I
A_9	1.8+I	1.3	3.1+I
A_{10}	2.1+I	1.3+I	3.4+2I
A_{11}	2.6+3I	0.4	3+3I

Table 2: Indegree, outdegree, and total degree of the neutrosophic adjacency matrix.

Attribute	Interval A_i	$\lambda(A_i)$	Order
A_1	[3.3, 7.3]	5.3	2
A_2	[4.6, 5.6]	5.1	3
A_3	[4, 7]	5.5	1
A_4	[3.2, 5.2]	4.2	9
A_5	[4.3, 5.3]	4.8	5
A_6	5.1	5.1	3
A_7	[3.7, 5.7]	4.7	6
A_8	[3.7, 4.7]	4.2	9
A_9	[3.1, 4.1]	3.6	11
A_{10}	[3.4, 5.4]	4.4	8
A_{11}	[3, 6]	4.5	7

Table 3: Interval-valued total degree, de-neutrosophicated values and order number of the attributes.

Thus, according to the results in Table 3, we have that the order of the attributes sorted in descended order is the following:

$A_3 \succ A_1 \succ A_2 \sim A_6 \succ A_5 \succ A_7 \succ A_{11} \succ A_{10} \succ A_4 \sim A_8 \succ A_9$.

Conclusion

The mobile application for panic button system is a way to guarantee the public security of the Ecuadorian citizens. This paper aimed to study the possibility to improve the quality of its software application. Thus, it is necessary to sort by importance the different attributes of software quality, i.e. the non-functional requirements of the software. We applied the technique of neutrosophic cognitive maps, where three experts assessed the pair-wise causal relationships between eleven attributes. Then, we arrived to the conclusion that "Efficiency" is the most important of the attributes, followed by "Portability", and after there are both, "Reliability" and "Usability by users' community".

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Neutrosophic AHP for the prioritization of requirements for a computerized facial recognition system

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Abstract. The Cooperative of Taxis and Vans of Puyo in Ecuador is dedicated to the transportation of people and minor loads. Due to the considerable number of members of this cooperative, it is difficult to determine the presence of each of the participants in the meetings. That is why it was decided to implement a facial recognition system that allows identifying the presence of members in each moment. However, in order to apply this system, certain requirements are needed for guaranteeing its success. This paper aims to apply the neutrosophic Analytic Hierarchy Process (NAHP) technique for analyzing the prioritization of requirements necessary to implement a facial recognition system in the cooperative. Neutrosophic AHP permits including the indetermination incorporated in neutrosophic models and additionally experts can provide their evaluations based on linguistic terms, which results in greater ease and effectiveness to evaluate.

Keywords: prioritization of software requirements, facial recognition system, neutrosophic AHP, multicriteria-decision making

1 Introduction

The Cooperative of Taxis and Vans of Puyo in Ecuador is an organization whose main activity is the transportation of passengers and minor loads. They provide this service since the year 1972 to the city of Puyo. With almost 50 years of service the number of members in this cooperative has grown to 79. The entity periodically summons a meeting of members either for accountability, approval of financial statements, sessions for sporting events, among others.

Due to the large number of members of the cooperative, there have been inconveniences in the process of making the calls. Although calls are made approximately 5 days in advance either by the delivery of the summons of minutes in person or by sending Whatsapps or emails, not always all members attend the meetings.

Attendance is taken by the secretary of the institution in a period of 15 to 30 minutes only once at the beginning of the meeting. This implies difficulties in maintaining the history of the attendees to each one of the convocations, due to the fact that many of the members present at the sessions do not sign the payroll because of the lack of time or delays. In addition these meetings are prolonged ending, many times after midnight.

In order to solve this difficulty, it is proposed to implement a computerized facial recognition system, obtaining many benefits, such as security and reliability in the attendance registry, since this system will identify the faces of the members, thus discarding any type of impersonation at the time of registration and will allow a better management of time in the convocations, see [1].

However, this solution leads to new challenges such as, the high cost of implementing a system like this, the training or hiring of personnel to manage the system, the cost of maintenance or updating, among others. Therefore, we propose in this paper to yield a process of prioritization of requirements, see [2].

Software engineers are involved in complex decisions that require multiple points of view. A specific case is the requirements prioritization process. This process is used to decide what software requirement to develop in a given iteration from a group of candidate requirements. The criteria involved in this process can be of different nature so that they must be evaluated in different domains and the results can be shown in a linguistic domain.

Multiple models of prioritization of requirements have been proposed in the literature; see [2-9]. However, there are two fundamental limitations to these proposals:

- Lack of management of information with different nature.
- The results are shown quantitatively and are difficult for understanding by the software engineers.

This paper fills a research gap, when it is affirmatively answered the question about if there exists a tool that overcomes the aforementioned limitations. Thus, the motivation of this paper is to apply an efficient tool, such that those drawbacks are surmounted. Hence, this paper aims to identify and select the requirements necessaries for implementing an effective computerized facial recognition system in the Cooperative of Taxis and Vans of Puyo, Ecuador. This is not a straightforward problem, because its solution needs of financial, human and technological considerations.

For this end, we apply the Neutrosophic Analytic Hierarchy Process technique NAHP . Saaty's Analytic Hierarchy Process (AHP) technique ([10]), which is a multicriteria-decision technique used to evaluate a set of criteria-based alternatives by a group of experts in the field. This technique starts from a tree, where the upper level leaf represents the goal, the leaves at the next lower level represent the criteria to evaluate such a goal, at the lower level there are the leaves that represent the sub-criteria on the criteria and so on. The lowest level contains the leaves representing the alternatives.

In this method the elements of the same level in the tree are pair-wise compared, as to the importance rate of each other, this gives a score to each criterion and sub-criterion with respect to their peers. These scores influence the evaluation of the alternatives.

In this paper the neutrosophic AHP (NAHP) is used, which is the AHP technique defined in the neutrosophic framework, see [11-13]. One advantage of using neutrosophy is that experts can evaluate the choices by means of linguistic terms, thus they can assess the alternatives more accurately than by using numerical scales. On the other hand, many researchers have dedicated their research subjects to design and implement face recognition systems, moreover, the scientific literature have many examples of face recognition systems based on several points of view, e.g., see [14]. Multicriteria decision-making is successfully modeled in neutrosophic environments, see for example [15, 16].

This paper is organized as follows; Section 2 describes the main concepts of neutrosophic AHP technique. Section 3 describes the technique applied to solve the problem of prioritization of the requirements for the design of the facial recognition software in the taxi base of Puyo. To finish the conclusions are given in the last Section.

2 Neutrosophic Analytic Hierarchy Process

We start with some preliminaries from both, the classical AHP in subsection 2.1, and the neutrosophic AHP in subsection 2.2,

2.1 Introduction to the AHP Technique

Analytic Hierarchy Process (AHP) starts from a hierarchical structure represented by a tree, such that there is an upper unique leaf representing the goal. This leaf is the parent of other leaves of criteria, which are the parents of the leaves of sub-criteria and so on. The bottom level contains the leaves of alternatives, see Figure 1.

This schematic representation is used by a group of experts in assessing the alternatives based on pair-wise comparison matrices according to certain scale. Saaty proposed the scale that he considered is the better to evaluate decisions; it can be seen in Table 1.

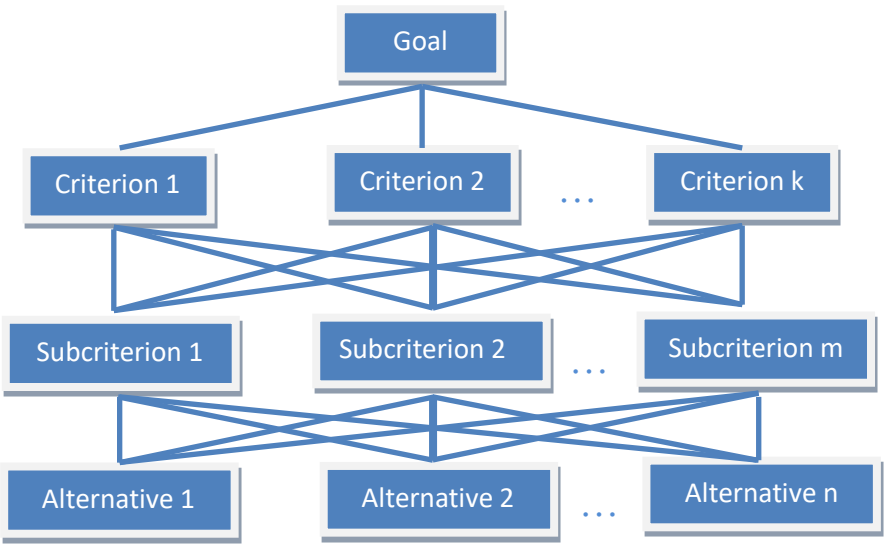

Figure 1: Scheme of a generic tree representing an Analytic Hierarchy Process

Intensity of importance on an absolute scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment strongly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Very strong importance	An activity is strongly favored and its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments.	When comprise is needed
Reciprocals	If activity *i* has one of the above numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*.	

Table 1: Intensity of importance according to the classical AHP

Other detail to consider when applying this technique is the calculus of the *Consistency Index* (CI), which is function depending on λ_{max}, the maximum eigenvalue of the matrix. Saaty establishes that consistency of the evaluations can be determined by equation$CI = \frac{\lambda_{max}-n}{n-1}$, where n is the order of the matrix. Also, the *Consistency Ratio* (CR) is defined by equation CR = CI/RI, where RI is given in Tab. 2.

Order (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Table 2: RI associated to every order.

If CR≤0.1 we can consider that experts' evaluation is sufficiently consistent and hence we can proceed to use AHP.

AHP aims to score criteria, sub-criteria and alternatives, and to rank every alternative according to these scores. For more details about this technique [10] can be consulted.

AHP can also be used in group assessment. In such a case, the final value is calculated by the weighted geometric mean, see Equations 1 and 2. Weights are utilized to measure the importance of each expert's criteria, where some factors are considered like expert's authority, knowledge, effort, among others.

$$\bar{x} = \left(\prod_{i=1}^{n} x_i^{w_i}\right)^{1/\sum_{i=1}^{n} w_i} \quad (1)$$

If expert's weights sum up one, i.e. $\sum_{i=1}^{n} w_i = 1.$, Equation 1 converts to Equation 2,

$$\bar{x} = \prod_{i=1}^{n} x_i^{w_i} \quad (2)$$

2.2 Basic concepts of the Neutrosophic AHP

Definition 1: ([17-19]) The *Neutrosophic set* N is characterized by three membership functions, which are the

truth-membership function T_A, indeterminacy-membership function I_A, and falsity-membership function F_A, where U is the Universe of Discourse and $\forall x \in U$, $T_A(x)$, $I_A(x)$,$F_A(x) \subseteq]^-0, 1^+[$, and $^-0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$.

See that according to the definition, $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard or non-standard subsets of $]^-0, 1^+[$ and hence, $T_A(x)$, $I_A(x)$ and $F_A(x)$ can be subintervals of [0, 1].

Definition 2: ([17-19]) The *Single-Valued Neutrosophic Set* (SVNS) N over U is $A = \{\langle x; T_A(x), I_A(x), F_A(x)\rangle : x \in U\}$, where $T_A: U \to [0, 1]$, $I_A: U \to [0, 1]$, and $F_A: U \to [0, 1]$, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

The *Single-Valued Neutrosophic* (SVNN) number is symbolized by N = (t, i, f), such that $0 \leq t, i, f \leq 1$ and $0 \leq t + i + f \leq 3$.

Definition 3: ([12-13, 18-19]) The *single-valued trapezoidal neutrosophic number*,

$\tilde{a} = \langle (a_1, a_2. a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy and falsity membership functions are defined as follows:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_3 \leq x \leq a_4 \\ 0, & \text{otherwise} \end{cases} \quad (3)$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{\left(a_2 - x + \beta_{\tilde{a}}(x-a_1)\right)}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \beta_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \frac{\left(x - a_2 + \beta_{\tilde{a}}(a_3-x)\right)}{a_3-a_2}, & a_3 \leq x \leq a_4 \\ 1, & \text{otherwise} \end{cases} \quad (4)$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{\left(a_2 - x + \gamma_{\tilde{a}}(x-a_1)\right)}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \gamma_{\tilde{a}}, & a_2 \leq x \leq a_3 \\ \frac{\left(x - a_2 + \gamma_{\tilde{a}}(a_3-x)\right)}{a_3-a_2}, & a_3 \leq x \leq a_4 \\ 1, & \text{otherwise} \end{cases} \quad (5)$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0, 1]$, $a_1, a_2, a_3, a_4 \in \mathbb{R}$ and $a_1 \leq a_2 \leq a_3 \leq a_4$.

Definition 4: ([12-13, 18-19]) Given $\tilde{a} = \langle (a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3, b_4); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two single-valued trapezoidal neutrosophic numbers and λ any non null number in the real line. Then, the following operations are defined:

1. Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$
2. Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$
3. Inversion: $\tilde{a}^{-1} = \langle ({a_4}^{-1}, {a_3}^{-1}, {a_2}^{-1}, {a_1}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, where $a_1, a_2, a_3, a_4 \neq 0$.
4. Multiplication by a scalar number:
$$\lambda\tilde{a} = \begin{cases} \langle (\lambda a_1, \lambda a_2, \lambda a_3, \lambda a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda > 0 \\ \langle (\lambda a_4, \lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda < 0 \end{cases}$$
5. Division of two trapezoidal neutrosophic numbers:
$$\frac{\tilde{a}}{\tilde{b}} = \begin{cases} \langle \left(\frac{a_1}{b_4}, \frac{a_2}{b_3}, \frac{a_3}{b_2}, \frac{a_4}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_4 > 0 \; and b_4 > 0 \\ \langle \left(\frac{a_4}{b_4}, \frac{a_3}{b_3}, \frac{a_2}{b_2}, \frac{a_1}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_4 < 0 \; and b_4 > 0 \\ \langle \left(\frac{a_4}{b_1}, \frac{a_3}{b_2}, \frac{a_2}{b_3}, \frac{a_1}{b_4}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_4 < 0 \; and b_4 < 0 \end{cases}$$
6. Multiplication of two trapezoidal neutrosophic numbers:
$$\tilde{a}\tilde{b} = \begin{cases} \langle (a_1 b_1, a_2 b_2, a_3 b_3, a_4 b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, & a_4 > 0 \; and b_4 > 0 \\ \langle (a_1 b_4, a_2 b_3, a_3 b_2, a_4 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, & a_4 < 0 \; and b_4 > 0 \\ \langle (a_4 b_4, a_3 b_3, a_2 b_2, a_1 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, & a_4 < 0 \; and b_4 < 0 \end{cases}$$

Where, $\wedge$ is a t-norm and $\vee$ is a t-conorm.

Let us remark that if $a_2 = a_3$ in Definitions 3 and 4, we say the single-valued trapezoidal neutrosophic number is a *single-valued triangular neutrosophic number*, see [20].

The second step of the model is to apply the NAHP. The proposed linguistic scale is based on triangular neutrosophic numbers summarized in Table 3, according to the scale defined [12].

The hybridization of AHP with neutrosophic set theory was used in [12-13]. This is a more flexible approach to model the uncertainty in decision making. Indeterminacy is an essential component to be assumed in real world organizational decisions.

The neutrosophic pair-wise comparison matrix is defined in Equation 6.

$$\tilde{A} = \begin{bmatrix} \tilde{1} & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \vdots & & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \quad (6)$$

$\tilde{A}$ satisfies the condition $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$, according to the inversion operator defined in Definition 4.

Authors in [12] defined two indices to convert a neutrosophic triangular number in a crisp number. They are the equations of score and accuracy in Equations 7 and 8, respectively:

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \quad (7)$$

$$\mathbf{A}(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (8)$$

Saaty scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\tilde{1} = \langle(1,1,1); 0.50, 0.50, 0.50\rangle$
3	Slightly influential	$\tilde{3} = \langle(2,3,4); 0.30, 0.75, 0.70\rangle$
5	Strongly influential	$\tilde{5} = \langle(4,5,6); 0.80, 0.15, 0.20\rangle$
7	Very strongly influential	$\tilde{7} = \langle(6,7,8); 0.90, 0.10, 0.10\rangle$
9	Absolutely influential	$\tilde{9} = \langle(9,9,9); 1.00, 1.00, 1.00\rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\tilde{2} = \langle(1,2,3); 0.40, 0.65, 0.60\rangle$
		$\tilde{4} = \langle(3,4,5); 0.60, 0.35, 0.40\rangle$
		$\tilde{6} = \langle(5,6,7); 0.70, 0.25, 0.30\rangle$
		$\tilde{8} = \langle(7,8,9); 0.85, 0.10, 0.15\rangle$

Table 3:Saaty's scale translated to a neutrosophic triangular scale.

Given the criteria and sub-criteria tree and the neutrosophic triangular scale in Table 3, the NAHP consists in the following:

1. To design an AHP tree. This contains the selected criteria, sub-criteria and alternatives from the first stage.
2. To create matrices per level from the AHP tree, according to experts' criteria expressed in neutrosophic trapezoidal scales associated with linguistic terms, and with regard to the matrix scheme in Equation 6.
3. To evaluate the consistency of these matrices. Abdel-Basset et al. make reference to Buckley, see [21, 22], who demonstrated that if the crisp matrix $A = [a_{ij}]$ is consistent, then the neutrosophic matrix $\tilde{A} = [\tilde{a}_{ij}]$ is also consistent. Thus, $\tilde{A}$ is converted to the crisp matrix A applying formulas 7 or 8, such that it fulfils the condition $a_{ij} = 1/a_{ji}$. See that for simplicity we preferred to evaluate in form of single-valued triangular neutrosophic number.
4. To follow the other steps of a classical AHP.

3 Results

Here we expose the result for applying the neutrosophic AHP to the problem we are solving, which is a real-life example. Then, we specify the steps we followed to achieve this end.

1. To establish prioritization framework: Experts, criteria and requirements are selected in order to prioritize the latter. The framework is defined as follows:
    - $E = \{E_1, E_2, ..., E_n\}$ with $n \geq 2$, is the group of experts who will participate in the process.

- $C=\{C_1,C_2,...,C_k\}$ with $k \geq 2$, is the set of criteria to be evaluated.
- $R=\{R_1,R_2,...,R_m\}$ with $m \geq 2$, is the set of requirements to be prioritized.

These elements are used to design the tree that represents the AHP that has the structure shown in Figure2 for each expert:

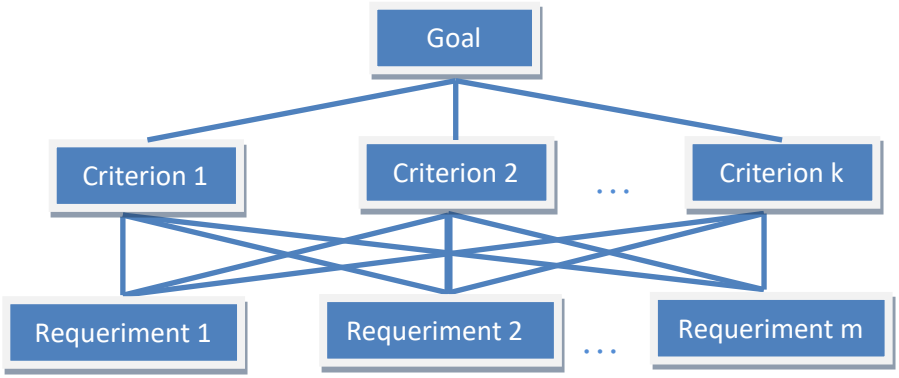

Figure 2: Scheme of the tree representing an Analytic Hierarchy Process for the prioritization of requirements to design a computerized facial recognition system by each expert.

2. Collection of information: The neutrosophic pair-wise comparison matrices are obtained as in Equation 6, given by each expert E_i.
3. The AHP neutrosophic technique is applied for each of the trees corresponding to each expert. For each requirement and expert we obtain the importance that each requirement has according to each criterion with respect to the others.
4. The calculated value of the importance of each requirement is aggregated with respect to the group of experts, using Formulas 1 or 2. To apply these equations a weight must be assigned to each expert, in this paper we will assign the same weight for everyone.
5. Numbers are ordered by each requirement, giving priority to those with the highest values.

There were three experts to carry out the evaluations, which will be denoted from now on by E_1, E_2 and E_3.

The criteria for evaluating are the following three:

C_1. The requirement feasibility and efficiency respect to the user.

C_2. Cost: It is the criterion to determine the cost of implementing the requirement for each individual candidate.

C_3. Technical Complexity: It is the technical level of the software and hardware needed to implement the requirement.

The requirements to be evaluated are as follows:

The system has to be able to:

R_1: Record all calls made in the cooperative.

R_2: Store the information of each member including photographs of their front faces.

R_3: Capture images by means of a webcam with the possibility of saving it later.

R_4: Detect faces of people within the camera field of vision.

R_5: Identify the members registered in the system and record their attendance at the meetings of the cooperative.

R_6: Generate reports with the attendance list for each call.

R_7: The graphical interface should be user-friendly.

R_8: Quickly process the images captured by the camera.

R_9: The system must provide ease of maintenance to the person in charge.

R_{10}: Login to the system must be validated by the user name and password.

The three obtained pair-wise matrices corresponding to criteria, one per expert are summarized in Tables 4, 5, and 6. Let us note that the values are expressed in form of the scale given in Table 1.

Criteria	C_1	C_2	C_3
C_1	$\tilde{1}$	$\tilde{3}$	$\tilde{5}$
C_2	$\tilde{3}^{-1}$	$\tilde{1}$	$\tilde{2}$
C_3	$\tilde{5}^{-1}$	$\tilde{2}^{-1}$	$\tilde{1}$

Table 4:Pair-wise matrix corresponding to criteria given by Expert 1.

Criteria	C_1	C_2	C_3
C_1	$\tilde{1}$	$\tilde{3}$	$\tilde{4}$
C_2	$\tilde{3}^{-1}$	$\tilde{1}$	$\tilde{3}$

C_3	$\tilde{4}^{-1}$	$\tilde{3}^{-1}$	$\tilde{1}$

Table 5:Pair-wise matrix corresponding to criteria given by Expert 2.

Criteria	C_1	C_2	C_3
C_1	$\tilde{1}$	$\tilde{3}$	$\tilde{4}$
C_2	$\tilde{3}^{-1}$	$\tilde{1}$	$\tilde{2}$
C_3	$\tilde{4}^{-1}$	$\tilde{2}^{-1}$	$\tilde{1}$

Table 6:Pair-wise matrix corresponding to criteria given by Expert 3.

Tables 7, 8 and 9, contain the average evaluation for the total of experts corresponding to the Requirements, one per each criterion.

Requirement	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}
R_1	1	0.29242	0.26495	0.20653	0.97872	1.98851	1.76250	2.24351	3.41980	3.41980
R_2	3.41980	1	0.82786	0.82786	2.24351	2.94214	2.53120	2.94214	4.38707	4.38707
R_3	3.77431	1.20793	1	0.97872	2.94214	3.41980	2.94214	3.97500	4.38707	5.34380
R_4	4.84186	1.20793	0.97872	1	3.41980	3.77431	3.77431	3.96332	5.08434	5.08434
R_5	0.97872	0.44573	0.33989	0.29242	1	2.31135	2.31135	2.94214	3.77431	3.97500
R_6	0.50289	0.33989	0.29242	0.26495	0.43265	1	0.70026	1.98851	2.24351	1.98851
R_7	0.56738	0.39507	0.33989	0.26495	0.43265	1.42805	1	1.61117	1.98851	2.31135
R_8	0.44573	0.33989	0.25157	0.25231	0.33989	0.50289	0.62067	1	0.93750	1.42805
R_9	0.29242	0.22794	0.22794	0.19668	0.26495	0.44573	0.50289	0.93750	1	1.20793
R_{10}	0.29242	0.22794	0.18713	0.19668	0.25157	0.50289	0.43265	0.70026	0.82786	1

Table 7: Average crisp pair-wise matrix corresponding to requirements given by the experts according to criterion C_1.

Requirement	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}
R_1	1	2.00054	2.00054	2.23001	0.67640	0.50899	0.44454	0.33734	0.26564	0.29462
R_2	0.49986	1	1.45842	0.93750	0.58114	0.44843	0.34504	0.33734	0.25235	0.25157
R_3	0.49986	0.65963	1	0.79717	0.42682	0.29462	0.25157	0.22682	0.19717	0.18713
R_4	0.44843	0.93750	1.25445	1	0.49986	0.29462	0.26960	0.22682	0.19717	0.23020
R_5	1.41310	1.65539	2.34289	2.00054	1	0.56738	0.44454	0.39507	0.26564	0.34504
R_6	1.96466	2.23001	3.39417	3.39417	1.76250	1	0.95035	0.29462	0.20755	0.26564
R_7	2.24953	2.89821	3.97500	3.70926	2.24953	1.00576	1	0.44843	0.29462	0.34504
R_8	2.96435	2.96435	4.40876	4.40876	2.53120	3.39417	2.23001	1	0.84365	0.84365
R_9	3.76455	3.96274	5.07170	5.07170	3.76455	4.81804	3.39417	1.18533	1	0.98082
R_{10}	3.39417	3.97500	5.34380	4.34401	2.89821	3.76455	2.89821	1.18533	0.98082	1

Table 8: Average crisp pair-wise matrix corresponding to requirements given by experts according to criterion C_2.

Requirement	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}
R_1	1	0.28805	0.26960	0.20450	0.98082	2.00054	1.76250	2.23001	3.39417	3.39417
R_2	3.47163	1	0.84365	0.79717	2.27074	2.96435	2.53120	2.96435	4.40876	4.40876
R_3	3.70926	1.18533	1	0.95035	2.96435	3.47163	2.96435	3.97500	4.40876	5.34380
R_4	4.88986	1.25445	1.00576	1	3.47163	3.85047	3.85047	4.05318	5.14729	5.14729
R_5	0.98082	0.44039	0.33734	0.28805	1	2.34289	2.34289	2.96435	3.76455	3.97500
R_6	0.49986	0.33734	0.28805	0.25971	0.42682	1	0.65963	2.00054	2.27074	2.00054
R_7	0.56738	0.39507	0.33734	0.25971	0.42682	1.45842	1	1.60396	2.00054	2.34289
R_8	0.44843	0.33734	0.25157	0.24672	0.33734	0.49986	0.59592	1	0.93750	1.41310
R_9	0.29462	0.22682	0.22682	0.19428	0.26564	0.44039	0.49986	0.93750	1	1.18533
R_{10}	0.29462	0.22682	0.18713	0.19428	0.25157	0.49986	0.42682	0.67640	0.84365	1

Table 9: Average crisp pair-wise matrix corresponding to requirements given by experts according to criterion C_3.

We supported the calculus with the aid of the software Octave 4.2.1, specially the function *eig* to estimate the maximum eigenvalue of the crisp pair-wise matrices, see [23]. Thus, let us remark that we shall apply formula 8 for converting the pair-wise matrices in crisp matrices. The obtained CRs were 0.0034808, 0.024394,and 0.0014231for Expert 1, Expert 2 and Expert 3, respectively, which are smaller than 0.1. Whereas, for the matrices of Requirements we obtained the CRs are smaller than 0.1 respect to every expert and every criterion.

Table 10 summarizes the priority vectors of the three experts for the criteria, applying Equation 2 with weights $w_i = 1/3$ for i = 1, 2, 3.

Criteria	Average over experts of Criteria Priority Vectors	Order
C_1	0.61143	1
C_2	0.25372	2
C_3	0.13375	3

Table 10: Average of priority vectors obtained for every criterion over the experts and their order.

Table 11 summarizes the weights for every requirement and the final order.

Requirement\Criterion	C_1(0.61143)	C_2(0.25372)	C_3(0.13375)	Requirements Priority Vector	Order
R_1	0.084669	0.058097	0.084123	0.077761	6
R_2	0.167878	0.041460	0.167974	0.135631	3
R_3	0.199339	0.030708	0.198023	0.156159	2
R_4	0.218413	0.034742	0.221580	0.171995	1
R_5	0.102241	0.063551	0.102015	0.092282	4
R_6	0.057777	0.084364	0.057414	0.064411	10
R_7	0.062954	0.101726	0.062809	0.072702	9
R_8	0.041391	0.168992	0.041086	0.073680	7
R_9	0.034464	0.217979	0.034189	0.080951	5
R_{10}	0.030875	0.198381	0.030788	0.073329	8

Table 11: The requirements priority vectors and the final order of requirements.

According to the results summarized in Table 11 the requirements are ordered as follows:

$$R_4 \succ R_3 \succ R_2 \succ R_5 \succ R_9 \succ R_1 \succ R_8 \succ R_{10} \succ R_7 \succ R_6.$$

Conclusion

This paper was devoted to study the prioritization of requirements for a computerized facial recognition system

of the Cooperative of Taxis and Vans of Puyo, Ecuador, with the aim to record the presence of the members to the meetings. For this end, we applied the neutrosophic AHP technique with three experts' criteria, having as an advantage that experts' assessment are given in form of linguistic terms, which is the most natural human manner to evaluate. The three criteria are viz., efficiency of the system, cost, and technical complexity. Moreover, evidently the indeterminacy modelled by neutrosophy is also incorporated. The results were that the requirements that should be prioritized are the following in that order of preference, the system must be able to:

- Detect faces of people within the camera field of vision.
- Capture images by means of a webcam with the possibility of saving it later.
- Store the information of each member including photographs of their front faces.
- Identify the members registered in the system and record their attendance at the meetings of the cooperative.

This paper contributed to solve a real-life complex problem by using NAHP. It illustrates the applicability of this technique in a field like the decision making for the prioritization of requirements for a computerized facial recognition system.

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A neutrosophic linguistic model for internal control evaluation to an Ecuadorian Company

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Abstract. The internal control of a company is essential to evaluate the performance of the institution during a certain period of time, which allows taking the necessary measures to correct in advance the mistakes that are being made or to enhance the positive practices within the company. In this paper we propose to evaluate the Commercial Company Manolo's located in the city of Babahoyo, Ecuador, regarding the aspects measured in the internal control. For this, we use the neutrosophic 2-tuples method. This method is a part of the Computing with Word (CWW) that is distinguished by performing calculations on words rather than numbers and is an easier and more natural way to evaluate by experts. The inclusion of neutrosophy allows for greater accuracy of the results, since the calculations incorporate indeterminacy. Three experts evaluated the internal control for this investigation.

Keywords: internal control, computing with words, linguistic model, 2-tuple method.

1 Introduction

There exist several concepts and theories of control, for Munch: "control is the phase of the administrative process through which the standards are established to measure the results obtained in order to correct deviations, prevent them and continuously improve the performance of the company", see [1, 2].

Also he explains: "The control is of vital importance as it serves to verify the effectiveness of the management, promotes quality assurance, allows the protection of the assets of the company, guarantees the fulfillment of the plans, set out measures to prevent errors and reduce cost and time. With this, the causes of deviations are detected and analyzed, in order to avoid repeating them, is the foundation for the planning process", see [2].

According to Estupiñán ([3]): "internal control is a process carried out by the board of directors, management and staff of the entity, designed to provide reasonable security with a view to achieving objectives in the area of internal control."

Internal control has as its purposes the following:

1. Effectiveness and efficiency of operations.- Supports the basic objectives of the company, including performance goals profitability and resource safeguarding.
2. Reliability of financial information.- Relates to the preparation and publication of trustworthy financial statements, including interim and summary financial statements and financial information derived from statements such as publicly reported distribution gains.
3. Compliance with applicable laws and regulations.- Ensures compliance with the laws and regulations to which the company is subject. Internal control includes the organizational plan and all coordinated methods and measures taken within an enterprise to safeguard its assets, to verify the accuracy and veracity of accounting data.

Paz in [4], details that the internal control system are appropriate policies and procedures that generate the administration of a company to help achieving one of the objectives of each company to affirm, as much as possible, as the person in charge of carrying out everything about its business, including all kinds of administration policies, asset protection, as well as to avoid fraud and error, the accuracy of most accounting records, and a timely preparation of accounting information.

Some authors emphasize that internal control in companies is of vital importance for the optimization and growth of the business, both in the administrative and in the operation; thus benefiting from the shareholders to the client itself, since it will have a degree of confidence over the company and will prevail over time generating profits and internal growth in the entity, see [5].

Reyes in ([6]) also indicates that one of the most obvious reasons for the importance of control is because even the best of plans can be derived. The control is used to:

- Create better quality: process failures are detected and process.
- Remove errors.
- Facing change, this is an inescapable part of the environment of any organization.

The contribution of this research project is to inform to the manager of the commercial Manolo's on the knowledge of the activities and operations of its business, through the evaluation of the internal control and application of the COSO II method with their respective components, which are, viz., control environment, risk assessment, control activities, information and communication, monitoring controls, to obtain the complete, timely information and knowledge of the current situation of the company, see [1].

To meet this objective, a neutrosophic linguistic model is used, in particular the 2-tuples linguistic model ([7, 8]). This model is part of the Computing with Word (CWW), see [9-12], which allows calculation based on linguistic rather than numerical terms ([13]), which is a more natural way to evaluate by experts. The inclusion of neutrosophy ([14-16]) brings more accuracy to the model, because it also takes into account the indeterminacy of the evaluations, see [17]. In addition, as part of the method there exists a numerical term in the range [-0.5, 0.5) that measures the accuracy of the indexes of the linguistic values defined in the scale.

After conducting a search on the application of neutrosophic methods to measure the state of internal control in a company, the authors of this paper did not find any approach in this regard. For this reason, this paper could be considered the first neutrosophic measurement of internal control.

Within the review carried out by us it was found that there exist mathematical methods and techniques to measure the state of the internal control. In [18] a methodology is designed to guide the internal control of small companies with respect to risks, for this end they define some economic indices that allow measuring them by decision makers. In [19] a method is proposed to perform internal control based on statistics, specifically linear regression. Ge and Koester in [20] also use statistical and econometric methods for this purpose.

In [21] a reference is made to the Chinese Internal Control Index *IC_INDEX*, which is used to measure the quality of internal control in the Chinese companies, which is constructed using the Analytic Hierarchy Process (AHP) technique. That article studies the relationship between the internal control of the company and the risk of a crash in the stock market, where statistical methods are applied. A similar method for the same purpose can be found in [22].

In general, the AHP technique is recurrent to resolve this problem, to obtain weights that measure the importance of the criteria used in internal control. Wu in [23] proposes an internal control measurement system in manufacturing companies, where the AHP-fuzzy method is applied, with the intention of trapping the uncertainty using fuzzy logic, specifically for this type of company. Also Zhang in [24] uses this technique applied in administrative institutions.In [25] the uncertainty is also captured by measuring in the fuzzy frame, using the fuzzy stratified evaluation method.

In [26] mathematical programming is utilized for the validation of internal control mechanisms in local governments. In [27] the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is proposed as part of a Decision Support System in internal control to select the best employees of the company. On the other hand, Petridis et al. in [28] select internal auditors based on the hybridization of TOPSIS with non-linear programming.

All these techniques and methods could be generalized to the neutrosophic environment, where not only uncertainty is considered, but also the indeterminacy, which is typical of decision-making, achieving a modeling more in line with reality. In [29] a method is proposed to solve linear programming problems in a neutrosophic environment. Neutrosophic AHP was designed in [30]. The neutrosophic TOPSIS study can be found in [31]. In [32] a combination of AHP and TOPSIS is applied for solving a real-life problem. Giri et al. in [33] design a TOPSIS method to solve multicriteria decision problems based on trapezoidal interval neutrosophic numbers. Additionally, these methods can be automated with the support of toolboxes developed in Matlab ([34]) or the python programming language ([35]).

Apart from the fact that the measurement proposed in this research is based on neutrosophic theory and therefore carries its characteristics, it also has the advantage that it is based on CWW, which is why specialists can assess using linguistic terms and not numerical ones, which is more understandable for both, the evaluators and the evaluated employees.

This paper is divided as follows, the section of materials and methods describes the main definitions of the 2-tuples method, and in addition to define the method we will follow in this paper to perform calculations. The section of Results is dedicated to describe the evaluation of the three experts on the internal control aspects of Manolo's company located in Babahoyo, Ecuador. Finally we give the conclusions.

2 Materials and Methods

Here we describe the main concepts related to linguistic models, especially 2-tuple linguistic representation.

2-tuple linguistic representation model aims to compute processes with words without loss of information. It is based on the concept of symbolic translation.

Let $S = \{s_0, s_1, \dots, s_g\}$ be a set of linguistic terms and $\beta \epsilon [0, g]$ a value in the granularity interval of S.

Definition 1. ([8, 9])The *Symbolic Translation* of a linguistic terms_i is a number valued in the interval [-0.5, 0.5) which expresses the difference of information between a quantity of information expressed by the value $\beta \epsilon$ [0, g], obtained in a symbolic operation and the nearest integer value, $i \in \{0, \dots, g\}$ which indicates the index of the nearest linguistic label (s_i) in S.

Based on this concept, a model for the representation of linguistic information is developed, which makes use of a pair of values or 2-tuples. This representation model defines a set of functions that facilitate operations on 2-tuples.

Definition 2. ([8, 9]) 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:

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

$$\Delta(\beta) = (s_i, \alpha), \text{ such that } \begin{cases} s_i, & i = \text{round}(\beta) \\ \alpha = \beta - i, & \alpha \in [-0.5, 0.5) \end{cases} \quad (1)$$

Where "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 numeric value in $[0, g]$.

In [17] the concept of 2-Tuple Linguistic Neutrosophic Number (2TLNN) is proposed to solve problems based on Single-Valued Neutrosophic Sets and 2-tuples linguistic sets (2TLSs).

A 2TLNN is defined as follows [17]:

Suppose that $S = \{s_0, \dots, s_g\}$ is a 2TLSs with odd cardinality t+1. It is defined for $(s_T, a), (s_I, b), (s_F, c) \in L$ and a, b, c $\in [0, t]$, where $(s_T, a), (s_I, b), (s_F, c) \in L$ independently express the degree of truthfulness, indeterminacy, and falsehood by 2TLSs, then 2TLNN is defined as follows:

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

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

The score and accuracy functions allow us to rank 2TLNN [17]. Let$l_1 = \{(s_{T_1}, a), (s_{I_1}, b), (s_{F_1}, c)\}$be a 2TLNN in L, the score and accuracy functions in $l_1$are defined as follows, respectively:

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

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

Definition 3. Given a 2TLNN, $l_j = \langle (s_{T_j}, a_j), (s_{I_j}, b_j), (s_{F_j}, c_j) \rangle$ (j = 1, 2,…, n) with vector of weights $w_i = (w_1, w_2, \dots, w_n)^T$ which satisfies the conditions $w_i \in [0, 1]$ and $\sum_{i=1}^{n} w_i = 1$, then the following two aggregation operators are defined, which are the Linguistic Neutrosophic Number-weighted arithmetic averaging (LNNWAA) and the Linguistic Neutrosophic Number-weighted geometric averaging (LNNWGA), respectively, [36]:

$$\text{LNNWAA}(l_1, l_2, \dots, l_n) = \sum_{j=1}^{n} w_j l_j = \langle s_{t - t\prod_{j=1}^{n}\left(1 - \frac{T_j}{t}\right)^{w_j}}, s_{t\prod_{j=1}^{n}\left(\frac{I_j}{t}\right)^{w_j}}, s_{t\prod_{j=1}^{n}\left(\frac{F_j}{t}\right)^{w_j}} \rangle \quad (5)$$

$$\text{LNNWGA}(l_1, l_2, \dots, l_n) = \prod_{j=1}^{n} l_j^{w_j} = \langle s_{t\prod_{j=1}^{n}\left(\frac{T_j}{t}\right)^{w_j}}, s_{t - t\prod_{j=1}^{n}\left(1 - \frac{F_j}{t}\right)^{w_j}}, s_{t - t\prod_{j=1}^{n}\left(1 - \frac{F_j}{t}\right)^{w_j}} \rangle \quad (6)$$

$$\text{WAO}(l_1, l_2, \dots, l_n) = \langle s_{\sum_{j=1}^{n} w_j T_j}, s_{\sum_{j=1}^{n} w_j I_j}, s_{\sum_{j=1}^{n} w_j F_j} \rangle \quad (7)$$

Given $C = \{c_1, c_2, \dots, c_m\}$ $(m \ge 2)$, a number of criteria and $K = \{k_1, k_2, \dots, k_n\}$ $(n \ge 2)$ denoting n experts, then a decision-making problem is defined as follows:

1. Experts $K = \{k_1, k_2, \dots, k_n\}$ $(n \ge 2)$ are selected to assess internal control in Manolo's company.
2. Specify the scale of linguistic terms that will be used for evaluating.
3. Aggregate the result for each criterion for all experts, using Equation 7 with weights fixed as 1/n.
4. Aggregate the precedent results for all criteria, using Equation 7 with weights fixed as 1/m.
5. Either the score or the accuracy functions are applied to evaluate the results, obtaining a unique 2-tuple value.

3 Results

This section is devoted to expose experts' evaluations and calculations about the internal control in the commercial Manolo's. We use the criteria recommended in the Committee of Sponsoring Organizations of the Treadway Commission (COSO), see [37]. These are five agencies initiative to improve internal control within organizations.

According to the COSO framework, internal control consists of five interrelated components; these will derive from the way in which the directorate manages the enterprise and will be integrated into the management process. The components are the same for all organizations (public or private) and the implementation of each of them depends on its size.

The components are the following:

6. Control Environment.
7. Risk Assessment.
8. Control Activities.
9. Information and Communication.
10. Monitoring Controls.

A brief explanation of every one of them is the following:

Control Environment: The control environment or environment is the basis of the internal control pyramid, providing discipline to the structure. It supports the remaining components, so it is essential to establish the foundations of an effective and efficient internal control system. It sets the standard for the operation of the enterprise and influences the awareness of its managers.

The factors to be considered within the Control Environment are: Integrity and Ethical Values, Capacity of the managers, Management Style, the Assignment of Authority and Responsibility, the Organizational Structure and, Policies and Practices used by the personnel.

Risk Assessment: Each enterprise faces various internal and external risks that must be evaluated. A precondition to the Risk Assessment is the identification of the objectives at the different levels, which must be linked to each other.

The Risk Assessment consists of the identification and analysis of the risks, which are relevant to the achievement of the objectives, and serves as a basis to determine how they should be managed. In turn, given the permanent changes in the environment, it will be necessary for the enterprise to have mechanisms to identify and address the risks associated with the change.

The evaluation should analyze which objectives in the area have been appropriately defined, if they are consistent with the institutional objectives, if they were duly communicated, if the risks were detected and analyzed properly, and if they have been classified according to the relevance and probability of occurrence.

Control Activities: The control activities are the policies, procedures, techniques, practices and mechanisms that allow management to manage (mitigate) the risks identified during the Risk Assessment process and ensure that the guidelines established by it are carried out.

The Control Activities are carried out at all levels of the enterprise and at each stage of the management, based on the development of a Risk Map, as indicated in the previous point.

In the evaluation of the Internal Control System, it should not only be considered if the activities relevant to the identified risks were established, but also if they are applied in real life and if the results obtained were as expected.

Information and communication: The relevant information must be identified, collected and disseminated in a timely manner that allows each manager to fulfil his or her responsibilities in charge. There must be effective communication - in a broad sense - that flows in all directions across all areas of the enterprise, in descending and ascending ways.

Management must clearly communicate the responsibilities of each manager within the Internal Control System implemented. Managers have to understand their role in the Internal Control System and how individual activities are related to the work of the rest.

Monitoring Controls: Internal Control Systems require - mainly - Supervision, that is, a process that verifies the validity of the Control System over time. This is achieved through continuous monitoring activities, periodic evaluations or a combination of both.

In our investigation for evaluating the five precedent aspects, three experts were hired for assessing the commercial Manolo´s, they are identified with the notation k_i for i = 1, 2, 3. The linguistic scale used for evaluating is S = {s_0 = "Very bad", s_1 = "Bad", s_2 = "More or less", s_3 = "Good", s_4 = "Very good"}, and the criteria are denoted as follows:

C_1: Control Environment.
C_2: Risk Assessment.
C_3: Control Activities.
C_4: Information and Communication.

C_5: Monitoring Controls.

We asked experts for both, how they evaluate and how they do not evaluate that Commercial Manolo´s satisfies C_1, C_2, C_3, C_4, and C_5, as well as what is the linguistic term in S they cannot determine to evaluate this company. The answers can be seen in Table 1.

Criterion/Expert	E_1	E_2	E_3
C_1	(s_1, s_0, s_3)	(s_1, s_2, s_3)	(s_1, s_0, s_2)
C_2	(s_1, s_2, s_3)	(s_1, s_2, s_3)	(s_1, s_0, s_2)
C_3	(s_2, s_3, s_0)	(s_2, s_1, s_3)	(s_2, s_3, s_0)
C_4	(s_0, s_1, s_2)	(s_1, s_0, s_2)	(s_1, s_0, s_3)
C_5	(s_1, s_0, s_2)	(s_1, s_0, s_3)	(s_0, s_1, s_2)

Table 1: Triple of evaluations by each expert on every criterion of the internal control. Each triple is composed by the truth member, the indeterminacy member and the false member, respectively.

Let us note that $\alpha = 0$ for each linguistic value in each triple of Table 1.

The values of each criterion in Table 1 are aggregated using Equation 7, also we aggregate the linguistic values for all criteria; see Table 2.

Criterion	WAM
C_1	($<s_1, 0>$, $<s_1, -0.333>$, $<s_3, -0.333>$)
C_2	($<s_1, 0>$, $<s_1, 0.333>$, $<s_3, -0.333>$)
C_3	($<s_2, 0>$, $<s_2, 0.333>$, $<s_1, 0>$)
C_4	($<s_1, -0.333>$, $<s_0, 0.333>$, $<s_2, 0.333>$)
C_5	($<s_1, -0.333>$, $<s_0, 0.333>$, $<s_2, 0.333>$)
Total	($<s_1, 0.2>$, $<s_1, -0.2>$, $<s_2, 0.2>$)

Table 2: Aggregation of the values in Table 1 according to Equation 7. Total results of aggregating the linguistic values for all criteria.

Table 3 contains the results of applying the score function to linguistic values and the linguistic terms in S associated with them, applied to the values in Table 2.

Criterion	*s*	Linguistic term
C_1	$<s_2, -0.11130>$	"More or less"
C_2	$<s_2, -0.33330>$	"More or less"
C_3	$<s_2, 0.22230>$	"More or less"
C_4	$<s_2, 0.0003>$	"More or less"
C_5	$<s_2, 0.0003>$	"More or less"
Total	$<s_2, 0.0667>$	"More or less"

Table 3: Score function evaluating the linguistic values in Table 2 and the linguistic terms associated with them.

According to Table 3 the evaluation of the enterprise is "More or less", for each criterion and in the general assessment.

Despite the fact that the situation of the company is not bad, in general in the face of these evaluations any company would take measures to improve the evaluations and to prevent them from getting worse, [38]. As all the criteria have the same evaluation, one way to improve them all would be by reinforcing the Control Environment, which is the base of all the others. It is necessary to identify the strengths and weaknesses of the management style that is being carried out.

Firstly, the strengths and weaknesses of the formal organization of the company must be identified, which is the space where the duties and rights of each worker are defined, as well as the object of their work. We have to investigate what is the managers and their subordinates' behavior in the workplace, if each of them ethically complies with what they should do from their job.

A deeper approach takes place when analyzing informal relationships between workers who work together, when we analyze what are the personal relationships among the subordinates, and among the subordinates with their bosses, if it is necessary to create more communication or on the contrary, if it is necessary for the manager to be more authoritative and determined with its subordinates. The top managers of the company must be able to carry out this study at all hierarchical levels of the enterprise. For this purpose, they can use surveys applied to workers and managers.

A second phase consists on determining what changes should be made to improve management within the company, determining where to relocate each worker, preferably considering more than one possibility for each one of them, with the idea of avoiding impositions.

The third phase would be the implementation of those changes. First of all, it is necessary to create conscience among workers about the need for change and the proposals studied would be suggested to them. In multiple organized assemblies, the opinions of workers and managers on the change proposed for each of them would be collected. With the studied ideas and opinions a final decision is made, which would be communicated to the workers and a change plan would be made for each one of them.

It is imperative that once this process begins, when hiring a new worker or changing the job to one already hired, including managers, that they go through a probationary period of proficiency in the job, where the skills shown are measured about their performances in the workplace, its comprehensiveness, its adaptability to changing conditions, and its relationship with the other members of the organization, both formally and informally.

All these steps will result in a management style that, if successful, will positively influence other aspects. An important point to keep in mind is that this process must be understood as dynamic and changing over time, in no way it should be rigid and immovable. It must be possible to change what does not work for the good of the organization, and at the same time it must maintain and reinforce what empowers the organization.

These changes must be considered in an integral way within the company, from the material working conditions as the subjective attitudes of the workers within the organization. A more effective way is to train managers in management techniques.

Let us emphasize that each company in the real-life may solve this situation in a different way, the strategy we outlined above corresponds to an ideal and applicable way of improving the management style.

Conclusion

This paper was dedicated to evaluate the internal control in the commercial Manolo's situated in Babahoyo, Ecuador. Three experts were hired to give their opinion according to the five criteria recommended by COSO. We used linguistic terms because it is an easier way to evaluate, particularly the linguistic scale S = {"Very bad", "Bad", "More or less", "Good", "Very good"} is used. The results was processed utilizing the neutrosophic linguistic model of 2-tuple, which provides the results of accuracy and a linguistic approach. We conclude that each criterion is evaluated as "More or less", and the conjoint evaluation is "More or less" as well, which is a not satisfactory result; therefore, executives of the enterprise must improve the performance in every one of these aspects.

Although this paper met the stated goal of solving a real-life practical problem, it also demonstrates that the used method is effective. We based on the fact that the administration of the company received the evaluation result in an understandable way, which would have been less clear if some traditional method such as TOPSIS, AHP or another one based on numerical results had been used and not based on linguistic terms such as the one applied in this paper. However, future research does not rule out combining the traditional methods mentioned above with linguistic ones. More specifically, to study the result of the measurements taken at Manolo's for improving its performance, it is proposed to apply this method another time, where the weighted average weights are calculated using the AHP technique.

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Neutrosociology for the Analysis of the Pros and Cons of the LIFE Series in UNIANDES, Ecuador

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Abstract. To teach English in Higher Education is of great importance to have professionals prepared for the challenges imposed by the globalization. Ecuador is a Spanish-speaking country for which the teaching of English is part of the programs of study of the courses taught in the Ecuadorian's universities. This paper aims to carry out a statistical study of the acceptance of the LIFE program in the teaching of English at the Regional Autonomous University of Los Andes (UNIANDES in Spanish), its pros and cons. This is measured according to a Likert scale, with five options, two positive, two negative and one neutral. We consider that none of these three levels should pass unnoticed, since each of them shows a tendency to consider. This includes the aspect of indeterminacy, which indicates the existence of contradictions, indifference, among other motivations of this type. Therefore, we perform a non-traditional processing of the Likert scale, more in line with the principles of Neutrosociology and Neutrosophic Statistics, where the indeterminate probability is taken into account for the social group which is student body.

Keywords: English course, higher education, neutrosociology, neutrosophic statistics

1 Introduction

The student body is a social group ([1]) that has particular characteristics. Although the members of the class group have common interests and the similar age, the selection of the class group is formally defined, with a program of study and disciplinary regulations designed by specialists that are not necessarily associated with the interests and needs of the students. Moreover, the faculty staff is also selected by the management of the study center, without the opinion of the students.

This type of social group is interesting for the sociologists. To study the needs of these people is important because they are the basis of future social groups. The better the academic preparation of people in their student stage, the greater their preparation in their professional stage. This includes the teaching of foreign languages within the curriculum.

At present, knowledge of English has become an imperative for professionals of all fields because without it they would be removed from all the scientific, social and business reality in a highly globalized world that is constantly moving and opens the doors to another world, see [2]. Therefore, the importance of knowledge of this language as an indispensable requirement in the current exchange, has been emphasized at the international level and from different perspectives, which has led to the application of different policies aimed at promoting English teaching in almost all countries of Latin America with accelerated interest, see [3].

Ecuador is prepared to this context and has established the need for learning English as a foreign language in the different educational institutions of the country. Thus, starting in the new millennium, the English language must begin to be studied according to international indicators ([4][2]) and its development is systematized from the initial levels of education until finishing at the university. Only in this way the levels required by the communicative transformation in which all educational centers are immersed, can be achieved.

However, despite these advances in learning a foreign language, students arrive at the university with a very low level of knowledge of English. This has been demonstrated by the placement tests performed on students entering the first semester of the Regional Autonomous University of Los Andes, during the previous academic periods none of them has demonstrated a high level of language proficiency, see [5].

In addition, once the LIFE course of the National Geographic Learning ([6-7]) has begun, it has been observed that despite having a textbook that meets essential premises in language teaching such as the development of the

four fundamental skills of the language, of working with very up-to-date issues regarding different spheres of life in several countries and of having a platform that supports and expands the individual work of the students, even the expected results do not cover the teachers' expectations according to the levels they are scheduled to have at the end of the third book in the series, LIFE 3 (2015). Therefore, the authors of this paper aim to assess the main results obtained so far with this series after five semesters using the aforementioned series.

To obtain the essential information in this investigation, a questionnaire was used as a technique for the survey analyzed with the Likert Scale ([8][3, 4]) in an adaptation of the Course Experience Questionnaire (CEQ 2010) of the Curtin University, Australia ([9][5]), with the objective of measuring the intensity or the degree of feeling towards various aspects related to the teaching-learning of English. The scale was applied to 83 students out of a total of 153 in the third semester for having already had previous experience of the LIFE series, which represents a sample of 54.24% of the total population. 8 of the 12 teachers who worked in these three semesters were also surveyed, representing a sample of 66.6% of this population of teachers. Twenty questions were grouped into seven fundamental groups that covered aspects related to motivation, methodology, and course organization among others.

The applied Likert scale contains among its options positive values in different gradations, as well as negative values in its different gradations, and one neutral value. Here we consider the importance of neutral responses, because the study of the social phenomenon would not be complete if the neutrality given by indifference or contradiction of opinions is not taking into account. That is why we process the data given on the Likert scale in a different way than the traditional manner, where we separate the percentages of positive, negative and neutral responses in their different gradations, to evaluate the pros and cons of that series for teaching English. Although the study is restricted to students of the Regional Autonomous University of Los Andes, we think that the results of this study can be generalized to other higher level centers of the Ecuadorian universities.

That is why the present study will be based on the Neutrosophic Sociology or briefly Neutrosociology, see [10]. Neutrosociology is the study of sociology using neutrosophic scientific methods. The huge social data that we face in sociology is full of indeterminacy: it is vague, incomplete, contradictory, hybrid, biased, ignorant, redundant, superfluous, meaningless, ambiguous, unclear, etc. That is why the neutrosophic sciences (which deal with indeterminacy) should be involved, such as: neutrosophy, neutrosophic set, neutrosophic logic, neutrosophic probability and neutrosophic statistics, neutrosophic analysis, neutrosophic measure, and so on.

Neutrosophic probability and neutrosophic statistics are used to study and analyze social facts, behaviors, and causes, see [11][6] . Neutrosophic Statistics refers to a set of data, such that the data or a part of it are indeterminate in some degree, and to methods used to analyze them.

This paper is divided according to the following structure; Section 2 describes some tools of Neutrosociology and Likert scale. Section 3 describes the results obtained from the study conducted at UNIANDES. The last section is dedicated to draw conclusions.

2 Materials and Methods

This section is dedicated to summarize the main concepts and definitions of the Neutrosophic Sociology. Additionally, we describe some details about evaluation with Likert scale.

2.1 Neutrosophic Sociology

According to Smarandache “the sociology is the neutrosophic scientific study of society”, see [10]. This is because when social phenomena are analyzed, it is not ruled out that there is a certain degree of indeterminacy, inaccuracy, contradiction, indifference, among others.

In modern societies, in addition to each individual as a basic unit, there are different groups of people where there are interactions within the group and between the groups, having some degree of internal and external cooperation and also of competence, conflict, lack of communication and information. The tools for the study of the Neutrosophic Sociology is the Neutrosophic Statistics, where the data, the populations, the parameters of the distribution functions, the hypothesis tests, among others, manifest themselves in a somewhat imprecise way.

Each neutrosophic concept, phenomenon, entity, can be measured based on the Neutrosophic Logic ([12-13]), where semantics are defined as follows:

Given P a proposition it can be measured with a triple of values as it is shown in Equation 1.

$$NL(P) = (t, i, f) \quad (1)$$

Where NL is the logical evaluation of P, such that this is t% true, i% indeterminate and f% false, and $0 \leq t+i+f \leq 3$.

In the case of working with Neutrosophic Statistics or Neutrosophic Probability, these three values can mean that if P is an event, t is the expected percentage of occurrence of P, f is the percentage of non-occurrence, while i is the percentage where there are contradictions of viewpoints, lack of information, indifference, among others, and $0 \leq t+i+f \leq 1$.

In addition, the triad that represents the semantics of neutrosophic logic can be generalized to the Refined Neutrosophic Logic ([14-15][7]), where more than one value of truthfulness, indeterminacy or falsehood can be

considered.

In general, semantics can be generalized as shown in Equation 2.

$$RNL(P) = (t_1,..,t_l, i_1,\ldots, i_m, f_1,\ldots, f_n) \quad (2)$$

Where $t_1,..,t_l, i_1,\ldots, i_m, f_1,\ldots, f_n \in [0, 1]$, such that l, m, n ≥1 and $0 \leq \sum_{i=1}^{l} t_i + \sum_{j=1}^{m} i_j + \sum_{k=1}^{n} f_k \leq l + m + n$.

A social change makes the society to get degrees of evolutions ($\mathcal{T}_1, \mathcal{T}_2, \ldots$) with respect to each of some social parameters, degrees of involution ($\mathcal{F}_1, \mathcal{F}_2, \ldots$) with respect to each of the other social parameters, and degrees of neutralities (neither evolution, nor involution) ($\mathcal{I}_1, \mathcal{I}_2, \ldots, \mathcal{I}_n, n \geq 0$) with respect to each of a third set of social parameters, and degrees of uncertainties (not clear if it is evolution or involution) ($\mathcal{I}_{n+1}, \mathcal{I}_{n+2}, \ldots$) with respect to each of a fourth set of social parameters, see [10].

2.2 The Likert scale

The Likert Scale was first introduced in 1932 and is very popular in psychometric tests, see [16]. This consists of asking questions to the enquired person to determine his/her personality trait, ability, perception. A set of possible answers with different degrees of acceptance, refutation and neutrality is proposed to the person.

Although the number of possible answers is not unique, the most common number of them is 5, even though it can be an even number, or a larger odd number, see [8, 16-18]. A neutral value is usually included (I don't know, I don't care, undecided). The greater the number of possible responses, the greater the accuracy of the responses, and the respondent will have more opportunity to express what he/she really thinks. In this case the approximation to what the respondent responds is greater.

On the other hand, if the number of possible responses is even, the positive responses will necessarily have either greater or lesser gradation than the negative responses and this asymmetry may impair the respondent's opportunity to be more precise in the responses.

As we emphasized earlier, the most common scale consists of 5 possible answers that is a symmetric scale, an example is the following:

1. strongly approve,
2. approve,
3. undecided,
4. disapprove,
5. strongly disapprove.

This scale is not formed of continuous variables and can be applied to a set of questions. The final value can be ordinal or an interval, and it is preferred to apply the median, mode, or frequency, rather than the mean or variance. The final processing to the set of questions can be done with the support of nonparametric techniques such as Chi-square test, Kendall Tau B or C test.

The study we do is not applied to a single person; we want to know the opinion of a social group, in the specific context of their opinion on the LIFE program for learning English. However, we think that this study can serve at least as an indication of the opinion of any group of higher education in Ecuador that uses this program.

Particularly in this paper we will not do a classic processing of the data obtained through the Likert scale, but from a scale of 5 elements we will determine the percentage of cases for each of the options, for all respondents, according to Formula 2. This type will allow explicit consideration of indeterminacy cases corresponding to the third point of the scale.

3 Results

The authors of this paper surveyed students of all careers who attended the third level of the Technology Transfer Center (TTC) of UNIANDES Santo Domingo, that corresponds to the third book of the LIFE series with the aim of assessing the main results obtained so far with the aforementioned Series. All teachers who at that time taught at that level were also surveyed.

Specifically, 83 students from a total of 153 in the third semester were surveyed for having already had previous experience of the LIFE series, which represents a sample of 54.24% of the total population. 8 of the 12 teachers who worked in these three semesters were also surveyed, representing a sample of 66.6% of this population of teachers.

The survey was based on the Likert scale, on a questionnaire from the Course Experience Questionnaire (CEQ 2010) of the Curtin University in Australia. The Likert scale was designed based on the following responses:

1. Strongly agree,
2. Agree,
3. Neither agree nor disagree,
4. Disagree,
5. Strongly disagree.

The results of the student survey are shown in Table 1, while the results of the teacher's survey are shown in

Table 2.

Aspect	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Total
1. Student-Teacher Interaction						
1. Dedication for explanations	51	26	5	1	0	83
2. Student-student interaction						
1. Teamwork skills	38	29	14	2	0	83
3.Rapport						
1. Teacher identifies potentialities	12	39	28	4	0	83
2. Work motivation	30	34	15	3	1	83
3. Attention to difficulties	33	28	21	0	1	83
4. Feedback						
1. Useful Feedback	30	41	9	2	1	83
2. Applicability of the learned contents	30	39	12	2	0	83
3. Knowledge of the progress of what is learned	23	46	14	0	0	83
4. The evaluation identifies weaknesses	25	39	14	5	0	83
5. Course Organization						
1. Adequate schedule	8	9	15	19	32	83
2. Evaluation frequency	23	35	21	3	1	83
3. Learning environment	25	32	20	3	3	83
6. Motivation of the course						
1. Course-specialty relationship	10	29	32	8	4	83
2. Motivation for research	14	33	28	6	2	83
3. Motivation for learning	23	31	20	3	6	83
4. Usefulness of what has been learned	30	33	13	3	4	83
7. Course Results						
1. Analysis and synthesis skills	15	30	31	4	3	83
2. Problem solving skills	12	35	24	10	2	83
3. Written and oral skills	22	34	22	4	1	83
4. Course Quality	24	34	20	2	3	83

Table 1: Results of the UNIANDES student survey according to the adaptation of the Course Experience Questionnaire of the Curtin University.

Aspect	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Total
1. Student-Teacher Interaction						
1. Dedication for explanations	5	3	0	0	0	8
2. Student-student interaction						
1. Teamwork skills	6	2	0	0	0	8
3.Rapport						
1. Enthusiasm when teaching	6	2	0	0	0	8
2. Attention to diversity	3	5	0	0	0	8
4. Feedback						

1. Identify learning styles	0	8	0	0	0	8
2. Exams reflect learning	2	3	3	0	0	8
3. Platform utility	1	3	2	0	2	8
4. Evaluation as reproduction of learning	3	4	1	0	0	8
5. Evaluation as creation of learning	1	7	0	0	0	8
5. Course Organization						
1. Issue difficulty	2	2	4	0	0	8
2. Teamwork	5	3	0	0	0	8
3. Frequency of evaluations	2	4	0	2	0	8
4. Classroom or laboratory conditions	1	4	2	1	0	8
6. Motivation of the course						
1. Extension of the topic to the professional context	3	5	0	0	0	8
2. Correspondence between program and profession	0	2	4	1	1	8
3. Extension of the topic to the Ecuadorian context	3	4	1	0	0	8
7. Course Results						
1. Need to investigate content	4	3	0	1	0	8
2. Language skills balance	4	2	2	0	0	8
3. Applicability of issues to reality	1	6	1	0	0	8

Table 2: Results of the survey of teachers of UNIANDES according to the adaptation of Course Experience Questionnaire of the Curtin University.

We consider the result of the surveys in the form of (t_1, t_2, i, f_1, f_2) where t_1 is the percent of being very in favor of the method, t_2 is the percent of being in favor of the method, i is the percent of indeterminacy, f_1 is the percent of being against the method and f_2 is the percent of being very against the method.

These indices are calculated as the total percentage of 'Strongly agree' to calculate t_1, as the total percentage of 'Agree' to calculate t_2, as the total percentage of 'Neither agree nor disagree' to calculate i, as the total percentage of 'Disagree' to calculate f_1, and as the total percentage of 'Strongly disagree' to calculate f_2.

The results were the following:

For students we obtained the five-tuple (0.28795181, 0.39518072, 0.22771084, 0.05060241, 0.03855422).

For teachers we obtained the five-tuple (0.34210526, 0.4736842, 0.13157895, 0.03289474, 0.01973684).

As it can be seen there exists a high rate of approval of the method in both surveys, and the disapproval does not reach 1%. However, there is a considerable index of indeterminacy, of approximately 23% for students and 13% for teachers, which must be carefully studied. Let us note that these results concern with the majority of students and teachers.

Conclusion

This paper was dedicated to investigating the pros and cons of using the LIFE method at the Regional Autonomous University of the Andes, in Ecuador. To do this, a survey was applied to teachers and students who passed the third level of the method, where they had to mark answers according to a Likert scale of 5 points. It was concluded that the majority of both, the students and teachers accept the method to a greater extent, while in an almost insignificant degree they reject the method, which means that there are many pros and few cons of applying the method. The most interesting part of the study is the degree of indeterminacy or indifference, which reached more than 13%, which is a point to investigate. Both, the two positive and the two negative values did not show large differences of gradation, which is another indicator to investigate, especially the fact that the feeling of "Strongly agree" is not very different to that of merely "agree".

This study was conducted from the perspective of Neutrosociology, which means that more than a simple survey this is a study of the social group consisting of university students and their learning of the English language, which may be a valid result for the other Ecuadorian universities which use this method. Thus, that is another challenge of research and future work, the study of the acceptance of this method in other universities in the country.

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Analysis of an strategic plan to increase the sales level of the company "TIENS" of Babahoyo using neutrosophic methods

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Abstract. In the world, natural medicine is increasingly appreciated as a complement to conventional medicine that treats diseases with industrially produced drugs. Natural medicine is cheaper, more accessible than the other one; it usually has fewer contraindications and also carries empirical and traditional knowledge. In Ecuador it is a very popular alternative for the population. "TIENS" Company produces natural medicines, which has been facing the difficulty that its sales are appreciably decreasing. That is why the company performs an analysis to increase the sale levels of produced medicines. To perform the evaluation of the alternatives, the neutrosophic AHP-SWOT method is used. This method allows studying the Strengths, Weaknesses, Opportunities, and Threats of the company, which in its original form does not allow quantifications, that is why the AHP technique is incorporated to evaluate pair-wise comparisons of criteria. In the neutrosophic framework, AHP-SWOT takes into account the indeterminacy that exists in decision making processes.

Keywords: Analytic Hierarchy Process (AHP), SWOT analysis, naturopathy, sale strategies.

1 Introduction

At the moment in which conventional medicine fails to achieve results in spite of a certain disease, some patients and their families resort to the help of natural medicines. All Ecuadorians of any condition or social class have the right to have quality medical care, either with traditional or alternative medicine, with natural medicines that benefit them in the improvement and total recovery of their health.

Similarly, there is space for researchers and entrepreneurs to open the possibilities of bio-knowledge, bio-economics and biotechnology. This is to sponsor all the initiative that, based on the responsible use of biodiversity, allows generating new jobs and expanding the offer to promote healthy eating, sustainable real estate construction, a cosmetic and beverage industry with alternative products, among others. Access to information and environmental education are the basis for an informed, committed and co-responsible citizenship in the processes of changing patterns of consumption and habitat management. The understanding of eco-dependence, in addition, extends to the care and protection of wildlife, confirming the importance of life and dignity in its broad ethical sense, so it is necessary to protect animal welfare with regulations, public policy and express jurisprudence, clear and direct cultural and strengthen sovereignty, see [1].

Around the world, natural medicine moves billions of dollars. In Ecuador every year 40% of patients have first come to a naturopathic physician, who gives them the treatment based on natural medicines, so patients end up trying natural medicine, see [1]. In this country many of the companies that sell natural medicine use a very good promotion which attracts more consumers.

Natural medicine is increasingly placed in a better position among drug-based medicine, which generates many gains and prestige for many countries and entrepreneurs who enjoy these varieties of vegetables and plants. This has resulted in several individuals and private companies devoting themselves to the manufacture and sale of natural medicines that can be profitable in terms of the market. Several of the companies indicate that naturopathic medicine drives to prevent cancer, prevent aging, wrinkles, cellulite, hair loss and male sexual dysfunction problems.

Natural or Alternative Medicine has been regularized by the Ministry of Public Health (MSP), which makes it gaining an important part of the Ecuadorian market, which is why it has already been implemented and will

continue to be done in all health centers. Natural or Alternative Medicine is classified into two groups: Natural or Alternative Medicine that is exercised by physicians who have a fourth level degree with specialization in Acupuncture, Homeopathy, and Neural Therapy; and alternative therapies, which are made up of Naturopathy, Phytotherapy, and Floral Therapy, among other techniques, see [2-4][1].

The Company "TIENS" is located in the city of Babahoyo, its commercial activity aims to produce and distribute products made from natural medicine with the purpose of taking care of the health and integrity of society in general, see[2].

The main difficulty that the company is currently going through is the decrease in the sale of its products, which is why its profits have declined over the months. Among the main causes is the increase in competitors that is growing more and more in the market, with similar products or with the same benefits at the lowest price. The entry of new competitors affects their profitability and puts their sustainability at risk.

Another cause detected is that the person in charge of the company has limited sales knowledge, which results in many of the processes being carried out empirically without a strategic horizon. Bad promotion has also been detected and that there are no marketing strategies within the company. The purpose of this paper is to carry out an analysis and evaluation of the possible alternatives of strategies to increase the level of sales of the products of the company "TIENS".

This analysis is performed based on the neutrosophic AHP-SWOT analysis ([5]), which combines the AHP technique with the representation of the SWOT matrix (Strengths, Weaknesses, Opportunities, and Threads). The Analytical Hierarchy Process (AHP) technique is a structured technique for dealing with complex decisions, it helps decision makers to find the solution that best suits their needs and their understanding of the problem, see [6-8]. This is a tool based on mathematics and psychology, it was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined, since then, see [9]. When the hierarchy is built, decision makers systematically evaluate their elements to compare them with each other; only two elements are compared at a time. When comparisons are made, decision makers can use concrete data about the elements, or they can use their judgments about the importance and relative meaning of the elements. It is essential for the AHP that human judgments, and not only the underlying information, can be used to conduct evaluations.

AHP converts these assessments to numerical values or priorities. A numerical weight or priority is derived from each element of a hierarchy, allowing diverse and often immeasurable elements to be compared with each other in a rational and consistent manner. This facility distinguishes AHP from other decision-making techniques. In the final step of the process, numerical priorities are calculated for each of the decision alternatives. These numbers represent the relative ability of the alternatives to achieve the objective of the decision, so as to allow a direct consideration of the different courses of action.

Conversely, the SWOT analysis ([10-13]) is a methodology for studying the situation of a company or a project, analyzing its internal characteristics (Weaknesses and Strengths) and its external situation (Threats and Opportunities) in a square matrix. This methodology presents as a limitation that by itself it does not offer a quantitative evaluation on the situation of the organization, which is why it can be found associated with other techniques, including AHP, see[3, 4] [14-17].

The neutrosophic AHP-SWOT combines the AHP with the SWOT in a neutrosophic framework, which allows quantitative calculations of Strengths, Weaknesses, Opportunities, and Threats, where the typical indeterminacies of decision-making are taken into account, as developed by Abdel-Basset et al. in [5][5].

This paper is divided according to the following structure, below is a section of preliminary concepts, describing the neutrosophic AHP-SWOT method, with all of its elements. Next, a section is devoted to analyze strategies of the company “TIENS” based on neutrosophic AHP-SWOT. We culminate with a final section dedicated to giving conclusions.

2 Preliminaries

This section describes the main concepts and methods used in neutrosophic AHP-SWOT, in particular, the SWOT technique, the AHP methodology, and the neutrosophic AHP.

2.1 AHP method

This subsection describes the main elements of the Neutrosophic AHP method.

Definition 1: ([18-19]) The *Neutrosophic set* N is characterized by three membership functions, which are the truth-membership function T_A, indeterminacy-membership function I_A, and falsity-membership function F_A, where U is the Universe of Discourse and $\forall x \in U$, $T_A(x)$, $I_A(x)$,$F_A(x) \subseteq]^-0, 1^+[$, and $^-0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$.

See that according to the definition, $T_A(x)$, $I_A(x)$ and $F_A(x)$ are real standard or non-standard subsets of $]^-0, 1^+[$ and hence, $T_A(x)$, $I_A(x)$ and $F_A(x)$ can be subintervals of [0, 1].

Definition 2: ([18-19]) The *Single-Valued Neutrosophic Set* (SVNS) N over U is $A = \{\langle x; T_A(x), I_A(x), F_A(x)\rangle : x \in U\}$, where $T_A: U \to [0, 1]$, $I_A: U \to [0, 1]$, and $F_A: U \to [0, 1]$, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

The *Single-Valued Neutrosophic number* (SVNN) is symbolized by N = (t, i, f), such that 0 ≤t, i, f ≤ 1 and 0 ≤t + i + f≤ 3.

Definition 3: ([18-19]) The *single-valued trapezoidal neutrosophic number*,

$\tilde{a} = \langle(a_1, a_2. a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy and falsity membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \le x \le a_2 \\ \alpha_{\tilde{a}}, & a_2 \le x \le a_3 \\ \alpha_{\tilde{a}}\left(\frac{a_4-x}{a_4-a_3}\right), & a_3 \le x \le a_4 \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\beta_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \le x \le a_2 \\ \beta_{\tilde{a}}, & a_2 \le x \le a_3 \\ \frac{(x-a_2+\beta_{\tilde{a}}(a_4-x))}{a_4-a_3}, & a_3 \le x \le a_4 \\ 1, & \text{otherwise} \end{cases} \quad (2)$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2-x+\gamma_{\tilde{a}}(x-a_1))}{a_2-a_1}, & a_1 \le x \le a_2 \\ \gamma_{\tilde{a}}, & a_2 \le x \le a_3 \\ \frac{(x-a_3+\gamma_{\tilde{a}}(a_4-x))}{a_4-a_3}, & a_3 \le x \le a_4 \\ 1, & \text{otherwise} \end{cases} \quad (3)$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0,1]$, $a_1, a_2, a_3, a_4 \in \mathbb{R}$ and $a_1 \le a_2 \le a_3 \le a_4$.

Definition 4: ([6][18-19]) Given $\tilde{a} = \langle(a_1, a_2, a_3, a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle$ and $\tilde{b} = \langle(b_1, b_2, b_3, b_4); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}}\rangle$ two single-valued trapezoidal neutrosophic numbers and λ any non null number in the real line. Then, the following operations are defined:

7. Addition: $\tilde{a} + \tilde{b} = \langle(a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle$
8. Subtraction: $\tilde{a} - \tilde{b} = \langle(a_1 - b_4, a_2 - b_3, a_3 - b_2, a_4 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle$
9. Inversion: $\tilde{a}^{-1} = \langle(a_4^{-1}, a_3^{-1}, a_2^{-1}, a_1^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle$, where $a_1, a_2, a_3, a_4 \neq 0$.
10. Multiplication by a scalar number:
$$\lambda\tilde{a} = \begin{cases} \langle(\lambda a_1, \lambda a_2, \lambda a_3, \lambda a_4); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle, & \lambda > 0 \\ \langle(\lambda a_4, \lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle, & \lambda < 0 \end{cases}$$
11. Division of two triangular neutrosophic numbers:
$$\frac{\tilde{a}}{\tilde{b}} = \begin{cases} \langle\left(\frac{a_1}{b_4}, \frac{a_2}{b_3}, \frac{a_3}{b_2}, \frac{a_4}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, a_4 > 0 \; and \; b_4 > 0 \\ \langle\left(\frac{a_4}{b_4}, \frac{a_3}{b_3}, \frac{a_2}{b_2}, \frac{a_1}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, a_4 < 0 \; and \; b_4 > 0 \\ \langle\left(\frac{a_4}{b_1}, \frac{a_3}{b_2}, \frac{a_2}{b_3}, \frac{a_1}{b_4}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, a_4 < 0 \; and \; b_4 < 0 \end{cases}$$
12. Multiplication of two triangular neutrosophic numbers:
$$\tilde{a}\tilde{b} = \begin{cases} \langle(a_1 b_1, a_2 b_2, a_3 b_3, a_4 b_4); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, & a_4 > 0 \; and \; b_4 > 0 \\ \langle(a_1 b_4, a_2 b_3, a_3 b_2, a_4 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, & a_4 < 0 \; and \; b_4 > 0 \\ \langle(a_4 b_4, a_3 b_3, a_2 b_2, a_1 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, & a_4 < 0 \; and \; b_4 < 0 \end{cases}$$

Where, ∧ is a t-norm and ∨ is a t-conorm.

Let us observe that when we set $a_2 = a_3$ in Definitions 3 and 4, then the single-valued trapezoidal neutrosophic number is called a *single-valued triangular neutrosophic number*, see [20].

Next, for the modeling we have to apply the NAHP. We propose a linguistic scale by using triangular neutrosophic numbers as can be seen in Table 1, see also the scale defined in [5].

In [5, 8] there is a combination of AHP with neutrosophic set theory. This combination permits to model the indeterminacy typical of every decision-making process.

See Equation 4 for appreciating the neutrosophic pair-wise comparison matrix.

$$\tilde{A} = \begin{bmatrix} \vdots & \ddots & \vdots \\ \tilde{a}_{n1} \; \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \quad (4)$$

Matrix $\tilde{A}$ satisfies the condition $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$, based on the inversion operator of Definition 4.

Two indices to convert neutrosophic triangular numbers in crisp numbers are defined in [5]. These are the score and accuracy Equations, respectively, see Equations 5 and 6:

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \quad (5)$$

$$\mathbf{A}(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (6)$$

Saaty scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\tilde{1} = \langle(1,1,1); 0.50, 0.50, 0.50\rangle$
3	Slightly influential	$\tilde{3} = \langle(2,3,4); 0.30, 0.75, 0.70\rangle$
5	Strongly influential	$\tilde{5} = \langle(4,5,6); 0.80, 0.15, 0.20\rangle$
7	Very strongly influential	$\tilde{7} = \langle(6,7,8); 0.90, 0.10, 0.10\rangle$
9	Absolutely influential	$\tilde{9} = \langle(9,9,9); 1.00, 1.00, 1.00\rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\tilde{2} = \langle(1,2,3); 0.40, 0.65, 0.60\rangle$
		$\tilde{4} = \langle(3,4,5); 0.60, 0.35, 0.40\rangle$
		$\tilde{6} = \langle(5,6,7); 0.70, 0.25, 0.30\rangle$
		$\tilde{8} = \langle(7,8,9); 0.85, 0.10, 0.15\rangle$

Table 1: Saaty's scale translated to a neutrosophic triangular scale.

2.2 The Neutrosophic AHP-SWOT

This subsection is dedicated to explain the algorithm of Neutrosophic AHP-SWOT, introduced in [5]. In the following we describe the algorithm used by Abdel-Basset et al.

Step 1 Select a group of experts at performing SWOT analysis.

In this step, experts identify the internal and the external factors of the SWOT analysis by employing questionnaires/interviews. Figure 1 presents the SWOT analysis diagram:

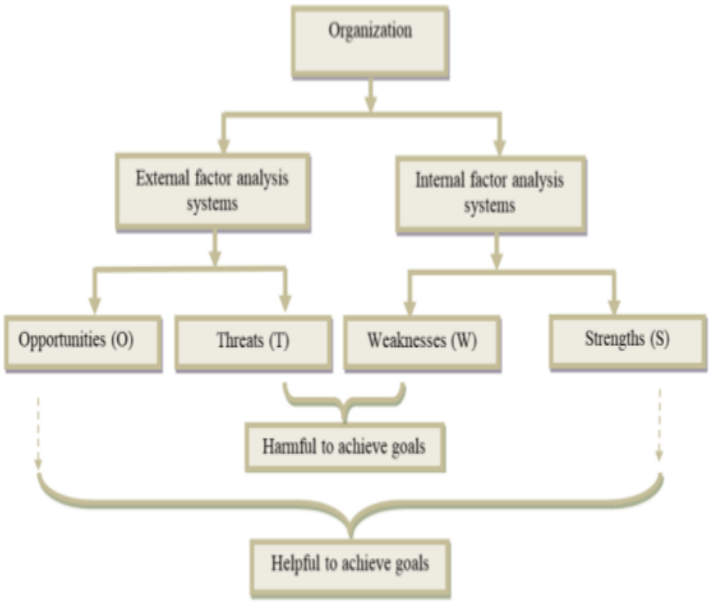

Figure 1: Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis diagram. Source [5].

Step 2 Structure the hierarchy of the problem.

The hierarchy of the problem has four levels:

- The first level is the goal the organization wants to achieve.
- The second level consists of the four strategic criteria that are defined by the SWOT analysis (i.e., criteria).

- The third level contains the factors that are included in each strategic factor of the previous level (i.e., sub-criteria).
- The final level includes the strategies that should be evaluated and compared. The general hierarchy is presented in Figure 2.

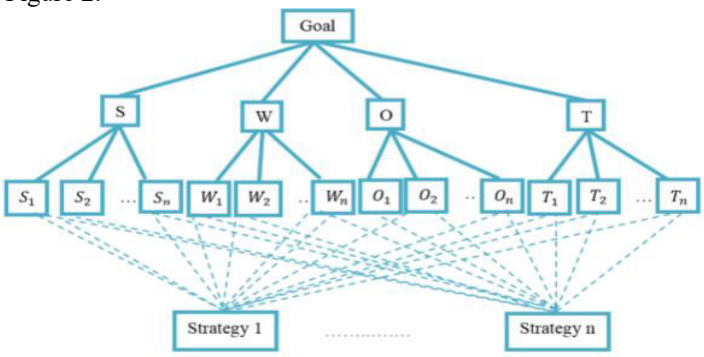

Figure 2: The hierarchy of a problem. Source [5].

Step 3 Structure the neutrosophic pair-wise comparison matrix of factors, sub-factors and strategies, through the linguistic terms which are shown in Table 1.

The neutrosophic scale is attained according to expert opinions. The neutrosophic pair-wise comparison matrix of factors, sub-factors and strategies are as Equation 4.

Step 4 Check the consistency of experts' judgments.

If the pair-wise comparison matrix has a transitive relation, i.e., $a_{ik} = a_{ij}a_{jk}$ for all i,j and k, then the comparison matrix is consistent, focusing only on the lower, median and upper values of the triangular neutrosophic number of the comparison matrix.

Step 5 Calculate the weight of the factors (S, W, O, T), sub-factors $\{(S_1,...,S_n), (W_1,...,W_n), (O_1,...,O_n),(T_1,...,T_n)\}$ and strategies/alternatives (Alt_1, ... , Alt_n) from the neutrosophic pair-wise comparison matrix, by transforming it to a deterministic matrix using Equations 7 and 8.

To get the score and the accuracy degree of $\tilde{a}_{ji}$ the following equations are used:

$$S(\tilde{a}_{ji}) = {}^{1}\!/_{S(\tilde{a}_{ij})} \quad (7)$$

$$A(\tilde{a}_{ji}) = {}^{1}\!/_{A(\tilde{a}_{ij})} \quad (8)$$

With compensation by accuracy degree of each triangular neutrosophic number in the neutrosophic pair-wise comparison matrix, we derive the following deterministic matrix:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \quad (9)$$

Determine the ranking of priorities, namely the Eigen Vector X, from the previous matrix as follows:

1. Normalize the column entries by dividing each entry by the sum of the column.
2. Take the total of the row averages.

Step 6 Calculate the total priority of each strategy (alternative) for the final ranking of all strategies using Equation 10.

The total weight value of the alternative j (j = 1,...,n) can be n as follows:

$$Tw_{Alt_j} = w_S * \sum_{i=1}^{n} w_{S_i} * w_{Alt_j} + w_W * \sum_{i=1}^{n} w_{W_i} * w_{Alt_j} + w_O * \sum_{i=1}^{n} w_{O_i} * w_{Alt_j} + w_T * \sum_{i=1}^{n} w_{T_i} * w_{Alt_j} \quad (10)$$

where (i = 1,...,n) and (w_S,w_W,w_O,w_T) are the weights of Strengths, Weaknesses, Opportunities and Threats; (w_{Si},w_{Wi},w_{Oi},w_{Ti}) are the sub-factor weights; and w_{Alt_j} is the weight of the alternative j, corresponding to its sub-factor.

See that Step 4 refers to consider when applying this technique, this is by using the calculus of the *Consistency Index* (CI), which is function depending on λ_{max}, the maximum eigenvalue of the matrix. Saaty establishes that consistency of the evaluations can be determined by equation $CI = \frac{\lambda_{max}-n}{n-1}$, where n is the order of the matrix. Also, the *Consistency Ratio* (CR) is defined by equation CR = CI/RI, where RI is given in Table 2.

Order (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Table 2: RI associated to every order.

If CR≤0.1 we can consider that experts' evaluation is sufficiently consistent and hence we can proceed to use AHP. We apply this procedure to matrix A in Equation 9.

3 Results

In the following we present the results obtained from applying the neutrosophic AHP-SWOT method to analyze the strategic plans that was designed to increase the sales of the company "TIENS". We will begin by showing the factors that constitute Strengths, Weaknesses, Opportunities, and Threats detected by the managers and specialists of the company, see [1][7].

Table 3 contains the obtained SWOT matrix.

STRENGTHS	WEAKNESSES
S_1: Value added to product	W_1: Little financial margin
S_2: Low prices, discounts and promotions	W_2: Lack of capacity to meet demand
S_3: High academic level of human talent	W_3: Lack of ability to compete with prices
S_4: High level of operating software	
OPPORTUNITIES	**THREATS**
O_1: Location in the downtown area of the City	T_1: New competitors
O_2: Strategic alliances with suppliers	T_2: Economic instability
O_3: Application of technology	T_3: Unfair Competition

Table 3: SWOT Matrix corresponding to the "TIENS" Company.

In addition, managers and specialists determined to apply the following strategies to improve the company's sales level:

Alt_1. Cost leadership strategy: it is based on the company obtaining a competitive advantage in relation to costs, that is, the company produces its products using lower costs and at the same time is efficient in all areas of production, marketing and all those that have relationship with production.

Alt_2. Organizational Growth Strategy: This strategy has as main foundation that the company prospers when it increases the sales of its products, because it manages to expand.

Alt_3. Promotion and advertising strategies: The "TIENS" Company will carry out advertising and promoting strategies to publicize the variety of its products and at the same time motivate people to acquire them, and also let all the people know about the benefits for the health that possesses each of its products.

There was a team of 4 experts, who were asked to evaluate the criteria and sub-criteria. The group decision assessments were obtained by calculating the median of experts' individual evaluations over the same aspect. The calculations were supported on the software Octave 4.2.1, see [21].

Table 4 contains the neutrosophic pair-wise comparison matrix between Strengths, Weaknesses, Opportunities, and Threats.

Factors	**Strengths**	**Weaknesses**	**Opportunities**	**Threats**
Strengths	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$	$1/\tilde{2}$
Weaknesses	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$	$1/\tilde{3}$
Opportunities	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$	$1/\tilde{2}$
Threats	$\tilde{2}$	$\tilde{3}$	$\tilde{2}$	$\tilde{1}$

Table 4: The neutrosophic comparison matrix of Strengths, .Weaknesses, Opportunities, and Threats.

Table 5 contains the crisp values of Table 4, after applying Equation 6.

Factors	Strengths	Weaknesses	Opportunities	Threats
Strengths	1	1	1	0.56738
Weaknesses	1	1	1	0.39507
Opportunities	1	1	1	0.56738
Threats	1.7625	2.5312	1.7625	1

Table 5: The crisp comparison matrix of factors.

This matrix satisfies CR = 0.0061536≤0.1.
The following vector of the normalized matrix was obtained from Table 5:

$$X = \begin{bmatrix} 0.20625 \\ 0.18923 \\ 0.20625 \\ 0.39827 \end{bmatrix}$$

Table 6 contains the comparison matrix between the Strengths.

Strengths	S_1	S_2	S_3	S_4
S_1	$\tilde{1}$	$\tilde{3}$	$\tilde{1}$	$\tilde{5}$
S_2	$1/\tilde{3}$	$\tilde{1}$	$1/\tilde{5}$	$\tilde{2}$
S_3	$\tilde{1}$	$\tilde{5}$	$\tilde{1}$	$\tilde{5}$
S_4	$1/\tilde{5}$	$1/\tilde{2}$	$1/\tilde{5}$	$\tilde{1}$

Table 6: The neutrosophic comparison matrix of Strengths.

Table 7 contains the crisp values of Table 6, after applying Equation 6.

Strengths	S_1	S_2	S_3	S_4
S_1	1	2.5312	1	5.3438
S_2	0.39506	1	0.18713	1.7625
S_3	1	5.3438	1	5.3438
S_4	0.18713	0.56738	0.18713	1

Table 7: The crisp comparison matrix of Strengths.

This matrix satisfies CR = 0.021625≤0.1.
The following vector of the normalized matrix was obtained from Table 7:

$$X = \begin{bmatrix} 0.368447 \\ 0.117185 \\ 0.442914 \\ 0.071445 \end{bmatrix}$$

Table 8 contains the comparison matrix between the Weaknesses.

Weaknesses	W_1	W_2	W_3
W_1	$\tilde{1}$	$1/\tilde{2}$	$1/\tilde{4}$
W_2	$\tilde{2}$	$\tilde{1}$	$1/\tilde{3}$
W_3	$\tilde{4}$	$\tilde{3}$	$\tilde{1}$

Table 8: The neutrosophic comparison matrix of Weaknesses.

Table 9 contains the crisp values of Table 8, after applying Equation 6.

Weaknesses	W_1	W_2	W_3
W_1	1	0.56738	0.25157
W_2	1.7625	1	0.39506
W_3	3.9750	2.5312	1

Table 9: The crisp comparison matrix of Weaknesses.

This matrix satisfies CR = 0.0014135≤0.1.
The following vector of the normalized matrix from Table 9 was obtained:

$$X = \begin{bmatrix} 0.14655 \\ 0.24850 \\ 0.60496 \end{bmatrix}$$

Table 10 contains the comparison matrix between the Opportunities.

Opportunities	**O_1**	**O_2**	**O_3**
O_1	$\tilde{1}$	$\tilde{1}$	$\tilde{3}$
O_2	$\tilde{1}$	$\tilde{1}$	$\tilde{3}$
O_3	$1/\tilde{3}$	$1/\tilde{3}$	$\tilde{1}$

Table 10: The neutrosophic comparison matrix of Opportunities.

Table 11 contains the crisp values of Table 10, after applying Equation 6.

Opportunities	**O_1**	**O_2**	**O_3**
O_1	1	1	2.5312
O_2	1	1	2.5312
O_3	0.39506	0.39506	1

Table 11: The crisp comparison matrix of Opportunities.

This matrix satisfies CR = 0≤0.1.
The following vector of the normalized matrix from Table 11 was obtained:

$$X = \begin{bmatrix} 0.41752 \\ 0.41752 \\ 0.16495 \end{bmatrix}$$

Table 12 contains the comparison matrix between the Threats.

Threats	**T_1**	**T_2**	**T_3**
T_1	$\tilde{1}$	$1/\tilde{5}$	$1/\tilde{3}$
T_2	$\tilde{5}$	$\tilde{1}$	$\tilde{3}$
T_3	$\tilde{3}$	$1/\tilde{3}$	$\tilde{1}$

Table 12: The neutrosophic comparison matrix of Threats.

Table 13 contains the crisp values of Table 12, after applying Equation 6.

Threats	**T_1**	**T_2**	**T_3**
T_1	1	0.18713	0.39506
T_2	5.3438	1	2.5312
T_3	2.5312	0.39506	1

Table 13: The crisp comparison matrix of Threats.

This matrix satisfies CR = 0.0035≤0.1.
The following vector of the normalized matrix from Table 13 was obtained:

$$X = \begin{bmatrix} 0.11052 \\ 0.62628 \\ 0.26320 \end{bmatrix}$$

Table 14 summarizes the comparison of each strategy from the point of view of each factor and sub-factor.

Factors/Sub-Factors	**Weight**	**Strategies**		
		Alt_1	**Alt_2**	**Alt_3**
Strengths	0.20625			
S_1	0.368447	0.38950	0.38950	0.22099

S_2	0.117185	0.33333	0.33333	0.33333
S_3	0.442914	0.33333	0.33333	0.33333
S_4	0.071445	0.26578	0.26578	0.46844
Weaknesses	0.18923			
W_1	0.14655	0.41753	0.41753	0.16495
W_2	0.24850	0.41753	0.41753	0.16495
W_3	0.60496	0.50568	0.30746	0.18687
Opportunities	0.20625			
O_1	0.41752	0.22069	0.22069	0.55862
O_2	0.41752	0.41753	0.41753	0.16495
O_3	0.16495	0.457219	0.457219	0.085561
Threats	0.39827			
T_1	0.11052	0.33333	0.33333	0.33333
T_2	0.62628	0.57675	0.30843	0.11482
T_3	0.26320	0.26578	0.26578	0.46844
Total		0.41803	0.32841	0.25356
Rank of Strategies		1	2	3

Table 14: Comparing strategies respect to SWOT factors and sub-factors and their ranking.

According to the results in Table 14, the strategies are ordered in the following order: $\mathrm{Alt}_1 \succ \mathrm{Alt}_2 \succ \mathrm{Alt}_3$.

Conclusion

This paper was dedicated to study and evaluate three strategies to increase the sales of natural medicines produced by the "TIENS" Company in the city of Babahoyo in Ecuador. For this end, the neutrosophic AHP-SWOT method was applied. This method has the advantages of each of the incorporated techniques, theories and methods. SWOT permits the representation of the four aspects that prejudice or benefit company performance, both internally and externally, however this representation alone does not permit the quantification of these advantages. Thus, AHP combined with SWOT allows the assessment of the company's situation quantitatively. For its part, neutrosophic theory lets the modeling of the imprecision contained in any decision-making process. Four experts carried out evaluations and it was concluded that the best strategy is the "Cost Leadership Strategy", followed by the "Organizational Growth Strategy" and finally the "Promotion and Advertising Strategies". Although in principle these three strategies are not mutually exclusive, if one of them had to be selected, the order of priority is given. Future works by the authors of this paper include the study of the impact of applying these strategies in the company.

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Using a neutrosophic model to evaluate website usability of a web portal for the commercial management of an advertising company

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Abstract. In the field of the development of Information Technology solutions, web applications are the most used tools for the businesses commercial management in their different scales. However, in the company "JM" Advertising, located in the city of Quevedo, Ecuador, does not have a digital medium in this regard, which supports the commercial management. That is, it does not have a digital catalog of products and services, nor orders online or online collections. In this context, web usability plays a key role in the process of developing successful websites. This paper proposes a methodology that allows the evaluation of the usability of two prototypes of web portals in the 'JM' advertising company. This methodology is applicable to other companies of similar functions. The methodology contains tools such as neutrosophic TOPSIS and neutrosophic AHP. Evaluation in the framework of neutrosophy incorporates the indeterminacy that is typical of decision-making processes, while the combination of AHP with TOPSIS allows us to take the advantages of both techniques.

Keywords: Publicity, website, neutrosophic AHP, neutrosophic TOPSIS

1 Introduction

In recent years, the World Wide Web has undergone major changes, especially since the appearance of Web 2.0 and Web 3.0, which in their elementary composition permits active interaction among users. For the business world this reality has also had new effects and types of participation, social networks are now the important means of disseminating Business Web Portals. However, this is the last step in promoting this virtual space.

In a company that sells goods, products and services, it is necessary to promote business management through the Web, with the construction of web portals that will allow worldwide dissemination of its offer in this increasingly competitive virtual world, but it is necessary to know and evaluate the effectiveness of incurring the expenses of the website.

In Ecuador, small and medium businesses are not yet inserted in the web, mainly in cities such as Quevedo where most businesses and companies do not yet have a presence in the virtual world, at least not in a professional and technical way.

For this reason, the contribution of this work is important, since it offers an easy, fast and flexible way to evaluate the usability of a web portal. The usability of a web portal refers to the ease with which people can use the web portal in order to achieve the proposed objective, see [1-5].

In the research conducted in the company "JM" Advertising, it is evident the lack of online facilities to attract new customers. The lack of communication and location channels wastes the opportunity to attract new customers. The increasing access to the web has made customers look for ways to order different products online, in the case of the advertising company "JM" Advertising despite having an efficient work team, in machinery, production and delivery management, customer s only have the opportunity to place their orders in the offices.

The advertising company "JM", is dedicated to graphic design, mainly of Gigantographies, related products and services, does not have a web portal, like other companies dedicated to the same business in Quevedo, hence one motivation of this work is to make a decision on two prototypes of websites for this company applying neutrosophic techniques.

Web portals are also known as websites. A website is a collection of internet pages related and common to an Internet domain or subdomain on the World Wide Web, it is a set of electronic hypertext documents (web pages) that compose and refer to a particular topic. Normally they are defined by a welcome page (home page), which will be the one that is initially displayed and from which the other pages can be accessed through links.

With its help users can generate and publish news, create taxonomies (classification systems) with which the administrator classifies content, insert logos or personalized or corporate images of the portal, add sections, manage user databases, etc. A content manager that currently has more than 30% of the network content is in WordPress. WordPress.com hosts content from newly initiated bloggers to companies such as Time, CNN and TechCrunch, around the world.

On the other hand, the plugin that helps managing the online store is Woocommerce, which is a plugin that allows users to create an online store. It is created exclusively for WordPress, so it maintains the same usage code, words and functionalities that users use to manage its blog.

Advertising is a form of commercial communication that attempts to increase the consumption of a product or service through the media and propaganda techniques. The main objective of advertising is to sell, achieve short-term results. The first thing the campaign should get is for the consumer to go to the store and buy. And it is perfectly possible to make selling campaigns that, in addition, work in the medium and long term by building the brand which in the future can and should be made invulnerable to the competition.

This research aims to design a methodology to determine the criteria and opinions that constitute the most important aspects to know the usability of the use of websites in the company 'JM' Advertising or in another similar company.

To evaluate the set of criteria surveyed in this selection problem, two techniques have been chosen: AHP and TOPSIS, see [1][6-7]. The first one is used to determine the weight of the importance that each of the attributes has, while the second one is used to determine an ordering of two alternatives in the usability evaluation. The idea of combining these two techniques is recommended in some papers, see [2][8-9]. The use of AHP guarantees a lower bias in decision making because the decision is considered consistent only when the Consistency Ratio (CR) is less than or equal to 10 percent ([3][6, 10-11]). On the other hand, TOPSIS guarantees the objectivity of the decision because it consists in ordering the alternatives based on how close to the ideal solution evaluations are and how far to the undesirable solution they are ([4][9]).

These techniques are combined in the framework of neutrosophy, which allows incorporating indeterminacy that exists in all decision making. A similar methodology was developed by Abdel-Basset et al. in [12] to evaluate supply chain alternatives, where a Neutrosophic ANP-TOPSIS method for decision-making is proposed. Other works propose techniques such as neutronophic TOPSIS and neutrosophic AHP, see [13-15].

This paper is divided as follows, Section 2 of Basic Concepts, is dedicated to briefly expose both, the techniques of neutrosophic AHP and neutrosophic TOPSIS. Section 3 is dedicated to expose the methodology that is proposed to evaluate the usability of two possible web portals of the products of the company 'JM' Advertising, located in the city of Quevedo, Ecuador, as well as the results of such evaluations. The last section is devoted to conclusions.

2 Basic Concepts

This section contains the main concepts necessaries to develop the methodology we propose in this paper. Subsection 2.1 describes the basis of Neutrosophic AHP, whereas Subsection 2.2 describes the Neutrosophic TOPSIS.

2.1 Neutrosophic AHP

AHP is a technique developed by Thomas Saaty in 1983, and is considered a technique that belongs to the multicriteria family, see [6]. This technique has some advantages; like that it decomposes a problem at different levels, proposing a structure for its solution. On the top the main objective to achieve is placed and in the lower levels the categories and subcategories of them are added, which represents one of the greatest advantages of the technique, since it allows solving complex problems. Another advantage, for what it is widely cited, is that it is based on the quantitative analysis of an assessments set expressed by means of a scale established by Saaty. Additionally, the Consistency Ratio is a measure of the group decision consistency degree.

On the other hand, the neutrosophic AHP technique was developed by Abdel-Basset et al. in [13], with the additional advantages that we cite below:

"Has the same advantages of classical AHP beside the following advantages:

- Provides user with a richer structure framework than the classical AHP, fuzzy AHP and intuitionistic fuzzy AHP.
- Describes the preference judgment values of the decision maker efficiently, handling vagueness and uncertainty over fuzzy AHP and intuitionistic fuzzy AHP because it consider three different grades "membership degree, indeterminacy degree and non-membership degree.

- Point out how to improve inconsistent judgments."

Firstly, neutrosophic AHP technique needs of some previous concepts, which we describe in the following:

Definition 1: The *neutrosophic set* N is characterized by three membership functions, which are the truth-membership function T_A, indeterminacy-membership function I_A, and falsity-membership function F_A, where U is the universe of discourse and $\forall x \in U$, $T_A(x)$, $I_A(x)$,$F_A(x) \subseteq]^-0, 1^+[$, and $^-0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$.

See that according to the definition, $T_A(x)$, $I_A(x)$, and $F_A(x)$ are real standard or non-standard subsets of $]^-0, 1^+[$ and hence, $T_A(x)$, $I_A(x)$ and $F_A(x)$ can be subintervals of [0, 1].

Definition 2: ([13-14]) The *Single-Valued Neutrosophic Set* (SVNS) N over U is $A = \{\langle x; T_A(x), I_A(x), F_A(x)\rangle : x \in U\}$[6], where $T_A: U \to [0, 1]$, $I_A: U \to [0, 1]$, and $F_A: U \to [0, 1]$, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

The *Single-Valued Neutrosophic number* (SVNN) is symbolized by N = (t, i, f), such that $0 \leq t, i, f \leq 1$ and $0 \leq t + i + f \leq 3$.

Definition 3: ([13-14, 16-17]) The *single-valued triangular neutrosophic number*,

$\tilde{a} = \langle (a_1, a_2. a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy and falsity membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, & x = a_2 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_2 < x \leq a_3 \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{(a_2 - x + \beta_{\tilde{a}}(x - a_1))}{a_2 - a_1}, & a_1 \leq x \leq a_2 \\ \beta_{\tilde{a}}, & x = a_2 \\ \frac{(x - a_2 + \beta_{\tilde{a}}(a_3 - x))}{a_3 - a_2}, & a_2 < x \leq a_3 \\ 1, & \text{otherwise} \end{cases} \quad (2)$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{(a_2 - x + \gamma_{\tilde{a}}(x - a_1))}{a_2 - a_1}, & a_1 \leq x \leq a_2 \\ \gamma_{\tilde{a}}, & x = a_2 \\ \frac{(x - a_2 + \gamma_{\tilde{a}}(a_3 - x))}{a_3 - a_2}, & a_2 < x \leq a_3 \\ 1, & \text{otherwise} \end{cases} \quad (3)$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0, 1]$, $a_1, a_2, a_3 \in \mathbb{R}$ and $a_1 \leq a_2 \leq a_3$.

Definition 4: ([16-17]) Given $\tilde{a} = \langle (a_1, a_2, a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two single-valued triangular neutrosophic numbers and λ any non null number in the real line. Then, the following operations are defined:

13. Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$
14. Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_3, a_2 - b_2, a_3 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$
15. Inversion: $\tilde{a}^{-1} = \langle (a_3{}^{-1}, a_2{}^{-1}, a_1{}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, where $a_1, a_2, a_3 \neq 0$.
16. Multiplication by a scalar number:
$$\lambda\tilde{a} = \begin{cases} \langle (\lambda a_1, \lambda a_2, \lambda a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda > 0 \\ \langle (\lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda < 0 \end{cases}$$
17. Division of two triangular neutrosophic numbers:

$$\frac{\tilde{a}}{\tilde{b}} = \begin{cases} \langle\left(\frac{a_1}{b_3}, \frac{a_2}{b_2}, \frac{a_3}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, a_3 > 0 \; and \; b_3 > 0 \\ \langle\left(\frac{a_3}{b_3}, \frac{a_2}{b_2}, \frac{a_1}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, a_3 < 0 \; and \; b_3 > 0 \\ \langle\left(\frac{a_3}{b_1}, \frac{a_2}{b_2}, \frac{a_1}{b_3}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, a_3 < 0 \; and \; b_3 < 0 \end{cases}$$

18. Multiplication of two triangular neutrosophic numbers:

$$\tilde{a}\tilde{b} = \begin{cases} \langle(a_1b_1, a_2b_2, a_3b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, & a_3 > 0 \; and \; b_3 > 0 \\ \langle(a_1b_3, a_2b_2, a_3b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, & a_3 < 0 \; and \; b_3 > 0 \\ \langle(a_3b_3, a_2b_2, a_1b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}}\rangle, & a_3 < 0 \; and \; b_3 < 0 \end{cases}$$

Where, $\wedge$ is a t-norm and $\vee$ is a t-conorm.

In the following we expose the AHP algorithm defined in [13].

Step 1. Decomposition:

The problem is formed hierarchically at various levels. The first level of hierarch represents the overall goal, the second level represents the decision criteria and sub-criteria and third level is composed of all possible alternatives.

Step 2. Comparative judgments with neutrosophic values:

After analyzing the complex multi-criteria decision making problem into three levels, the pair-wise comparisons is used to generate neutrosophic judgment matrix. The vagueness of decision makers is represented by triangular neutrosophic numbers $\tilde{a}_{ij}$, given in Table 1.

Saaty scale	Definition	Neutrosophic Triangular Scale
1	Equally influential	$\tilde{1} = \langle(1,1,1); 0.50, 0.50, 0.50\rangle$
3	Slightly influential	$\tilde{3} = \langle(2,3,4); 0.30, 0.75, 0.70\rangle$
5	Strongly influential	$\tilde{5} = \langle(4,5,6); 0.80, 0.15, 0.20\rangle$
7	Very strongly influential	$\tilde{7} = \langle(6,7,8); 0.90, 0.10, 0.10\rangle$
9	Absolutely influential	$\tilde{9} = \langle(9,9,9); 1.00, 1.00, 1.00\rangle$
2, 4, 6, 8	Sporadic values between two close scales	$\tilde{2} = \langle(1,2,3); 0.40, 0.65, 0.60\rangle$
		$\tilde{4} = \langle(3,4,5); 0.60, 0.35, 0.40\rangle$
		$\tilde{6} = \langle(5,6,7); 0.70, 0.25, 0.30\rangle$
		$\tilde{8} = \langle(7,8,9); 0.85, 0.10, 0.15\rangle$

Table 1: Saaty's scale translated to a neutrosophic triangular scale.

Then construct the neutrosophic pair-wise comparison matrix such that:

$$\tilde{A} = \begin{bmatrix} \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & \tilde{1} \end{bmatrix} \quad (4)$$

Where $\tilde{a}_{ji} = \tilde{a}_{ij}^{-1}$.

Step 3. For calculating overall priority of each alternative and determine final ranking of all alternatives, we should first determine weights of each criterion from the corresponding pair-wise comparison matrix.

Step 4. To determine the weight of each criterion from corresponding neutrosophic pair-wise comparison matrix, we first transform neutrosophic pair-wise comparison matrix to numeric pair-wise comparison matrix, using the following equations:

Let $\tilde{a} = \langle(a_1, a_2, a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}\rangle$ be a single valued triangular neutrosophic number, then,

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \quad (5)$$

$$\mathbf{A}(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (6)$$

They are called the score and accuracy degrees of $\tilde{a}_{ij}$, respectively. To get score and accuracy degree of $\tilde{a}_{ji}$ we use the following equations, respectively:

$$S(\tilde{a}_{ji}) = {}^{1}\!/_{S(\tilde{a}_{ij})} \quad (7)$$

$$\mathbf{A}(\tilde{a}_{ji}) = {}^{1}\!/_{\mathbf{A}(\tilde{a}_{ij})} \quad (8)$$

With compensation by score value of each triangular neutrosophic number in neutrosophic pair-wise comparison matrix, we have the following deterministic matrix:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \quad (9)$$

From the previous matrix we can easily find a ranking of priorities, namely the Eigen Vector X as follows:

1. Normalize the column entries by dividing each entry by the sum of the column.
2. Take the totality row averages.

Step 5. To measure an inconsistency within the judgments in each comparison matrix and for the entire hierarch, AHP methodology provides a consistency index (CI). To discern if there is any inconsistency in neutrosophic judgment matrix, AHP utilizes consistency index and consistency ratio (CR). If CR is greater than 0.1, the judgments are untrustworthy because they are too near to randomness and the exercise is incorrect or must be repeated.

To calculate CI and CR do the following steps:

1. Calculate the eigenvalues of the matrix obtained in Step 4.
2. Let us call λ_{max} the maximum eigenvalue.
3. Compute the consistency index(CI) as follows:

$$\mathrm{CI} = \frac{\lambda_{\max} - \mathrm{n}}{\mathrm{n} - 1} \quad (10)$$

where n is the number of items being compared.

4. Compute the consistency ratio, which is defined as:

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \quad (11)$$

Where RI is the consistency index of a randomly generated pair-wise comparison matrix, according to Table 2.

Order (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Table 2: RI associated to every order.

Step 6. Calculate overall priority of each alternative and determine final ranking of all alternatives.

2.2 Neutrosophic TOPSIS

First of all we expose the definition of *Single Valued Neutrosophic Weighted Average Operator*.

Let $\{A_1, A_2, \ldots, A_n\}$ be a set of n SVNNs, where $A_j = (a_j, b_j, c_j)$ (j = 1, 2, …, n), then the *Single Valued Neutrosophic Weighted Average Operator* (SVNWAO) on the set is calculated with the following Equation ([15]):

$$\sum_{j=1}^{n} \lambda_j A_j = \left(1 - \prod_{j=1}^{n} (1 - a_j)^{\lambda_j}, \prod_{j=1}^{n} b_j^{\lambda_j}, \prod_{j=1}^{n} c_j^{\lambda_j} \right) \quad (12)$$

Where λ_j is the weight of A_j, $\lambda_j \in [0, 1]$ and $\sum_{j=1}^{n} \lambda_j = 1$.

Let $A^* = (A_1^*, A_2^*, \cdots, A_n^*)$ be a vector of n SVNNs such that $A_j^* = (a_j^*, b_j^*, c_j^*)$ (j = 1, 2, …, n) and $B_i = (B_{i1}, B_{i2}, \cdots, B_{im})$ (i = 1, 2, …, m) are m vectors of n SVNNs such that $B_{ij} = (a_{ij}, b_{ij}, c_{ij})$ (i = 1, 2, …, m) (j = 1, 2, …, n). Then the *Separation Measure* between B_is and A^* is calculated by the following Equation:

$$s_i = \left(\frac{1}{3} \sum_{j=1}^{n} \left\{ (a_{ij} - a_j^*)^2 + (b_{ij} - b_j^*)^2 + (c_{ij} - c_j^*)^2 \right\} \right)^{\frac{1}{2}} \quad (13)$$

(i = 1,2,..., m).

The TOPSIS method for SVNNs consists of the following:

Let us assume that $A = \{\rho_1, \rho_2, \cdots, \rho_m\}$ is a set of alternatives and $G = \{\beta_1, \beta_2, \cdots, \beta_n\}$ is a set of criteria, the following steps will be carried out:

Step 1: Determine the weight of the experts.

For this, specialists evaluate according to the linguistic scale that appears in Table 3, and the calculations are made with their associated SVNN, let us call $A_t = (a_t, b_t, c_t)$ the SVNN corresponding to the t^{th} decision maker (t = 1, 2,…, k). The weight is calculated by the following formula:

$$\lambda_t = \frac{(a_t + c_t)}{\quad} \qquad (14)$$

$\lambda_t \geq 0$ and $\sum_{t=1}^{k} \lambda_t$.

Linguistic terms	**SVNSs**
Very important (VI)	(0.9, 0.1, 0.1)
Important (I)	(0.75,0.25,0.20)
Medium (M)	(0.50,0.50,0.50)
Unimportant (UI)	(0.35,0.75,0.80)
Very unimportant (VUI)	(0.10,0.90,0.90)

Table 3. Importance weight as linguistic variables.

Step 2: Create the neutrosophic decision matrix of aggregated SVNNs.

This matrix is defined as $D = \sum_{t=1}^{k} \lambda_t D^t$, where $d_{ij} = (u_{ij}, r_{ij}, v_{ij})$ and it is used to aggregate all the individual assessments according to the terms given in Table 4.

Linguistic terms	**SVNSs**
Extremely good (EG)/extremely high (EH)	(1,0,0)
Very very good (VVG)/very very high (VVH)	(0.9, 0.1, 0.1)
Very good (VG)/very high(VH)	(0.8,0.15,0.20)
Good (G)/high (H)	(0.70,0.25,0.30)
Medium good (MG)/medium high (MH)	(0.60,0.35,0.40)
Medium (M)/fair(F)	(0.50,0.50,0.50)
Medium bad (MB)/medium low(ML)	(0.40,0.65,0.60)
Bad (B)/low(L)	(0.30,0.75,0.70)
Very bad (VB)/very low (VL)	(0.20,0.85,0.80)
Very very bad (VVB)/very very low (VVL)	(0.10,0.90,0.90)
Extremely bad (EB)/extremely low (EL)	(0,1,1)

Table 4: Linguistic terms used to provide the assessments

d_{ij} is calculated as the aggregation of the evaluations given by each expert $\left(u_{ij}^t, r_{ij}^t, v_{ij}^t\right)$, using the weights λ_t of each expert based on Equation 12.

In this way a matrix $D = (d_{ij})_{ij}$, is obtained, where each d_{ij} is a SVNN (i = 1,2,.., m; j = 1,2,…, n).

Step 3: Determination of the Criteria Weights.

Suppose that the weight of each criterion is given by $W = (w_1, w_2, \ldots, w_n)$, where w_j denotes the relative importance of the criterion β_j, if $w_j^t = (a_j^t, b_j^t, c_j^t)$ is the evaluation of the criterion β_j by the t^{th} expert.

Then Equation 12 is used, to aggregate the w_j^ts with the weights λ_t.

Step 4: Construction of the neutrosophic decision matrix of the SVNWAO with respect to the criteria.

$D^* = D \otimes W$, where $d_{ij}^* = W_j \otimes d_{ij} = \left(a_{ij}, b_{ij}, c_{ij}\right)$

Step 5: Calculation of the ideal SVNN positive and negative solutions.

The criteria can be classified as cost or benefit type.

Let G_1 be the set of criteria type benefits and G_2 the criteria type cost. The ideal alternatives will be defined as

follows:

$$\rho^{+} = \left(a_{\rho^{+}w}(\beta_j), b_{\rho^{+}w}(\beta_j), c_{\rho^{+}w}(\beta_j)\right) \quad (15)$$

Denotes the positive ideal solution, corresponding to G_1.

$$\rho^{-} = \left(a_{\rho^{-}w}(\beta_j), b_{\rho^{-}w}(\beta_j), c_{\rho^{-}w}(\beta_j)\right) \quad (16)$$

Denotes the negative ideal solution, corresponding to G_2.

Where:

$$a_{\rho^{+}w}(\beta_j) = \begin{cases} \max_i a_{\rho_i w}(\beta_j), \text{if } j \in G_1 \\ \min_i a_{\rho_i w}(\beta_j), \text{if } j \in G_2 \end{cases}, b_{\rho^{+}w}(\beta_j) = \begin{cases} \max_i b_{\rho_i w}(\beta_j), \text{if } j \in G_1 \\ \min_i b_{\rho_i w}(\beta_j), \text{if } j \in G_2 \end{cases}, c_{\rho^{+}w}(\beta_j) = \begin{cases} \max_i c_{\rho_i w}(\beta_j), \text{if } j \in G_1 \\ \min_i c_{\rho_i w}(\beta_j), \text{if } j \in G_2 \end{cases}.$$

On the other hand, $a_{\rho^{-}w}(\beta_j) = \begin{cases} \min_i a_{\rho_i w}(\beta_j), \text{if } j \in G_1 \\ \max_i a_{\rho_i w}(\beta_j), \text{if } j \in G_2 \end{cases}, b_{\rho^{-}w}(\beta_j) = \begin{cases} \min_i b_{\rho_i w}(\beta_j), \text{if } j \in G_1 \\ \max_i b_{\rho_i w}(\beta_j), \text{if } j \in G_2 \end{cases}, c_{\rho^{-}w}(\beta_j) = \begin{cases} \min_i c_{\rho_i w}(\beta_j), \text{if } j \in G_1 \\ \max c_{\rho_i w}(\beta_j), \text{if } j \in G_2 \end{cases}.$

Paso 6: Calculation of distances to the positive and negative ideal SVNN solutions.

With the support of Equation 13, the following equations are calculated:

$$s_i^{+} = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^{+}\right)^2 + \left(b_{ij} - b_j^{+}\right)^2 + \left(c_{ij} - c_j^{+}\right)^2\right\}\right)^{\frac{1}{2}} \quad (17)$$

$$s_i^{-} = \left(\frac{1}{3}\sum_{j=1}^{n}\left\{\left(a_{ij} - a_j^{-}\right)^2 + \left(b_{ij} - b_j^{-}\right)^2 + \left(c_{ij} - c_j^{-}\right)^2\right\}\right)^{\frac{1}{2}} \quad (18)$$

Step 7: Calculation of the *Closeness Coefficient* (CC).

The CC of each alternative is calculated with respect to the positive and negative ideal solutions.

$$\tilde{\rho}_j = \frac{s^{+}}{s^{+} + s^{-}} \quad (19)$$

Where $0 \leq \tilde{\rho}_j \leq 1$.

Step 8: Determination of the order of the alternatives.

3 Methodology for evaluating the usability of the portal web

3.1 Methodology

The criteria that will be considered in this paper to measure the web portal usability follow the rules that a usable web must fulfill, these are:

C_1. **Quick Charge**: This aspect is related to the time the portal pages are loaded. Pages should load in an average time of 4 seconds. A long wait can cause the user to cancel the visit to the site.

C_2. **Simplicity**: The portal should be as simple as possible; it should not force users to learn different paths or schemes for navigation in different parts of the site. The overwhelming use of animations should be avoided.

C_3. **Researchable**: The actual text must be accessible to search engines. The presence of graphics and programming codes are not taken into account by search engines and should be avoided as much as possible.

C_4. **For the Majority**: Sites must be used in any browser and computer. That is why the technical compatibility of the portal with any platform is needed. It is recommended to use plain and simple HTML.

C_5. **Updating**: An outdated site loses credibility that is why it must be periodically updated.

Apart from these criteria we add another one that summarizes several aspects in a single non-technical one of the web portal, we refer to it as *Aesthetics*, and this is the following:

C_6: It is comprehensible, novel, understandable, intelligent, and attractive.

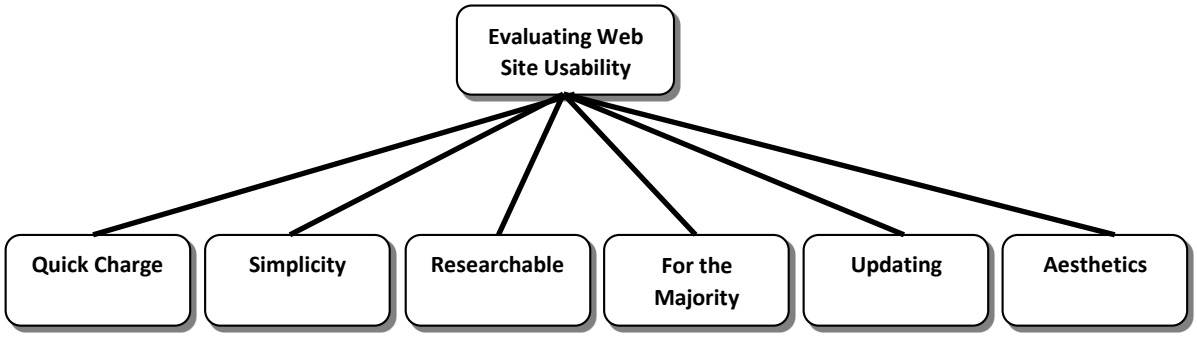

Figure 1: Hierarchical tree representing the criteria for evaluating web usability.

The algorithm that we propose to solve the problem of evaluating the usability of the web portal is the following:

1. The neutrosophic AHP technique is applied to the tree of Figure 1 to obtain the weights of criteria C_1, C_2, C_3, C_4, C_5, and C_6, which will be denoted by w_1, w_2, w_3, w_4, w_5, and w_6, respectively. To do this, one or more specialists must perform the evaluations.
2. Neutrosophic TOPSIS method with weights w_1, w_2, w_3, w_4, w_5, and w_6, is applied for each of the criteria. Evaluations can be carried out by advertising specialists, or experimentally with users' presence, or both of them.

2.2 The case 'JM' Company

To study the case of 'JM' Company, three specialists were hired who evaluated by consensus the preference by pairs of criteria C_1, C_2, C_3, C_4, C_5, and C_6 according to Table 1. The resulting matrix is given in Table 5.

Criterion	C_1	C_2	C_3	C_4	C_5	C_6
C_1	$\tilde{1}$	$\tilde{3}$	$\tilde{1}$	$\tilde{1}$	$\tilde{2}$	$1/\tilde{5}$
C_2	$1/\tilde{3}$	$\tilde{1}$	$1/\tilde{3}$	$\tilde{3}$	$1/\tilde{3}$	$1/\tilde{5}$
C_3	$\tilde{1}$	$\tilde{3}$	$\tilde{1}$	$\tilde{1}$	$\tilde{3}$	$1/\tilde{5}$
C_4	$\tilde{1}$	$1/\tilde{3}$	$\tilde{1}$	$\tilde{1}$	$\tilde{1}$	$1/\tilde{5}$
C_5	$1/\tilde{2}$	$\tilde{3}$	$1/\tilde{3}$	$\tilde{1}$	$\tilde{1}$	$1/\tilde{5}$
C_6	$\tilde{5}$	$\tilde{5}$	$\tilde{5}$	$\tilde{5}$	$\tilde{5}$	$\tilde{1}$

Table 5: The neutrosophic comparison matrix of usability criteria in 'JM' Company.

Table 6 contains the results of applying Formula 6 on the values of Table 5, to obtain crisps values.

Criterion	C_1	C_2	C_3	C_4	C_5	C_6
C_1	1	2.5312	1	1	1.7625	0.18713
C_2	0.39506	1	0.39506	2.5312	0.39506	0.18713
C_3	1	2.5312	1	1	2.5312	0.18713
C_4	1	0.39506	1	1	1	0.18713
C_5	0.56738	2.5312	0.39506	1	1	0.18713
C_6	5.3438	5.3438	5.3438	5.3438	5.3438	1

Table 6: Crisp values of the neutrosophic comparison matrix of usability criteria in 'JM' Company.

The matrix represented in Table 6 satisfies CR = 0.084139 <0.1, therefore the group evaluations are consistent. We used Octave 4.2.1 software for calculations, especially the *eig* function for eigenvalue calculation, see [18].

The obtained vector of weights is: $w = [0.120151, 0.083023, 0.130799, 0.084749, 0.090803, 0.490475\ ]$.

Next we apply the neutrosophic TOPSIS method to determine the evaluation of the Company 'JM' in each of the previous criteria.

Two alternatives of websites prototypes are considered to evaluating, they are:

A_1: The website must be mainly designed using texts with a privileged position in search engines.

A_2: The website must be designed with graphics, animations and videos that show the work of the company, which appears in an intermediate position in the search engines.

The alternative of designing a visually very attractive web portal with a privileged position in search engines could entail a high cost to the enterprise, thus, this alternative is not considered.

The three experts gave their opinion on each of the alternatives. It was considered they have a weight expressed in linguistic terms as Very Important (VI), then the numerical weights of each of them is the same and equal to 1/3.

Tables 7-12 contain the evaluations of the three experts for each of the criteria.

Quick Charge			
Alternative	**Expert 1**	**Expert 2**	**Expert 3**
$\mathbf{A_1}$	VVH	EH	VVH
$\mathbf{A_2}$	H	H	H

Table 7: The ratings of the alternatives for Quick Charge

Simplicity			
Alternative	**Expert 1**	**Expert 2**	**Expert 3**
$\mathbf{A_1}$	VH	VH	VVH
$\mathbf{A_2}$	F	MH	MH

Table 8: The ratings of the alternatives for Simplicity

Researchable			
Alternative	**Expert 1**	**Expert 2**	**Expert 3**
$\mathbf{A_1}$	VVH	VH	VH
$\mathbf{A_2}$	F	H	F

Table 9: The ratings of the alternatives for Researchable

For the Majority			
Alternative	**Expert 1**	**Expert 2**	**Expert 3**
$\mathbf{A_1}$	VH	VVH	VVH
$\mathbf{A_2}$	MH	MH	MH

Table 10: The ratings of the alternatives for For the Majority

Updating			
Alternative	**Expert 1**	**Expert 2**	**Expert 3**
$\mathbf{A_1}$	MH	MH	F
$\mathbf{A_2}$	VH	VH	VH

Table 11: The ratings of the alternatives for Updating

Aesthetics			
Alternative	**Expert 1**	**Expert 2**	**Expert 3**
$\mathbf{A_1}$	L	F	L
$\mathbf{A_2}$	VH	VVH	VH

Table 12: The ratings of the alternatives for Aesthetics

Table 13 contains the Aggregated SVN decision matrix.

	β_1	β_2	β_3	β_4	β_5	β_6
$\mathbf{A_1}$	<1 , 0, 0>	<0.84, 0.13, 0.16>	<0.84, 0.13, 0.16>	<0.87, 0.11, 0.13>	<0.57, 0.39,0.43>	<0.37, 0.66, 0.63>
$\mathbf{A_2}$	<0.7,0.25, 0.3>	<0.57, 0.39, 0.43>	<0.58, 0.40, 0.42>	<0.60, 0.30, 0.40>	<0.80, 0.15, 0.20>	<0.84, 0.13, 0.16>

Table 13: Aggregated SVN decision matrix**.**

Table 14 contains the Aggregated weighted SVN decision matrix.

	β_1	β_2	β_3	β_4	β_5	β_6
$\mathbf{A_1}$	<0.12, 0.00,	<0.07, 0.01, 0.01>	<0.11, 0.02, 0.02>	<0.07, 0.01, 0.01>	<0.05, 0.04, 0.04>	<0.18, 0.32, 0.31>

A_2	0.00> <0.08, 0.03, 0.04>	<0.05, 0.03, 0.04>	<0.08, 0.05, 0.05>	<0.05, 0.03, 0.03>	<0.07, 0.01, 0.02>	<0.41, 0.06, 0.08>

Table 14: Aggregated weighted SVN decision matrix.

Table 15 summarizes the SVN-PIS and SVN-NIS values, which are the positive ideal and negative ideal values.

	SVN-PIS	SVN-NIS
β_1	<0.12, 0.00, 0.00>	<0.08, 0.03, 0.04>
β_2	<0.07, 0.01, 0.01>	<0.05, 0.03, 0.04>
β_3	<0.11, 0.02, 0.02>	<0.08, 0.05, 0.05>
β_4	<0.07, 0.01, 0.01>	<0.05, 0.03, 0.03>
β_5	<0.07, 0.01, 0.02>	<0.05, 0.04, 0.04>
β_6	<0.41, 0.06, 0.08>	<0.18, 0.32, 0.31>

Table 15: SVN-PIS and SVN-NIS.

Table 16 contains the separation measures and the Closeness Coefficient of each alternative.

Alternative	**S^-**	**S^+**	**CC**	**Ranking**
A_1	0.056862	0.24159	0.80948	1
A_2	0.24159	0.056862	0.19052	2

Table 16: Separation measures and the Closeness Coefficient of each alternative.

Therefore, it is concluded that $A_1 \succ A_2$.

Conclusion

This paper was dedicated to evaluating two prototypes of websites for the company 'JM', an advertising company from the city of Quevedo in Ecuador, based on the usability of web portals. Currently, this company does not advertise its products online. There were three experts who evaluated the alternatives, the evaluation tools used were neutrosophic AHP and neutrosophic TOPSIS. This combination guarantees consistency by the use of AHP and the objectivity of the decision by the use of TOPSIS. The framework of neutrosophy allows greater accuracy in the decision, because uncertainty is taken into account in the decision-making process and also indeterminacy. It was concluded that the best option is: "Design a website mainly containing texts with a privileged position in search engines" over "Design a website with graphics, animations and videos that show the work of the company, which appears in an intermediate position in the search engines". It is recommended to use this methodology to evaluate usability of websites of similar companies. Future work will concentrate in extenddong the proposal with new ways of handle vagueness and uncertainty of the initial information [25-30].

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Delphi method for evaluating scientific research proposals in a neutrosophic environment

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Abstract. The scientific research proposal is part of the task to be carried out in academic and research institutions around the world. This is a complex decision-making problem, because decision-makers must determine the projects that are appropriate to the subjects addressed by the institution, those projects must be achievable within a reasonable deadline, they must have the financial means and the budget necessary to be carried out, the staff must be sufficiently qualified and an optimum number of personnel must be available to succeed the tasks and not interfere with other research projects. This is a predictive problem, thus, the proposed model is based on Delphi method for evaluating research projects and is supported by neutrosophy. Delphi method is widely applied in the prediction of future events, in this model we introduce the uncertainty and indeterminacy modeled with neutrosophy. As the best of our knowledge, this model is the first one, which applies a neutrosophic Delphi method in the evaluation of scientific research proposals. Finally, a hypothetical case study illustrates the applicability of the method.

Keywords: Research proposal, Delphi method, fuzzy Delphi method, single valued neutrosophic set, single valued triangular neutrosophic number.

1 Introduction

A research proposal is a document that proposes a research project, usually in science or academia, and that usually constitutes a request for sponsorship of such research, see [1-10]. The proposals are evaluated on the cost and potential impact of the research, and on the robustness of the proposed plan to carry it out. Generally, research proposals address several critical points, including the following:

- Which research questions will be addressed and how they will be addressed,
- How much time and expenses will be needed for research,
- What previous research has been done on the subject,
- How research results will be evaluated,
- How research will benefit the sponsoring organization and other parties.

Research proposals could be requested, which means that they are sent in response to a request with specific requirements, such as a request for proposals, or may be unsolicited, which means that they are sent without prior request. Other types of proposals include "pre-proposals", where a letter of intent or documentary summary is sent for review prior to the submission of a full proposal; follow-up proposals, which reiterate an original proposal and its funding requirements to ensure continued funding; and proposals for renewal, which seek the continued sponsorship of a project that would otherwise be terminated.

Academic research proposals are usually written as part of the initial requirements for writing a thesis, research work or dissertation. In general, they follow the same format as a research work, with an introduction, a review of literature, a discussion of the methodology and objectives of research, and a conclusion. This basic structure can vary between projects and between fields, each of which may have its own requirements.

The scientific method is a methodology for obtaining new knowledge, which has historically characterized science, consisting of systematic observation, measurement, experimentation, and the formulation, analysis and modification of hypotheses. Other characteristics of the scientific method are deduction, induction, abduction, prediction, falsifiability, the reproducibility and repeatability of the results, and the peer review. The rules and

principles of the scientific method seek to minimize the influence of the subjectivity of the scientist in his\her work, which reinforces the validity of the results, and therefore of the knowledge obtained.

The selection of the most appropriate research topic in the academic or the research institution is not a trivial problem, it needs of the assessment of the topic relevance in the near future, that is, it is a predictive problem. It is also complex, since the decision depends on different factors, some of them depend on the institution's researchers and others are external. This complexity of the problem requires of the experts' opinion on the subject, rather than measuring with objective indicators. The experts are those who can carry out the selection of the most promising projects, which give visibility to the institution and at the same time those projects must be achievable within a reasonable time. Other aspects to be considered are that researchers must have the capacity to attain the selected projects, that there exists the optimal number of scientific personnel working on the project, that the institution must have the necessary financial support to accomplish the research, and the project must be sufficiently relevant such that it can be published in high-impact scientific journals in a relatively short period of time or it results in patents, palpable economic and social results, among others.

Due to the problem complexity and the large number of variables to consider, the proposal selection contains elements of uncertainty and at the also experts could have doubts, ignorance, inconsistencies, among other elements.

This paper aims to propose a model for research proposals selection and evaluation. This model is based on the Delphi method, which is used in predicting future scenarios or events through expert assessment, see [11, 12]. Basically Delphi method is based on the intuitive idea that a group of experts will come to better conclusions than only one of them. The Delphi method consists of applying questionnaires to a group of experts, anonymously, and then each of them gives a response in a first round. The index of agreement between experts is then calculated using a central tendency statistical measure, and if the agreement is not sufficient, a second round is conducted for the experts to reconsider their assessments and so on until sufficient consensus is reached among them. One criticism of the method is that it can converge very slowly and therefore some experts may not continue to collaborate, nevertheless this is a widely used method.

Other authors have extended this method into uncertainty environments, for example fuzzy Delphi includes uncertainty and represents it in form of fuzzy sets, in particular fuzzy numbers are used, see [13-17]. Ishikawa et al. in [18] propose a fuzzy Delphi method where a survey is designed in such a way that a single round is sufficient to perform the calculations. In general, the fuzzy Delphi method has application in several real problems, see [13-17].

Other approaches are based on neutrosophy, which generalizes fuzzy sets, fuzzy intuitionist sets, among others. In the context of neutrosophy Delphi method takes into account the neutrality given by contradictions, ignorance, inconsistencies, among other ones, typical of decision-making. Some papers model fuzzy Delphi method into a neutrosophic framework, see [19, 20]. Abdel-Basset et al. use Delphi method combined with AHP, in a neutrosorphic environment, see [21].

The model proposed in this paper is based on the Delphi method, which helps to select a set of scientific research proposals in a neutrosophic environment. We have not found in the consulted literature the use of Delphi method applied in this topic in a neutrosophic environment. This neutrosophic Delphi method uses single value triangular neutrosophic number, see [22]. The method takes advantage of the possibility of evaluating research proposals in form of linguistic terms, in addition to considering the uncertainty and indeterminacy inherent to neutrosophy frameworks. It is a decision-making model because it allows the evaluation of project alternatives by criteria. In addition, we explicitly set out the minimum criteria that should be considered in conducting evaluations.

The paper consists of the following structure; after this introduction follows Section 2 which contains the concepts necessary to design the model, such as the basic concepts of neutrosophy, its aggregation operators, among others, as well as a brief explanation of the Delphi method. Section 3 describes the proposed model and provides an illustrative case study of the application of the model in a real-life problem. The paper finishes with the conclusions.

2 Basic concepts

This section discusses the concepts and methods to be used throughout this article. Section 2.1. contains a brief explanation of the classic Delphi method, whereas Section 2.2. contains the main concepts of neutrosophy, among them we can find, neutrosophic sets, single valued neutrosophic sets, single valued triangular neutrosophic numbers, aggregation operators for single valued triangular neutrosophic numbers, among other concepts of interest.

2.1 The Delphi method

The Delphi method is a structured communication technique, which is developed as an interactive systematic prediction method, based on a panel of experts, see [11, 12]. It aims to achieve a consensus based on discussion

among experts. It is a repetitive process, where its operation is based on the elaboration of a questionnaire to be answered by the experts. Once the information is received, another questionnaire based on the previous one is re-performed to be answered again.

Finally, the study will draw its conclusions from the statistical analysis of the obtained data.

The Delphi as a methodology of forecasting uses expert judgments in technology or social processes considering the responses to a questionnaire to examine the likely guidelines for the development of specific technologies, meta-types of technologies or different processes of social change. The summary of expert judgments (in the forms of quantitative assessments and written comments) are provided as feedback to the experts themselves as parts of a next round of questionnaire. Experts then reassess their views in the light of this information, and a group consensus tends to emerge. The Delphi technique is based on firm concepts to draw conclusions with supported arguments.

Delphi is based on:

- Anonymity of participants.
- Repeatability and controlled feedback.
- Group response in statistical form.

Before starting Delphi, a number of previous tasks are performed, such as:

- Define the context and time horizon in which the forecast on the subject under study is to be made.
- Select the panel of experts and get the commitment to collaboration. People who are elected should not only be very knowledgeable about the subject on which the study is being conducted, but should present a plurality in their approaches. This plurality should avoid the appearance of biases in the information available in the panel.
- Explain to experts what the method is. This is intended to get obtaining reliable forecasts, because the experts are going to know at all times what is the objective of each of the processes required by the methodology.

The core of Delphi technique is a series of questionnaires. The first questionnaire may include general questions. At each later stage, the questions become more specific because they are formed with the answers to the previous questionnaire.

The Delphi technique comprises at least three phases:

1. A questionnaire is sent to a group of experts.
2. A summary of the first phase is prepared.
3. A summary of the second phase is prepared.

Three phases are usually recommended, but more phases can be used, as in the safety management Delphi study.

The number of experts involved can range from just a few to more than 100, depending on the scope of the issue. A range of 15-30 is recommended for a focal issue. As long as experts participate, the costs as well as the coordination required for the technique will also be raised.

2.2 Basic concepts of neutrosophy

Neutrosophy is a branch of philosophy that studies the origin, nature and scope of neutralities, as well as their interactions with different ideological spectra. In mathematics and logic, the most important concept is the neutrosorphic set that generalizes the fuzzy sets of Zadeh and the fuzzy intuitionist sets of Atanassov, in the following these definitions are formally defined.

Definition 1: ([22]) The *Neutrosophic set* N is characterized by three membership functions, which are the truth-membership function T_A, indeterminacy-membership function I_A, and falsity-membership function F_A, where U is the Universe of Discourse and $\forall x \in U, TA(x), IA(x), FA(x) \subseteq]-0,1+[, and\ -0 \leq inf\ TA(x) + inf\ IA(x) + inf\ FA(x) \leq sup\ TA(x) + sup\ IA(x) + sup\ FA(x) \leq 3+$.

See that according to Definition 3, $T_A(x)$, $I_A(x)$, and $F_A(x)$ are real standard or non-standard subsets of $]-0,1+[$ $and\ hence, TA(x), IA(x)\ and\ FA(x)\ can\ be\ subintervals\ of\ [0,1]$.

Definition 2: ([22]) The *Single-Valued Neutrosophic Set* (SVNS) N over U is $A = \{< x;\ TA(x), IA(x), FA(x) > : x \in U\}, where\ TA: U \rightarrow [0,1], IA: U \rightarrow [0,1], and\ FA: U \rightarrow [0,1], 0 \leq TA(x) + IA(x) + FA(x) \leq 3$.

The *Single-Valued Neutrosophic number* (SVNN) is symbolized by $N = (t, i, f)$, such that $0 \leq t, i, f \leq 1$ and $0 \leq t + i + f \leq 3$.

Definition 3: ([22]) The *single-valued triangular neutrosophic number* $\tilde{a} = \langle (a_1, a_2. a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set on $\mathbb{R}$, whose truth, indeterminacy and falsity membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \le x \le a_2 \\ \alpha_{\tilde{a}}, & x = a_2 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_2 < x \le a_3 \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

$$I_{\tilde{a}}(x) = \begin{cases} \frac{\left(a_2 - x + \beta_{\tilde{a}}(x-a_1)\right)}{a_2-a_1}, & a_1 \le x \le a_2 \\ \beta_{\tilde{a}}, & x = a_2 \\ \frac{\left(x - a_2 + \beta_{\tilde{a}}(a_3-x)\right)}{a_3-a_2}, & a_2 < x \le a_3 \\ 1, & \text{otherwise} \end{cases} \quad (2)$$

$$F_{\tilde{a}}(x) = \begin{cases} \frac{\left(a_2 - x + \gamma_{\tilde{a}}(x-a_1)\right)}{a_2-a_1}, & a_1 \le x \le a_2 \\ \gamma_{\tilde{a}}, & x = a_2 \\ \frac{\left(x - a_2 + \gamma_{\tilde{a}}(a_3-x)\right)}{a_3-a_2}, & a_2 < x \le a_3 \\ 1, & \text{otherwise} \end{cases} \quad (3)$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0,1]$, $a_1, a_2, a_3 \in \mathbb{R}$ and $a_1 \le a_2 \le a_3$.

Definition 4: ([22]) Given $\tilde{a} = \langle (a_1, a_2, a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ and $\tilde{b} = \langle (b_1, b_2, b_3); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$ two single-valued triangular neutrosophic numbers and λ any non null number in the real line. Then, the following operations are defined:

19. Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$
20. Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_3, a_2 - b_2, a_3 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$
21. Inversion: $\tilde{a}^{-1} = \langle (a_3^{-1}, a_2^{-1}, a_1^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, where $a_1, a_2, a_3 \neq 0$.
22. Multiplication by a scalar number:
$$\lambda\tilde{a} = \begin{cases} \langle (\lambda a_1, \lambda a_2, \lambda a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda > 0 \\ \langle (\lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda < 0 \end{cases}$$
23. Division of two triangular neutrosophic numbers:
$$\frac{\tilde{a}}{\tilde{b}} = \begin{cases} \langle \left(\frac{a_1}{b_3}, \frac{a_2}{b_2}, \frac{a_3}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 > 0 \; and \; b_3 > 0 \\ \langle \left(\frac{a_3}{b_3}, \frac{a_2}{b_2}, \frac{a_1}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \; and \; b_3 > 0 \\ \langle \left(\frac{a_3}{b_1}, \frac{a_2}{b_2}, \frac{a_1}{b_3}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, a_3 < 0 \; and \; b_3 < 0 \end{cases}$$
24. Multiplication of two triangular neutrosophic numbers:
$$\tilde{a}\tilde{b} = \begin{cases} \langle (a_1 b_1, a_2 b_2, a_3 b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, & a_3 > 0 \; and \; b_3 > 0 \\ \langle (a_1 b_3, a_2 b_2, a_3 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, & a_3 < 0 \; and \; b_3 > 0 \\ \langle (a_3 b_3, a_2 b_2, a_1 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, & a_3 < 0 \; and \; b_3 < 0 \end{cases}$$

Where, $\wedge$ is a t-norm and $\vee$ is a t-conorm.

Let $\tilde{a} = \langle (a_1, a_2, a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$ be a single valued triangular neutrosophic number, then,

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \quad (4)$$

$$\mathbf{A}(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (5)$$

They are called the score and accuracy degrees of ã, respectively.

Let $\{\widetilde{A}_1, \widetilde{A}_2, \cdots, \widetilde{A}_n\}$ be a set of n SVTNNs, where $\widetilde{A}_j = \langle(a_j, b_j, c_j); \alpha_{\tilde{a}_j}, \beta_{\tilde{a}_j}, \gamma_{\tilde{a}_j}\rangle$ (j = 1, 2, …, n), then the *weighted mean of the SVTNNs* is calculated with the following Equation:

$$\widetilde{A} = \sum_{j=1}^{n} \lambda_j \widetilde{A}_j \quad (6)$$

Where λ_j is the weight of A_j, $\lambda_j \in [0, 1]$ and $\sum_{j=1}^{n} \lambda_j = 1$.

3 The Delphi model in the neutrosophic environment

This section is dedicated to describe the model proposed in this paper. Let us start with two tables, Tables 1 and 2. Table 1 contains the scale for measuring the weights of the criteria and Table 2 summarizes the scale of evaluations associated with the single-valued triangular neutrosophic numbers (SVNTN). We finish with a hypothetical case study.

3.1 The method

Linguistic terms	**SVTNN**
Extremely unimportant (EU)	⟨(0,0, 1); 0.00, 1.00, 1.00⟩
Not very important (NVI)	⟨(0, 1, 3); 0.17, 0.85, 0.83⟩
Not important (NI)	⟨(1, 3,5); 0.33, 0.75, 0.67⟩
Medium (M)	⟨(3, 5,7); 0.50, 0.50, 0.50⟩
Important (I)	⟨(5, 7,9); 0.67, 0.25, 0.33⟩
Very important (VI)	⟨(7, 9, 10); 0.83, 0.15, 0.17⟩
Extremely important (EI)	⟨(9, 10, 10); 1.00, 0.00, 0.00⟩

Table 1. Importance weight as linguistic variables and their associated SVTNN.

Linguistic term	**SVTNN**
Very low (VL)	⟨(0,0, 1); 0.00, 1.00, 1.00⟩
Medium low (ML)	⟨(0, 1, 3); 0.17, 0.85, 0.83⟩
Low (L)	⟨(1, 3,5); 0.33, 0.75, 0.67⟩
Medium(M)	⟨(3, 5,7); 0.50, 0.50, 0.50⟩
High (H)	⟨(5, 7,9); 0.67, 0.25, 0.33⟩
Medium high (MH)	⟨(7, 9, 10); 0.83, 0.15, 0.17⟩
Very high (VH)	⟨(9,10, 10); 0.00, 1.00, 1.00⟩

Table 2: Linguistic terms for evaluations associated with SVTNN.

Let us observe two important aspects, which are the following:

1. The scales shown in Tables 1 and 2 are inspired by the linguistic scales in [16]. SVTNNs are obtained by rescaling the original 0-1 scale to a 0-10 scale. The values $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}}$ are adapted from another scale appeared in [16].
2. The scale shown in Table 2 was linguistically taken in such a way, because the survey questions asked to experts will be done in the form of probability of events occurrence, which will be evaluated linguistically as Low, Medium low, etc.

Let us observe that the values obtained above are more accurate than fuzzy numbers, because they contain more elements; not only the belongingness, but also the non-belongingness and the indeterminacy.

The algorithm for evaluating research proposals that we offer is as follows:

1. Starts from a subject or group of subjects that are usually investigated in the institution.
2. Experts on the proposed subject or subjects are selected to evaluate the projects and at least one moderator. The experts will be denoted by E_1, E_2, …, E_n.
   Usually each academic or research institution has a group of specialists who are part of the scientific council that is where the scientific projects of the institution are discussed. This group of people could be used to carry out the evaluations, although external experts are also useful. Experts need not to be in touch with each other, so the moderator must design, implement and process the surveys.
3. The n experts are asked to propose projects that can serve as a research proposal on the basis of the topic identified in the previous point. Each of them proposes at least one, they are called p_1, p_2, …, p_m.
4. Experts could be asked to identify the criteria they consider for evaluating projects. However we suggest the following criteria:
   C_1: The project is a sufficiently relevant scientific contribution to the subject being investigated over a sufficiently long period of time.
   C_2: The project is scientifically achievable in a sufficiently short time.
   C_3: The institution has sufficient qualified staff to carry out the project.
   C_4: Sufficient personnel are available to conduct the investigation.
   C_5: There are the means and the budget necessary to carry out the research.
   C_6: The desired results will be obtained (publications in high-impact journals, patents, discussion of Master's or doctoral theses, solution of a real-life problem, etc.) in a reasonable time.
   C_7: The project serves as a basis or starting point for another project.
   C_8: The project gives scientific visibility, economic income, prestige, etc. to the institution.
   The survey can contain questions as follows:
   4.1. What do you think is the probability that project *P* will become a sufficiently relevant scientific contribution to the subject under investigation over a sufficiently long period of time?
   4.2. What do you think is the probability that project *P* will be scientifically achievable in a sufficiently short time?
   4.3. What do you think is the probability that the institution will have sufficiently qualified staff to carry out project *P*?
   4.4. What do you think is the probability that the institution will have sufficient available staff to carry out project *P*?
   4.5. What do you think is the probability that the institution will have the means and the budget to carry out project *P*?
   4.6. What do you think is the probability that the desired results of project *P* will be achieved in a reasonable time?
   4.7. What do you think is the probability that project *P* will serve as a basis for another project?
   4.8. What do you think is the probability that project *P* will provide scientific visibility, economic income, prestige, etc. to the institution?
   The answers will be given on the basis of the linguistic scale shown in Table 2.
   Each of the experts assesses the importance of each of the criteria. $\widetilde{w}_{ij}$ shall denote the linguistic value according to Table 1, which expert E_i associates with the criterion C_j (i = 1, 2,..., n; j = 1, 2, ..., 8). $w_{ij} = \boldsymbol{A}(\widetilde{w}_{ij})$ (i = 1, 2,..., n; j = 1, 2, ..., 8) is calculated using formula 5. Then they are normalized with respect to each expert, let us use the notation $W_{ij} = \frac{w_{ij}}{\sum_{i=1}^{n} w_{ij}}$.
5. Each expert E_i (i = 1, 2,..., n) evaluates each project p_k (k = 1, 2,..., m) with respect to criteria C_j (j = 1,2,..,8).
6. For each expert E_i (i = 1, 2,..., n), the evaluation of each project p_k (k = 1, 2,..., m) is obtained by aggregating their values by criterion using the W_{ij} weights in Formula 6. So we have an evaluation of each expert for each project. Let us denote by P_{ik} the evaluation of the k^{th} project by the i^{th} expert in form of the SVTNN associated with the linguistic term in Table 2.
7. It is calculated $\overline{P}_k = \frac{\sum_{i=1}^{n} P_{ik}}{n}$ which is the mean of the evaluation of each project for all experts.
8. The *Consensus Indexes* for each project p_k are calculated with formula $CI_k = \frac{\sum_{i=1}^{n} |\boldsymbol{A}(P_{ik}) - \boldsymbol{A}(\overline{P}_k))|}{n}$.
9. If $CI_k \leq 0.2$, see [16], then there exists sufficient expert consensus for all projects and go to Step 11, otherwise there is no consensus and go to point 10.

10. The moderator anonymously informs each of the experts about the results. He\she asks for explanations for each of them, including the weights assigned by them to the criteria and go to a next round. Emphasis is placed on those projects that reached a consensus index of $\mathrm{CI_k} > 0.2$, which reduces the algorithm complexity when concentrating recalculation only on those projects where there was not satisfactory consensus. Next go to point 5.
11. $\widetilde{\mathrm{P}}_k = \boldsymbol{A}(\overline{\mathrm{P}}_k)$ are calculated according to Equation 5. $\widetilde{\mathrm{P}}_k$ is ordered, where projects with higher values are preferred over those with lower values.
Finish.

3.2 Case Study of case: Comparative analysis

A research group of an academic institution has as its research topic artificial intelligence applied to digital image processing. The institution wishes to work on new projects on the subject so that they become doctoral theses of some members. Supervisors wish to determine which projects could be approved to obtain doctoral theses from a group of members within a maximum of five years. To this end, they decide to apply the method we propose in this article as follows:

1. They decided that the general theses themes should be "artificial intelligence applied to digital image processing".
2. They select one moderator within the institution. The moderator selects the panel of experts on the subject to carry out evaluations. Five experts were selected; let us denote them by E_1, E_2, E_3, E_4, E_5. None of them knows the identity of the others, which is why the moderator keeps in touch with each one via email. Any queries that experts have to make about the institution's data are directly asked to the moderator.
3. The moderator consults them to ask for proposed projects on the subject. These were four; let us call them p_1, p_2, p_3, p_4. This consultation process remains anonymous.
4. The moderator distributes the survey with the questions in Step 4 of the algorithm and asks them to evaluate the importance of each of the given criteria on the linguistic scale in Table 1.
The results were as follows as in Table 3 for linguistic evaluations and Table 4 for the crisp values of the normalized weights of evaluations in Table 3:

Criteria\Weight given by:	**E_1**	**E_2**	**E_3**	**E_4**	**E_5**
C_1	I	VI	I	M	I
C_2	VI	I	I	VI	I
C_3	VI	VI	M	I	VI
C_4	I	VI	I	I	VI
C_5	VI	I	VI	I	I
C_6	M	I	M	I	M
C_7	M	M	M	I	I
C_8	I	I	M	EI	I

Table 3: Importance given by experts to the criteria in form of linguistic terms.

Criteria\Weight given by:	**E_1**	**E_2**	**E_3**	**E_4**	**E_5**
C_1	0.122729	0.150978	0.145338	0.076947	0.121720
C_2	0.157475	0.117665	0.145338	0.152047	0.121720
C_3	0.157475	0.150978	0.094375	0.118498	0.156181
C_4	0.122729	0.150978	0.145338	0.118498	0.156181
C_5	0.157475	0.117665	0.186485	0.118498	0.121720
C_6	0.079694	0.117665	0.094375	0.118498	0.121720
C_7	0.079694	0.076406	0.094375	0.118498	0.121720
C_8	0.122729	0.117665	0.094375	0.178516	0.121720

Table 4: Importance given by experts to the criteria in form of normalized crisp values.

5. Each expert evaluates each project on the basis of the criteria. The results are given in Tables 5-9.

Criteria\Project:	**p_1**	**p_2**	**p_3**	**P_4**
C_1	H	M	L	H
C_2	M	M	VH	M

C_3	L	ML	H	L
C_4	L	VL	L	H
C_5	L	M	H	VL
C_6	M	ML	H	L
C_7	L	M	VH	L
C_8	L	ML	VH	VL

Table 5: Projects evaluated per criterion by Expert 1.

Criteria\Project:	p_1	p_2	p_3	P_4
C_1	VH	ML	M	MH
C_2	ML	H	H	H
C_3	L	L	MH	ML
C_4	M	ML	M	MH
C_5	L	H	MH	L
C_6	MH	L	H	VL
C_7	M	VL	H	VL
C_8	M	L	VH	L

Table 6: Projects evaluated per criterion by Expert 2

Criteria\Project:	p_1	p_2	p_3	P_4
C_1	M	VL	VL	VH
C_2	L	ML	M	H
C_3	M	L	M	M
C_4	VL	ML	ML	MH
C_5	M	H	MH	L
C_6	M	L	MH	VL
C_7	M	MH	H	VL
C_8	M	VL	H	L

Table 7: Projects evaluated per criterion by Expert 3.

Criteria\Project:	p_1	p_2	p_3	P_4
C_1	MH	MH	VL	MH
C_2	L	MH	H	MH
C_3	ML	L	MH	VL
C_4	ML	L	ML	MH
C_5	VL	ML	VH	L
C_6	VL	L	MH	VL
C_7	ML	H	H	ML
C_8	ML	L	MH	VL

Table 8: Projects evaluated per criterion by Expert 4.

Criteria\Project:	p_1	p_2	p_3	P_4
C_1	M	ML	ML	VH
C_2	H	H	H	VH
C_3	ML	L	VH	VL
C_4	ML	ML	M	M
C_5	VL	L	M	L
C_6	VL	L	MH	VL
C_7	VL	H	H	VL
C_8	L	VL	H	L

Table 9: Projects evaluated per criterion by Expert 5.

6. Table 10 contains the project evaluation by each expert after aggregating the set of projects, using the criteria weights of Table 4 in form of SVTNN.

Expert\Project	p_1	p_2	p_3	P_4
E_1	⟨(1.97,3.97, 5.97); 0.33, 0.75, 0.67⟩	⟨(1.55,2.95, 4.82); 0.00, 1.00, 1.00⟩	⟨(5.46,7.10, 8.38); 0.33, 0.75, 0.67⟩	⟨(2.02,3.46, 5.18); 0.00, 1.00, 1.00⟩
E_2	⟨(3.49,5.22, 6.80); 0.17, 0.85, 0.83⟩	⟨(1.56,3.11, 5.03); 0.00, 1.00, 1.00⟩	⟨(5.40,7.29, 8.78); 0.50, 0.50, 0.50⟩	⟨(2.94,4.40, 5.90); 0.00, 1.00, 1.00⟩
E_3	⟨(2.27,3.98, 5.84); 0.00, 1.00, 1.00⟩	⟨(1.78,3.01, 4.68); 0.00, 1.00, 1.00⟩	⟨(3.63,5.19, 6.77); 0.00, 1.00, 1.00⟩	⟨(3.62,5.09, 6.47); 0.00, 1.00, 1.00⟩
E_4	⟨(0.69,1.68, 3.37); 0.00, 1.00, 1.00⟩	⟨(2.73,4.61, 6.38); 0.17, 0.85, 0.83⟩	⟨(5.33,6.94, 8.21); 0.00, 1.00, 1.00⟩	⟨(2.55,3.60, 4.84); 0.00, 1.00, 1.00⟩
E_5	⟨(1.10,2.14, 3.82); 0.00, 1.00, 1.00⟩	⟨(1.57,3.05, 4.93); 0.00, 1.00, 1.00⟩	⟨(4.62,6.34, 7.95); 0.17, 0.85, 0.83⟩	⟨(2.90,3.95, 5.10); 0.00, 1.00, 1.00⟩

Table 10: Projects evaluated by Experts.

7. From Table 10 it is obtained $\overline{P}_1 = \langle(1.904, 3.398, 5.16); 0.00, 1.00, 1.00\rangle$, $\overline{P}_2 = \langle(1.838, 3.346, 5.168); 0.00, 1.00, 1.00\rangle$, $\overline{P}_3 = \langle(4.888, 6.572, 8.018); 0.00, 1.00, 1.00\rangle$, and $\overline{P}_4 = \langle(2.806, 4.100, 5.498); 0.00, 1.00, 1.00\rangle$. In addition we have $\widetilde{P}_1 = \boldsymbol{A}(\overline{P}_1) = 2.6155$, $\widetilde{P}_2 = \boldsymbol{A}(\overline{P}_2) = 2.5880$, $\widetilde{P}_3 = \boldsymbol{A}(\overline{P}_3) = 4.8695$, and $\widetilde{P}_4 = \boldsymbol{A}(\overline{P}_4) = 3.1010$.
8. Table 11 contains the crisp values by applying the accuracy function to the values in Table 10.

Expert\Project	p_1	p_2	p_3	P_4
E_1	3.3497	2.3300	5.8894	2.6650
E_2	4.1683	2.4250	6.7094	3.3100
E_3	3.0225	2.3675	3.8975	3.7950
E_4	1.4350	3.6872	5.1200	2.7475
E_5	1.7650	2.3875	5.0821	2.9875

Table 11: Projects evaluated by Experts in form of crisp values.

Therefore, the Consensus Indexes for the projects are the following:
$\mathrm{CI}_1 = 0.945$, $\mathrm{CI}_2 = 0.38824$, $\mathrm{CI}_3 = 0.85898$, and $\mathrm{CI}_4 = 0.36120$.

9. Let us observe, all of them are greater than 0.2, which means that another round is necessary. Thus, go to the next point.
10. The moderator informs the experts on the results and requests that each one reconsider the weights given to the criteria and evaluations. The process should be repeated in a second round. We must go to Step 5, but we will not repeat this for simplicity. See that if any of the projects had achieved $\mathrm{CI}_k \leq 0.2$ it would not be taken into account for the next round and calculations and effort would simplify. Experts should concentrate more on reaching agreement on projects 1 and 3.
11. We obtain $\widetilde{P}_1 = 2.6155$, $\widetilde{P}_2 = 2.5880$, $\widetilde{P}_3 = 4.8695$, and $\widetilde{P}_4 = 3.1010$.
Thus, so far we have $p_3 \succ p_4 \succ p_1 \succ p_2$ and project p_3 is the preferred. Nevertheless, the moderator has to repeat the round.

Conclusion

This paper was devoted to introduce a method of evaluation and selection of scientific research proposals in academic or research institutions. The model is basically a Delphi method in a neutrosorphic environment. This method supports the research project selection according to a group of experts' criteria. The Delphi method ensures that the opinion is agreed among the experts. The neutrosorphic framework offers the advantage of including not only uncertainty, but also indeterminacy in decision-making. Another advantage is that experts carry out evaluations with the help of linguistic scales, which makes the final results more veridical. In addition, the limitation of the classic Delphi method on slow convergence is attenuated, since with this model the projects that are reevaluated in the next round are only those where there was not sufficient consensus. To our knowledge, this is the first time that a model like this is designed which combines the Delphi method in a neutrosophic framework for the solution of this kind of problem. The paper provides the criteria to be followed for measurement, which does not mean that they are not modifiable. A hypothetical case study illustrates how to use the method and demonstrates its usefulness.

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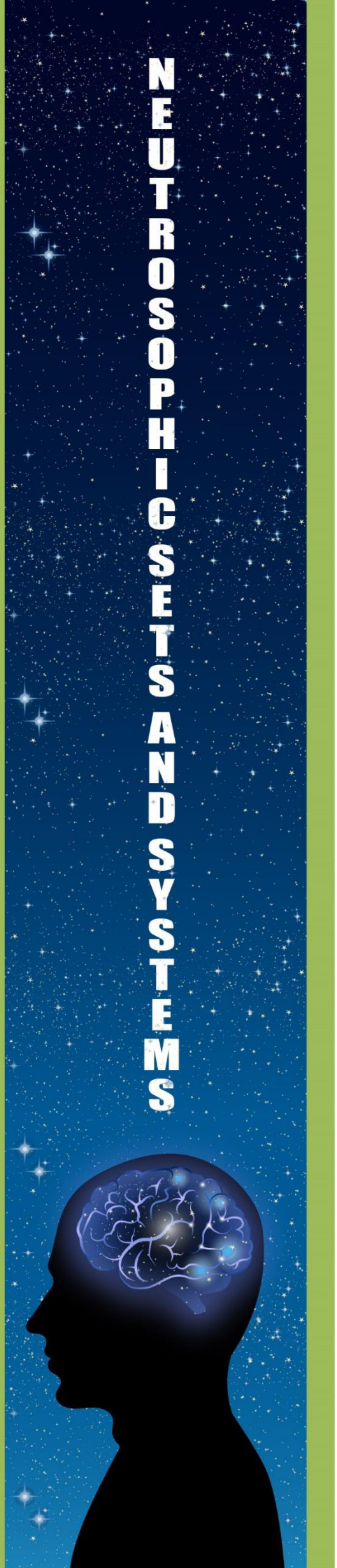

Information about the Journal

Neutrosophic as science supports the validation and resolution of research problems in the social and humanistic sciences. The present issue shows the use of this discipline in branches such as health, psychology, education, environmental management, sustainability, and the legal sciences. Solution based on a neutrosophic version of methods such as cognitive mapping, Iadov, Delphi, and analytic hierarchy process are shown. Moreover, new advanced for dealing with neutrality like neutrosophic personality model and neutrosophic statistics methods are included. These works reveal expertise and the search for solutions to different problems generated when uncertainty and indetermination arise in the social context

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