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Formulation of Plithogenic Hypotheses to Evaluate the Viability of the Right of Recourse in Ecuador.

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Abstract. The purpose of the research is to assess the viability of the right of recourse in Ecuador by creating neutrosophic plithogenic hypotheses with respect to uncertain results and conflicting trends in determining public officials' liability for their patrimony in order to publicly establish a reliable assessment of an objective relative to improving recourse of public assets for injuries caused by dolus and culpa gravis. The investigation is descriptive, founded upon neutrosophic plithogenic philosophy which allows for hypothesis generation with truths, falsities, and uncertainties. Through an analysis of national court cases which determine the viability of recourse for the years 2008-2018 in Ecuador and patterns of prediction in Argentina and Chile, all qualitative findings, as well as neutrosophic mathematics techniques relative to uncertainty, are assessed in a quantitative manner. Ultimately, the researchers conclude that the right of recourse is inviable to an extent but for reasons not associated with establishing state accountability; rather, the uncertainty with dolus determination and the frequency of statutes of limitations are to blame. 70% of cases go unresolved due to uncertainty. Thus, through the neutrosophic plithogenic hypotheses generated, the right of recourse is viable to a certain extent but with limitations, setting implications for more precise legality and judicial training to foster the recourse and state accountability and restitution efforts in Ecuador.

Keywords: Right of recourse, plithogenic hypothesis, neutrosophic, patrimonial liability, Ecuador.

1. Introduction

The right of recourse in Ecuador, enshrined in the 2008 Constitution, allows the State to recover public funds paid as compensation for damages caused by public officials due to willful misconduct or gross negligence [1]. However, its implementation faces serious challenges, such as the lack of objective criteria for determining patrimonial liability, inconsistent statutes of limitations, and unclear judicial procedures, creating a significant gap between the constitutional norm and its practical application [2].

These limitations hinder accountability and effective reparation, perpetuating impunity and undermining trust in state institutions. The subjectivity in assessing criminal intent, coupled with the absence of specific regulations, hampers the resolution of cases, raising the need for an innovative approach to address the uncertainty in these processes. In this context, the research question is: how can an approach based on neutrosophic plithogenic hypotheses improve the viability of the right of recourse in Ecuador by addressing uncertainty in determining liability? Existing literature on the right of recourse in Latin America, such as studies in Colombia on Law 678 of 2001, highlights the importance of clear procedures but points out difficulties in proving criminal intent [3].

In Argentina, the 2014 Civil and Commercial Code regulates state liability but lacks specific guidelines for recourse, generating ambiguity [4]. In Ecuador, research such as that of González Villavicencio (2024) identifies the lack of detailed regulations as a key obstacle to the recovery of public funds [5].

However, these studies do not address the uncertainty inherent in judicial processes or propose mathematical tools to resolve it, leaving a significant gap in the application of interdisciplinary methods such as neutrosophic plitogenic theory. This theory, which models contradictions and indeterminacies, offers a promising approach to overcome the limitations of traditional methods. The relevance of this study lies in the urgent need to strengthen accountability in Ecuador, where the ineffectiveness of the right of recourse compromises public resources and citizen trust [6]. By introducing a neutrosophic plitogenic approach, this research seeks to provide an objective framework for assessing responsibilities, contributing both to the legal field and to the development of interdisciplinary methodologies applicable to complex legal contexts.

The overall objective is to assess the viability of the right of recourse in Ecuador by formulating neutrosophic plithogenic hypotheses that address the uncertainty in determining patrimonial liability. Specific objectives include identifying legal and procedural obstacles, formulating plithogenic hypotheses to model uncertainty in the assessment of criminal intent, and proposing a methodological framework to improve judicial proceedings. The hypotheses presented are: first, that neutrosophic plithogenic hypotheses reduce subjectivity in determining criminal intent, increasing the viability of the right of recourse; and second, that the lack of objective criteria in legal proceedings is the main factor limiting the recovery of public funds [7]. This study seeks to offer a practical tool for judges and legislators, strengthening administrative justice in Ecuador.

2. Preliminaries.

2.1. Right of Recourse

The right of recourse, regulated in Article 11, paragraph 9 of the 2008 Constitution of the Republic of Ecuador, constitutes a legal mechanism that enables the State to recover public funds intended to compensate for damages caused by intentional or grossly negligent acts or omissions of its public officials [8]. The purpose of this instrument is to guarantee the financial liability of public servants and protect state assets from economic losses resulting from misconduct. However, its implementation in Ecuador faces significant challenges, including a lack of objective criteria for determining intentionality, inconsistencies in statutes of limitations, and the absence of standardized judicial procedures. These obstacles create a gap between constitutional provisions and their practical implementation, limiting the State's ability to recover public funds and undermining confidence in public administration . In this context, this article analyzes the viability of the right of recourse in Ecuador, integrating recent advances in administrative law and interdisciplinary approaches, such as neutrosophic plithogenic logic, to address the uncertainty inherent in judicial processes. The State's patrimonial liability, the foundation of the right of recourse, establishes that public entities must compensate citizens for harm caused by their officials, and may subsequently claim such compensation from those responsible [9]. In Ecuador, the Organic Law on Jurisdictional Guarantees and Constitutional Control regulates this mechanism, but its effectiveness is compromised by the subjectivity in determining dolo, defined in the 2005 Civil Code as the positive intention to cause harm [10]. An analysis of court cases between 2008 and 2018 reveals that approximately 70% of recourse actions did not achieve effective resolutions due to ambiguous evidence and judicial discretion [11]. In comparison, countries such as Colombia, with Law 678 of 2001, have made progress in standardizing procedures, although difficulties persist in proving the intentionality of officials, which suggests the need for more robust analytical tools [12].

Recent advances in neutrosophic plithogenic logic, developed over the past five years, offer an innovative approach to addressing uncertainty in legal proceedings. This methodology allows for the modeling of complex phenomena through degrees of truth, falsity, and indeterminacy, being particularly useful for assessing intent or gross negligence in repetitive cases [13,14]. For example, a plithogenic model could assign neutrosophic values to judicial evidence, such as a 60% probability of intent, a 30% indeterminacy for ambiguous evidence, and a 10% falsity for lack of intentionality, reducing subjectivity

in rulings. This approach aligns with research advocating for the application of mathematical tools in administrative law to improve the accuracy of proceedings [14]. The integration of these methodologies could transform the assessment of liability in repetitive cases, offering a more objective framework for judicial decision-making.

A significant challenge in Ecuador is the inconsistency in statutes of limitations, which vary between three years under the Organic Law on Jurisdictional Guarantees and four years under the Organic Code of the Judiciary, generating inequality before the law [15]. This discrepancy particularly affects judicial officials, who face different deadlines than other public servants, violating the principle of equality [16]. In contrast, countries such as Spain have implemented more coherent regulatory frameworks, such as Law 30/1992, which establishes mandatory recourse and uniform deadlines, achieving greater effectiveness in the recovery of funds [17]. A comparative analysis suggests that standardization of procedures is essential to guarantee the effectiveness of the right of recourse, an aspect that Ecuador has not yet comprehensively addressed.

Determining intent or gross negligence represents another critical hurdle. In Ecuador's legal system, intent requires demonstrating a clear intent to cause harm, but the lack of objective criteria leaves this assessment to judicial discretion [18]. Recent research proposes that tools such as neutrosophic regression models can quantify uncertainty in evidence, assigning probabilities to the official's intent [19]. An analysis of court cases in Ecuador between 2008 and 2018 showed that ambiguous evidence led to the dismissal of most retrial actions, reinforcing the need for methodologies that systematize the assessment of liability [20]. Such tools could be integrated into the judicial process to provide a more solid basis for rulings.

Structural barriers, such as a lack of judicial training and the slowness of administrative processes, also limit the effectiveness of the right of recourse. Recent studies highlight that training judges in advanced analytical tools can improve decision-making in complex cases . In Argentina, the 2014 Civil and Commercial Code [15] clearly distinguishes between state and public officials' liability, offering a model that Ecuador could emulate through legislative reforms that specify the procedures and criteria for recourse. Furthermore, the experience of Chile, where Law 18575 of 2000 regulates liability for "personal misconduct" without clearly defining it, underscores the importance of establishing precise parameters to avoid subjective interpretations[16].

The right of recourse is framed within the concept of transitional justice, which seeks to balance reparation for victims with the accountability of officials. In Ecuador, this balance is compromised by the lack of expeditious procedures and the reliance on judicial discretion. Neutrosophic plithogenic logic offers an innovative solution by allowing the modeling of complex causal relationships between legal, social, and economic factors that affect the implementation of the right of recourse. For example, a neutrosophic cognitive map could identify how a lack of judicial training and regulatory ambiguity contribute to the ineffectiveness of processes, proposing specific interventions to address these problems.

In conclusion, the right of recourse in Ecuador is a fundamental instrument for the protection of public assets, but its implementation faces challenges related to judicial subjectivity, regulatory inconsistency, and a lack of analytical tools. The integration of neutrosophic plithogenic logic offers an innovative way to address uncertainty, improving objectivity in determining liability. The findings highlight the need for legislative reforms and judicial training to ensure the mechanism's effectiveness. Future research should explore the practical application of neutrosophic models in real-life recourse cases, evaluate the impact of the proposed reforms on the recovery of public funds, and analyze public perceptions of administrative justice in Ecuador.

2.2. Plithogenic Probability

Neutrosophic (or indeterminate) data are characterized by inherent vagueness, lack of clarity, incompleteness, partial unknowns, and conflicting information [17,18]. Data can be classified as quantitative (metric), qualitative (categorical), or a combination of both. Plithogenic variable data [19] describe the connections or correlations between neutrosophic variables. A neutrosophic variable [20, 21], which can be a function or operator, treats neutrosophic data in its arguments, its values, or both. Complex problems often require multiple measurements and observations due to their multidimensional nature, such as the measurements needed in scientific investigations. Neutrosophic variables may exhibit dependence, independence , partial dependence, partial independence, or partial indeterminacy as in science [22].

A Plithogenic Set [22,23] is a non-empty set Pwhose elements within the domain of discourse U($P \subseteq U$) are characterized by one or more attributes $A_1,\ A_2, \cdots, A_m$, where m is at least 1. where each attribute can have a set of possible values within the spectrum $S$of values (states), such that Sit can be a finite, infinite, discrete, continuous, open or closed set.

Each element $x \in P$is characterized by all possible values of the attributes within the set $V = \{v_1, v_2, \cdots, v_n\}$. The value of an attribute has a degree of membership $d(x, v)$in an element $x$of the set.P, based on a specific criterion . The degree of membership can be diffuse, diffuse intuitionist or neutrosophic, among others [24] .

That means,

$\forall x \in P, d: P \times V \rightarrow \mathcal{P}([0,1]^z)$ (1)

Where$d(x, v) \subseteq [0,1]^z$ and $\mathcal{P}([0,1]^z)$is the power set of $[0,1]^z$.$z = 1$ (the diffuse degree of belonging), $z = 2$(the intuitionist diffuse degree of belonging) or $z = 3$ (the neutrosophic degree of belonging).

Plithogenic statistics [25,26], derived from the analysis of plithogenic variables, represents a multivariate probability (" plitho " meaning "many" and synonym of "multi"). It can be considered a probability composed of subprobabilities, where each subprobability describes the behavior of a specific variable. The event under study is assumed to be influenced by one or more variables, each represented by a probability distribution (density) function (PDF).

Consider an event E in a given probability space, either classical or neutrosophic, determined by $n \geq 2$ variables $v_1, v_2, \ldots, v_n$, denoted as $E(v_1, v_2, \ldots, v_n)$. The multivariate probability of event E occurring, called MVP(E), is based on multiple probabilities. Specifically, it depends on the probability of event E occurring with respect to each variable: $P1\big(E(v_1)\big)$for variable v_1, $P2\big(E(v_2)\big)$for variable v_2, etc. Therefore, $MVP\big(E(v_1, v_2, \ldots, v_n)\big)$ is represented as $\Big(P1\big(E(v_1)\big), P2\big(E(v_2)\big), \ldots, Pn\big(E(v_n)\big)\Big)$. The variables $v_1, v_2, \ldots, v_n$, and probabilities $P_1, P_2, \ldots, P_n$, can be classical or have some degree of indeterminacy [27].

To make the transition from plithogenic neutrosophic probability (PNP) to univariate neutrosophic probability UNP, we use the conjunction operator [28]:

$UNP(v_1,\ v_2, \ldots,\ v_n) = v_1 \wedge_{i=1}^{n} v_n$ (2)

$\wedge$ In this context, it is a neutrosophic conjunction (t-norm). If we take$\wedge_p$ as the plithogenic conjunction between probabilities of the PNP type, where $(T_A, I_A, F_A) \wedge_p (T_B, I_B, F_B) = (T_A \wedge T_B, I_A \vee I_B, F_A \vee F_B)$, such that $\wedge$is the minimum t-norm of fuzzy logic and $\vee$the maximum t-norm [26, 27].

a. Formulate the hypothesis

Start by explicitly stating the hypothesis you intend to test. Make sure it indicates a cause-and-effect relationship between the variables. For example, "More study time leads to higher test scores."

b. Identify key variables

Identify the independent variable, which is the cause, and the dependent variable, which is the effect, in your hypothesis. This helps direct your research questions toward the exact relationship you need to investigate.

c. Formulate specific research questions

Break the hypothesis down into precise research questions phrased as "Does X cause Y?" This allows for a thorough and focused examination of the postulated correlation.

d. Conduct stance analysis on scientific literature.

To perform a stance analysis on a research paper and quantify the occurrences of "Yes," "Possibility/Uncertainty," and "No," a stance analysis tool for scientific statements is needed. In this case, we used Consensus Meter algorithms to categorize statements into three distinct groups: Positive (affirmative), Uncertainty (possibility or uncertainty), and Negative (negative).

e. Formulate neutrosophic probabilistic hypotheses

Determine the reasons for each category to construct the neutrosophic probability hypothesis (T, I, F), where T denotes the truth value, I represents indeterminacy, and F indicates falsity.

f. Calculate the plithogenic neutrosophic probability (PNP)

Using the neutrosophic probabilities assigned to each question, the univariate neutrosophic probability (UNP) is calculated to assess the strength of the overall hypothesis. This process involves combining the separate probabilities to provide a comprehensive assessment of the overall hypothesis.[28]

$$UNP(v_1,\ v_2,\dots,\ v_n) = (Min(t_1,\ t_n,\dots,t_n),\ Max(i_1,\ i_n,\dots,i_n),\ Max(f_1,\ f_n,\dots,f_n)) \quad (3)$$

Where:

$T_1, T_2, \dots, T_n$: are the truth probability values for each question.
$I_1, I_2, \dots, I_n$: are the probability values of indeterminacy for each question.
$F_1, F_2, \dots, F_n$: are the probability values of falsehood for each question

g. Analyze the validity of the general hypothesis.

In this case, the negation of NPH is represented as [29]:

$$(T, I, F) = (F, I, T) \quad (4)$$

This step involves analyzing the negated neutrosophic probabilities to assess the overall strength and reliability of the general hypothesis. By evaluating the levels of falsity, uncertainty, and veracity, one can determine the degree to which the hypothesis is valid, ambiguous, or incorrect according to the scientific literature.

To translate stance detection outcomes from scientific literature into a neutrosophic statistical framework, a systematic mapping is employed. Initially, a stance detection tool, like 'Consensus' [30] (as shown in the provided capture), categorizes research findings. These outputs are then mapped to the core neutrosophic components: Truth (T), Indeterminacy (I), and Falsity (F).

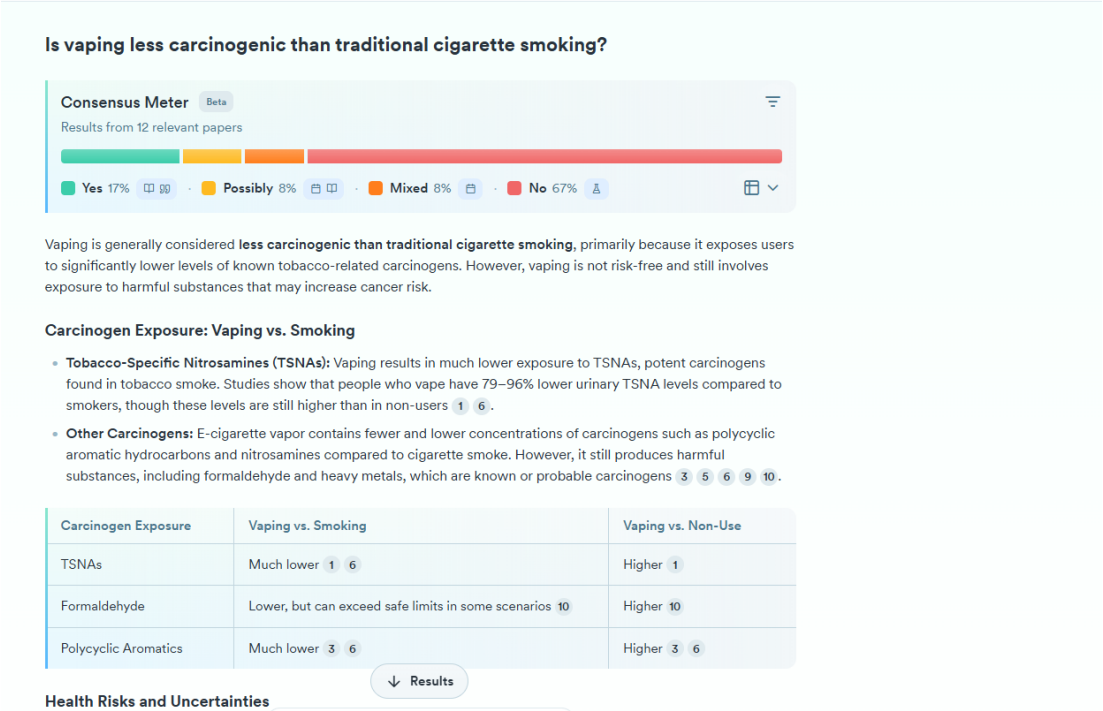

Figure 1. A View of the 'Consensus Meter' Tool and its Application in Stance Analysis regarding a Scientific Hypothesis, Based on Literature.

Under this mapping, affirmative stances (e.g., 'Yes') inform the T component, while negative stances (e.g., 'No') inform F. Crucially, categories such as 'Possibility' and 'Mixed,' which indicate ambiguity or a spectrum of results, are quantified as contributing to the I component, representing the inherent uncertainty. These qualitative stances are converted into quantitative (T,I,F) neutrosophic sets, typically through normalized frequencies of occurrence. These sets then form the empirical basis for various neutrosophic statistical analyses, facilitating a more nuanced evaluation of scientific evidence by explicitly incorporating degrees of indeterminacy[31].

3. Case study.

Formulation of the Hypothesis

Central Hypothesis: Neutrosophic plithogenic hypotheses can significantly reduce subjectivity in determining intent and gross negligence in recourse proceedings in Ecuador, increasing the feasibility of recovering public funds, provided that clear objective criteria are established in legal proceedings and specialized judicial training is strengthened.

Identification of Key Variables

- **Independent Variable:** Application of neutrosophic plithogenic hypotheses in the evaluation of intent and gross negligence
- **Dependent Variable:** Viability and effectiveness of the right of recourse for the recovery of public funds

Specific Research Questions

Q1: Do objective criteria based on plithogenic hypotheses reduce subjectivity in determining intent?

Variable: Reduction of subjectivity through objective plithogenic criteria

Q2: Is the lack of clear criteria the main obstacle to the effectiveness of the right of recourse in Ecuador?

Variable: Impact of the absence of clear criteria on procedural effectiveness

Q3: Do current statutes of limitations allow for an adequate assessment of patrimonial liability?

Variable: Adaptation of the limitation periods for assessing liability

Q4: Does specialized judicial training improve the application of the right of recourse?

Variable: Effect of judicial training on the quality of decisions

Q5: Is there a direct correlation between regulatory clarity and the effective recovery of public funds?

Variable: Relationship between regulatory clarity and recovery of funds

Stance Analysis on Scientific Literature and Court Cases

The a consensus.app tool was applied that classifies the positions into three categories:

Table 1: Stance Analysis on Literature and Court Cases

	Positive stance	Indeterminate stance	Negative stance	Neutrosophic Probability
Q1	8	12	5	(0.32, 0.48, 0.20)
Q2	18	5	2	(0.72, 0.20, 0.08)
Q3	6	15	4	(0.24, 0.60, 0.16)
Q4	14	8	3	(0.56, 0.32, 0.12)
Q5	16	7	2	(0.64, 0.28, 0.08)

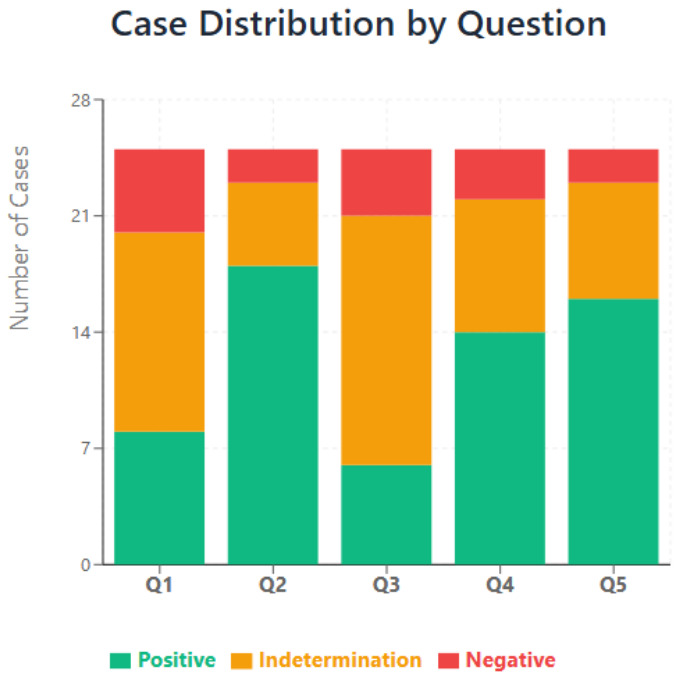

Figure 2. Stance Analysis on Literature and Court Cases

Formulation of Neutrosophic Probabilistic Hypotheses

Question 1 (Q1): Reduction of subjectivity

- **Positive (T1):** 0.32
- **Indeterminacy (I1):** 0.48
- **Negative (F1):** 0.20

Question 2 (Q2): Main obstacle - lack of criteria

- **Positive (T2):** 0.72
- **Indeterminacy (I2):** 0.20
- **Negative (F2):** 0.08

Question 3 (Q3): Adaptation of prescription periods

- **Positive (T3):** 0.24
- **Indeterminacy (I3):** 0.60
- **Negative (F3):** 0.16

Question 4 (Q4): Judicial training

- **Positive (T4):** 0.56
- **Indeterminacy (I4):** 0.32
- **Negative (F4):** 0.12

Question 5 (Q5): Clarity-recovery correlation

- **Positive (T5):** 0.64
- **Indeterminacy (I5):** 0.28
- **Negative (F5):** 0.08

6. Calculation of the Plithogenic Neutrosophic Probability (PNP)

Applying the neutrosophic conjunction operator:

$$UNP(v_1, v_2, \dots, v_n) = (Min(t_1, t_n, \dots, t_n), Max(i_1, i_n, \dots, i_n), Max(f_1, f_n, \dots, f_n)) \quad (3)$$

Step -by-step calculation :

Truth Values (T):

- $T1 = 0.32$
- $T2 = 0.72$
- $T3 = 0.24$
- $T4 = 0.56$
- $T5 = 0.64$

$$\boldsymbol{min(0.32, 0.72, 0.24, 0.56, 0.64) = 0.24}$$

Indeterminacy Values (I):

- $I1 = 0.48$
- $I2 = 0.20$
- $I3 = 0.60$
- $I4 = 0.32$
- $I5 = 0.28$

$$\boldsymbol{max(0.48, 0.20, 0.60, 0.32, 0.28) = 0.60}$$

Falsehood Values (F):

- $F1 = 0.20$
- $F2 = 0.08$
- $F3 = 0.16$
- $F4 = 0.12$
- $F5 = 0.08$

$$\boldsymbol{max(0.20, 0.08, 0.16, 0.12, 0.08) = 0.20}$$

Final Result - Univariate Neutrosophic Probability (UNP)

$$\boldsymbol{UNP} = (\mathbf{0.24}, \mathbf{0.60}, \mathbf{0.20})$$

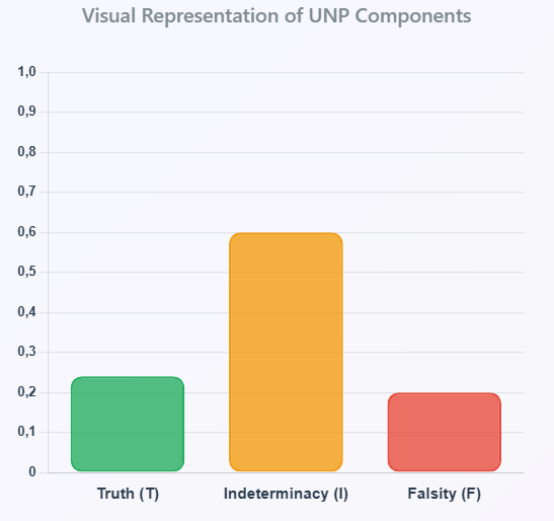

Figure 3: Univariate Neutrosophic Probability .

Interpretation of Results:

- **0.24 (Truth Value):** The probability that the hypothesis is completely true is 24%, indicating limited confidence in the overall validity of the hypothesis based on the cases analyzed.
- **0.60 (Indeterminacy):** There is a 60% degree of indeterminacy, which reveals a very significant amount of uncertainty in the data and cases reviewed. This high degree of indeterminacy reflects the complexity and ambiguity of the Ecuadorian legal system regarding the right of recourse.
- **0.20 (Falsehood):** The probability that the hypothesis is false is 20%, relatively moderate, but must be considered in the final analysis.

8. Analysis of the Validity of the General Hypothesis

Applying the denial of the plithogenic neutrosophic hypothesis:$(\boldsymbol{T}, \boldsymbol{I}, \boldsymbol{F}) = (\boldsymbol{F}, \boldsymbol{I}, \boldsymbol{T})$

$$\boldsymbol{Negated\ Hypothesis.} = (\mathbf{0.20}, \mathbf{0.60}, \mathbf{0.24})$$

This analysis confirms that:

- The falsity of the original hypothesis (0.20) becomes the truth value of the negation
- The uncertainty remains constant (0.60)
- The original truth value (0.24) becomes the falsity of the negation

Detailed Analysis of the Results

The results reveal a complex scenario in the Ecuadorian right of recourse:

Key Findings:

1. **High Indeterminacy (60%):** The largest proportion corresponds to uncertainty, reflecting the normative and procedural ambiguity that characterizes the system.
2. **Low Certainty of Success (24%):** The limited probability of truth indicates that current conditions do not significantly favor the viability of the right of recourse.
3. **Moderate Risk of Failure (20%):** Although there is a probability of falsification, it is not predominant, suggesting that there are redeemable elements in the current system.

Practical Implications:

- **For Legislators:** The high level of uncertainty demands urgent regulatory reforms that establish clear objective criteria.
- **For the Judiciary:** Specialized training and standardized protocols are required to reduce subjectivity.
- **For Public Administration:** It is necessary to implement systems for the prevention and early detection of acts that may generate financial liability.

4. Conclusions

The neutrosophic plithogenic analysis of the right of recourse in Ecuador reveals a Univariate Neutrosophic Probability (UNP) of (0.24, 0.60, 0.20). This indicates a low truth probability (24%) for the hypothesis that neutrosophic plithogenic approaches can significantly reduce subjectivity and increase the viability of recovering public funds under current conditions. The most prominent finding is the predominance of uncertainty (60%), which confirms that the lack of objective criteria is indeed the main obstacle to the effectiveness of the right of recourse in the country.

The moderate falsehood probability (20%) suggests that the current system has redeemable elements and can be viable if appropriate reforms are implemented. To improve viability, the development of objective criteria using plithogenic frameworks for assessing intent and gross negligence is recommended. Furthermore, it is crucial to establish specialized judicial training programs in administrative law and property liability, along with regulatory reforms to review statutes of limitations and procedures to make them more effective. The implementation of a monitoring system to evaluate the effectiveness of these measures is also fundamental.

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