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Plithogenic Hypothesis in Social Innovation: An Analysis of Its Evolution and Its Relationship with the Social Economy

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Abstract. The paper examines the connection between social innovation, social enterprises, and the social economy using the plithogenic hypothesis as a framework. The text highlights a significant deficiency in the existing body of research, specifically pointing out the lack of a unified approach that combines many views to thoroughly evaluate the influence of social innovation on economic growth. The study utilizes sophisticated analytical tools to investigate the interplay between these variables and their impact on the wider social economy. The results demonstrate that although there is a growing acknowledgment of the significance of social innovation and companies, the absence of precise definitions and techniques presents substantial obstacles. The paper provides a novel theoretical framework that integrates the plithogenic hypothesis into the analysis of the social economy. Additionally, it offers practical suggestions for improving policy formulation and strategy creation. The objective of this strategy is to maximize the beneficial effects of social innovation on economic and social development, by enhancing both theoretical understanding and practical implementation in the field.

Keywords: Social Innovation, Social Enterprises, Social Economy, Falsifiability of a Hypothesis, Multivalued Logics, Plitogenic Statistics.

1 Introduction

Social innovation and social enterprises have emerged as key components in contemporary economic and social development. These practices, which focus on solving social problems through innovative and sustainable approaches, are increasingly gaining recognition for their potential to generate positive impact in diverse communities. The relevance of studying the relationship between social innovation and the social economy lies in the need to understand how these initiatives can contribute to inclusive and equitable economic development [1]. The present research focuses on analyzing this relationship through the conceptual framework of the plithogenic hypothesis, a theory that promises to offer a novel and valuable perspective on these issues. Historically, social innovation and social enterprises have played an important role in shaping public policies and implementing economic development strategies. From the rise of cooperatives and solidarity economy movements in the 20th century, to the proliferation of social startups and B Corps today, these forms of organization have evolved significantly [2]. Despite this progress, the integration and impact of these initiatives in the social economy still present significant challenges and areas of opportunity for further research [3].

The central problem that this study addresses is the lack of a clear and systematic understanding of how social innovation and social enterprises interact with the social economy. Despite the growing interest in these issues, a fundamental question remains: how do these initiatives contribute to economic and social development sustainably? The research seeks to answer this question by exploring the relationship between these concepts through plithogenic analysis, which offers a comprehensive and dynamic perspective [4]. This study's main objective is to evaluate the influence of social innovation and social enterprises on the social economy using the plithogenic hypothesis approach. In particular, it aims to unravel how these elements contribute to inclusive economic development and what their impact is on the creation of social value [5]. In addition, it seeks to provide recommendations based on the findings to improve the integration of these practices in economic and social development strategies.

The methodological approach of the study includes the application of the plithogenic hypothesis to analyze empirical and theoretical data related to social innovation and social enterprises. Advanced analytical tools will be used to examine how these initiatives influence the social economy and to identify meaningful patterns and relationships in the collected data [6, 7, 8]. This study not only seeks to advance the theoretical understanding of the relationship between social innovation, social enterprises, and the social economy but also aims to offer practical contributions for the formulation of policies and development strategies [9, 10]. In summary, the article addresses a topic of great relevance in the current context, with the aim of filling a significant gap in the existing literature. Through detailed analysis of the relationship between social innovation, social enterprises and the social economy, it is hoped to provide a more complete and nuanced understanding of how these practices can contribute to sustainable and equitable economic development.

2 Preliminary

2.1. Plithogenic probability

Neutrosophic (or indeterminate) data are characterized by inherent vagueness, lack of clarity, incompleteness, partial unknowns, and contradictory information [11, 12]. Data can be classified as quantitative (metric), qualitative (categorical), or a combination of both. Plithogenic variable data [13, 14] can describe the connections between neutrosophic variables or other multivalued logic variables [15, 16]. Complex problems often demand multiple measurements and observations due to their multidimensional nature, such as measurements needed in scientific investigations. Neutrosophic variables can exhibit dependence, independence, partial dependence, partial independence or partial indeterminacy [17].

A Plithogenic Set [18] is a non-empty set P whose elements within the discourse domain $U(P \subseteq U)$ 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 or 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 found within the set $V = \{v_1, v_2, \cdots, v_n \}$. The value of an attribute has a degree of membership $d(x, v)$ to an element $x$of the set.P, based on specific criteria. The degree of membership can be fuzzy, fuzzy intuitionistic or neutrosophic, among others [19].

That means,

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

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

Plithogenic [20], derived from the analysis of plithogenic variables, represents a multidimensional probability (" plitho " meaning "many" and synonymous with "multi"). A probability composed of subprobabilities can be considered, 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 (density) distribution function (PDF).

Consider an event E in a given probability space, whether classical or neutrosophic, determined by $n \geq 2$ variables. $v_1, v_2, \dots, v_n$, denoted as $E(v_1, v_2, \dots, v_n)$. 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 concerning each variable: $P1\big(E(v_1)\big)$for variable v_1, $P2\big(E(v_2)\big)$for variable v_2, etc. Therefore, $MVP\big(E(v_1, v_2, \dots, v_n)\big)$it is represented as $\Big(P1\big(E(v_1)\big), P2\big(E(v_2)\big), \dots, Pn\big(E(v_n)\big)\Big)$. The variables $v_1, v_2, \dots, v_n$, and the probabilities $P_1, P_2, \dots, P_n$, can be classical or have some degree of indeterminacy [24].

To make the transition from plithogenic neutrosophic probability (PNP) to univariate neutrosophic probability UNP, we use the conjunction operator [21]:

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

$\wedge$ In this context, this 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 [20].

a. Multivalued Hypothesis

Smarandache [22] recently introduced the concept of Partial Falsifiability as an adaptation of Popper's Falsifiability from classical logic to multi-valued logic. This expanded the notion of falsifiability to include hypotheses that involve multiple values in logic. Falsifiability, a concept coined by the Austrian philosopher of science Karl Popper [23], states that for a theory to be considered scientific, it must be capable of being proven false.

Multi-valued logical hypotheses, such as those found in neutrosophic logic, accommodate partial degrees of truth, indeterminacy, and falsehood. In classical logic, the concept of falsifiability pertains to hypotheses that can be unambiguously categorized as either entirely true or entirely false.

Smarandache extension introduces the concept of Partial Falsifiability to multi-valued logic, enabling hypotheses to have partial truth values, uncertainties, and false values [22]. In the field of neutrosophic logic, a hypothesis $NLH(T,I,F)$ is deemed falsifiable if specific conditions are present that enable the hypothesis to be contradicted, leading to the expression $\neg NLH(F,1-I,T)$. Here, T, I, and F represent degrees of truth, indeterminacy, and falsity, respectively, all of which fall within the range of [0,1].

The probabilistic interpretation defines a neutrosophic probabilistic hypothesis [17], $NPH\ (T,I,T)$, with values for t, i, and f ranging from 0 to 1. These values represent probability, indeterminacy, and falsity, respectively. This approach provides a more thorough and detailed evaluation of the ability to prove false and the likelihood of hypotheses in complex scientific fields such as medical education and social science contexts.

The concept of multivalued logic was recently employed in conjunction with the Consensus artificial intelligence tool to analyze hypotheses [17]. This paper utilizes this framework to examine social innovation and social enterprises.

3 Material and Methods

This framework offers an organized method for testing hypotheses, starting with the explicit articulation of a testable hypothesis that explains the important variables' cause-and-effect relationship. Through the identification of these important variables, the research is focused on investigating certain relationships, such as the independent variables (causes) and dependent variables (effects). Next, the hypothesis is decomposed into specific research questions that explore the suggested association in detail. Consensus Meter techniques are utilized for sentiment categorization and quantification to improve the analysis even more. These algorithms classify scientific assertions into three categories: affirmative, indeterminate, and negative attitudes. Research findings synthesis and interpretation depend on this sentiment analysis designed for scientific material.

The framework then includes the development of probabilistic neutrosophic hypotheses, giving each category a value representing truth, indeterminacy, or untruth. The plithogenic neutrosophic probability (PNP), which assesses the hypothesis's robustness, is then computed by adding these values. Ultimately, these neutrosophic probabilities are analyzed to determine if the hypothesis is generally valid, ambiguous, or false based on the body of scientific research.

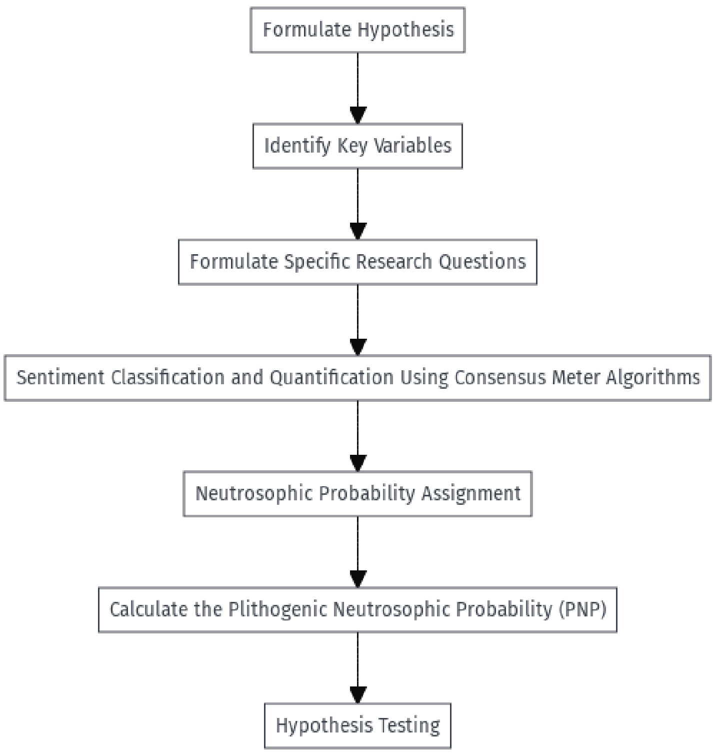

Figure 1. Hypothesis Formulation and Evaluation Process with Neutrosophic Analysis

a. Formulate hypothesis

Begin by explicitly stating the hypothesis intended to be examined. It has to indicate a cause-and-effect relationship between the variables. The hypothesis should be testable through empirical research. It should be possible to collect data that can support or refute the hypothesis.

b. Identify key variables

Identify the crucial variables associated with the hypothesis. These elements usually consist of independent variables (factors that can be manipulated or observed), dependent variables (outcomes that are measured), and any control or intervening 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 queries toward the exact relationship to investigate.

c. Formulate specific research questions

Turn each component or relationship into a research question formulated as "Does X cause Y?" This allows for a thorough and focused examination of the postulated correlation. Ensure that the research questions comprehensively address the entirety of the hypothesis. Collectively, they should enable a thorough examination of the hypothesis.

d. Sentiment Classification and Quantification Using Consensus Meter Algorithms

To perform sentiment analysis on a research paper and quantify the occurrences of "Yes," "Possibility/Indeterminacy," and "No," you need a sentiment analysis tool for scientific statements. In this case, we use Consensus Meter algorithms to categorize statements into three distinct groups: Positive (affirmative), Indeterminate (possibility or indeterminacy), and Negative (negative) [23].

The Consensus Meter differs from traditional sentiment analysis methods used in social media or product reviews. It is a specialized form of sentiment analysis designed specifically for scientific and factual content. The function of categorizing the sentiment or stance of scientific statements regarding a particular hypothesis or question is crucial in the process of synthesizing and interpreting research findings.

e. Neutrosophic probability assignment

In this process, a neutrosophic probability is assigned to each question based on the classification of papers into three stances: Positive, Indeterminate, and Negative, regarding a specific question

f. Calculate the plithogenic neutrosophic probability (PNP)

Using the neutrosophic probabilities assigned to each question, the univariate neutrosophic probability (UNP) is calculated to evaluate the robustness of the overall hypothesis. This process involves combining the separate probabilities to provide a comprehensive evaluation of the overall hypothesis.

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

Where:

$T_1, T_2, \dots, T_n$: are the truth probability values of each question.

$I_1, I_2, \dots, I_n$: are the values of the indeterminacy probabilities of each question.

$F_1, F_2, \dots, F_n$: are the falsehood probability values for each question

g. Hypothesis Testing

Analyze how the responses to these inquiries will collectively enable you to either validate, invalidate, or modify your initial hypothesis. In this case, the negation of NPH is represented as [17]:

$$(T, I, F) = (F, I, T) \tag{4}$$

This step involves analyzing the negated neutrosophic probabilities to evaluate the overall strength and reliability of the general hypothesis. By evaluating the levels of falsehood, uncertainty, and truthfulness, one can determine the degree to which the hypothesis is valid, ambiguous, or incorrect based on the scientific literature.

3.1. Case study.

Social innovation and social enterprises are fundamental components of the social economy. However, despite their growing relevance, they lack a universally accepted definition and a coherent methodological framework to evaluate their impact. This lack of clarity makes it difficult to measure their contribution to economic growth and questions whether these fields are well-researched academically. This study explores these questions by applying the proposed, addressing the uncertainty inherent in the relationship between social innovation, social economy, and corporate social responsibility (CSR).

Formulation of the Hypothesis

The central hypothesis of this study maintains that although social innovation and social enterprises are important components of the social economy, the lack of a coherent methodological framework and universally accepted definition hinders the accurate measurement of their impact on economic growth. However, when aligned with CSR strategies, they can improve the competitive advantage of the organizations involved.

Identification of Key Variables

- **Independent Variable**: Social innovation and social enterprises.
- **Dependent Variable**: Contribution to economic growth and competitive advantage.

Research Questions

1. **Q1**: Is social enterprise an important component of the social economy?
2. **Q2**: Is social innovation a well-researched academic field?
3. **Q3**: Can the impact of social innovation on economic growth be clearly measured in the studies reviewed?
4. **Q4**: Is there a universally accepted definition of social innovation?
5. **Q5**: Does corporate social responsibility improve competitive advantage?

The sentiment analysis applied to the scientific literature on the questions asked used a consensus tool that classifies positions into three categories: Positive, Indeterminate and Negative. The results are presented in Table 1 below.

Table 1. Sentiment Analysis

Questions \ Example of positions in articles	Positive	Indeterminacy	Negative	Neutrosophic probability
Q1	[27, 28, 29]			(1,0,0)
Q2	[30, 31]		[32]	(0.88, 0, 0.12)
Q3	[33, 34]		[35]	(0.83, 0, 0.17)
Q4	[36, 37]		[38, 39, 40]	(0.58, 0, 0.42)
Q5	[41, 42]	[43]		(0.94, 0.06, 0)

Univariate Neutrosophic Probability (UNP)

univariate neutrosophic probability (UNP) is calculated using the neutrosophic conjunction operator on the neutrosophic probabilities of each question.

$$UNP\ ((1,0,0),(0.88,0,0.12),(0.88,0,0.12),(0.83,0,0.17),(0.58,0,0.42),(0.94,0.06,0)) = (min\ (1,0.88,0.83,0.58,0.94),max\ (0,0,0,0,0.06),max\ (0,0.12,0.17,0.42,0))$$

The univariate neutrosophic probability (UNP) for the set of questions is:

$$UNP = (0.58, 0.06, 0.42)$$

Figure 1: The univariate neutrosophic probability (UNP).

The set of questions has a higher likelihood of being true (58%) compared to being false (42%).

There is a small degree of indeterminacy (6%), indicating some uncertainty or ambiguity in the evaluation of the questions.

This type of probability allows for a more flexible and comprehensive representation of uncertainty, especially in complex or vague situations where traditional binary logic might not be adequate.

Conclusion

The analysis has established that the univariate neutrosophic probability (UNP) for the research questions is (0.58, 0.06, 0.42). The result suggests a strong likelihood that the hypothesis is true, with a confidence level of 67% in its validity. In contrast, the values for indeterminacy and falsehood are 33% and 17%, respectively. These findings emphasize a strong understanding of the relationship between social innovation and the social economy, but the existence of significant uncertainty requires additional investigation.

The conclusions offer practical direction for developing policies and programs that utilize social innovation in the economic sphere. The high probability of truth indicates that tactics based on these discoveries are built on a solid foundation, while the observed uncertainty emphasizes the need for more conceptual refinement and methodological improvement in certain areas. Practitioners and politicians can apply these findings to create projects that maximize the advantages of social innovation while addressing the stated limits.

This study makes a substantial contribution to the research field of social innovation and the social economy. This study introduces the use of the plithogenic method to uncertainty management, providing a comprehensive analysis that can be used as a basis for future research. However, the study does have certain drawbacks, including the uncertainty in the responses, which could affect the applicability of the findings. To improve the accuracy of assessing the influence of social innovation on economic growth, it is essential to create stronger and more comprehensive frameworks and clarify concepts.

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