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Neutrosophic Statistics in the Analysis of the Causes of Tax Evasion

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Abstract. In Ecuador, taxes have become one of the main sources of public income after the fall in oil prices. That is why it is important to integrate tax policies and tax compliance with the taxpayer since it is considered essential in the State's development plans. On the other hand, the payment of taxes constitutes one of the main mechanisms to maintain and strengthen the government fiscal policy and, in some cases, the main source of economic resources that allow the State to conserve and improve the levels of public funds. Unfortunately, citizens have difficulty filing taxes, and that is due to the lack of tax culture. This paper is developed through a neutrosophic statistical analysis to determine the possible causes of non-compliance with tax obligations. Currently, the breach of formal duties continues to be part of the usual procedure of taxpayers for which it is necessary to analyze its causes. It is a process that involves indeterminacy; hence it will be better treated with a neutrosophic approach.

Keywords: public revenue, taxpayer, taxes, neutrosophic statistics.

1 Introduction

"Tax evasion is any elimination or reduction of a tax amount produced within the scope of a country, by those who are legally obliged to pay it and who achieve such result through fraudulent, omission or violation of legal provisions" [1]. Tax evasion is a fact that worries all countries of the world due to the effects it has produced [2]. It corresponds to commissive events of the taxpayer that contravenes and violates the fiscal norm and by which a taxable wealth is totally or partially subtracted from the payment of the tax provided by law [3].

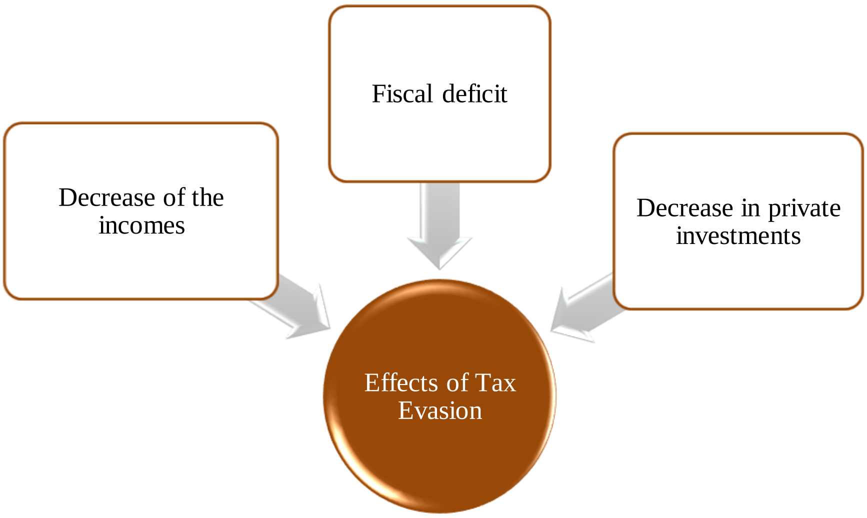

Figure 1. Effects of tax evasion.

Taxes are incomes that the State and other public sector entities receive from taxpayers in the form of taxes, fees, special contributions to finance public services, and the execution of programs that help sustain the country's welfare state [4]. These taxes generate greater strengthening of public services, which is why their collection is essential because this satisfies the basic needs of society.

To demonstrate the main causes and their impact on the development of the Ecuadorian economy, The Tax Administration has been directed with a coercive approach, but both theory and numerous studies have shown that it is important to consider the taxpayer's perception of the fairness of the tax system, as well as its morality [5].

[6] indicates that "tax evasion or fiscal evasion is an illegal act that consists of hiding assets or income to pay fewer taxes, and nowadays there are many ways used by taxpayers to evade taxes; in fact, some are very well elaborated, sophisticated, and others, on the other hand, surprise for their simplicity, for how simple and effective they are, but it is not easy to know them all.

Tax policy promotes redistribution and stimulates employment, the production of goods and services, and responsible ecological, social, and economic behaviors" [7]. For this reason, it is necessary to make theoretical contributions to support state policy. At present, it is important to generate a reference framework for tax education, since the commitment depends on it, in such a way that in the social structure it complies with each of the redistribution principles [8].

Ecuador needs to continue applying increasingly efficient tax policies, which discourage tax evasion, by taxpayers, through the implementation of different mechanisms of coercion, education and culturalization, since ignorance of tax obligations does not exempt the taxpayer from responsibilities [9-11].

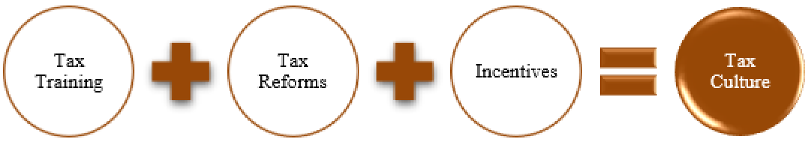

Figure 2. Support mechanisms to increase the tax culture.

The person who simulates, hides, omits, falsifies, or deceives in the determination of the tax obligation, to stop paying the taxes in whole or in part, will be punished with a custodial sentence of 1 to 10 years, depending on the type of tax fraud committed [12] and to detect the evader, the decision is left to the taxpayer as well as the probability of being detected and captured; the taxpayer intuits the control carried out by the collecting entity and the handling of incomplete and imperfect information to decide to fall into tax evasion [13].

Despite the efforts made by the Internal Revenue Service (IRS) to strengthen controls to reduce the level of evasion and to enhance the processes aimed at increasing collection, such objectives have not yet been achieved [13, 14].

There will always be tax evasion and the non-compliance with the tax payment means that the country stops moving forward to achieve the millennium goals such as: minimize extreme hunger and unemployment, achieve schooling for children, reduce infant mortality, improve the health of the dispossessed, fight disease and ensure the conservation of the environment [5, 15].

This study defines the problem situation as non-compliance with the tax payment for the analysis of tax evasion. From this, the main objective is to analyze the causes of tax evasion and the specific objectives are:

- Determine the causes that influence non-compliance with the tax payment
- Carry out the measurement and modeling of the variable
- Project viable alternatives based on the strategy

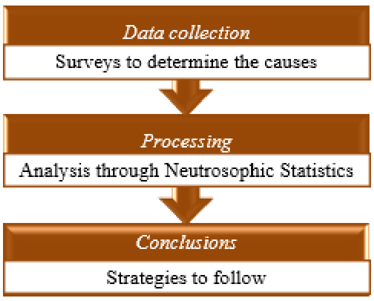

Figure 3. Development of the study of non-compliance with the tax payment.

2 Materials and methods

Whereas Classical Statistics deals with determinate data and determinate inference methods, Neutrosophic Statistics deals with indeterminate data. That is, data that has some degree of indeterminacy (unclear, vague, partially unknown, contradictory, incomplete, etc.), and from indeterminate inference methods that also contain degrees of indeterminacy (for example, instead of arguments and crisp values for probability distributions, graphs, diagrams, algorithms, functions, etc. inaccurate or ambiguous arguments and values may be present) [16-22].

Neutrosophic Statistics was founded by Prof. Dr. Florentin Smarandache [23], from the University of New Mexico, United States, in 1998, who developed it in 2014 by introducing the Neutrosophic Descriptive Statistics (NDS). Later, Prof. Dr. Muhammad Aslam from King Abdulaziz University, Saudi Arabia, founded in 2018 the Neutrosophic Inferential Statistics (NIS), the Neutrosophic Applied Statistics (NAS), and the Neutrosophic Statistical Quality Control (NSQC).

The Neutrosophic Statistics is also a generalization of the Interval Statistics, due, among other things, to the fact that while the Interval Statistics is based on the Interval Analysis, the Neutrosophic Statistics is based on the Analysis of Sets (understanding by such all set types, not just intervals).

If all the data and inference methods are determined, then the Neutrosophic Statistics coincide with Classical Statistics. As the world has more indeterminate data than determined, neutrosophic statistical procedures are more needed than classical ones.

Neutrosophic Numbers of form N = a + bI have been defined by WB Vasantha Kandasamy and F. Smarandache in 2003 [24], and were interpreted as "a" is the determinate part of the number N, and "bI" as the indeterminate part of the number N by F. Smarandache in 2014 [16]. Neutrosophic probabilities and statistics[25], are a generalization of classical and imprecise probabilities and statistics. The Neutrosophic Probability of an event E is the joint probability that event E occurs, the probability that event E does not occur, and the probability of not knowing whether event E occurs or not [26]. The function that models the neutrosophic probability of a random variable x is called the neutrosophic distribution:

$$NP(x) = (T(x), I(x), F(x)),$$

T (x) represents the probability that the value x occurs, F (x) the probability that the value x does not occur, and I (x) the indeterminate/unknown probability of the value x.

3 Results

Data collection

A Neutrosophic Frequency Distribution is a table showing absolute and relative frequencies, partial or total indeterminacies. Indeterminacies mainly occur due to imprecise, unknown or incomplete data related to absolute frequencies. The relative frequencies then become imprecise, incomplete or may even become unknown, an example of this is the following distribution of neutrosophic frequencies associated with the analysis of the causes of tax evasion.

Nr	Cause	Neutrosophic absolute frequency	Neutrosophic relative frequency
1	Unawareness	15	[0.179, 0.214]
2	Trust third parties.	[20,30]	[0.238, 0.429]
3	Lack of liquidity	25	[0.298, 0.357]
4	Loss of documentation	[10.14]	[0.119, 0.2]
		[70.84]	[0.833, 1.2]

Table 1. Causes of tax evasion.

As can be seen, for the cases of Unawareness and Lack of liquidity, the number of individuals who present this cause of non-payment of taxes is known precisely (15 and 25 times, respectively). However, it is not possible to specify the number of times that the causes have been observed to be Trusting third parties and Loss of documentation.

From the table, we can see that, for the case of 2, this has happened between 20 and 30 times, but the exact information is not available, the same for the figure of Loss of documentation. This indicates the existence of indeterminacies related to frequencies. The last column reveals the neutrosophic relative frequencies associated with each event.

As there is imprecise information, it is necessary to calculate the extremes (min and max) of the absolute or estimated frequencies.

$$min_{fn} = 15 + 20 + 25 + 10 = 70$$

$$max_{fn} = 15 + 30 + 25 + 24 = 84$$

Subsequently, to calculate the relative frequencies, the minimum and maximum values of these must be calculated for each of the results tabulated as individuals who report that cause of non-compliance. For this, the following formula will be applied:

$$min_{fnri} = \frac{min_{fni}}{max_{fn}}, \text{ and}$$

$$max_{fnri} = \frac{max_{fni}}{min_{fn}}$$

In the case of frequencies that do not present indeterminacy, it is true that:

$$min_{fni} = max_{fni} = fni$$

Therefore:

$$min_{fnr0} = \frac{min_{fn0}}{max_{fn}} = \frac{15}{84} = 0.179$$

$$max_{fnr0} = \frac{max_{fn0}}{min_{fn}} = \frac{15}{70} = 0.214$$

$$min_{fnr15} = \frac{min_{fn15}}{max_{fn}} = \frac{20}{84} = 0.238$$

$$max_{fnr15} = \frac{max_{fn15}}{min_{fn}} = \frac{30}{70} = 0.429$$

$$min_{fnr20} = \frac{min_{fn20}}{max_{fn}} = \frac{25}{84} = 0.298$$

$$max_{fnr20} = \frac{max_{fn15}}{min_{fn}} = \frac{25}{70} = 0.357$$

$$min_{fnr30} = \frac{min_{fn20}}{max_{fn}} = \frac{10}{84} = 0.119$$

and

$$max_{fnr30} = \frac{max_{fn15}}{min_{fn}} = \frac{14}{70} = 0.2$$

The value of the accumulated neutrosophic relative frequency was then obtained through the sum of the reported neutrosophic relative frequencies.

$$Frna = [0.179\,, 0.214] + [0.238\,, 0.429] + [0.298\,, 0.357] + [0.119\,, 0.2] = [0.833\,, 1.2]$$

Neutrosophic statistical analysis

To visually show the neutrosophic absolute frequencies, different types of graphs can be used, which must contain and differentiate the determined and the indeterminate part of the analyzed data.

The frequency of recording the causes of non-compliance can be represented by a column chart as shown in the figure.

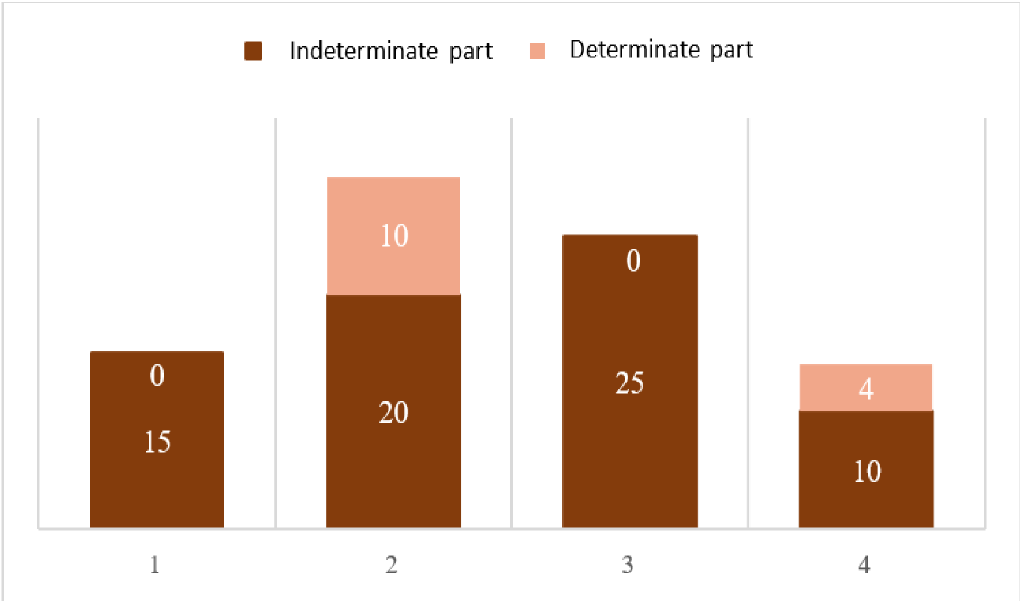

Figure 4. Neutrosophic column chart.

It can be seen that the frequencies related to causes 2 and 3 are indeterminate with indeterminacy values of 10 and 4, respectively.

Chapter conclusion

In this case, 15 specialists are selected from the neutrosophic sample and the possible causes of tax evasion are analyzed and modeled using a neutrosophic cognitive map. Indeterminacy is expressed with the question mark (?). The identified causes are:

Node	Cause
N1	Unawareness
N2	Trust third parties.
N3	Lack of liquidity
N4	Loss of Documentation

Table 2. Causes and nodes identified

"N0" represents on the map the causes of tax evasion

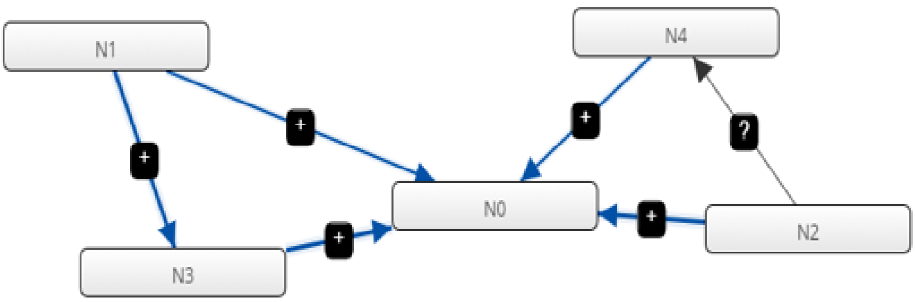

Figure 5. NCM graphic representation of the causes of non-payment.

	N0	N1	N2	N3	N4
N0	0	0	0	0	0
N1	0.75	0	0.25	0	0
N2	0.5	0	0	0	I
N3	0.75	0	0	0	0
N4	0.25	0	0	I	0

Table 3. Neutrosophic adjacency matrix

The nodes are subsequently classified. The following measures are used in the proposed model based on the absolute values of the adjacency matrix.

- Outdegree $od(v_i)$is the sum of the rows in the neutrosophic adjacency matrix. It reflects the strength of the relations (c_{ij}) salient of the variable.

$$od(v_i) = \sum_{i=1}^{N} c_{ij} \tag{1}$$

- Indegree is the sum of the columns that Reflects the Strength of the salient relations (c_{ij}) of the variable.

$$id(v_i) = \sum_{i=1}^{N} c_{ji} \tag{2}$$

- Total centrality (total degree), is the sum of the indegree and the outdegree of the variable.

$$td(v_i) = od(v_i) + id(v_i) \tag{3}$$

The measures of centralities are calculated. Outdegree and Indegree measurements are presented in Table 4.

Node	Outdegree	Indegree
N0	0	*2.25*
N1	1	*0*
N2	0.5 + I	*0.25*
N3	0.75	*0*
N4	0.25	*I*

Table 4. Centrality measures

The nodes are classified according to the following rules:

- **The Transmitting variables:** They have positive or indeterminate outdegree and zero indegree.
- **The receiving variables:** They have an indeterminate or positive indegree and zero outdegree.
- **The ordinary variables:** They have a degree of indegree and outdegree other than zero.

The nodes are classified below:

In this case, nodes P1, E1, and T2 are transmitters, S1 is a receiver, and T1 is ordinary.

	Transmitter	**Receiver**	**Ordinary**
N0		X	
N1	X		
N2			X
N3	X		
N4			X

Table 5. Classification of nodes

The total grade was calculated (Equation 5.3). The results are shown in Table 6.

	td
N0	2.25
N1	1
N2	0.75 + I
N3	0.75
N4	0.25 + I

Table 6. Total degree

Static analysis in NCM initially results in neutrosophic numbers of the form (a + bI), where I = indeterminacy). That is why a neutralization process is required, as proposed by Salmerón and Smarandache. I ∈ [0, 1] is replaced by its maximum and minimum values.

N0	*2.25*
N1	1
N2	[0.75, 1.75]
N3	0.75
N4	[0.25, 1.25]

Table 7. De-neutrosophication of centrality values

The total grade was calculated (Equation 5.4). Finally, we work with the average of the extreme values to obtain a single value:

$$\lambda([a_1, a_2]) = \frac{a_1 + a_2}{2} \tag{4}$$

Then,

$$A \succ B \Leftrightarrow \frac{a_1 + a_2}{2} > \frac{b_1 + b_2}{2} \tag{5}$$

The results are shown in Table 8.

	Td
N0	2.25
N1	1
N2	1.25
N3	0.75
N4	0.75

Table 8. Centrality using the mean of the extreme values

The order obtained is: $\mathbf{N_0} \succ \mathbf{N_2} \succ \mathbf{N_1} \succ \mathbf{N_3} \sim N_4$**.** where the nodes *Trusting on third parties* and *Unawareness* are the main factors.

Strategies to consider

The Tax Administration should minimize the adverse effects of trusting third parties and ignorance, such as the main nodes that activate the neutrosophic network in non-compliance with the tax payment. Therefore, the strategy to consider will be: the tax policy should be aimed at improving the perception that taxpayers have about the fulfillment of their tax obligations, through the expansion of the sanctioning part of the current tax legal framework, the increase in tax rates penalization for tax non-compliance, optimization of information systems and increase in educational campaigns, to make taxpayers understand that for the development of a country the commitment of all its citizens is necessary.

Conclusions

- The government and SRI should focus on improving the efficiency of the collection to eliminate the public deficit, implementing mechanisms from constant educational training, and implementing applications and web pages.
- The neutrosophic statistical analysis and the neutrosophic statistics can determine the possible causes and non-compliance with tax obligations. Currently, the breach of formal duties continues to be part of the usual procedure of taxpayers, which is why it is necessary to analyze using a tool that includes indeterminacy.
- After application in this case study, the model is found to be practical to use. The NCM provides great flexibility and considers the interdependencies of the analysis of the causes of tax evasion.

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