# Fusion of Expert Judgment using the Neutrosophic Delphi Method to Evaluate Tax Behavior

**Ingrid Joselyne D. Basurto[1], Carmen Marina M. Cabrita[2], Pico P. Ermerly Espinosa[3], Tonguc Cagin[4,*]**

[1] Universidad Regional Autónoma de los Andes Quevedo. Ecuador.
[2] Universidad Regional Autónoma de los Andes Tulcán. Ecuador.
[3] Universidad Regional Autónoma de los Andes Ambato. Ecuador.
[4] College of Business Administration, American University of the Middle East, 54200, Egaila, Kuwait
Emails: uq.ingriddiaz@uniandes.edu.ec; ut.carmenmmc56@uniandes.edu.ec; jurisprudencia@uniandes.edu.ec, tonguc.cagin@aum.edu.kw

**Abstract**

The tax behavior of taxpayers has gained increasing relevance in the economic and legal context of Ecuador. The tax system plays a fundamental role in the generation of income for the State and the financing of public policies. In this sense, understanding and evaluating how taxpayers comply with their tax obligations becomes crucial to guarantee equity and efficiency in tax collection. In this regard, the objective is to examine the various legal aspects that affect the compliance of tax obligations by taxpayers in the Babahoyo canton. The Neutrosophic Delphi method was used to model the study. As a result, it is seen that the tax authorities should promote educational campaigns in the canton for the knowledge and understanding of their citizens about the current regulations and thus strengthen the tax system for the benefit of the economic and social development of the country.

**Keywords:** Expert Judgment; Neutrosophic Delphi; Tax Behavior; Data Fusion

## 1. Introduction

Tax evasion and avoidance [1] pose formidable challenges to the Ecuadorian tax system, undermining the equity and efficiency of tax collection critical for the funding of public services and social welfare programs. Such malpractices not only compromise the financial integrity of the state but also exacerbate disparities within the society by diminishing resources meant for public welfare. Despite rigorous enforcement efforts and the implementation of various educational initiatives aimed at enhancing tax compliance, persistent issues like inadequate tax culture [2], prevalent informality, and a lack of transparency within the tax administration system continue to hinder progress.

The adoption of the neutrosophic Delphi [3] method in this study introduces a novel approach to addressing these complexities. By leveraging the principles of neutrosophy [4], which embrace the indeterminacy and variability of expert opinions, this method provides a robust framework for achieving consensus on effective strategies to combat tax evasion and avoidance. This analytical technique is particularly suited for the Ecuadorian context, where the dynamic interplay between legal norms, taxpayer behaviors, and administrative practices demands a flexible and nuanced analytical approach.

This research aims to conduct a comprehensive legal and behavioral analysis of tax compliance in the Canton of Babahoyo, utilizing neutrosophy to dissect the multifaceted challenges faced by the tax system. Through the neutrosophic Delphi method, it seeks to identify key determinants of tax non-compliance and propose actionable recommendations that foster a more equitable and efficient tax administration. By focusing on factors such as tax education, regulatory simplicity, and inter-institutional collaboration, the study endeavors to outline a path towards improved tax compliance and, ultimately, a stronger fiscal foundation for Ecuador.



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## 2. Preliminaries

### 2.1 Delphi Neutrosophic Method

The neutrosophic Delphi method is appropriate for obtaining information from experts based on sector knowledge, capacity, and ability to analyze the consulted items. Therefore, it is suitable in areas of knowledge that are "complex, dynamic, and indeterminate of the Neutrosophic Set (NS), characterized by the three membership functions." Moreover, its use is recommended in studies where there is indeterminacy in the information on previous empirical evidence [5].

In development, after the different rounds applied in a neutrosophic Delphi method, the responses of the panelists are analyzed based on Single-Valued Neutrosophic Numbers (SVNN) [6]. Thus, the objective of the neutrosophic Delphi method is to achieve the highest possible consensus among the involved panelists. The proposed phases define questions for obtaining criteria and consensual responses to be evaluated by the Coordinating Group.
The composition of the group presented in the panel of experts must ensure the necessary heterogeneity and significance to address the object of research of the study. For the final selection of experts by the coordination group, the neutrosophic expert competence coefficient (KN) is used, calculated from the following definition:
Definition 1[]. Let X be a universe of discourse. A Single Value Neutrosophic Set (SVNS) A over X is an object of the form as described in the following equation [13]:

$$A = \{\langle x, u_A(x), r_A(x), v_A(x)\rangle : x \in X\} \quad (1)$$

Where $u_A, r_A, v_A : X \to [0,1]$, satisfy 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 true, indeterminate, and false membership functions of x in A, respectively. So let it be expressed as A = (a, b, c), where a, b, c [0,1] and satisfies $0 \leq a + b + c \leq 3$ for the modeling of the method.
Let A = (a, b, c) be an SVNN, the scoring function S of an SVNN, based on the true membership degree, the indeterminate membership degree, and the false membership degree, is defined by the following Equation [8]:

$$S(K_N) = \frac{1 + a - 2b - c}{2} \quad (2)$$

Where $S(K_n) \in \{-1; 1\}$ and where when applying equation (1), we obtain:

$$K_N = \{\langle x, u_K(x), r_K(x), v_K(x)\rangle : x \in X\} \quad (3)$$

In this coefficient, two factors were averaged, the knowledge coefficient ($K_{cn}$) and the argumentation coefficient ($K_{an}$).

$$K_N = \frac{1}{2}(K_{aN} + K_{cN}) \quad (4)$$

Where S ($K_{an}$) and S ($K_{cn}$) $\in \{-1; 1\}$ and whereby applying equation (1), we obtain:

$$K_{aN} = \{\langle x, u_{Ka}(x), r_{Ka}(x), v_{Ka}(x)\rangle : x \in X\} \quad (5)$$
$$K_{cN} = \{\langle x, u_{Kc}(x), r_{Kn}(x), v_{Kn}(x)\rangle : x \in X\} \quad (6)$$

The so-called neutrosophic knowledge coefficient is determined by the information that the expert himself presents about the object of study, determined through a self-assessment process on a scale to establish knowledge of the topic analyzed and object of study (see Table 1) [9].

Table 1: Linguistic terms used to determine $K_{aN,}K$and evaluate the proposed criteria.

| **Linguistic term** | **SVNN** |
|---|---|
| Full knowledge of the study topic (FK) | (1,0,0) |
| Very very good at the study topic (VVGK) | (0.9, 0.1, 0.1) |
| Very good at the study topic (VGKS) | (0.8,0,15,0.20) |
| Good at the study topic (GK) | (0.70,0.25,0.30) |
| Moderately good at the study topic (MGK) | (0.60,0.35,0.40) |
| Knows the study topic (K) | (0.50,0.50,0.50) |
| Moderately poor knowledge of the study topic (MPK) | (0.40,0.65,0.60) |
| Poor knowledge of the study topic (PK) | (0.30,0.75,0.70) |



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| | |
|---|---|
| Very poor knowledge of the study topic (VPKS) | (0.20,0.85,0.80) |
| Very very poor knowledge of the study topic (VVPK) | (0.10,0.90,0.90) |
| No knowledge of the study topic (NK) | (0,1,1) |

For the evaluation and validation of questionnaires using the Delphi method, the scale (see Table 2) was used to achieve greater objectivity in information processing. This allows for the assessment of the criteria put forward by the judges of the expert panel for each item individually.
Through linguistic terms with Single-Valued Neutrosophic Numbers (SVNN) of consensus on the foundation of the expert's opinion, (see Table 2), criteria are evaluated using the neutrosophic argumentation coefficient.

Table 2: Linguistic terms used. Source: own elaboration.

| **Linguistic term I** | **SVNN** | **Linguistic term II** |
|---|---|---|
| Very Suitable (VS) | (0.92,0.1,0.12) | Indispensable (I) |
| Quite Suitable (QS) | (0.7,0.2,0.25) | Very Useful (VU) |
| Suitable (S) | (0.50,0.55,0.5) | Useful (U) |
| Slightly Suitable (SS) | (0.3,0.75,0.80) | Somewhat Useful (SU) |
| Not Suitable (NS) | (0.10,0.90,0.95) | Not Useful (NU) |

To determine the consensus among the participants of the expert panel, the concordance coefficient was used, determined through the expression [10]:

$$Cc = \left(1 - \frac{V_n}{V_t}\right) 100 \qquad (7)$$

where: $V_n$ is the number of negative votes provided by the judges and $V_t$ is the total number of votes cast by the judges. Therefore, a consensus level should be reached when the concordance coefficient Cc obtains a value higher than 75%, concluding the process. However, if the concordance coefficient does not reach a value higher than 75%, a new round of evaluation should be established to consider the timely assessments provided by the expert panel.

## 3. Results

To understand the opinion of the expert panel and try to reach some degree of consensus for the development of the Tax Administration and to avoid confrontation among them, a questionnaire is presented to them. This is to demonstrate the efficacy of the tax system for forecasting the impact on the local development of the canton of Babahoyo. Each expert must determine the validity of the key factors.

**Round 1**– Determination of the factors

The expert panel must analyze and determine which elements affect the efficacy of the tax system. Below, the application of the neutrosophic Delphi method to 5 proposed key factors is presented. Tables are used to record the experts' responses in each round.

Proposed key factors:
1. Tax incentives (F1)
2. Inter-institutional collaboration (F2)
3. Effective control and oversight (F3)
4. Tax education (F4)
5. Simplification and regulatory clarity (F5)

**Round 2**– Importance

Evaluate which factors are most important in tax evasion in the canton of Babahoyo.

It is necessary to determine the level of importance of each factor. Therefore, it is requested to evaluate it according to the scale (see Tables 3 and 4), to determine the cut-off points and scale of the neutrosophic indicators (see Tables 5 and 6).

The responses sent by the experts are consolidated and evaluated by the Analysis Group, considering each impact as a key factor in the processing of the method. From the processed results, the key factors for the study's focus are obtained.



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Table 3: Level of validation of the criteria. Source: own elaboration.

| Expert | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| **E1** | (0.92,0.1,0.12) | (0.7,0.2,0.25) | (0.92,0.1,0.12) | (0.3,0.75,0.80) | (0.92,0.1,0.12) |
| **E2** | (0.92,0.1,0.12) | (0.50,0.55,0.5) | (0.92,0.1,0.12) | (0.3,0.75,0.80) | (0.92,0.1,0.12) |
| **E3** | (0.92,0.1,0.12) | (0.50,0.55,0.5) | (0.92,0.1,0.12) | (0.3,0.75,0.80) | (0.92,0.1,0.12) |
| **E4** | (0.92,0.1,0.12) | (0.50,0.55,0.5) | (0.50,0.55,0.5) | (0.92,0.1,0.12) | (0.92,0.1,0.12) |
| **E5** | (0.10,0.90,0.95) | (0.92,0.1,0.12) | (0.50,0.55,0.5) | (0.3,0.75,0.80) | (0.10,0.90,0.95) |
| **E6** | (0.10,0.90,0.95) | (0.7,0.2,0.25) | (0.92,0.1,0.12) | (0.50,0.55,0.5) | (0.10,0.90,0.95) |
| **E7** | (0.92,0.1,0.12) | (0.10,0.90,0.95) | (0.7,0.2,0.25) | (0.50,0.55,0.5) | (0.92,0.1,0.12) |
| **E8** | (0.10,0.90,0.95) | (0.50,0.55,0.5) | (0.92,0.1,0.12) | (0.50,0.55,0.5) | (0.10,0.90,0.95) |
| **E9** | (0.7,0.2,0.25) | (0.3,0.75,0.80) | (0.50,0.55,0.5) | (0.3,0.75,0.80) | (0.7,0.2,0.25) |

Table 4: Relative frequency, neutrosophic cumulative probability. Source: own elaboration.

| Indicators | I | VU | U | SU | NU |
|---|---|---|---|---|---|
| **F1** | 0.2222 | 0.5556 | 0.5556 | 0.7778 | 1,0000 |
| **F2** | 0.3333 | 0.4444 | 0.6667 | 0.7778 | 1,0000 |
| **F3** | 0.0000 | 0.4444 | 0.4444 | 0.6667 | 1,0000 |
| **F4** | 0.2222 | 0.5556 | 0.7778 | 0.8889 | 1,0000 |
| **F5** | 0.2222 | 0.4444 | 0.7778 | 0.8889 | 1,0000 |

Table 5: Calculation of cut points. Source: own elaboration.

| Indicators | I | VU | U | SU | NU |
|---|---|---|---|---|---|
| **F1** | -0.76 | 0.14 | 0.14 | 0.76 | 3.50 |
| **F2** | -0.43 | -0.14 | 0.43 | 0.76 | 3.50 |
| **F3** | -3.50 | -0.14 | -0.14 | 0.43 | 3.50 |
| **F4** | -0.76 | 0.14 | 0.76 | 1.22 | 3.50 |
| **F5** | -0.76 | -0.14 | 0.76 | 1.22 | 3.50 |
| **Cut points** | **-2.09** | **-1.33** | **-1.07** | **-0.76** | **0.88** |

Table 6: Scale of neutrosophic indicators. Own elaboration.

| Indicators | Average | N - Avg. | SVNN |
|---|---|---|---|
| **F1** | 0.76 | **-1.63** | (0.7,0.2,0.25) |
| **F2** | 0.82 | **-1.69** | (0.7,0.2,0.25) |
| **F3** | 0.03 | **-0.90** | (0.3,0.75,0.80) |
| **F4** | 0.97 | **-1.84** | (0.7,0.2,0.25) |
| **F5** | 0.92 | **-1.79** | (0.7,0.2,0.25) |

From the responses obtained, it is found that tax education, simplification and regulatory clarity, and inter-institutional collaboration are the factors that most affect tax obligations.

**Round 3**- Acceptance

Do you think these 5 factors are useful for assessing the process of tax evasion?
If you do not find any of the parameters listed useful or convenient, please mark them with an (N).
Responses from the 9 experts are received (see Table 7). The expert was not asked to reject any criteria, nor to provide an explanation for their acceptance or not, only to indicate which they would not consider useful.

Table 7: Evaluated factors. Source: own elaboration.

| Expert | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| **E1** | | | | | |
| **E2** | | | | | |
| **E3** | | | | | |
| **E4** | | | NO | | |
| **E5** | | | | | |



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| | | | | | |
|---|---|---|---|---|---|
| **E6** | NO | | | | |
| **E7** | | | | | |
| **E8** | | | | | |
| **E9** | NO | | | | |
| **Coefficient** | **77.78** | **100** | **88.89** | **100** | **100** |

The majority accepted the general criteria issued by the other experts.
There was a majority agreement in the common opinion.
Experts E4, E6, and E9 each rejected one of the 5 criteria.
Factors F1, F3, and F5 obtained 100% concordance.
Therefore, consensus is considered to have been reached. The coordinating group considered this level of consensus achieved, thus concluding the process (see Table 8). Hence, there is consensus among the responses for the five factors analyzed.

From the results obtained from the experts, a consensus greater than $C \geq 75\%$ was achieved. From the responses obtained, a consensus was reached by the analysis group that synthesized the information on the influential causes of tax evasion, for which the experts argued the following in terms of recommendations:

1. Simplify tax procedures.
2. Promote tax education and knowledge of current regulations.
3. Implement digital technologies and improve coordination among tax authorities.
4. Encourage collaboration between institutions to enhance the detection and correction of tax irregularities.
5. Strengthen the legal and regulatory framework.

## 5. Conclusions

The use of the Neutrosophic Delphi method has proven to be a valuable tool in assessing tax behavior in the Babahoyo canton, Ecuador. The findings suggest that tax authorities could improve equity and efficiency in tax collection through the implementation of educational campaigns targeted at taxpayers. These campaigns would help increase knowledge and understanding of current tax regulations, which is essential for strengthening the tax system and, consequently, contributing to the country's economic and social development. The research underscores the importance of a solid legal and regulatory framework to support these initiatives, thus ensuring greater compliance with tax obligations and a fairer distribution of the tax burden. Furthermore, this study highlights the potential of applying neutrosophic approaches in tax behavior research, allowing for a deeper understanding of taxpayers' perceptions and attitudes towards tax compliance. By incorporating the uncertainty and indeterminacy inherent in expert opinions, the Neutrosophic Delphi method offers unique insights that could guide authorities in creating more effective and locally adapted fiscal policies. Ultimately, this approach promotes greater citizen participation and tax awareness that benefits both taxpayers and the comprehensive development of the country.

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