



Application of the Neutrosophic COPRAS Information Fusion Method to Assess the Impact of Retirement on Well-being and Family Cohesion

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Abstract

This study leverages the Neutrosophic COPRAS method to assess strategies for easing the transition into retirement, focusing specifically on the critical role of emotional and psychological support. By incorporating neutrosophic sets, the research captures the complexity and ambiguity inherent in human perceptions of retirement and its impact on family dynamics, especially within the socio-economic and cultural context of Ecuador. The Neutrosophic COPRAS method facilitates a nuanced analysis, enabling the evaluation of strategies under conditions of uncertainty and indeterminacy. Key findings highlight the necessity of implementing targeted support programs that directly address the emotional and psychological challenges associated with retirement. The study's innovative approach not only contributes to the understanding of retirement's effect on family dynamics but also showcases the Neutrosophic COPRAS method as a valuable tool for decision-making in complex scenarios. It calls for the development of policies and programs that are specifically designed to meet the unique needs of the Ecuadorian population, emphasizing the importance of cultural and socio-economic considerations in crafting interventions to promote healthy retirement adaptation and family cohesion.

Keywords: Neutrosophic COPRAS method; Information Fusion retirement; family dynamics, socio-economic factors.

1. Introduction

The transition into retirement marks a significant phase in an individual's life, encompassing profound shifts not only in their personal identity and daily routines but also in their relationships within the family unit. In Ecuador, as in many parts of the world, retirement is a period that can significantly impact the well-being and cohesion of families, prompting changes in roles, responsibilities, and the dynamics of intergenerational interaction[1,2]. Recognizing the complexity and depth of this life stage, the present research endeavors to delve into the multifaceted effects of retirement on family members and their interconnected relationships. This study adopts the innovative Neutrosophic COPRAS[3] method to systematically evaluate and identify strategies that effectively support a healthy adaptation to retirement, with a focus on strengthening the bonds that underpin the family structure.

Central to the discussion presented herein is the recognition of psychological and emotional support as pivotal strategies for facilitating a seamless transition into retirement. These strategies, coupled with the promotion of open communication and a culture of mutual support within family settings, are identified as essential components in navigating the challenges posed by retirement. Moreover, this investigation underscores the significance of considering the cultural and socioeconomic backdrop against which the retirement process unfolds for Ecuadorian families. It posits that tailored policies and targeted programs, sensitive to the nuanced needs of distinct retiree cohorts, are imperative for addressing the diverse implications of retirement across the societal spectrum[4,5].

By integrating these key insights, this article articulates a comprehensive approach necessary for grappling with the broad spectrum of issues associated with retirement in Ecuador. It argues for a holistic intervention strategy that addresses the emotional, psychological, cultural, and socioeconomic dimensions of retirement, aiming to facilitate a positive and enriching retirement experience for all involved. Through the application of the Neutrosophic COPRAS method, this study contributes significantly to our understanding of the retirement process and its implications for family dynamics, highlighting the critical need for supportive measures that cater to the varied realities of retirees and their families[6,7]. This nuanced understanding and targeted approach are essential for fostering positive adaptation to retirement, thereby enhancing family solidarity and improving the overall quality of life during this pivotal stage.

2. Methodology

Before analyzing the neutrosophic decision matrix of the method, it is necessary to define the neutrosophic set under analysis [8] [9]. The neutrosophic set is defined by the following elements: true (ϑ), indeterminate (η), and false (δ) of x in Q , respectively, and their images constitute either standard or non-standard subsets within the range $(0, 1)$. For X within the universe of discourse, the single-valued neutrosophic set Q over X is defined as an object in the representation $l = \{\langle x, \vartheta_A(x), \eta_A(x), \delta_A(x) \rangle : x \in X\}$.

Where $\vartheta_A(x)$, $\eta_A(x)$, $\delta_A(x)$ meet the following condition $0 \leq \vartheta_A(x) + \eta_A(x) + \delta_A(x) \leq 3$ for all $x \in X$. Thus, to define each neutrosophic number it is expressed in the form h, i, j for the modeling of the neutrosophic COPRAS method. Therefore, the following functions are defined:

$h = \vartheta_A(x)$ for true membership functions, where $\in \{0,1\}$.

$i = \eta_A(x)$ for indeterminate membership functions, where $\in \{0,1\}$.

$j = \delta_A(x)$ for false membership functions, where $\in \{0,1\}$.

Therefore, the neutrosophic number defined for the study is determined as $l = (h, i, j)$, where $h, i, j \in \{0,1\}$ and meets the following condition $0 \leq h + i + j \leq 3$. Thus, it is defined as the score function B of a neutrosophic number according to the proposal by Smarandache or Basset.

A. COPRAS Neutrosophic Method.

COPRAS stands for "Complex Proportional Assessment of Systems" and is a mathematical method used in multi-criteria decision-making, where different criteria are combined and weights are assigned to classify and rank alternatives [10]. It is used to evaluate and select options in complex situations where multiple factors and criteria must be taken into account. To determine decision elements within neutrosophic sets, the Neutrosophic COPRAS method is preferred, which allows for the evaluation and selection of options in uncertain and more complex situations. Thus, it not only evaluates which alternative is the best but also visualizes the relationship and dependence with other alternatives and how they affect the environment of the study analyzed.

The modeling of the Neutrosophic COPRAS method involves the following mathematical methodology:

- I. Define the criteria and alternatives: Identify the relevant criteria and the alternatives that are to be evaluated and compared.
- II. Assign weights to the criteria: Determine the relative weights of each criterion to reflect their importance in the decision-making process (Table 1).

Table 1: Neutrosophic linguistic terms used to assess the criteria. Source: own elaboration.

Linguistic scale	SVNN (h, i, j)	Performance index
Very Important (VI)	(0.91,0.25,0.13)	High
Important (I)	(0.7,0.45,0.17)	Satisfying
Medium (M)	(0.5,0.55,0.45)	Optimum
Not Important (NI)	(0.31,0.8,0.75)	Low
Very Not Important (VNI)	(0.11,0.95,0.93)	Very low

III. Evaluation of alternatives: The alternatives are evaluated for each criterion and a score is assigned (see Table 2).

Table 2: Linguistic terms used to determine and evaluate the proposed alternatives. Source: own elaboration.

Linguistic term	SVNN
Extremely Good (EG)	(1,0,0)
Very Very Good (VVG)	(0.95,0.12,0.17)
Very Good (VG)	(0.85,0.22,0.27)
Good (G)	(0.75,0.32,0.37)
Moderately Good (MG)	(0.65,0.42,0.47)
Medium (M)	(0.55,0.52,0.57)
Moderately Bad (MB)	(0.45,0.62,0.67)
Bad (B)	(0.35,0.72,0.77)
Very Bad (VB)	(0.25,0.82,0.87)
Very Very Bad (VVB)	(0.15,0.92,0.97)
Extremely Bad (EB)	(0,0.98,1)

- IV. Normalization of scores: Scores are normalized to ensure that all alternatives are comparable.
- V. Calculation of the association rules matrix: The association rules matrix is used to combine the normalized scores and the weights of the criteria to calculate a final score for each alternative.
- VI. Ranking of the alternatives: Alternatives are ranked based on their final score to determine the best option.

The Neutrosophic COPRAS method selects the best decision alternatives by considering the ideal and worst-ideal solutions [11], in a step-by-step classification and evaluation of the alternatives in terms of their importance, indeterminacy, dependence, and degree of utility [12]. The algorithm of the Neutrosophic COPRAS method consists of the following steps:

Step 1: Calculation of the normalized decision matrix l_{ij}^* , using Equation (1).

$$l_{ij}^* = \frac{l_{ij}}{\sum_{i=1}^m l_{ij}} \tag{1}$$

Step 2: Determine the weighted neutrosophic normalized decision matrix D_{hij} , according to Equation (2).

$$D_{hij} = x_{hij}^* \cdot w_{hj} = \begin{bmatrix} w_{h1} l_{11} & w_{h2} l_{12} & \dots & w_{hn} l_{1n} \\ w_{h1} l_{21} & w_{h2} l_{22} & \dots & w_{hn} l_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ w_{h1} l_{m1} & w_{h2} l_{m2} & \dots & w_{hn} l_{mn} \end{bmatrix} \tag{2}$$

Where l_{ij}^* is the value of the normalized neutrosophic performance of i_{th} alternatives in j_{th} criteria and w_{hj} is the weight associated with the j_{th} criteria.

Step 3: The sums S_{i+} and S_{i-} of the weighted normalized values are calculated for both the beneficial (B) and non-beneficial (NB) criteria respectively. These sums S_{i+} and S_{i-} are calculated using Equations (3) and (4) respectively.

$$S_{i+} = \sum_{k=1}^k D_{hij} \quad (3)$$

$$S_{i-} = \sum_{k=1}^k D_{hij} \quad (4)$$

Step 4: Determine the relative importance of the alternatives Q_i using Equation (5).

$$Q_i = S_i + \frac{\sum_{j=1}^m S_{i-}}{S_{i-} \sum_{j=1}^m \frac{1}{S_{i-}}} \quad (5)$$

The relative importance Q_i of an alternative shows the degree of satisfaction achieved by this alternative.

Step 5: Calculation of the performance index P_i of each alternative, using Equation (6):

$$P_i = \frac{Q_i}{Q_{max}} \cdot 100 \quad (6)$$

Where Q_{max} is the maximum value of relative importance. The performance index value P_{hi} is used to obtain a complete ranking of the candidate alternatives. In summary, the COPRAS Neutrosophic method allows combining different criteria and weights to evaluate and select alternatives in complex multi-criteria decision-making situations in environments of indeterminacy.

3. Case Study

Retirement is a process that not only affects the retired individual but also has significant repercussions within the family context. Below are the cultural and socioeconomic factors that influence retirement and its effect on family dynamics:

- Intergenerational care culture: In Ecuador, there is a strong culture of intergenerational care, where older adults are often respected and valued as an essential part of the family. When a family member retires, they are expected to contribute to the care and support of their children and grandchildren. This cultural expectation can generate additional pressure for the retiree, who might feel responsible for maintaining an active role in supporting the family, even after retirement.
- Rhythms and life timings: The Ecuadorian culture may be marked by more traditional rhythms and life timings, where retirement is seen as a stage of rest and reflection. However, this can conflict with the current socioeconomic reality, where many retirees face economic difficulties and need to return to work or seek new forms of income. This discrepancy between cultural expectations and reality can create tensions within the family.
- Family support and solidarity networks: The family plays a fundamental role in the emotional and financial support of its members in Ecuador. During retirement, the lack of a solid social security system can lead to relatives assuming a greater support role for the retiree. This can affect family dynamics if there are economic limitations to providing such support, generating stress and conflicts within the family.
- Gender perspectives: In Ecuadorian culture, traditional gender roles still prevail in many cases. The retirement of a male family member might be perceived differently from the retirement of a woman, and this can influence the distribution of roles and responsibilities within the family after retirement. Cultural expectations about gender roles can influence how family members perceive and deal with retirement.
- Access to economic resources: Socioeconomic factors play an important role in the retirement experience. Access to economic resources, such as pensions, savings, and social

security, can determine the retiree's degree of financial independence and, therefore, its impact on family dynamics. Those with limited resources may depend more on family support, affecting the dynamics of family relationships.

- Financial education: The lack of financial education can negatively affect retirement planning and the management of available resources. Insufficient financial preparation for retirement can generate uncertainty and concern in the retiree and their family, affecting the emotional and financial stability of the household.
- Expectations of well-being and quality of life: Expectations of well-being and quality of life during retirement can vary according to cultural and socioeconomic factors. Some retirees may have realistic and adjusted expectations, while others may face emotional challenges when facing a reality different from what was expected. These differences can influence how the family copes with and adapts its dynamics to retirement.

Cultural and socioeconomic factors play a significant role in the impact of retirement on family dynamics in Ecuador. Cultural expectations, family support, financial situation, and gender perspectives are some of the aspects that influence how family members face and experience retirement. It is crucial to consider these factors when designing support strategies for retirees and their families, in order to promote a healthy adaptation to this stage of life and strengthen family bonds in the context of retirement. Additionally, strategies should be proposed that promote a healthy adaptation to retirement and strengthen family ties at this stage of life (see Table 3).

Table 3: Support strategies for retirees and their families in Ecuador. Source: Own elaboration.

Code	Strategies
S1	Orientation and education programs on retirement: Implement orientation and education programs aimed at both future retirees and their relatives. These programs should address emotional, financial, and social aspects related to retirement. Provide information on how to financially plan for retirement, how to maintain an active and healthy life, and how to deal with changes in family dynamics. These programs can be offered by governmental institutions, non-governmental organizations, and companies.
S2	Promote dialogue and open communication: Encourage open and honest communication among family members about retirement and its implications. Facilitate dialogue spaces where concerns and expectations about this stage of life can be expressed. Effective communication helps to understand and address the concerns of each family member and will strengthen emotional bonds.
S3	Emotional and psychological support: Establish emotional and psychological support services aimed at retirees and their families. Retirement can be a stage of emotional adjustment and loss of roles, and having trained professionals to provide support can help retirees face changes with greater emotional well-being. Support and containment spaces should also be offered for families, where they can express their concerns and share experiences.
S4	Promotion of intergenerational activities: Encourage participation in intergenerational activities that involve older adults and other family members, including children and youth. These activities can include cultural, sporting, or volunteering events. Interaction between generations promotes mutual understanding, strengthens family bonds, and provides opportunities to share experiences and knowledge.
S5	Creation of social support networks: Promote the creation of social support networks for retirees and their families. These networks can be formed by communities, groups of friends, or retiree associations, where solidarity and the exchange of resources and information are encouraged. Support networks can provide a sense of belonging and accompaniment during the retirement transition.

These strategies aim to address both the individual and family aspects of retirement in Ecuador. By promoting a healthy adaptation to this stage of life, family bonds are strengthened, and a conducive environment for the well-being and satisfaction of retirees and their loved ones is created. These strategies must be implemented in a coordinated manner among governmental institutions, civil society organizations, and the private sector, so they can have a significant impact on Ecuadorian

society. Additionally, their effectiveness should be constantly evaluated, and adjustments made according to the changing needs and realities of retirees and their families. However, to further develop the study, it is necessary to enhance the most significant strategy to prioritize among the proposals. To determine which strategy has the highest priority over the others, it is required to model the provided information using the Neutrosophic COPRAS method by using the criteria for its evaluation (see Tables 4 to 7).

Table 4: Evaluation Criteria. Source: Own elaboration.

Code	Criterion	Weight (w_{hj})
C1	Impact on the well-being of the retiree and their family: It is evaluated how each strategy contributes to the physical, emotional, and economic well-being of both the retiree and their family. Those strategies that have a more significant positive impact will be better evaluated.	(0.7,0.45,0.17)
C2	Feasibility and sustainability: The feasibility of implementing each strategy is analyzed by considering aspects such as the necessary resources, the availability of institutional support, and the possibility of maintaining the strategy over the long term.	(0.31,0.8,0.75)
C3	Participation and acceptance: The degree of acceptance and expected participation by retirees and their families for each strategy is evaluated. Those with greater backing will be considered a priority.	(0.5,0.55,0.45)
C4	Intergenerational impact: How each strategy promotes interaction and support among generations is analyzed, by strengthening family bonds and generating long-term benefits for all ages.	(0.31,0.8,0.75)
C5	Degree of coverage and accessibility: It considers how broad the coverage of each strategy is and whether it is accessible to most retirees and their families in different regions of the country.	(0.31,0.8,0.75)
C6	Effectiveness and measurable results: The effectiveness of each strategy is evaluated and whether its results can be measured to verify the achievement of the proposed objectives.	(0.11,0.95,0.93)

Table 5: Evaluation Matrix. Source: own elaboration.

Alt.	C1	C2	C3	C4	C5	C6
S1	80	90	70	85	100	100
S2	95	60	85	95	80	70
S3	100	100	85	100	100	90
S4	80	90	75	88	87	95
S5	60	80	80	75	70	86
Total	415	420	395	443	437	441

Table 6: Calculation of the normalized neutrosophic decision matrix x_{hij}^* , according to Equation (1).

Source: Own elaboration.

Alt.	C1	C2	C3	C4	C5	C6
S1	(0.75,0.32,0.37)	(0.85,0.22,0.27)	(0.65,0.42,0.47)	(0.75,0.32,0.37)	(1,0,0)	(1,0,0)
S2	(0.85,0.22,0.27)	(0.55,0.52,0.57)	(0.75,0.32,0.37)	(0.85,0.22,0.27)	(0.75,0.32,0.37)	(0.65,0.42,0.47)
S3	(1,0,0)	(1,0,0)	(0.75,0.32,0.37)	(1,0,0)	(1,0,0)	(0.85,0.22,0.27)
S4	(0.75,0.32,0.37)	(0.85,0.22,0.27)	(0.65,0.42,0.47)	(0.75,0.32,0.37)	(0.75,0.32,0.37)	(0.85,0.22,0.27)
S5	(0.55,0.52,0.57)	(0.75,0.32,0.37)	(0.75,0.32,0.37)	(0.65,0.42,0.47)	(0.65,0.42,0.47)	(0.75,0.32,0.37)

Table 7: Determine the weighted normalized decision matrix D_{hij} , according to Equation (2).
Source: Own elaboration.

	C1	C2	C3	C4	C5	C6
Weight	(0.71,0.45,0.24)	(0.31,0.8,0.75)	(0.5,0.55,0.45)	(0.31,0.8,0.75)	(0.31,0.8,0.75)	(0.11,0.95,0.93)
S1	(0.35,0.72,0.77)	(0.25,0.82,0.87)	(0.25,0.82,0.87)	(0,0.98,1)	(0.25,0.82,0.87)	(0,0.98,1)
S2	(0.45,0.62,0.67)	(0,0.98,1)	(0.35,0.72,0.77)	(0.25,0.82,0.87)	(0,0.98,1)	(0,0.98,1)
S3	(0.55,0.52,0.57)	(0.25,0.82,0.87)	(0.35,0.72,0.77)	(0.25,0.82,0.87)	(0.25,0.82,0.87)	(0,0.98,1)
S4	(0.35,0.72,0.77)	(0.25,0.82,0.87)	(0.25,0.82,0.87)	(0,0.98,1)	(0,0.98,1)	(0,0.98,1)
S5	(0.25,0.82,0.87)	(0,0.98,1)	(0.35,0.72,0.77)	(0,0.98,1)	(0,0.98,1)	(0,0.98,1)
Classification	B	B	B	NB	NB	B

To select the best strategy, it is necessary to determine S_{i-} , S_{i+} , Q_i according to Equation (3 to 6). The results obtained, are represented in Figure 1, which integrates the neutrosophic environment and the visualization of the relationships between strategies.

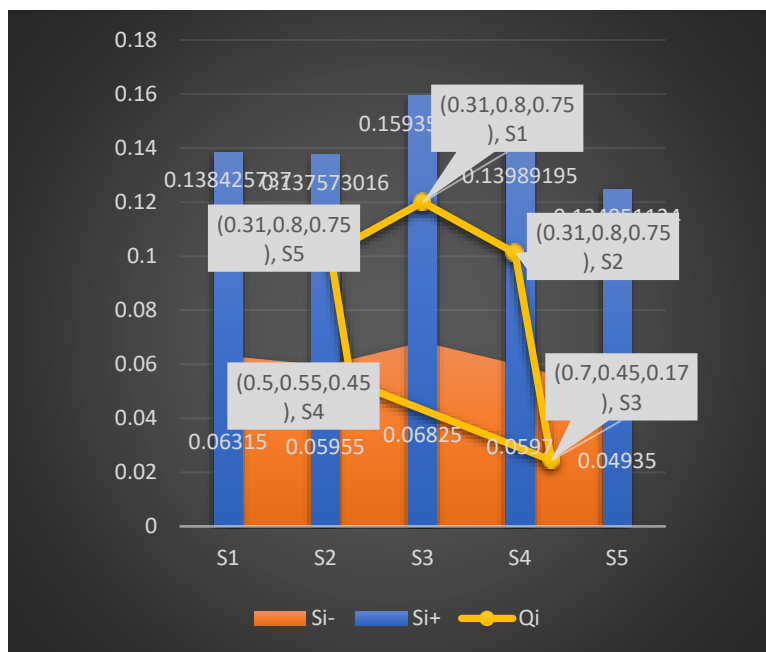


Figure 1: Neutrosophic environment for S_{i-} , S_{i+} and Q_i . Source: Own elaboration.

In Figure 1, it can be observed that in the neutrosophic environment where the proposed strategies converge, three findings are detailed:

- ❖ **Neutrosophic Areas:** Two areas are evidenced, of which the area with greater benefit sees the alternatives S3 and S4 converging, which to a certain extent could be said to encompass the same neutrosophic area. Meanwhile, the other area is focused on long-term action, where the strategies S1, S2, and S5 converge.
- ❖ **Performance Analysis P_i :** The figure denotes that among the strategies integrating the neutrosophic pentagon, strategy S3 achieved a satisfactory performance according to the neutrosophic evaluation (0.7,0.45,0.17). Therefore, it is positioned above the other strategies, making it the best strategy to promote a healthy adaptation to retirement and strengthen family bonds at this stage of life. However, strategy S4 obtained an optimal rating (0.5,0.55,0.45) for solving the problem of the study, followed by S3. Strategies S1, S2, and S5 each scored a low performance, which denotes the need to work on these last as a group solution to act on the impact of retirement on family dynamics in Ecuador.
- ❖ **Neutrosophic Subsets:** For strategies S1, S2, and S5, a classification of (0.35, 0.85,0.75) or low performance is observed. Both strategies share the same classification and focus under

a neutrosophic subset of *integrating retirees into society*. Therefore, it should project into a more comprehensive strategy that includes S1, S2, and S5, due to dependencies among them.

After conducting the analysis with the Neutrosophic COPRAS method, it has been determined that the strategy associated with emotional and psychological support promotes a healthy adaptation to retirement and strengthens family bonds in Ecuador. Therefore, work is required on the emotional and psychological state of retirees as a first step before other strategies are implemented.

6. Conclusion

The utilization of the Neutrosophic COPRAS method in this study introduces an innovative approach to evaluating strategies aimed at facilitating a smooth transition into retirement, with a particular focus on emotional and psychological support. This methodological approach allows for a nuanced assessment that incorporates not just binary truth values but also the indeterminacy intrinsic to human perceptions regarding retirement and its effects on family dynamics. By embracing neutrosophic sets, the complexity and ambiguity of evaluation criteria are captured and analyzed, highlighting the relevance of such an approach in the socio-economic and cultural context of Ecuador. The prioritization of strategies through Neutrosophic COPRAS underscores the pivotal role of psychological support in promoting healthy retirement adaptation, indicating the necessity of implementing targeted support programs to address the emotional challenges associated with this life transition.

Furthermore, the Neutrosophic COPRAS method enhances the understanding of the interrelations and dependencies among various strategies, showcasing its capability to manage uncertainty and indeterminacy, thus offering a robust decision-making tool in complex and multifaceted contexts. This study not only contributes to the existing literature on retirement's impact on family dynamics in Ecuador but also demonstrates the applicability and value of the Neutrosophic COPRAS method in social and behavioral research. By emphasizing the need for emotionally and psychologically focused interventions, alongside the development of policies and programs tailored to Ecuador's unique cultural and socioeconomic backdrop, this research underscores the method's contribution to social science methodologies, providing new insights into strategy evaluation in situations marked by high levels of uncertainty and complexity.

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