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# Design a FUZZY-TOPSIS (FTOPSIS) Model in Decision-Making with Multiple Criteria for the Implementation of Telecommuting in a Public Higher Education Institute

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**Abstract**

This article aimed to analyze the decision-making process regarding the implementation of telecommuting in a Public Higher Education Institution in Brazil. The basis for telecommuting was the 'Normative Instruction of the Federal Government (IN 65 of July 30, 2020)' and the 'University Council Resolution Nº 213, of December 6, 2021', which provide alternative frameworks (theoretical or legal aspects) for conducting telecommuting. These frameworks encompass fully remote work or a hybrid approach, where different sectors alternate between in-person and remote work to maintain face-to-face services. By employing the FUZZY-TOPSIS (FTOPSIS) approach, it becomes possible to hierarchize the alternatives and establish a systematic analysis, thereby reducing the inherent subjectivity in the decision-making process. This approach facilitates informed decision-making regarding future actions related to the implementation of telecommuting.



*Keywords:* Multi-criteria decision-making; TOPSIS; FTOPSIS; Implementation of telecommuting; Public Higher Education Institution.

## 1. Introduction

Multi-criteria decision-making (MCDM) and fuzzy multi-criteria decision-making (FMCDM) have been one of the fastest-growing areas during the last decades, depending on the business sector's changes, and is a crucial topic in expert system and operation research. Since MCDM has found acceptance in operation research, engineering,

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economics, management science, social problems, medicine, networking, and communication. Therefore, the discipline has created several methodologies used to solve different types of problems [1–7]. In discrete alternative multi-criteria decision problems, the primary concern for the decision aid is the following: Choosing the most preferred alternative to the decision maker (DM); Ranking alternatives in order of importance for selection problems; Screening alternatives for the final decision [8,9].

Decision-making is finding the best alternative among a set of feasible alternatives. Multiple attribute decision-making (MADM) problems (e.g., decision-making problems considering several attributes) are widely spread in real-life decision situations [10].

The technique for order preference by similarity to ideal solution (TOPSIS) proposed by Hwang and Yoon [13] is one of the well-known methods for solving classical MADM problems. The underlying logic of TOPSIS method is to define the positive-ideal solution (PIS) and the negative-ideal solution (NIS). The PIS is the solution that maximizes the benefit criteria and minimizes the cost criteria. In contrast, the NIS is the solution that minimizes the benefit criteria and maximizes the cost criteria. The optimal alternative is the shortest distance from the positive solution and the farthest distance from the negative solution. Chen and Tsao [11] extended the concept of TOPSIS to develop a method for solving MADM problems with interval-valued fuzzy data and compared the results using different distance measures, including Hamming distance, Euclidean distance, and their normalized forms [12].

Fuzzy set theory, which is introduced by Zadeh [13], can handle subjective judgments [3,14]. Sun [15] developed an evaluation model based on fuzzy TOPSIS to help industrial practitioners with performance evaluations in a fuzzy environment. It is considering that the socio-economic environment becomes more complex, and the preference information provided by decision-makers usually needs to be more precise [16]. There may be hesitation or uncertainty about preferences because a decision should be made under time pressure and lack of knowledge or data, or the decision-makers need more attention and information processing capacities. In such cases, it is suitable and convenient to express the DM preferences through fuzzy sets theory [17–20].

The innovative contribution of the proposal consists of the use of alternatives through the theoretical review and local legal aspects of the Brazilian Public University in the face of the implementation of telecommuting. The approximation of the FUZZY-TOPSIS (FTOPSIS) approaches makes it possible to hierarchize the alternatives, establishing a systematic analysis and reducing the subjectivity inherent to the decision-making process for the actions that will be chosen in future decisions about the implementation of telecommuting. Furthermore, we understand that the FTOPSIS method is employed to order the alternatives. The proposed model fits the reality of the situation. Its calculation is simple, so it can efficiently help the decision-maker (in this case, the leaders) make decisions. The questionnaire was applied to ten leaders of sectors of a Public Higher Education Institution, three leaders of the academic area, and seven leaders of sectors of the administrative area. These leaders studied and proposed the adoption of telecommuting in a hybrid and/or whole way with their subordinates. Twenty-three assertions were identified, fourteen were based on teleworking legislation, and another nine were found in the literature (see Table 1).

Finally, we extend the TOPSIS concept to solve problems in which the preference of information provided by decision makers is presented as decision matrices, where each of the elements is characterized by an interval-valued intuitionist fuzzy number (IVIFN), and the weights of the attributes are known. This study is justified by the fact that the COVID-19 pandemic accelerated discussions on telecommuting and the advantages and disadvantages of this model in the world. The need and orientation of governments worldwide in early 2020 for organizations to leave their workers at home raised the possibility of maintaining this model after the pandemic. For Anekwe et al. [21], the reduction of operating costs can be listed as one of the advantages of this work model, as well as the decrease in employee turnover, increased productivity, and quality of work. That flexibility helps in greater autonomy and planning of their lives. Several organizations have adopted telecommuting to improve the quality of life of their worker's [24] because, in addition to reducing travel time and congestion, it implies an environmental issue, can also help improve the individual's quality of life and balance between personal and professional life, providing more time for families to take care of their parents or children.

This article sought to analyze decision-making on implementing of telecommuting in a Public Higher Education Institution in Brazil. Telecommuting was based on a 'Normative Instruction of the Federal Government (IN 65 of July 30, 2020)' and on 'University Council Resolution Nº 213, of December 6, 2021', which define alternative (theory or legal aspects) for carrying out tele that can be done entirely at a distance or in a hybrid way, in which the sectors take turns between the servers so that the sector maintains face-to-face service, but also remotely.

## 2. TOPSIS method

Step 1: Develop the decision matrix – the decision matrix must be assembled initially $A \times C$ (1), where $A_1, A_2, \dots, A_m$ are the alternatives among which decision makers $(D_1, D_2, \dots, D_n)$ have to choose e $C_1, C_2, \dots, C_o$ are criteria with which alternative performance are measured, $x_{ij}$ is the rating of alternative $A_i$ with respect to criterion $C_j$. From this moment on, applying the steps suggested by the TOPSIS method begins. This study used the decision-maker's assessment of each alternative.

| | | $D_1$ | $D_2$ | … | $Dj$ | … | $D_n$ |
|---|---|---|---|---|---|---|---|
| | $A_1$ | $x_{11}$ | $x_{12}$ | … | $x_{1j}$ | … | $x_{1n}$ |
| $C_1$ | … | … | … | … | … | … | … |
| … | $A_i$ | $x_{i1}$ | $x_{i2}$ | … | $x_{ij}$ | … | $x_{in}$ |
| $C_o$ | … | … | … | … | … | … | … |
| | $A_m$ | $x_{m1}$ | $x_{m2}$ | … | $x_{mj}$ | … | $x_{mn}$ |

(1)

Step 2: Decision matrix normalization can be performed in several ways. Normalization is used to transform the data to a standard scale. This study used linear normalization according to equation (2).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, i = 1, \dots, m; j = 1, \dots, n. \quad (2)$$

Step 3: Calculate the matrix with the weights: understanding that all the indicators (leaders), due to the context of the theme of the implementation of telecommuting, need to be evaluated linearly. Therefore, the same weight was considered for each index when calculating the weighting seen in Table 1, as there is no difference in weight between the leaders who participated in the survey. Therefore, the weights used were 1. The normalized matrix was multiplied by the respective criteria weights to calculate the normalized and weighted matrix. The definition of weights is carried out according to perceptions of value by the decision-maker or a group of decision-makers. We used the linear weight with formula (3) in this study.

Table 1. Normalized and weighted matrix

| **Alternatives [Authors]** | ***Leader 1*** | ***Leader 2*** | ***Leader 3*** | ***Leader 4*** | ***Leader 5*** | ***Leader 6*** | ***Leader 7*** | ***Leader 8*** | ***Leader 9*** | ***Leader 10*** |
|---|---|---|---|---|---|---|---|---|---|---|
| Balancing family life and work [22] | 0.1459 | 0.2696 | 0.2377 | 0.2409 | 0.2164 | 0.2739 | 0.1405 | 0.2198 | 0.2333 | 0.2414 |
| Reduction in personal expenses [21] | 0.1459 | 0.1541 | 0.2377 | 0.2065 | 0.1546 | 0.1174 | 0.1757 | 0.1570 | 0.1333 | 0.0690 |
| Reducing expenses for the organization you work for [21] | 0.2188 | 0.1541 | 0.1585 | 0.2409 | 0.1237 | 0.1565 | 0.1405 | 0.1570 | 0.1333 | 0.2069 |
| work optimization [21] | 0.2553 | 0.1541 | 0.1981 | 0.2065 | 0.2164 | 0.2348 | 0.2108 | 0.2198 | 0.2333 | 0.2414 |
| The flexibility of working hours [23,24] | 0.2188 | 0.1541 | 0.2774 | 0.2065 | 0.2164 | 0.2348 | 0.2460 | 0.2198 | 0.1667 | 0.2069 |
| Planning and discipline for working hours [21] | 0.1823 | 0.2696 | 0.2377 | 0.2065 | 0.2164 | 0.1565 | 0.2108 | 0.2198 | 0.2000 | 0.1724 |
| Increased job satisfaction [22] | 0.1823 | 0.2311 | 0.1981 | 0.2409 | 0.2164 | 0.2739 | 0.1757 | 0.2198 | 0.2333 | 0.2414 |
| Increased server health [22] | 0.2188 | 0.2311 | 0.2377 | 0.2409 | 0.2164 | 0.2739 | 0.1757 | 0.2198 | 0.2333 | 0.2414 |
| Increased autonomy at work [25] | 0.2188 | 0.2311 | 0.2377 | 0.1721 | 0.2164 | 0.1957 | 0.1757 | 0.2198 | 0.2333 | 0.1379 |
| Increased productivity [22,23,26–29] | 0.2553 | 0.2311 | 0.1981 | 0.2065 | 0.2164 | 0.1957 | 0.1405 | 0.2198 | 0.2333 | 0.2414 |
| Increased efficiency [28,29] | 0.2188 | 0.2311 | 0.1981 | 0.1721 | 0.2164 | 0.1957 | 0.1405 | 0.2198 | 0.2333 | 0.2414 |
| Increased transparency [28,29] | 0.1459 | 0.1926 | 0.1585 | 0.1721 | 0.2164 | 0.0783 | 0.1757 | 0.2198 | 0.2000 | 0.1724 |
| Increased quality of work [28,29] | 0.1459 | 0.2311 | 0.1585 | 0.2065 | 0.2164 | 0.1957 | 0.2108 | 0.2198 | 0.2000 | 0.2414 |
| Time-saving [28,29] | 0.2553 | 0.1541 | 0.1585 | 0.2409 | 0.2164 | 0.2348 | 0.2460 | 0.2198 | 0.2333 | 0.2414 |
| Cost reduction [21,28,29] | 0.2553 | 0.1541 | 0.1585 | 0.2065 | 0.1546 | 0.1565 | 0.2108 | 0.2198 | 0.2000 | 0.1724 |
| Attract and retain talent [21,27–29] | 0.2553 | 0.1541 | 0.1981 | 0.1721 | 0.2164 | 0.2348 | 0.2460 | 0.1884 | 0.1333 | 0.1379 |
| Improvement of the worker's quality of life [21,27–29] | 0.2188 | 0.2311 | 0.2377 | 0.2409 | 0.2164 | 0.2739 | 0.2460 | 0.2198 | 0.2333 | 0.2414 |
| Physical space optimization [28,29] | 0.2188 | 0.1541 | 0.1585 | 0.2065 | 0.2164 | 0.1565 | 0.2108 | 0.1884 | 0.2000 | 0.1034 |
| Employee Motivation and Commitment [28,29] | 0.1459 | 0.2311 | 0.1981 | 0.2065 | 0.2164 | 0.2348 | 0.2460 | 0.2198 | 0.2000 | 0.2069 |
| Socio-environmental and economic sustainability [28,29] | 0.2553 | 0.2311 | 0.1585 | 0.1721 | 0.2164 | 0.1957 | 0.2460 | 0.1884 | 0.2333 | 0.2414 |
| Optimization of budgetary resources and natural resources [28,29] | 0.2188 | 0.1926 | 0.1981 | 0.1377 | 0.2164 | 0.1957 | 0.2460 | 0.1884 | 0.2000 | 0.1724 |
| Digital culture and modernization of flows and processes [28,29] | 0.0729 | 0.1926 | 0.2377 | 0.2065 | 0.2164 | 0.1957 | 0.2460 | 0.1884 | 0.2000 | 0.2414 |
| Improving the quality of life of mother servants [21,28,29] | 0.2188 | 0.2696 | 0.2774 | 0.2409 | 0.2164 | 0.1957 | 0.2460 | 0.2198 | 0.2333 | 0.2414 |

$$v_{ij} = w_j \times r_{ij}$$

$v_{ij}$: is the result of each element with the weight matrix.
$w_j$: is the weight defined for each attribute or criterion.
$r_{ij}$: is the result of each element of the normalized matrix.

(3)

Step 4: Identification of the positive ideal solution (PIS) and negative ideal solution (NIS). In this step, the best levels are determined, representing the ideal solution ($S^+$) for each analyzed criterion. The same procedure is carried out for the worst levels, which represent the anti-ideal solution ($S^-$). Table 2 presents the evaluation referring to the PIS and NIS, considering each index's impacts in relation to the expectations indicated by the indicators. Equations (4) present the respective calculations of $S^+$ and $S^-$.

$$S^+ = \{(max\ v_{ij} | i \in I), (\min v_{ij} \mid i \in J)\}$$
$$S^- = \{(min\ v_{ij} | i \in I), (\max v_{ij} \mid i \in J)\}$$

Where $I$ is associated with benefit criteria, and $J$ is associated with cost criteria.

(4)

Table 2. PIS and NIS solutions

| Impacts | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) | (+) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Leader 1 | Leader 2 | Leader 3 | Leader 4 | Leader 5 | Leader 6 | Leader 7 | Leader 8 | Leader 9 | Leader 10 |
| PIS ($S^+$) | 0.2553 | 0.2696 | 0.2774 | 0.2409 | 0.2164 | 0.2739 | 0.2460 | 0.2198 | 0.2333 | 0.2414 |
| NIS ($S^-$) | 0.0729 | 0.1541 | 0.1585 | 0.1377 | 0.1237 | 0.0783 | 0.1405 | 0.1570 | 0.1333 | 0.0690 |

Step 5: Calculate the separation measures for each alternative about the ideal and anti-ideal solution. Calculate the separation measures, using n-dimensional between each alternative and its positive ideal solution ($D^+$) and its anti-ideal solution ($D^-$) are calculated by the following equations (5).

$$D^+ = \sqrt{\sum_{j=1}^{n} [v_{ij}(x) - v_j^+(x)]^2}$$
$$D^- = \sqrt{\sum_{j=1}^{n} [v_{ij}(x) - v_j^-(x)]^2}$$

(5)

Step 6: Calculate the relative closeness to the ideal solution. Finally, we arrive at the coefficient $C$ or the result of the approximation of the ideal situation $C_i$ (6) and the definition of the ordering of the alternatives. For ranking alternatives using this index, we can rank alternatives in decreasing order. Alternatives with $C_i$ close to 1 are the best, as the alternative with the highest proximity coefficient represents the optimal alternative [30].

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-}$$

Since $D_i^- \geq 0$ and $D_i^+ \geq 0$, then, clearly, $C_i \in [0,1]$.

(6)

Therefore, the basic principle of the TOPSIS method is that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest distance from the negative ideal solution. Besides, the TOPSIS method introduces two reference points but does not consider the relative importance of the distances from these points.

## 3. TOPSIS method with fuzzy data

Similar to the TOPSIS method, aggregation with fuzzy data makes it possible to choose an alternative with the maximum similarity to the positive ideal solution. In this section, the TOPSIS method in the fuzzy environment is described. Based on the TOPSIS method to obtain the judgment of leaders in each alternative rating scale is required. This rating scale is considered a linguistic variable [19]. The linguistic variables used in this paper are expressed as positive triangular fuzzy numbers in Table 3.

Table 3. Linguistic variables for the ratings

| Linguistic scales (Importance) | Symbol | Number | Corresponding triangular fuzzy number |
|---|---|---|---|
| Extremely low importance | EL | 1 | (1,1,2) |
| Very low importance | VL | 2 | (1,2,3) |
| Low importance | L | 3 | (2,3,4) |
| Medium importance | M | 4 | (3,4,5) |
| High importance | H | 5 | (4,5,6) |
| Very high importance | VH | 6 | (5,6,7) |
| Extremely high importance | EH | 7 | (6,7,7) |

Based on chosen linguistic variables for rating the alternatives with respect to criteria by experts, the fuzzy decision matrix must be constructed. Linguistic variables are adjectives attributed to the parameters or alternatives. The prime advantage of linguistic variables is that they are expressed in natural language. A fuzzy number is a fuzzy subset in the universe of discourse $x$ that is both convex and normal. In any linguistic scale, linguistic variables are represented by a set of corresponding fuzzy numbers. These fuzzy numbers, such as the one illustrated in the universe of discourse x, exhibit both convexity and normality characteristics.

Step 1: Collect the subjective evaluations on the decision-maker on the importance of weights.

Step 2: The linguistic terms are converted into triangular fuzzy numbers to construct the fuzzy decision matrix of each alternative as shown in Table 4.

Table 4. Fuzzy decision matrix

| *bb* | *Leader 1* | *Leader 2* | *Leader 3* | *Leader 4* | *Leader 5* | *Leader 6* | *Leader 7* | *Leader 8* | *Leader 9* | *Leader 10* |
|---|---|---|---|---|---|---|---|---|---|---|
| Balancing family life and work | (3,4,5) | (6,7,7) | (5,6,7) | (6,7,7) | (6,7,7) | (6,7,7) | (3,4,5) | (6,7,7) | (6,7,7) | (6,7,7) |
| Reduction in personal expenses | (3,4,5) | (3,4,5) | (5,6,7) | (5,6,7) | (4,5,6) | (2,3,4) | (4,5,6) | (4,5,6) | (3,4,5) | (1,2,3) |
| Reducing expenses for the organization you work for | (5,6,7) | (3,4,5) | (3,4,5) | (6,7,7) | (3,4,5) | (3,4,5) | (3,4,5) | (4,5,6) | (3,4,5) | (5,6,7) |
| work optimization | (6,7,7) | (3,4,5) | (4,5,6) | (5,6,7) | (6,7,7) | (5,6,7) | (5,6,7) | (6,7,7) | (6,7,7) | (6,7,7) |
| The flexibility of working hours | (5,6,7) | (3,4,5) | (6,7,7) | (5,6,7) | (6,7,7) | (5,6,7) | (6,7,7) | (6,7,7) | (4,5,6) | (5,6,7) |
| Planning and discipline for working hours | (4,5,6) | (6,7,7) | (5,6,7) | (5,6,7) | (6,7,7) | (3,4,5) | (5,6,7) | (6,7,7) | (5,6,7) | (4,5,6) |
| Increased job satisfaction | (4,5,6) | (5,6,7) | (4,5,6) | (6,7,7) | (6,7,7) | (6,7,7) | (4,5,6) | (6,7,7) | (6,7,7) | (6,7,7) |
| Increased server health | (5,6,7) | (5,6,7) | (5,6,7) | (6,7,7) | (6,7,7) | (6,7,7) | (4,5,6) | (6,7,7) | (6,7,7) | (6,7,7) |
| Increased autonomy at work | (5,6,7) | (5,6,7) | (5,6,7) | (4,5,6) | (6,7,7) | (4,5,6) | (4,5,6) | (6,7,7) | (6,7,7) | (3,4,5) |
| Increased productivity | (6,7,7) | (5,6,7) | (4,5,6) | (5,6,7) | (6,7,7) | (4,5,6) | (3,4,5) | (6,7,7) | (6,7,7) | (6,7,7) |
| Increased efficiency | (5,6,7) | (5,6,7) | (4,5,6) | (4,5,6) | (6,7,7) | (4,5,6) | (3,4,5) | (6,7,7) | (6,7,7) | (6,7,7) |
| Increased transparency | (3,4,5) | (4,5,6) | (3,4,5) | (4,5,6) | (6,7,7) | (1,2,3) | (4,5,6) | (6,7,7) | (5,6,7) | (4,5,6) |
| Increased quality of work | (3,4,5) | (5,6,7) | (3,4,5) | (5,6,7) | (6,7,7) | (4,5,6) | (5,6,7) | (6,7,7) | (5,6,7) | (6,7,7) |
| Time-saving | (6,7,7) | (3,4,5) | (3,4,5) | (6,7,7) | (6,7,7) | (5,6,7) | (6,7,7) | (6,7,7) | (6,7,7) | (6,7,7) |
| Cost reduction | (6,7,7) | (3,4,5) | (3,4,5) | (5,6,7) | (4,5,6) | (3,4,5) | (5,6,7) | (6,7,7) | (5,6,7) | (4,5,6) |
| Attract and retain talent | (6,7,7) | (3,4,5) | (4,5,6) | (4,5,6) | (6,7,7) | (5,6,7) | (6,7,7) | (5,6,7) | (3,4,5) | (3,4,5) |
| Improvement of the worker's quality of life | (5,6,7) | (5,6,7) | (5,6,7) | (6,7,7) | (6,7,7) | (6,7,7) | (6,7,7) | (6,7,7) | (6,7,7) | (6,7,7) |
| Physical space optimization | (5,6,7) | (3,4,5) | (3,4,5) | (5,6,7) | (6,7,7) | (3,4,5) | (5,6,7) | (5,6,7) | (5,6,7) | (2,3,4) |
| Employee Motivation and Commitment | (3,4,5) | (5,6,7) | (4,5,6) | (5,6,7) | (6,7,7) | (5,6,7) | (6,7,7) | (6,7,7) | (5,6,7) | (5,6,7) |
| Socio-environmental and economic sustainability | (6,7,7) | (5,6,7) | (3,4,5) | (4,5,6) | (6,7,7) | (4,5,6) | (6,7,7) | (5,6,7) | (6,7,7) | (6,7,7) |
| Optimization of budgetary resources and natural resources | (5,6,7) | (4,5,6) | (4,5,6) | (3,4,5) | (6,7,7) | (4,5,6) | (6,7,7) | (5,6,7) | (5,6,7) | (4,5,6) |
| Digital culture and modernization of flows and processes | (1,2,3) | (4,5,6) | (5,6,7) | (5,6,7) | (6,7,7) | (4,5,6) | (6,7,7) | (5,6,7) | (5,6,7) | (6,7,7) |
| Improving the quality of life of mother servants | (5,6,7) | (6,7,7) | (6,7,7) | (6,7,7) | (6,7,7) | (4,5,6) | (6,7,7) | (6,7,7) | (6,7,7) | (6,7,7) |

Step 3: Form a fuzzy-weighted decision matrix by multiplying the normalized decision matrix with the corresponding fuzzy weight. Construct normalized fuzzy decision matrix R as shown in equation (7). This study used the same criteria and weight equation (3) adopted in Step 3 of the TOPSIS method.

$$R = [r_{ij}]_{m \times n}$$
$$r_{ij} = \left(\frac{a_{ij}}{c_j^+}, \frac{b_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+}\right), j \in B; \text{ for cases “the bigger, the better”}$$
$$r_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right), j \in B; \text{ for cases “the smaller, the better”}$$
$$c_j^+ = \max_i c_{ij} \; if \; j \in B; \text{ maximum } 3^a\text{. Coordinate between all numbers in the same column}$$
$$a_j^- = \min_i a_{ij} \; if \; j \in C; \text{ least } 1^a\text{. Coordinate between all numbers in the same column}$$
Where $B$ is associated with the benefit, and $C$ is associated with the cost criteria.

(7)

Below, a summary fragment is presented in Table 5, presenting the results of the equation calculations (7):

Table 5. Normalized decision matrix with corresponding fuzzy weight

| *Alternatives* | *Leader 1* | *Leader 2* | *Leader n* | *Leader 10* |
|---|---|---|---|---|
| Balancing family life and work | (0.4282,0.5715,0.7143) | (0.8571,1,1) | ... | (0.8571,1,1) |
| Reduction in personal expenses | (0.4286,0.5714,0.7143) | (0.4286,0.5714,0.7143) | ... | (0.1429,0.2857,0.4286) |
| … | ... | (3,4,5) | ... | (5,6,7) |
| ... | ... | (3,4,5) | ... | (6,7,7) |
| … | ... | (3,4,5) | ... | (5,6,7) |
| Improving the quality of life of mother servants | (0.7143,0.8571,1) | (0.8571,1,1) | ... | (0.8571,1,1) |

Step 4: Construct fuzzy positive-ideal solution ($S^+$) and fuzzy negative-ideal solution ($S^-$) as shown in equation (8).

$$S^+ = (v_1^+, v_2^+, \dots, v_n^+)$$
$$S^- = (v_1^-, v_2^-, \dots, v_n^-)$$
$$\text{Where } v_j^+ = (1,1,1) \text{ and } v_j^- = (0,0,0), j = 1, 2, \dots, n. \tag{8}$$

Fixed ideal and anti-ideal solutions are not necessarily feasible in the context of our problem.

Step 5: Calculate the Euclidean distance of each alternative from fuzzy positive ($S^+$) and negative ($S^-$) using equation (9).

$$S_i^+ = \sum_{j=1}^{n} d(v_{ij}, v_j^+), \quad i = 1, 2, \dots, \quad m.$$
$$S_i^- = \sum_{j=1}^{n} d(v_{ij}, v_j^-), \quad i = 1, 2, \dots, \quad m.$$
Where $d(.,.)$ *represents the distance between two fuzzy numbers calculated by*
$$d(m, n) = \sqrt{\frac{1}{3}[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2]} \tag{9}$$

Step 6: The closeness coefficient $C_i$ of the alternatives are calculated using equation (6) and ranked as per descending order as shown in Table 6.

## 4. Data analysis

In both TOPSIS and FTOPSIS methods, the results obtained (see Table 6), the first three most indicated alternatives, respectively, form: 'Improvement of the worker's quality of life' (Rank=1); 'Improving the quality of life of mother servants' (Rank=2); 'Increased server health' (Rank=3) that appears in the literature over the years [21]. Likewise, the three least indicated alternatives were: 'Reduction in personal expenses'; 'Reducing expenses for the organization you work for'; and 'Increased transparency', with a slight change in ordering between methods. This result may indicate that the concern of the sectors' leaders is more associated with alternatives that favor the worker's satisfaction and quality of life because they do not have so much control over the costs of the organization studied, which is of a public nature. Therefore, the use of both methods to solve a decision problem proved to be adequate.

Table 6. Consolidated results of the TOPSIS and FTOPSIS rankings

| *Method* | | TOPSIS | | | | FTOPSIS | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Criteria* | *Alternatives* | D+ | D- | $C_i$ | Rank | D+ | D- | $C_i$ | Rank |
| T | Balancing family life and work | 0.1570 | 0.3552 | 0.6935 | 6 | 1.650 | 8.715 | 0.8408 | 5 |
| T | Reduction in personal expenses | 0.3241 | 0.1416 | 0.3041 | 23 | 3.934 | 6.404 | 0.6194 | 23 |
| T | Reducing expenses for the organization you work for | 0.2783 | 0.2389 | 0.4620 | 21 | 3.425 | 6.908 | 0.6685 | 22 |
| T | work optimization | 0.1536 | 0.3482 | 0.6940 | 5 | 1.718 | 8.676 | 0.8347 | 7 |
| T | The flexibility of working hours | 0.1518 | 0.3293 | 0.6845 | 7 | 1.820 | 8.586 | 0.8251 | 8 |
| T | Planning and discipline for working hours | 0.1702 | 0.2740 | 0.6169 | 13 | 2.047 | 8.355 | 0.8033 | 12 |
| T | Increased job satisfaction | 0.1342 | 0.3492 | 0.7223 | 4 | 1.605 | 8.765 | 0.8452 | 4 |
| T | Increased server health | 0.0965 | 0.3687 | 0.7925 | 3 | 1.357 | 9.047 | 0.8696 | 3 |
| T | Increased autonomy at work | 0.1757 | 0.2775 | 0.6122 | 14 | 2.171 | 8.214 | 0.7910 | 14 |
| L | Increased productivity | 0.1618 | 0.3340 | 0.6736 | 9 | 1.843 | 8.535 | 0.8224 | 9 |
| L | Increased efficiency | 0.1763 | 0.3099 | 0.6374 | 12 | 2.069 | 8.304 | 0.8006 | 13 |
| L | Increased transparency | 0.2930 | 0.1921 | 0.3960 | 22 | 3.196 | 7.145 | 0.6909 | 21 |
| L | Increased quality of work | 0.1930 | 0.2854 | 0.5966 | 15 | 2.182 | 8.215 | 0.7901 | 15 |
| L | Time-saving | 0.1703 | 0.3630 | 0.6806 | 8 | 1.650 | 8.715 | 0.8408 | 5 |
| L | Cost reduction | 0.2310 | 0.2629 | 0.5322 | 19 | 2.668 | 7.702 | 0.7427 | 19 |
| L | Attract and retain talent | 0.2182 | 0.2932 | 0.5734 | 17 | 2.566 | 7.791 | 0.7523 | 18 |
| L | Improvement of the worker's quality of life | 0.0662 | 0.3819 | 0.8522 | 1 | 1.131 | 9.278 | 0.8914 | 1 |
| L | Physical space optimization | 0.2572 | 0.2287 | 0.4707 | 20 | 2.920 | 7.474 | 0.7190 | 20 |
| L | Employee Motivation and Commitment | 0.1573 | 0.2987 | 0.6550 | 11 | 1.922 | 8.496 | 0.8155 | 11 |
| L | Socio-environmental and economic sustainability | 0.1657 | 0.3385 | 0.6713 | 10 | 1.843 | 8.535 | 0.8224 | 10 |
| L | Optimization of budgetary resources and natural resources | 0.1928 | 0.2720 | 0.5851 | 16 | 2.397 | 7.983 | 0.7691 | 17 |
| L | Digital culture and modernization of flows and processes | 0.2240 | 0.2849 | 0.5599 | 18 | 2.326 | 8.081 | 0.7765 | 16 |
| L | Improving the quality of life of mother servants | 0.0863 | 0.3696 | 0.8106 | 2 | 1.153 | 9.227 | 0.8889 | 2 |

Note: T: Theory and L: Legal aspects

The FMCDM techniques can suitably explain the DM evaluation of existing alternatives for selecting the best alternative when the criteria have subjective perceptions. The uncertainty and subjectivity of this method can result in weighting errors and difficulties in the process of criterion weight selection [31,32]. We used the same value for all decision-makers to avoid inaccurate weighting, understanding that leaders have equivalent roles. Thus, the idea of a linguistic variable is highly beneficial for transactions with cases that have increased complexity or are not entirely determinant to be reasonably described in conventional quantitative terms, where fuzzy numbers are introduced to express linguistic variables appropriately [4,30,33,34].

## 5. Conclusion

In general, multicriteria problems often involve uncertain and imprecise data, and fuzzy set theory is well-suited for addressing them. This study proposes a linguistic decision process to resolve a multiple criteria decision-making problem within a fuzzy environment, specifically focusing on leaders' perceptions regarding the implementation of telecommuting at the university. In this decision process, the evaluation of alternatives is conducted using linguistic variables rather than numerical values. The integrated FTOPSIS model presented in this paper facilitates the measurement of distance between two fuzzy triangular numbers and extends the TOPSIS procedure to the fuzzy environment. Notably, the vertex method can be easily applied to calculate the distance between any two fuzzy numbers with linear membership functions. Additionally, when employing the group decision process, various aggregation functions can be utilized to consolidate the fuzzy classifications provided by the decision-makers. Furthermore, to further advance the study, non-compensatory multicriteria methods can be employed. Some examples of such methods include PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation), ELECTRE (Elimination and Choice Translating Reality), and AHP (Analytic Hierarchy Process). These methods consider non-compensatory aspects and can provide valuable insights in decision-making processes within fuzzy environments. Please note that the list of non-compensatory methods mentioned above is not exhaustive, and further exploration of specific non-compensatory multicriteria methods may be beneficial for the study.

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