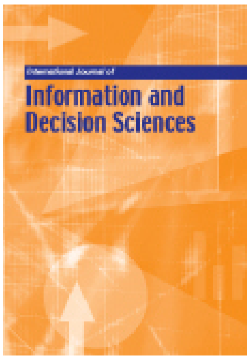

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Abstract: This study aims to use fuzzy logic to select a project manager based on soft skills. In the first phase, a focus group interview was applied to establish the weights according to the soft skills list selected. In the second phase, the fuzzy TOPSIS logic was applied. According to the concept of the fuzzy TOPSIS, a closeness coefficient is defined to determine the ranking order of all alternatives. The results allowed the construction of the framework here called fuzzy TOPSIS ranked multi-criteria for selecting the best candidate according to the profile and criteria adopted. The contribution of this study is to allow the attribution of values to soft skills that, in essence, are subjectivity. This framework is friendly, the investment required is low, and it is adaptable to different contexts.

Keywords: fuzzy TOPSIS; multi-criteria decision; project manager selection; soft skill; human resources; competencies; competence; people management; project manager.

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1 Introduction

The project manager is continuously bombarded with information and demands from the most diverse (Pinto and Slevin, 1989; Patanakul et al., 2016), a situation that should increase with the use of new technologies to increase the productivity and competitiveness of organisations (Gemünden et al., 2018). The project-based organisation is a way to obtain agility and flexibility to reach the organisational objectives (Miterev et al., 2017). This kind of organisation allows leading to the incorporation of new project managers in companies from the most diverse sectors of the economy, mainly in the context of digital transformation (Guinan et al., 2019).

In this context, the project managers, as well as project teams, become key factors in organisational success (Korvin et al., 2002; Patanakul et al., 2016). As mentioned by Guinan et al. (2019), it is necessary to develop new skills for project managers, and their teams are given the challenges arising from technological changes. Therefore, based on the information presented so far, the increasing incorporation of project managers into organisations stands out, which brings opportunities for studies on this professional. For this reason, we start here from the perspective that when the company approves a project, it is essential to make the right choice for the future project manager.

Moreover, the task of selecting a project manager is complex and uncertain because it is often more subjective. However, companies usually look for more objective methods for this task. In general, a successful project manager must possess skills related to the execution of tasks and skills to interact with people (Hendarman and Cantner, 2018; Stevenson, 2010). As explained by Gruden and Stare (2018), the skills related to the behaviour of project managers contribute to increasing the performance of projects. Fisher (2011), Skulmoski and Hartman (2010) and Alvarenga et al. (2019) have debated which competencies of the project manager can reduce project failures. Research on the skills of project managers separates them into two categories: technical skills called hard skills, and personal skills recognised as soft skills.

Competencies linked to hard skills are constituted by knowledge, experience, and technical foundations. Soft skills are recognised for creative thinking, personal integrity, self-motivation, and communicative skills (Uzoka et al., 2018). Regarding these two types of competencies, Uzoka et al. (2018) demonstrated that the development of soft skills contributes to achieving success in projects. In addition to this idea, Skulmoski and Hartman (2010) point out that project management hard skills do not lead the 3 project manager to superior performance as soft skills can. Although both skills are essential for the project manager, as pointed out by Gustavsson and Hallin (2014) and Vale et al. (2018), this study focused on the assessment of soft skills to promote the best selection of project managers.

Based on the presented information, this study adopted the objective of presenting a framework using fuzzy logic to select a project manager based on soft skills. The choice to build a framework for evaluating the soft skills of project managers using fuzzy logic was due to the level of subjectivity present in this type of skill. As highlighted by Kelemenis et al. (2011), the adoption of fuzzy logic is adequate when there is uncertainty, imprecise knowledge, and the possibility of subjective preference.

Other researchers have also used Fuzzy based frameworks to treat problems in several areas (Korvin et al., 2002; You et al., 2012; Shipley et al., 1997). Guo et al. (2016) studied how to solve the fuzzy multi-period portfolio selection problem with V-Shaped transaction cost. Korvin et al. (2002) indicate the use of a fuzzy set for selecting people in multiple phases of the project and taking into account the match between individual skills, the skills needed for each phase, and flexible budget considerations. Thus, due to the imprecise nature of soft skills, we adopt fuzzy triangular numbers and linguistic variables to represent the decision criteria. These same methods were supported in studies such as Karatop et al. (2015), Chen (2000), Kelemenis et al. (2011), Afshari (2017), Dursun and Karsak (2010), among others.

The framework proposed here optimises the evaluation of candidates based on ten soft skills pre-selected as decision criteria (Stevenson, 2010; Pedrosa and Silva, 2019). The evaluation process by the decision-makers was carried out based on a prior weighting of values for each soft skill, which were ranked in a focus group session. It is worth mentioning here that the linguistic values used for assigning the weights of the criteria, and evaluating the candidates, are based on the fuzzy triangular classification method (Karatop et al., 2015; Baykasoglu et al., Das, 2007).

We reinforce that the contribution of this study is anchored in the complexity of project manager selection more assertively. For this, we used the ranking in this study using the fuzzy technique for order preference by similarity to an ideal solution (TOPSIS) method. The TOPSIS technique is a technique for decision-making by multiple attributes, being able to order a series of viable alternatives according to the characteristics of each attribute. The use of fuzzy sets works as an essential tool for making decisions that incorporate inaccurate judgments like the process of selecting professionals. The authors also point out that fuzzy triangular numbers are appropriate for quantifying subjective information, such as creativity, personality, or leadership, to select professionals.

We recognise the framework described as fuzzy TOPSIS ranked multi-criteria, as it starts the selection process by ranking the criteria and ends with the ranking of the candidates. The ranking was adopted because of the ease with which people in the organisation establish ranks of their activities and people. The analysis applied in this study was possible due to the ease of using fuzzy sets. Fuzzy TOPSIS was applied to capture the subjectivity of the studied competencies. Another contribution of the proposed framework is the ease of application, the low investment required, in addition to adaptability to different situations and contexts.

2 Literature review

The skills of project managers are formed by a set of soft skills and hard skills. As already noted, hard skills are linked to technical skills such as drawing up a schedule, drawing the critical path, or even risk analysis. Soft skills are represented by personal behaviours and skills such as leadership, communication, self-motivation, among others. Hard skills are apparently more explicit and easily verifiable, an example can be seen in the study by Farashah et al. (2019), as the authors related certification with performance. Although this may seem like a natural positive relationship, we can infer that this factor shows only the technical knowledge related to project management. In the same vein, the PULSE 2018 Report (PMI, 2019) mentions the information that 72% of PMO leaders say that certification is very relevant for mid-career project managers. An interesting aspect of this report is that it is attributed to certification professionals as a driver for the development of technical, leadership, and digital skills. We emphasise that leadership cannot be recognised as analogous to technical or digital skills. Leadership-related skills come from behavioural aspects (Gruden and Stare, 2018).

Several studies adopted objective criteria such as organisational planning, poor communication practices, inadequate training and learning, faulty selection of process improvement methodology, staff acquisition, communications planning, among others, related to critical success factors (Zwikael and Globerson, 2006; Antony and Gupta, 2019). According to Skulmoski and Hartman (2010), the behavioural skills of project managers contribute substantially to the success of projects.

Stevenson (2010) ranked the most relevant competencies when researching IT executives in the industry sector in the United States. The authors started from a list of 15 competencies of the successful project manager from the perspective of recruiters. The result of Stevenson (2010) research was that the six skills considered most important were the following soft skills: leadership, multi-level communication skills, verbal communication skills, written communication skills, attitude, and coping skills with ambiguity and change. Additionally, the research by Pedrosa and Silva (2019) identified which are the main soft skills requested in the online advertisements for IT project manager jobs in Brazil. In the same vein, Vale et al. (2018) carried out a bibliometric study to identify the skills of project managers.

Based on the studies mentioned above, we selected for this research ten soft skills that served to evaluate project managers in a selection process, as described in Table 1.

Table 1 Soft skills of project managers

Soft skills	*Criteria number*	*Description*
Communication	C1	Ability to apply verbal and non-verbal communication between project stakeholders
Leadership	C2	Ability to inspire and influence to engage the time in the project activities to achieve objectives
Interpersonal relationship	C3	Ability to deal with people to maintain proximity and a sense of belonging.
Flexibility and creativity	C4	Ability to deal with change and adversity.
Empathy	C5	Ability to put yourself in the other's shoes for understanding their point of view.
Conflict management	C6	Ability to interact with individuals at different hierarchical levels to resolve conflicts.
Negotiation	C7	Ability to interact with stakeholders regarding the performance of activities.
Attitude	C8	Positive behaviour of the project manager related to their posture, proactivity, among others
Stress management	C9	Ability to work under pressure while managing project adversities happens.
Team management	C10	Ability to interact and motivate team members.

Source: Elaborated by authors based on Pedrosa and Silva (2019), Vale et al. (2018), and Stevenson (2010)

The soft skills listed make up a set of skills understood in this study as relevant to the success of a project. Thus, starting from the premise that when starting a project, assertiveness in the selection of the project manager is a determining factor for its success, we propose a fuzzy TOPSIS ranked multi-criteria framework based on the assessment of these soft skills for the selection of this professional. In this sense, Dursun and Karsak (2010) stated, when presenting an algorithm based on fuzzy TOPSIS for the selection of people, that this is a reliable procedure of multi-criteria decision-making (MCDM).

In line with the framework proposed here, Dursun and Karsak (2010) developed a Fuzzy-algorithm for decision-making with several criteria to correct the problems encountered when using classic personnel selection methods. Chen (2000) proposed a vertex method that is effective and simple to measure the distance between two triangular points of diffuse numbers. These authors were the precursors in the application of the TOPSIS procedure to the diffuse environment.

Additionally, we highlight that other methods are also applied to select professionals (Behzadian et al., 2012; Zavadskas et al., 2012). Keren et al. (2014) proposed a method for calculating the weighted scores and the classification of candidates for selecting professionals for project management. The method proposed by the authors combines the data envelopment analysis (DEA) and the analytical hierarchical process (AHP) and uses the DEA classification methods to improve the selection. Torfi and Rashidi (2011) also use AHP in selecting project managers, but in combination with fuzzy TOPSIS. AHP is used to determine the relative weights of the evaluation criteria, and fuzzy TOPSIS was used to rank candidates.

Zhao et al. (2009) used fuzzy comprehensive evaluation methods in the selection of a project manager based on management capacity, leadership level, technical level, and personal qualities. Strnad and Guid (2010) presented a fuzzy-genetic decision support system for project team formation. Kelemenis et al. (2011) proposed a selection model for Support managers ‘using an extension of fuzzy TOPSIS. Karatop et al. (2015) suggested a framework for assessing the level of competence of employees to obtain performance at an ideal level of the emotional and intellectual capabilities of employees based on their experiences. Sadeghi et al. (2014) evaluated project managers using MCDM TOPSIS based on three dimensions of knowledge, performance, and behavioural competency.

In this study, the choice to rank previously selected competencies will help professionals and companies that do not master such knowledge. We highlight that this is the main difference of this study from others discussed here. Besides, the discussion process for attributing weights to decision makers contributes to differentiate the research proposed here. Boyd and Jiao-Zhong (1991) corroborate this choice by stating that the candidate should be evaluated by a committee of experts, but that such a tactic is costly and challenging to implement. Additionally, we reinforce that proposing the ranking through a discussion session and adopting fuzzy TOPSIS to choose the best option among the candidates, contributes to the uncomplicated application of the framework proposed here. Therefore, in the next section, the procedures applied in this study are presented.

3 Materials and methods

3.1 Initial procedures and context

The research presented here was applied following the qualitative and quantitative approaches (Creswell, 2010). The qualitative approach was adopted to understand the phenomenon observed from the perspective of the researched social actor (Miles and Huberman, 1994), initially, from the literature, and then in the application of the focus group session. The quantitative approach followed in support of the qualitative perspective with the application of statistical techniques in the treatment of the collected data.

The qualitative approach of this research applied in the focus group session is understood by the set of applied procedures. In the beginning, the researchers started a group interview to discuss the subject of soft skills and project manager selection. Some rounds of discussion were mediated before any assessment being carried out. Respondents expressed their opinions and understandings about each soft skill brought by the researchers. In order to seek a common understanding of what was being dealt with and how the assessment would take place, in this case with linguistic variables (Table 3).

Regarding the number of respondents in the focus group section, we report that the number of people to evaluate the alternatives and assign weights to the criteria is in line with the procedures adopted by Kutlu Gündoğdu and Kahraman (2019) with three experts and Kutlu and Ekmekçioğlu (2012) which used three experts. It should be noted that the objective is not to seek an N of evaluators that determine generalisation as in other methods. Here the objective is to capture the perception of the studied reality from the experts' assessments. We also inform that in this study the objective was to let everyone know their roles in the process of evaluating candidates for a position as project manager and the soft skills adopted. We explain that the number of evaluators is adequate given the method applied here, despite using mathematical models from the evaluations obtained in the focus group session. The logic used is different from other models based on mean or variances. In Fuzzy logic, linguistic variables and their conversion into numerical variables are used, as is explored later in this article.

We have to make it clear that the quantitative approach in this research is justified by the chosen data treatment method. Thus, we collected the opinion of experts in the qualitative stage through the focus group session, which represented abstractions of reality from the perspective of the interviewed agents (Krueger and Casey, 2014). These abstractions were translated into meanings through linguistic variables, where it was decided to use the fuzzy set method. This method represents quantitatively, the universe of discourse through the function of group belonging (Chen, 2000). For the ordering of the experts' opinions regarding the candidates, the fuzzy TOPSIS analysis method was chosen, which allows the ordering of the options to be carried out through the evaluation of criteria with their respective weights, capturing the imprecision of a decision-maker by an expert (Krohling and Pacheco, 2015; Samvedi et al., 2013).

Thus, in the research first phase, an appraisal was carried out in the literature on studies that dealt with the skills of project managers. After analysing the selected articles, it was evident which soft skills have a considerable impact on the success of the projects (Vale et al., 2018; Gustavsson and Hallin, 2014; Stevenson, 2010; Skulmoski and Hartman; 2010). Thus, based on the researches studied, we selected ten soft skills to ensure that what we wanted to assess would be consistent with the reality of the social actor surveyed (Miles and Huberman, 1994). This choice made it possible to arrive at the criteria for selecting project managers (Table 1), which were mainly based on Pedrosa and Silva (2019), Vale et al. (2018), and Stevenson (2010) researches.

3.2 Procedures of the proposed framework

After choosing the criteria, we moved to a focus group session for validation and weighting of these criteria that would be used to evaluate and select the project managers most suited to the simulated job vacancy. The evaluation took place via a form that presented the ten soft skills as criteria with blank spaces for the interviewees to fill in with a number between 1 and 10, where 1 would be the most relevant criterion and 10 the least relevant. Thus, at the end of the session, we would have the ranking of the ten soft skills by all specialists. The focus group session was attended by ten experts in the field, as follows in the description of Table 2.

Table 2 Description of the experts

	Gender	*Experience time*	*Industry*	*Position*
E1	Female	6 years	Education	Head Brazil
E2	Male	7 years	Education/retail enterprises	Consultant
E3	Male	3 years	Manufacturing	Quality control analyst
E4	Male	15 years	Public service	Computer analyst
E5	Male	20 years	Education	Senior project manager
E6	Male	20 years	Public service	Sector manager
E7	Female	10 years	Information technology	Senior project manager
E8	Male	7 years	Telecommunication	Senior engineer
E9	Female	25 years	Telecommunication	Program manager
E10	Male	9 years	Public service	Project portfolio coordinator

The focus group session lasted 2h30 and comprised three phases. The first phase lasted around 30 minutes. The activity was explained, and all the participants explain their points of view. We used a coffee break to break the ice. After this break, we move on to the second phase of the session. This phase served to discuss the type/context of the project that would be managed and what criteria we would use to select the project managers. In this phase, we promote awareness about the process and the simulated vacancy to be filled. It is worth noting that the project management context described for this job vacancy included dealing with uncertainty, interacting with various stakeholders in person and remotely, applying agile and predictive methods (waterfall), in addition to the ease of incorporating new information and communication technologies.

As a precaution in conducting the activities of this session, the mediators endeavoured so that during all conversations it was possible for the participation of all those involved, thus mitigating or eliminating the possibility that the results would be skewed by the view of a dominant participant (Morgan, 1996; Bloor et al., 2001). We emphasise that the professional maturity of those involved was a determining factor in their choice, which would also ensure that participation was not passive during the session (Krueger and Casey, 2014). In the third and last phase of the session, we proceeded to the ranking assessment of the skills. Initially, all participants were positioned on what were the most important criteria according to their perspectives. Then we move on to the assessment itself. We stress that the choice to expose the preferences of each one of the groups is aligned with the reality of a company, where we know the preferences of our co-workers.

Moderation was carried out by four researchers, where two of them were responsible for observing behaviours of dispersion or detachment from the purpose of the activity, speech monopoly, or other behaviours that would cause noise that would damage the study (Krueger and Casey, 2014). Another researcher was responsible for the timer and time management, so speech time was determined for each specialist at each stage of the session. This researcher was responsible for the homogeneous distribution of the speaking time and participation of all those involved. The fourth researcher involved was responsible for taking notes and signalling us to do whatever intervention was necessary. We emphasise that every care has been taken to ensure the reliability of the data collection process via the focus group session (Krueger and Casey, 2014; Bloor et al., 2001).

Based on this assessment, we arrived at a matrix with the ranking criteria that represents the opinion of each specialist. This information was used to build the ranking of criteria for assigning linguistic variables that represented the weight in fuzzy numbers (Azizi et al., 2015; Yazdani et al., 2019). To treat the criteria ranking matrix, we apply the sum of the points given by each specialist for each criterion that was initially used [equation (1)].

$$\sum_{k=1}^{10} t_{jk} \tag{1}$$

where k represents the number of experts and j criteria. Then, the results of each criterion were averaged, which is represented by equation (2).

$$\overline{t_j} = \frac{\sum_{k=1}^{10} t_{jk}}{10} \tag{2}$$

After finding the value of $\overline{t_j}$ for each criterion, we proceed to order the criteria according to this value. This value represented the t_j element of our study. Thus, we obtained from the data collected in the focus group session the ranking of the criteria with the application of the equations as mentioned earlier. The ranking criteria were first converted into weights based on equation (3), where q is equivalent to the weight of each attribute. We must explain that the application of equation (3) resulted in individual values that comprise a set of values between 0 and 1, and that the sum of these values cannot exceed 1.

$$q_j = \frac{\overline{t_j}}{\sum_{j=1}^{n=10} t_j} \tag{3}$$

The next step included the assignment of weights to the criteria based on fuzzy numbers following the model already adopted by Afshari (2017). Thus, firstly there was a need to normalise the data so that each value represented a number that was identified on the elaborated fuzzy scale (Table 3). It is worth mentioning that the adopted fuzzy scale served to assign linguistic variables and fuzzy variables to be applied as the weight of the criteria and evaluation of the candidates for the simulated job.

Table 3 Linguistic variables for weighting and assessing candidates

Variável Linguística	*Sigla*	*Fuzzy number*
Very high	VH	(0.75; 1.0; 1.0)
High	H	(0.5; 0.75;1.0)
Average	A	(0.25;0.5; 0.75)
Low	L	(0; 0.25; 0.5)
Very low	VL	(0; 0; 0.25)

A number from a fuzzy triangular set can be defined by a tripod with points in a set [a, b, c], where $a_n \leq b_n \leq c_n$ (Dursun and Karsak, 2010). We highlight that the chosen Fuzzy scale followed the same guidelines as the studies by Chen (2000), Dursun and Karsak (2010), Lima Jr. and Carpinetti (2015), and Afshari (2017). In addition, the adoption of triangular fuzzy numbers approximations can be justified by the indication of Karsak (2002), as the author stresses that fuzzy triangular numbers are appropriate for quantifying the vague information about most decision problems including personnel selection. Therefore, already with the chosen scale and criteria with assigned weights, we applied equation (4), which served to normalise the data so that they were represented by a set of fuzzy numbers.

$$N_{qj} = 1 - \left(q_j - min\left(q_{jk}\right) / (max)\left(q_{jk}\right) - min\left(q_{jk}\right)\right) \tag{4}$$

Based on the results of the application of equation (4), weights were assigned to each of the criteria. An important aspect regarding this phase is that normalisation also corresponded to an inversion of the values on the ranking scale since the ranking was performed, taking into account that the closer to the value 1, the more relevant the criterion was. Thus, the application of equation (4) made all the values obtained fit within the Fuzzy scale of Table 3, and the more the normalised value was close to 1, the better the evaluation of the criterion would be.

After the three preliminary phases of preparation for the assessment based on

1 choice of criteria

2 choice of decision-makers

3 establishment of linguistic variables, and fuzzy TOPSIS numbers with their equivalent weights, we move on to the evaluation of candidates.

This stage of the study took into account the values presented in Table 3. Then, we move on to an evaluation simulation of five candidates for a project manager position. We take into account the random assessment of three decision-makers. It is worth mentioning here that this phase did not explore a real case; that is, it is a simulation with evaluations to understand the process built here.

Table 4 Matrix for evaluating the criteria

Criteria	*Communication C1*	*Leadership C2*	*Interpersonal relationship C3*	*Flexibility and creativity C4*	*Empathy C5*	*Conflict management C6*	*Negotiation C7*	*Attitude C8*	*Stress management C8*	*Team management C10*
E1	1	4	6	2	9	7	8	3	10	5
E2	2	1	5	6	10	4	3	8	9	7
E3	2	3	4	5	6	7	8	1	10	9
E4	1	2	4	9	3	6	10	7	8	5
E5	2	1	8	9	10	3	6	4	5	7
E6	1	4	3	5	2	10	8	6	9	7
E7	4	1	5	5	2	7	8	3	10	9
E8	1	2	3	4	6	7	8	5	10	9
E9	10	9	4	3	7	6	5	8	1	2
E10	9	10	5	2	4	8	3	6	1	7

The data obtained from the evaluation of the five candidates by the three evaluators were grouped first in a combined decision matrix. Equation (5) was used for this process of combining the assessments.

$$a_{ij} = \min_k \left\{a_{ij}^k\right\}, b_{ij} = \frac{1}{k}\sum_{k=1}^{k} b_{ij}^k, c_{ij} = \max_k \left\{c_{ij}^k\right\} \tag{5}$$

For the construction of the combined matrix, the assessment based on the linguistic variables attributed to the criteria by each appraiser was taken into account, which was subsequently adjusted for the ‘*a*’, ‘*b*’, and ‘*c*’ positions of the triangular fuzzy numeric set. Equation (5) shows that the ‘*a*’ position of the matrix is obtained by the minimum value; the ‘*b*’ position came from an average of the values in this position; and the ‘*c*’ position from the maximum value of each appraiser at the respective criteria and alternative. From the combined matrix, we proceed to the normalisation of the values obtained. This stage of data processing was performed based on equation (6) to arrive at the normalised fuzzy decision matrix.

$$w_{j1} = \min_k \left\{w_{j1}^k\right\}, w_{j2} = \frac{1}{k}\sum_{k=1}^{k} w_{j2}^k, w_{j3} = \max_k \left\{w_{j3}^k\right\} \tag{6}$$

After normalisation, we moved on to assigning weights for the construction of the weighted normalised fuzzy decision matrix. We use equation (7) in this phase. It is worth noting that all criteria were considered to be beneficial in the evaluation process; however, if any criteria would impair the performance, values should be treated by equation (8). An example of a criterion that can be classified as the cost is the number of resources used to perform a task, because the higher the value of this activity, the less beneficial it is for the evaluation.

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \text{and } c_j^* = \max_i \left\{c_{ij}\right\} (\text{benefit criteria}) \tag{7}$$

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) \text{and } a_j^- = \max_i \left\{a_{ij}\right\} (\text{cost criteria}) \tag{8}$$

Equation (9) was used to calculate the weighted normalised fuzzy decision matrix. In this step, the criteria values for each alternative are multiplied by the respective criteria weights. In the end, we obtain values that represent the attributes of each alternative according to the respective weight attributed by the decision-makers. In the case of this research, the weights assigned during the focus group.

$$\tilde{v}_{ij} = \tilde{r}_{ij} \times w_j$$

$$\tilde{A}_1 \oplus A_2 = (a_1, b_1, c_1) \oplus (a_2, b_2, c_2) = (a_1 * a_2, b_1 * b_2, c_3 * c_2) \tag{9}$$

Equations (10) and (11) were applied to calculate FPIS (fuzzy positive ideal solution) and FNIS (fuzzy negative ideal solution) (Singh and Kaushik, 2018; Li et al., 2016; Zeydan and Çolpan, 2009). Equation (10) takes into account the maximum value, and equation (11) takes into account the minimum value for the weighted normalised fuzzy decision matrix. Thus, the maximum and minimum values of positions ‘*a*’, ‘*b*’ and ‘*c*’ are counted to find A^* and A^-.

$$A^* = \left(v_1^*, v_2^*, ..., \tilde{v}_n^*\right), where\ \tilde{v}_j^* =_i^{m\,ax} \left\{v_{ij3}\right\} \quad (10)$$

$$A^- = \left(v_1^-, v_2^-, ..., \tilde{v}_n^-\right), where\ \tilde{v}_j^- =_i^{max} \left\{v_{ij1}\right\} \quad (11)$$

Equation (12) was applied to calculate the Euclidean distance for each criterion. In this step, the vortex method is used. The Euclidean distance is calculated by the square root of the mean of the differences in the positions '*a*', '*b*' and '*c*' squared. For example, position a_1 is equivalent to position '*a*' of the evaluated criterion for each alternative, and a_2 equals the value for the position '*a*' obtained from equation (11) for A^*. The same process is applied to reach Euclidean distances from A^-.

$$d(\tilde{x}, \tilde{y}) = \sqrt{\frac{1}{3}\left[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2\right]} \quad (12)$$

Therefore, after applying the aforementioned calculations, we built a matrix that allows calculating the distance of each alternative for FPIS and FNIS. To obtain these values, equations (13) and (14) were applied. Thus, the distance vortex between two fuzzy numbers was calculated using the Euclidean method.

$$d_i^* = \sum\nolimits_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^*\right) \quad (13)$$

$$d_i^- = \sum\nolimits_{j=1}^{n} d\left(\overline{v}_{ij}, \overline{v}_j^-\right) \quad (14)$$

With the application of equations (14) and (15), we arrive at a corresponding index for d_i^* and d_i^-. Equation (15) was used to calculate the closeness coefficient (CC) for each alternative.

$$CC_i = \frac{d_i^-}{d_i^- + d_i^*} \quad (15)$$

At the end of the process, we reach a ranking where it is possible to identify the best option among the candidates evaluated. At this stage of the research, it is only necessary to order the alternatives; in this case, the candidates to obtain the ranking of preference for selection according to the soft skills.

4 Results and analysis of the results

The data were analysed using the fuzzy TOPSIS ranked multi-criteria method through the initial ranking based on the experts' answers, which were consolidated in Table 4. We highlight that the answers were obtained during the focus group session, where the interviewees were encouraged to share their views on the criteria and their respective assessments. Remember that all criteria were previously selected.

Based on this information, we move on to the data treatment phase for the fuzzification of the weights shown in Table 5. We use equations (1) and (2) already presented in the methodological procedures section in this data treatment phase.

Table 5 Sum of evaluation averages

Criteria	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*
Sum	33	37	47	50	59	65	67	51	73	67
Mean	3.3	3.7	4.7	5.0	5.9	6.5	6.7	5.1	7.3	6.7
Criteria ranking	1	6	2	5	7	8	4	3	9	10

Table 6 Normalisation of evaluation weights

Criteria	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*
Criteria weight	0.060	0.067	0.086	0.091	0.107	0.118	0.122	0.093	0.133	0.122

Table 7 Normalisation and attribution of fuzzy linguistic variables

Criteria	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*
Data normalisation	1	0.904	0.644	0.575	0.356	0.205	0.151	0.548	0	0.151
Linguistic Variable	VH	VL	H	H	A	VL	VL	H	VL	V

Table 8 Matrix for evaluating candidates

Criteria	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*
					Decision-maker 1					
A1	VH	A	MA	VH	VL	VL	VH	VL	L	L
A2	H	VH	VL	H	A	VL	L	H	H	A
A3	A	VH	L	VL	VL	A	A	L	VH	VL
A4	H	A	VH	L	H	L	VL	VL	VH	A
A5	L	H	L	VH	VH	VH	VL	VL	VH	L
					Decision-maker 2					
A1	L	A	L	VH	L	VL	H	A	VL	VL
A2	H	A	VL	VH	VH	L	VL	VH	VH	A
A3	H	VH	VL	L	L	VH	VL	VL	VH	L
A4	VL	A	VH	L	H	L	VL	VL	VH	A
A5	L	VH	VL	H	H	A	L	L	VH	L
					Decision-maker 3					
A1	A	H	A	A	VL	A	VH	VH	A	L
A2	VH	A	A	H	A	A	A	H	H	VH
A3	VH	H	A	L	L	H	A	L	VH	VL
A4	A	VH	A	VL	H	A	A	A	VH	VL
A5	L	H	A	VH	VH	A	L	A	H	A

Table 9 Combined matrix of values

Candidates (A)	*C1*			*C2*			*C3*			*C4*			*C5*			*C6*			*C7*			*C8*			*C9*			*C10*		
A1	0.000	0.500	1.000	0.250	0.500	0.750	0.000	0.500	1.000	0.750	1.000	1.000	0.000	0.167	0.500	0.000	0.000	0.250	0.500	0.833	1.000	0.000	0.333	0.750	0.000	0.083	0.500	0.000	0.083	0.500
A2	0.500	0.750	1.000	0.250	0.667	1.000	0.000	0.000	0.250	0.500	0.917	1.000	0.250	0.833	1.000	0.000	0.167	0.500	0.000	0.083	0.500	0.500	0.917	1.000	0.500	0.917	1.000	0.250	0.500	0.750
A3	0.250	0.667	1.000	0.750	1.000	1.000	0.000	0.083	0.500	0.000	0.167	0.500	0.000	0.167	0.500	0.250	0.833	1.000	0.000	0.167	0.750	0.000	0.083	0.500	0.750	1.000	1.000	0.000	0.167	0.500
A4	0.000	0.250	1.000	0.250	0.500	0.750	0.750	1.000	1.000	0.000	0.250	0.500	0.500	0.750	1.000	0.000	0.250	0.500	0.000	0.000	0.250	0.000	0.000	0.250	0.750	1.000	1.000	0.250	0.500	0.750
A5	0.000	0.250	0.500	0.500	0.917	1.000	0.000	0.167	0.750	0.500	0.833	1.000	0.500	0.833	1.000	0.250	0.667	1.000	0.000	0.167	0.500	0.000	0.167	0.500	0.750	1.000	1.000	0.000	0.250	0.500

Table 10 Normalised fuzzy decision matrix

Candidates (A)	*C1*			*C2*			*C3*			*C4*			*C5*			*C6*			*C7*			*C8*			*C9*			*C10*		
A1	0.000	0.500	1.000	0.250	0.500	0.750	0.000	0.500	1.000	0.750	1.000	1.000	0.000	0.167	0.500	0.000	0.000	0.250	0.500	0.833	1.000	0.000	0.333	0.750	0.000	0.083	0.500	0.000	0.111	0.667
A2	0.500	0.750	1.000	0.250	0.667	1.000	0.000	0.000	0.250	0.500	0.917	1.000	0.250	0.833	1.000	0.000	0.167	0.500	0.000	0.083	0.500	0.500	0.917	1.000	0.500	0.917	1.000	0.333	0.667	1.000
A3	0.250	0.667	1.000	0.750	1.000	1.000	0.000	0.083	0.500	0.000	0.167	0.500	0.000	0.167	0.500	0.250	0.833	1.000	0.000	0.167	0.750	0.000	0.083	0.500	0.750	1.000	1.000	0.000	0.222	0.667
A4	0.000	0.250	1.000	0.250	0.500	0.750	0.750	1.000	1.000	0.000	0.250	0.500	0.500	0.750	1.000	0.000	0.250	0.500	0.000	0.000	0.250	0.000	0.000	0.250	0.750	1.000	1.000	0.333	0.667	1.000
A5	0.000	0.250	0.500	0.500	0.917	1.000	0.000	0.167	0.750	0.500	0.833	1.000	0.500	0.833	1.000	0.250	0.667	1.000	0.000	0.167	0.500	0.000	0.167	0.500	0.750	1.000	1.000	0.000	0.333	0.667

Thus, after obtaining the results of equation (2), we ordered the data so that they were ranked, taking into account the degree of relevance attributed by the specialists. The values obtained were converted into weights by the application of equation (3), as shown in Table 6. This phase objective is the criteria fuzzification to be used for the candidates' evaluation. As already highlighted, the values obtained in this phase correspond to a set of values between 0 and 1, it is noted that the sum of these values cannot exceed 1.

After the distribution of the weights of the evaluation criteria, we proceed to fuzzification of these weights following triangular fuzzy numbers approximations, which is the model already used by Afshari (2017). For this phase, we use the scale shown in Table 3 and equation (4). We must remember that normalisation also corresponds to an inversion of the values on the ordering scale, since the ranking was performed, taking into account that the closer to value 1, the more relevant was the criterion.

The values obtained in this phase represent an assessment of the contribution of each criterion within the adopted fuzzy scale (Table 3). We start from the understanding that within the logic of sets of fuzzy numbers, the criteria have a level of belonging in the evaluation. This perspective is anchored in studies such as those by Chen (2000), Dursun and Karsak (2010), Lima and Carpinetti (2015), and Afshari (2017). Table 7 represents the results of this calculation.

At this stage, the weights obtained by the experts' assessment were converted to the fuzzy scale shown in Table 3. This process allows the use of the natural ranking from 0 to 10, usually understood by the interviewees. Based on the fuzzified weights and with the scale for evaluation already determined, we move on to the candidates' evaluation phase. We adopted here a simulation process with random data taking into account the information previously obtained in the focus group phase. We established for this evaluation simulation three evaluators and five candidates, as shown in Table 8. We clarify that no specific software was used for simulation; we adopted Excel to support the application and data treatment. Candidates are here referred to in the review process as alternatives (A1...A5).

The values shown in Table 8 correspond to the three evaluators' results. It should be noted that the three simulated evaluators assess five candidates using the soft skills previously selected. At this stage, each candidate must receive a score for the 10 criteria represented by the soft skills by each of the evaluators. The grades used are the linguistic variables shown in Table 3. Thus, the values were obtained by applying the linguistic variables previously established. These values went through defuzzification, i.e., the values were converted into Fuzzy numerical sets. Thus, after obtaining the numerical matrices, equation (5) was applied, whose function is to build a combined matrix of values presented in Table 9.

Therefore, from the fuzzified matrix, we constituted the combined matrix that, for each criterion (C1…C10), the minimum, average and maximum values points are determined based on the experts' evaluations using the linguistic variables. This process used equation (5). After obtaining the combined matrix, we proceed to the normalisation of the values with the application of equation (6). The results of this treatment phase allow us to arrive at the normalised fuzzy decision matrix, shown in Table 10.

Therefore, with the combined matrix formulated and the results presented in Table 9, we proceeded to the matrix normalisation, where we normalised the results between the alternatives to present the respective representation of the fuzzy numbers in Table 10.

Table 11 Weighted normalised fuzzy decision matrix

Candidates (A)	*C1*			*C2*			*C3*			*C4*			*C5*			*C6*			*C7*			*C8*			*C9*			*C10*		
A1	0.000	0.500	1.000	0.063	0.250	0.563	0.000	0.500	1.000	0.563	1.000	1.000	0.000	0.000	0.125	0.000	0.000	0.063	0.375	0.833	1.000	0.000	0.000	0.188	0.000	0.021	0.250	0.000	0.028	0.333
A2	0.375	0.750	1.000	0.063	0.333	0.750	0.000	0.000	0.250	0.375	0.917	1.000	0.000	0.000	0.250	0.000	0.000	0.125	0.000	0.083	0.500	0.000	0.000	0.250	0.000	0.229	0.500	0.000	0.167	0.500
A3	0.188	0.667	1.000	0.188	0.500	0.750	0.000	0.083	0.500	0.000	0.167	0.500	0.000	0.000	0.125	0.000	0.000	0.250	0.000	0.167	0.750	0.000	0.000	0.125	0.000	0.250	0.500	0.000	0.056	0.333
A4	0.000	0.250	1.000	0.063	0.250	0.563	0.563	1.000	1.000	0.000	0.250	0.500	0.000	0.000	0.250	0.000	0.000	0.125	0.000	0.000	0.250	0.000	0.000	0.063	0.000	0.250	0.500	0.000	0.167	0.500
A5	0.000	0.250	0.500	0.125	0.458	0.750	0.000	0.167	0.750	0.375	0.833	1.000	0.000	0.000	0.250	0.000	0.000	0.250	0.000	0.167	0.5000	0.000	0.005	0.120	0.000	0.250	0.50	0.000	0.083	0.333

Table 12 FPIS (A^*) and FNIS (A^-)

Criteria	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*
A*	0.375, 0.750, 1.000	0.188, 0.500, 0.750	0.563, 1.000, 1.000	0.563, 1.000, 1.000	0.000, 0.000, 0.250	0.000, 0.000, 0.250	0.375, 0.833, 1.000	0.000, 0.000, 0.250	0.000, 0.250, 0.500	0.000, 0.167, 0.500
A–	0.000, 0.250, 0.500	0.063, 0.250, 0.563	0.000, 0.000, 0.250	0.000, 0.167, 0.500	0.000, 0.000, 0.125	0.000, 0.000, 0.063	0.000, 0.000, 0.250	0.000, 0.000, 0.063	0.000, 0.021, 0.250	0.000, 0.028, 0.333

Table 13 Values of di* for candidates

Candidates (A)	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*di**
A1	0.3227	0.1943	0.4345	0.0000	0.0722	0.1083	0.0000	0.0361	0.1958	0.1253	1,489
A2	0.0525	0.1203	0.7914	0.1185	0.0000	0.0722	0.5637	0.0000	0.012	0.0000	1,730
A3	0.1296	0.0000	0.6848	0.6483	0.0722	0.0000	0.4646	0.0722	0.0000	0.1156	2,187
A4	0.3608	0.1943	0.0000	0.6134	0.0000	0.0722	0.6825	0.1083	0.0000	0.0000	2,032
A5	0.4966	0.0434	0.4436	0.1448	0.0000	0.0000	0.5276	0.0722	0.0000	0.1076	1,836

Table 14 Values of di- for candidates

Candidates (A)	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*di–*
A1	0.3227	0.0000	0.5204	0.6483	0.0000	0.0000	0.6825	0.0722	0.0000	0.0000	2,246
A2	0.4621	0.1185	0.0000	0.5637	0.0722	0.0361	0.1521	0.1083	0.1879	0.1253	1,826
A3	0.3911	0.1943	0.1521	0.0000	0.0000	0.1083	0.3043	0.0361	0.1958	0.0160	1,398
A4	0.3412	0.000	0.7914	0.0481	0.0722	0.0361	0.0000	0.0000	0.1958	0.1253	1,610
A5	0.000	0.1658	0.3043	0.5276	0.0722	0.1083	0.1735	0.0361	0.1958	0.0321	1,616

Based on the data obtained from the application of equation (7), we proceeded to calculate the weighted normalised fuzzy decision matrix, where equation (9) was used. It is worth noting that all criteria were considered to be beneficial in the evaluation process. However, if any criteria would cause a loss in performance, the values should be treated by equation (8). We emphasise that this phase aims to generate a matrix that will serve for the final phase of calculating the indices that allow us to evaluate the best alternative based on the ten previously determined criteria. The matrix generated from the application of equation (9) is shown in Table 11.

We emphasise that with the application of the respective weights of each criterion, the process is balanced and comes close to an evaluation by the experts' preferences based on the reality dealt with. The weighted normalised fuzzy decision matrix data were used to calculate the FPIS (A^*) and FNIS (A^-). For this calculation, equations (10) and (11) were applied. The values of A^* are obtained by the value of the high fuzzy number for each criterion, starting with the last value, and in the case of a tie, we are going to the second and then to the first, respectively. In the case of A^- values, an inverse relation is applied, seeking the lowest value. The values of FPIS and PNIS are shown in Table 12.

The results presented in Table 12 originate from the FPIS and FNIS calculations, which allow the calculation of the Euclidean distance of each of the alternatives using the vortex method. The calculation of the Euclidean distance is based on the square root of the mean of the differences of the three squared points.

Thus, equation (12) was applied to calculate the Euclidean distance for each criterion. In addition to this calculation, to obtain the distance of each alternative for FPIS and FNIS, equations (13) and (14) were applied. Thus, the distance vortex between the fuzzy numbers uses as a method Euclidean. In Table 13, the application of equation (13) is presented, whichallowed reaching each candidate's di*.

It is worth noting that the values of di* represent on Table 13 the superior values of each alternative, in this case, the candidates that are being evaluated according to the predetermined competencies (C1…C10). In this same sense, Table 14 demonstrates the application of equation (14), allowing arrive at each candidate respective di-. The results presented in this table correspond to the lower values obtained.

After obtaining the values presented in Tables 13 and 14, we move on to the final phase that comprises the application of equation (15). This phase involves obtaining the CCi of each alternative, here representing the evaluated candidates presented in Table 15.

Table 15 Final ranking for candidate selection

Candidates (A)	*di**	*di–*	*Cci*	*Rank*
A1	1,489	2,246	0.601	1
A2	1,730	1,826	0.513	2
A3	2,187	1,398	0.390	5
A4	2,032	1,610	0.442	4
A5	1,836	1,616	0.468	3

By analysing the obtained Cci values, it is possible to evaluate the position dispersion between the candidates, i.e., the evaluated alternatives. We can see that this distance between candidates and their respective position in the ranking of alternatives serve as parameters to understand the qualification level according to the premises used at the beginning of this study. Thus, this distance demonstrates how much each candidate is able to take on a position that needs the skills determined here with their respective weights.

Therefore, based on the results presented, we can infer that the best alternative is candidate A1 and the worst placed A3. The present study used the fuzzy TOPSIS method as an alternative to models that establish a Boolean relationship between the elements. In addition to understanding which is the best alternative, it is also possible to identify the degree of belonging of the alternative to the proposed assessment.

5 Discussion

Based on the results presented, we can indicate which is the best alternative among the various candidates to manage projects in a given context. In the case explored here, we had a job vacancy for a project manager and five candidates. As highlighted by Fernandez and Fernandez (2008) and Guinan et al. (2019), the skills of managers and the insertion of new technologies in the work environment make this process more complicated. Gruden and Stare (2018) indicate that understanding the skills of the project manager leads to increasing the performance of the projects. In this way, the use of the framework exposed here allowed for a selection of the criteria and consequently properly evaluate the candidates with the weights assigned to the criteria.

It is worth emphasising that we use previously selected criteria; however, in new applications, researchers and practitioners can use other criteria. Thus, on another occasion, we could use a greater or lesser number of criteria, decrease or increase the number of candidates, which would depend on the reality of each organisation and job vacancies to be filled. One aspect that should be highlighted in this study is that the choice to build a framework for assessing the soft skills of project managers using fuzzy set logic was due to the level of subjectivity present in this type of skill. In addition, we reinforce that although this framework requires a reasonable number of steps, its application is relatively simple and adaptable. This is a relevant contribution for practitioners and scholars of the subject. As Boyd and Jiao-Zong (1991) pointed out, using the evaluation of several experts to select professionals is beneficial, but it is also costly and difficult to implement many times.

The use of the focus group session at the beginning of the process allows the teams and managers to understand which are the main criteria to be applied given the organisational context. In addition, the initial ranking and discussions made it possible to refine the choice of criteria and the allocation of the respective weights. This last aspect also has a relevant characteristic regarding the contribution of the proposed framework, and the ability to capture the subjectivity and the points of view of decision-makers in a natural way of this instrument makes it adaptable to different organisational realities. Therefore, we can say that each organisation has a reality that will be explained by its specialists and represented in the steps described in this framework.

Another critical point to be stressed is that subjective criteria could be assessed more objectively. Despite the initial use of ranking and after linguistic variables, the evaluations are adapting to the best solution as we apply each of the equations presented here. Thus, at the end of the data processing process, we have a ranking based on the fuzzy TOPSIS-ranked-multi-criteria framework application. This framework allows not only to understand which the best alternative is but also to know the degree of differences between them. Table 15 shows the ranking of candidates and the difference in the values assigned between them.

6 Conclusions

We consider that the objective was achieved because it was possible to present a framework that allows selecting project managers based on their soft skills. Because of the procedures presented here, we recognise the framework described as fuzzy TOPSIS ranked multi-criteria.

The ranking was adopted because of the ease with which people in the organisation establish ranks of their activities and people. People in the project management area are used to ordering and assigning values to the various manageable elements. Concerning this aspect, a contribution of this study is to allow the attribution of values to soft skills that carry a high degree of subjectivity. This activity was possible due to the ease of using fuzzy sets. Another contribution of the proposed framework is the ease of application, the low investment required, in addition to adaptability to different situations and contexts.

We can say that a limitation of this study lies in the non-application in a practical case, mainly in the form of a longitudinal study, which would allow monitoring the evaluation process and then the performance verification of the proposed framework. Based on this limitation, we suggest for future studies its application in longitudinal studies in combination with other methods for possible verification of its efficiency.

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