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Project portfolio selection criteria in the oil & gas industry and a decision support tool based on fuzzy Multimoora

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A B S T R A C T

Considering the acceleration in the development of alternative energy sources due to climate change and the net zero carbon commitments made in this direction, there are different assessments of how the capacity of the refining industry will change in the next two decades. Refinery companies are trying to adapt to altering conditions while also trying to determine their investment strategies. Project portfolio selection problem is one of the relevant issues to be considered in line with these changes. In this article, research has been undertaken to determine which criteria refinery companies take into consideration while selecting their project portfolios. Based on the identified criteria, it is also aimed to carry out a study that will guide sector practitioners in project selection. For this purpose, interviews were conducted with industry experts. The criteria were accredited by applying categorical content analysis to the data obtained and their importance weights were identified accordingly. The most deterministic criteria were abstracted from the findings and applied to a multi-criteria decision-making (MCDM) framework, namely fuzzy MULTIMOORA to suggest a decision support tool that ranks the projects against themselves. Some of the prominent outcomes of the study are also discussed, along with the previous studies and comparative results of the proposed decision support tool.

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1. Introduction

Nowadays, the widely accepted policy of transition to a low-carbon economy and the associated industry climate commitments, developments in renewable energy, and changing consumer preferences present significant challenges and opportunities for the oil refining industry. Different energy transition scenarios, reflecting possible responses of the sector to this challenging environment, reveal a broad range of estimates for the size of the global refining industry by 2040. The total distillation capacity projected in these scenarios ranges from a 7% increase to a 23% decrease (Ding et al., 2022). Industry executives are trying to determine their company strategies in the face of these changing conditions and to support these strategies with appropriate investments. Moreover, as these investments involve costly and complex projects requiring a high level of engineering and construction quality, the decision-making process should be conducted diligently, taking into account all the necessary parameters. Therefore, decision-makers in the industry are facing a project portfolio selection (PPS) problem, possibly more difficult than ever before, where they have to consider multiple selection criteria among various project alternatives.

Selecting the right projects among various alternatives is one of the most crucial tasks of company executives. The main objective of this process is to determine the optimal project portfolio that will provide maximum value for the organization (Jafarzadeh et al., 2018). This selection process is a typical multi-criteria decision-making (MCDM) problem among projects with various attributes (Ghasemzadeh et al., 1999).

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The PPS problem is a subject that has been studied by many researchers so far. Although some studies have been conducted before, the number on this subject started to increase in the 2000s and most of them were carried out after 2010 (Mohagheghi et al., 2019). It is observed that mathematical programming methods were used at the beginning. Subsequently, in parallel with the developments, metaheuristic methods and MCDM methods started to be used. There are also studies in literature where mixed methods were used.

The first examples of mathematical programming on the subject were given with linear programming starting in the 1980s. Golabi et al. (1981) studied the portfolio selection of solar energy projects by formulating the problem as an integer linear program. Ghasemzadeh et al. (1999) proposed a zero-one integer linear programming model as a general solution for optimal portfolio selection. Hassanzadeh et al. (2014) developed a model for R&D project portfolio selection using multi-objective binary integer linear programming for the case where both objective functions and constraints contain uncertainty. Yan and Ji (2018) studied the optimal portfolio selection using uncertainty theory for oil projects since the cash flows of projects are mostly determined by forecasts of experts due to the lack of historical investment data. As fuzzy set theory has started to be used in mathematical programming methods, studies have been carried out with this approach for the PPS problem. Carlsson et al. (2007) proposed a fuzzy mixed integer programming model to select the most appropriate portfolio among R&D projects. Wang and Hwang (2007) also formulated a fuzzy zero-one integer linear programming model that can handle uncertain and flexible parameters for the R&D portfolio selection problem. Perez and Gomez (2016) proposed a general nonlinear binary multi-objective mathematical model with fuzzy constraints for the PPS problem that takes into account the most important factors mentioned in the literature on this subject.

Among the publications on PPS, there are also studies that examine the problem using metaheuristics methods. Doerner et al. (2004) used Pareto Ant Colony Optimization to solve the PPS problem and compared the computational performance of this method with some other heuristic approaches. Rabbani et al. (2010) used Particle Swarm Optimization to address the PPS problem where total cost and risk are minimized while maximizing total benefits. Kumar et al. (2018) used Teaching Learning Based Optimization (TBLO) and TABU search methods both separately and in a hybrid form and compared the performance of these three algorithms on the PPS problem.

Regarding studies including MCDM methods, Huang et al. (2008) used the fuzzy Analytical Hierarchy Process (AHP) method while selecting R&D projects for the Taiwan Industrial Technology Development Program. Collan and Luukka (2013) used the fuzzy Technique for the Order of Prioritization by Similarity to Ideal Solution (TOPSIS) method to evaluate R&D projects, and Rouyendegh and Erol (2012) used the fuzzy Elimination and Choice Translating Reality (ELECTRE) method to select the best project. Similar studies such as Relich and Pawlewski (2017) utilized a weighted fuzzy set approach, while Yang et al. (2015) and Song et al. (2019) utilized Stochastic Multi-Attribute Acceptability Analysis (SMAA) methods.

Tavana et al. (2015) preferred mixed methods for the PPS problem in their study. Data envelopment analysis was used in the initial filtering stage of the projects, then the selected projects were ranked with the fuzzy TOPSIS method, and the most suitable projects for the project portfolio were determined with linear programming. Yu et al. (2012) used the genetic algorithm method to maximize the objective function determined by the Multi-Attribute Utility Theory (MAUT) method. Khalili-Damghani et al. (2013) first reduced the number of projects to be optimized using TOPSIS and then used fuzzy goal programming to select the project portfolio. Jafarzadeh et al. (2018) evaluated the criteria with the fuzzy Quality Function Deployment (QFD) and prioritized the projects with data envelopment analysis. In the studies conducted by Mohagheghi and Mousavi (2019) for high-tech projects and Mohagheghi et al. (2021) for large-scale construction projects, the alternatives were first evaluated using the Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA) ratio approach extended with the Pythagorean fuzzy set and then Weighted Aggregated Sum Product Assessment (WASPAS) was used to determine the project rankings.

This study aims to contribute constructively to the PPS problem from a special perspective, focusing on the oil refinery industry. Based on the lack of references on this specific subject, the purpose is to complement the literature from this point of view. In the first phase of the study, PPS criteria in the refinery industry were identified based on the interviews conducted among experts. Section 2 explains the methodology used in the study, while Section 4 presents the detailed results. The results are intended to make a significant and progressive scientific contribution to the sector and similar studies. In the second phase, a decision support tool was generated by utilizing the identified criteria. The fuzzy MULTIMOORA multi-criteria decision-making method, which has not been applied to the research subject before, is preferred for this purpose. Section 3 gives the theoretical background, while Section 5 explains the details of the fuzzy MULTIMOORA implementation. Finally, decision support tool results obtained from a case study of 10 empirical projects are discussed in Section 6.

2. Methodology

Semi-structured interview technique was conducted with subject matter experts to determine the project portfolio selection criteria. The questions asked during the interview were determined by taking into account the comments of academicians with experience in this type of research. Two sample interviews were conducted, and final adjustments were made in line with the evaluations of the interviewees. The list of potential interviewees was determined by purposive sampling and the interview phase started. Once the interviews were completed, the data was analyzed using a categorical content analysis method and criteria were established. To see the consistency of the results obtained, the same analysis was carried out by a second independent evaluator. When the results were compared, a similarity of 97% was observed. The identified criteria were applied to an MCDM based on fuzzy MULTIMOORA. Unlike previous fuzzy MULTIMOORA applications, fuzzy importance weightings are applied in the method. Project rankings between the various alternatives were calculated using collated sample project data. Since MULTIMOORA is a combination of three methods, two ranking methods, the Dominance-Directed Graph and the Rank Position Method, were used to obtain a single project ranking that combines the results of each component of MULTIMOORA. The findings are discussed, and recommendations are made for the method.

3. The Multimoora method

3.1. The crisp Multimoora method

The basis of this method is the MOORA method proposed by Brauers and Zavadskas (2006). The MOORA method is a combination of two different analyses. The first one, namely Ratio Analysis, is based on an optimization that processes the responses of alternatives on certain objectives. The results are compared with a second solution made with the Reference Points Approach. Later, the structure built on the binary analysis was strengthened with the Full Multiplicative Form approach and named MULTIMOORA (Brauers and Zavadskas, 2010). The main purpose of this extension is to achieve a more robust structure than methods that use a single analysis (Brauers and Zavadskas, 2012; Balezentis and Balezentis, 2014). Finally, the theory of dominance is proposed to arrive at a single ranking from the three rankings obtained from each approach of MULTIMOORA (Brauers and Zavadskas, 2011). Fig. 1 shows the structure of the MULTIMOORA method.

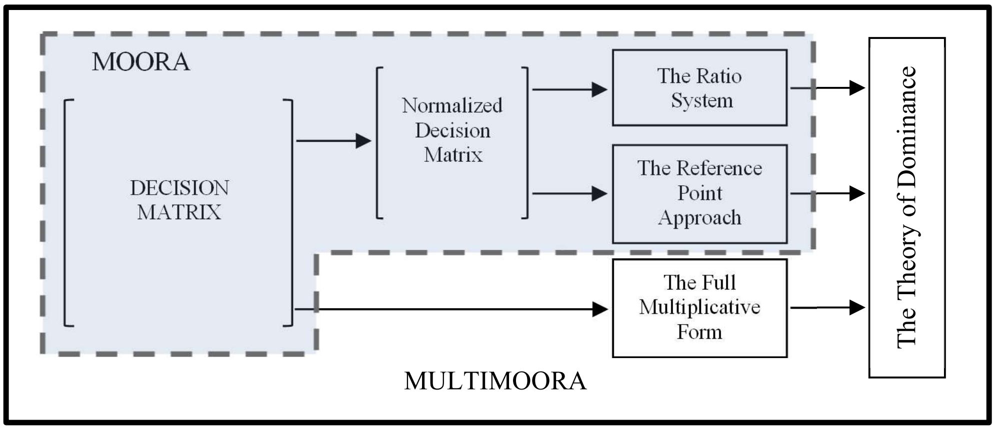

Fig. 1. The structure of the Multimoora method.

3.1.1. The ratio analysis

In the first step of the Ratio System, a decision matrix *X* is formed showing the responses of the alternatives on the objectives as shown in Eq. (1) (Brauers et al., 2008).

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1j} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots & \iddots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \iddots & \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mi} & \cdots & x_{mn} \end{bmatrix} \tag{1}$$

In *X* matrix, x_{ij} denotes the response of alternative *i* on objective *j* where *m* is the number of alternatives (i = 1, 2, 3,…, m) and *n* is the number of objectives (j = 1, 2, 3,…, n). The second step is the formation of the normalized decision matrix. In the normalization process, a vector normalization approach is preferred where the denominator is equal to the square root of the sum of the squares of the responses of each alternative per objective. When calculating the ${}_N x_{ij}$ normalized responses, the x_{ij} responses are divided by the denominator of objective *j* that applies to all alternatives. ${}_N x_{ij}$ values are dimensionless and range between [0,1]. Eq. (2) is the calculation formula of the normalized decision matrix:

$${}_N x_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{2}$$

where ${}_Nx_{ij}$ denotes the normalized response of alternative *i* on objective *j*. When comparing alternatives, the highest response is preferred for some objectives, while the lowest response is preferred for others. For example, in a comparison between mobile phones, it is preferred that the camera resolution is high, and the price is low. Therefore, in the third step, the ${}_Ny_i$ values of each alternative are calculated by adding the normalized values of the objectives that are desired to be maximum (beneficial) and subtracting the normalized values of the objectives that are desired to be minimum (non-beneficial). The ranking of the calculated ${}_Ny_i$ values from largest to smallest will give the ranking of the alternatives among themselves. Eq. (3) gives the normalized assessment values of alternatives:

$${}_Ny_i = \sum_{j=1}^{g} {}_Nx_{ij} - \sum_{j=g+1}^{n} {}_Nx_{ij} \tag{3}$$

where ${}_Ny_i$ denotes normalized assessment of alternative *i* with respect to all objectives, *g* is the number of beneficial objectives (*j* = 1, 2, 3,…, *g*) and *n-g* is the number of non-beneficial objectives (*j* = g+1, g+2, g+3,…, *n*). In some cases, there may be differences between the importance of objectives. In this case, the Significance Coefficient of each objective can be taken into account while calculating ${}_Ny_i$ values (Brauers and Zavadskas, 2011) as in Eq. (4):

$${}_Ny_i = \sum_{j=1}^{g} w_j\, {}_Nx_{ij} - \sum_{j=g+1}^{n} w_j\, {}_Nx_{ij} \tag{4}$$

where w_j is the Significance Coefficient of objective *j*.

3.1.2. The reference point approach

The second analysis used in the method is the Reference Point Approach. For this purpose, r_j reference points are determined for each objective in the first step. The selection of reference points is based on the values in the normalized decision matrix (Brauers et al., 2008). If the objective is beneficial, the maximum ${}_Nx_{ij}$ value for that objective among the alternatives is accepted as the reference point. If the objective is non-beneficial, the minimum ${}_Nx_{ij}$ value of that objective among the alternatives becomes the reference point. In the second step, the distances between each ${}_Nx_{ij}$ value and relevant r_j reference point are calculated, and the most ideal alternative is found by applying the Tchebycheff min-max approach (Mohammadi et al., 2012) given in Eq. (5) to the new matrix formed by the distances. In other words, the maximum distance of each alternative to the target reference points is found and the alternative with the minimum distance is considered as the most ideal alternative. The ranking from the smallest to the largest also determines the ranking among the alternatives.

$$\min_i \left\{ \max_j (w_j\, |r_j - {}_Nx_{ij}|) \right\} \tag{5}$$

3.1.3. The full multiplicative form

A utility function may contain a multiplicative utility component as well as the additive utility of them. In this case, the two-dimensional $u(y,z)$ function can be defined as a multilinear utility function such as Eq. (6) (Keeney & Raiffa, 1993).

$$\mathrm{u}(y,z) = k_y u_y(y) + k_z u_z(z) + k_{yz} u_y(y) u_z(z) \tag{6}$$

If k_{yz} is equal to zero, the function turns into an additive form, whereas if k_{yz} is greater than zero, it also includes the multiplicative component. However, if the coefficient k_{yz} is large enough, the multiplicative component in the function will become too dominant compared to the additive part and may bias the result. Given this condition, a method to include the multiplicative form is preferable to be non-linear, does not contain a summative form, does not use weights, and does not require normalization. However, if it is desired to stress the importance of an objective, a significance coefficient can be used as an exponent, provided that it is done unanimously or at least with a strong consensus of the parties concerned (Brauers and Zavadskas, 2010). Brauers and Zavadskas (2010) proposed the form with this approach in Eq. (7) and called it the Full Multiplicative Form to avoid confusion with other forms that may contain additive parts. The ranking is obtained by ordering the calculated U_i values which donate the total utility value of alternative *i* from largest to smallest.

$$U_i = \prod_{j=1}^{n} x_{ij} \tag{7}$$

If the objectives consist of beneficial and non-beneficial criteria, the full multiplicative form is proposed as Eq. (8):

$$U_i' = \frac{A_i}{B_i} \tag{8}$$

where $A_i = \prod_{j=1}^{g} x_{ij}$ denotes the product of objectives of *i*th alternative to be maximized with *g* being the number of beneficial objectives (*j* = 1, 2, 3,…, *g*) and $B_i = \prod_{j=g+1}^{n} x_{ij}$ denotes the product of objectives of *i*th alternative to be minimized with *n-g* being the number of non-beneficial objectives (*j* = g+1, g+2, g+3,…, *n*).

If the Significance Coefficient is applied to the objectives, the calculations are made as Eq. (9) and Eq. (10) where w_j is the Significance Coefficient of objective *j*.

$$A_i = \prod_{j=1}^{g} x_{ij}^{w_j} \tag{9}$$

$$B_i = \prod_{j=g+1}^{n} x_{ij}^{w_j} \tag{10}$$

3.1.4. The theory of dominance

Since MULTIMOORA is a method using three different approaches, it is necessary to reach a single ranking based on the three different rankings generated in these approaches. When the number of alternatives is small, the final ranking can be determined in a summary table. However, this is not easy to do when there are many alternatives, so Brauers et al. (2011) developed the theory of dominance. This theory uses the concepts of Dominance (absolute dominance, general dominance), Transitiveness, and Equability (absolute equability, partial equability, circular reasoning) to arrive at a single ranking.

3.2. The fuzzy Multimoora method

The first application of fuzzy logic theory to the MULTIMOORA method was made by Brauers et al. (2011). Subsequently, Balezentis et al. (2012a) extended this application to include linguistic variables and group decision-making. In both studies, the triangular fuzzy number form shown in Fig. 2 is preferred.

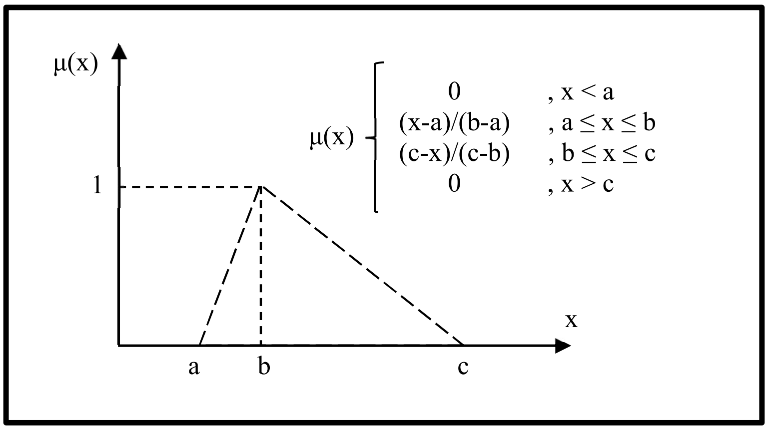

Fig. 2. Membership function of a triangular fuzzy number $\widetilde{A} = (a, b, c)$.

The basic operations of the method are as follows (Balezentis et al., 2012a). Let $\widetilde{A} = (a, b, c)$ and $\widetilde{B} = (d, e, f)$ are two positive fuzzy numbers, main algebraic operations are shown in Eq. (11), Eq. (12), Eq. (13) and Eq. (14).

$$\widetilde{A} \oplus \widetilde{B} = (a, b, c) \oplus (d, e, f) = (a + d, b + e, c + f) \tag{11}$$

$$\widetilde{A} \ominus \widetilde{B} = (a, b, c) \ominus (d, e, f) = (a - d, b - e, c - f) \tag{12}$$

$$\widetilde{A} \otimes \widetilde{B} = (a, b, c) \otimes (d, e, f) = (a \text{ x } d, b \text{ x } e, c \text{ x } f) \tag{13}$$

$$\widetilde{A} \oslash \widetilde{B} = (a, b, c) \oslash (d, e, f) = (a / d, b / e, c / f) \tag{14}$$

The distance between these two numbers is calculated according to the vertex method as given in Eq. (15).

$$d(\widetilde{A}, \widetilde{B}) = \sqrt{\frac{1}{3}[(a-d)^2 + (b-e)^2 + (c-f)^2]} \tag{15}$$

The centered method (center of area) is preferred for defuzzification. Accordingly, the best non-fuzzy performance value (BNP) is calculated by Eq. (16).

$$\text{BNP } \widetilde{A} = \frac{(c-a)+(b-a)}{3} + a \tag{16}$$

3.2.1. The fuzzy ratio system

Let decision matrix $\tilde{X}$ with $\tilde{x}_{ij} = (x_{ij}\ , x_{ij2}, x_{ij3})$ consists of the responses of alternatives on objectives. In this case, Eq.

(17), Eq. (18), and Eq. (19) are applied for the fuzzy ratio system (Balezentis et al., 2012b).
Eq. (17) Normalization of the decision matrix

$$_N\tilde{x}_{ij} = \left({_N}x_{ij1}\ ,{_N}x_{ij2}\ ,{_N}x_{ij3}\right) = \begin{cases} {_N}x_{ij1} & = \dfrac{x_{ij1}}{\sqrt{\sum_{i=1}^{m}\left[\left(x_{ij1}^2 + x_{ij2}^2 + x_{ij3}^2\right)\right]}} \\ {_N}x_{ij2} & = \dfrac{x_{ij2}}{\sqrt{\sum_{i=1}^{m}\left[\left(x_{ij1}^2 + x_{ij2}^2 + x_{ij3}^2\right)\right]}} \\ {_N}x_{ij} & = \dfrac{x_{ij3}}{\sqrt{\sum_{i=1}^{m}\left[\left(x_{ij1}^2 + x_{ij2}^2 + x_{ij3}^2\right)\right]}} \end{cases}, \quad \forall i,j. \tag{17}$$

Eq. (18) Calculation of $_N\tilde{y}_i$ values

$$_N\tilde{y}_i = \sum_{j=1}^{g} {_N}\tilde{x}_{ij} \ominus \sum_{j=g+1}^{n} {_N}\tilde{x}_{ij} \tag{18}$$

Eq. (19) Defuzzification of $_N\tilde{y}_i$= $({_N}y_{i1},\ {_N}y_{i2},\ {_N}y_{i3})$ and calculation of BNP_i value

$$BNP_i = \frac{({_N}y_{i3} - {_N}y_{i1}) + ({_N}y_{i2} - {_N}y_{i1})}{3} + {_N}y_{i1} \tag{19}$$

The ranking of the alternatives is constituted by sorting the BNP_i values from largest to smallest.

3.2.2. The fuzzy reference point approach

Fuzzy reference points $\tilde{r}_j$ for each objective are determined from the normalized fuzzy values found by Eq. (17) (Balezentis et al., 2012b). Eq. (20) is used in the case of a beneficial objective and Eq. (21) is used in the case of a non-beneficial objective.

$$\tilde{r}_j = \left(\max_i {_N}x_{ij1}, \max_i {_N}x_{ij2}, \max_i {_N}x_{ij3}\right) \tag{20}$$

$$\tilde{r}_j = \left(\min_i {_N}x_{ij1}, \min_i {_N}x_{ij2}, \min_i {_N}x_{ij3}\right) \tag{21}$$

The optimal alternative is found by applying the Tchebycheff min-max approach given in Eq. (22) to the new matrix formed by calculating the distances of each response in the normalized decision matrix from the relevant reference point with Eq. (15).

$$\min_i \left\{\max_j d\left(\tilde{r}_j, {_N}\tilde{x}_{ij}\right)\right\} \tag{22}$$

3.2.3. The fuzzy full multiplicative form

The fuzzy full multiplicative form is implemented by Eq. (23) (Balezentis et al., 2012b).

$$\tilde{U}_i' = \tilde{A}_i \oslash \tilde{B}_i \tag{23}$$

In Eq. (23), $\tilde{A}_i$ is the total fuzzy utility value of the objectives to be maximized where $\tilde{A}_i = (\tilde{A}_{i1},\ \tilde{A}_{i2},\ \tilde{A}_{i3}) = \prod_{j=1}^{g} x_{ij}$ with g being the number of beneficial objectives and $\tilde{B}_i$ is the total fuzzy utility value of the objectives to be minimized where $\tilde{B}_i = \left(\tilde{B}_{i1},\ \tilde{B}_{i2},\ \tilde{B}_{i3}\right) = \prod_{j=g+1}^{n} x_{ij}$ with *n-g* being the number of non-beneficial objectives.

Since $\tilde{U}_i'$ is a fuzzy number, BNP_i value is found by defuzzification for each alternative. The alternatives are ranked according to the BNP_i values from largest to smallest.

3.3. Ranking methods

Dominance Theory has been proposed together with MULTIMOORA to rank alternatives. However, it is not easy to automate, and many alternatives could receive the same ranking due to the circular reasoning approach (Hafezalkotob et al., 2019). In this study, the Dominance-Directed Graph (DDG) and Rank Position Method (RPM) are preferred as ranking methods instead of dominance theory.

3.3.1. Dominance-directed graph

This method is also known as the tournament method (Altuntaş et al., 2015). Assuming that each alternative is a team that participated in a tournament, 1 point is given to the situation where one team dominates the other, and 0 points are given otherwise. With this scoring procedure, the vertex matrix $M = [m_{ij}]$ of each tournament is generated. Using the vertex matrix, $A = M + M^2$ is calculated. Since each row of the matrix A represents an alternative, the sum of the values forming this row will be the score of that alternative. Alternatives are ranked starting from the highest score. Each of the three methods that constitute MULTIMOORA should be considered as a tournament and the score of the alternative should be considered as the total score obtained from these three tournaments.

3.3.2. Rank position method

According to this method, the ranking of each alternative is determined according to the value calculated by Eq. (24), which takes into account the ranking scores obtained from each method of MULTIMOORA (Altuntaş et al., 2015). The ranking is done starting from the alternative with the lowest calculated value.

$$\mathrm{r}(d_i) = 1 \,/\, \left(\sum_{j=1}^{k} 1 \,/\, position\ d_{ij}\right),\ \forall i. \tag{24}$$

In Eq. (24), $r(d_i)$ donates the calculated value of the alternative i where p is the number of alternatives (i = 1, 2, 3,…, p) and k is the number of methods (j = 1, 2, 3,…, k).

4. Project portfolio selection criteria in the oil & gas industry

In a study on project portfolio selection in the refinery sector, two different investment scenarios can be considered. The first one is the case of an investor who wants to enter the sector by building a completely new refinery plant. Here, the project portfolio to be selected by the investor will consist of candidate projects that will determine the capability and capacity of the planned facility. In contrast, an owner already operating in this sector has a project portfolio consisting of projects to meet the various needs of its existing facilities or to increase their capabilities. In these two cases, although the project selection criteria are quite similar, there will be differences between the approaches of decision-makers. This study has been carried out considering the second situation that addresses the existing owners in the sector.

It is assumed that the potential projects to be selected for the project portfolio are not at the idea stage, have been worked on, and have reached sufficient maturity. The main reason for this is the importance for decision-makers to have sufficient project data at the time of the final decision on the realization of the investment. In addition, it is also assumed that the project selection criteria will be valid under normal market conditions, in the absence of extraordinary situations such as war, epidemic, etc. that will affect investment policy. Finally, it is assumed that the project portfolio consists of projects within the budget limits of the investor.

To determine the criteria, the interviews were conducted with people determined by purposive sampling. In purposive sampling, the units in the sample are selected by the researcher in accordance with the principle of impartiality considering their characteristics in the universe (Koçak and Arun, 2006). Online or face-to-face interviews were conducted with 20 people selected with this approach. All the participants either worked in project development and/or realization processes within the refinery sector or were involved as decision-makers in the selection of the projects to be invested in. The average total experience of the interviewees is 24.8 years and the average experience in the refinery sector is 19.8 years. At the time of the interviews, 10 of the interviewees were working as senior managers such as a general manager, deputy general manager, or director in their respective companies. The other ten interviewees were working as managers, experts, consultants, or academicians.

Semi-structured interview technique was used in the interviews. The interviewees were basically asked the following questions.

- What criteria do you consider when choosing the right investments from a portfolio of potential oil and gas projects?
- What is the weight of each criterion in your decision?
- What are the characteristic measurement parameters (numerical or verbal) of these criteria?
- What expressions does it take if the measurement parameter is verbal?
- How does the increase or decrease of the measurement parameter affect your decision? (Type: beneficial or non-beneficial criteria)

The interviewees were asked to evaluate, in order of importance, the criteria on a five-level scale as very low, low, medium, high, and very high. All answers given were noted down by the interviewer on a pre-formatted form and shared with the interviewees via e-mail after the interview and asked for corrections, if any. All responses were collected in a single file of 101 items. While analyzing the data, the categorical analysis technique of content analysis was used. In this technique, the elements in the analyzed content are grouped into categories and subjected to frequency analysis (Bilgin, 2014). In the evaluation, when the duplicate and out-of-scope items of the interviewees were removed, the remaining 91 items were grouped into 15 different criteria. Table 1 shows the results of the analysis. According to the results of the study, the first five criteria are listed as follows; 1. Profitability, 2. Regulatory Requirements, 3. Contribution to Environmental, Social and Corporate Governance (ESG), 4. Operational Requirements, 5. Health and Safety. The frequency of mentioning these five criteria ranged from 10% to 22%, with a total frequency of 75%. Since all the participants emphasized the Profitability criterion, the frequency of participants who mentioned this criterion is 100%. Regulatory Requirement differs from the other criteria in terms of weight of importance. While the importance weight of the other four criteria is found to be high, the weight is very high for Regulatory Requirement.

Table 1
Results of analysis

Criteria	Measurement Parameter	Type of Parameter	Number of Mentioned Items	Frequency of Mention	Frequency of Participants Mentioned	Importance Weight: Very High	High	Medium	Low	Very Low	Average Weight	
Profitability	Net Present Value (NPV)	Numerical	20	22%	100%	8	11	1	0	0	4	High
Regulatory Requirements	Cost of not doing the project	Numerical	17	19%	85%	14	3	0	0	0	5	Very High
Contribution to ESG	Impact on ESG policy	Verbal	12	13%	60%	4	5	2	1	0	4	High
Operational Requirements	Risk assessment score	Verbal	10	11%	50%	2	4	4	0	0	4	High
Health and Safety	Risk assessment score	Verbal	9	10%	45%	3	5	1	0	0	4	High
Impact on Stakeholder Satisfaction	Impact on satisfaction	Verbal	5	5%	25%	1	1	2	0	1	3	Medium
Strengthening Resilience	Mitigating impact on business model risk	Verbal	4	4%	20%	0	2	1	1	0	3	Medium
Compliance with Company Strategies	Compliance with strategies	Verbal	3	3%	15%	1	2	0	0	0	4	High
Innovation	Innovation value	Verbal	3	3%	15%	0	0	1	2	0	2	Low
Project Cost	Total cost	Numerical	2	2%	10%	0	1	0	1	0	3	Medium
Impact on Company Financials	Impact on indebtedness indicator	Verbal	2	2%	10%	0	0	2	0	0	3	Medium
Market Domination	Strategic impact on market share	Verbal	1	1%	5%	0	1	0	0	0	4	High
Project Maturity	Maturity level	Verbal	1	1%	5%	0	1	0	0	0	4	High
Synergy Effect	Total profitability achieved with the contribution of the project	Numerical	1	1%	5%	0	0	1	0	0	3	Medium
Constructability	Adequacy of Construction resources	Verbal	1	1%	5%	0	1	0	0	0	4	High
TOTAL			91	100%								

When the results are compared between senior managers, who are more powerful in making decisions, and other participants, it is observed that the first five criteria have not changed, as can be seen in Table 2. However, these five criteria are much more distinctly differentiated from the other criteria of senior managers. While the total frequency of the five criteria increased to 83%, it remained at 67% for the other participants. In addition to these criteria, the frequency of mentioning the Impact on Stakeholder Satisfaction criterion reached 40% for the other participants. The Kolmogorov-Smirnov test was performed on the frequency of the criteria mentioned by senior managers and other participants. D_{max} is calculated as 0.193, which is much lower than the critical value of 0.404. Accordingly, there is no significant difference between the distribution of the frequency of criteria mentioned by senior managers and other participants.

Table 2
Comparison of senior managers and other participants

	Senior Managers			Other Participants		
Criteria	Frequency of Mention	Frequency of Participants Mentioned	Importance Weight	Frequency of Mention	Frequency of Participants Mentioned	Importance Weight
Profitability	23.8%	100%	4	20.4%	100%	4
Regulatory Requirements	19.0%	80%	5	18.4%	90%	5
Contribution to ESG	16.6%	70%	4	10.2%	50%	4
Operational Requirements	11.9%	50%	4	10.2%	50%	4
Health and Safety	11.9%	50%	5	8.2%	40%	4
Impact on Stakeholder Satisfaction	2.4%	10%	5	8.2%	40%	3
Strengthening Resilience	4.8%	20%	4	4.1%	20%	3
Compliance with Company Strategies	2.4%	10%	4	4.1%	20%	5
Innovation	4.8%	20%	2	2.0%	10%	3
Project Cost	-	-	-	4.1%	20%	3
Impact on Company Financials	-	-	-	4.1%	20%	3
Market Domination	-	-	-	2.0%	10%	4
Project Maturity	-	-	-	2.0%	10%	4
Synergy Effect	2.4%	10%	3	-	-	-
Constructability	-	-	-	2.0%	10%	4

According to the research results, the content of the criteria expressed by the participants can be summarized as follows.

(1) Profitability: It is a measure that correlates the total investment and operating costs of a project with the profits to be made from that project. Participants generally mentioned three different parameters when measuring this criterion: Internal rate of return, net present value, and payback period. While one group of participants prioritized the internal rate of return, another group of participants stated that the net present value should have a higher priority. According to Brealey and Myers (1991), the net present value is the parameter that most accurately guides the profitability decision.
(2) Regulatory Requirements: It is stated as the main criterion of the projects carried out to comply with the legal regulations necessary for the continuity of the refinery operations. These regulations can be related to the plant, or the characteristics of the products produced. Participants generally expressed this criterion as the cost of not doing the project. While some participants considered this cost only in terms of the financial impact of not investing in the continuity of operations, others found it more convenient to compare this financial impact with the cost of the investment and make an assessment based on the difference. Since the profitability criterion takes into consideration the return and cost of the investment, the evaluation of only the financial impact of not investing in the continuity of the business in this criterion would be more in line with the principle of independence of the criteria.
(3) Contribution to ESG: ESG is a criterion that has become increasingly important in recent years and evaluates a company's compliance with the environment, social values, and corporate governance ethics in its activities. Companies attaching more importance to this issue have gained more credibility in the markets. In support of this situation, the research revealed that projects that will contribute to ESG policy are prioritized more. Although some parameters have started to be used to rate companies in this respect, participants preferred to evaluate this criterion with linguistic variables since it is not yet widespread.
(4) Operational Requirements: In this criterion, the contribution of the projects to the safe continuation of the operations in the facilities or the elimination of bottlenecks is evaluated and most of the participants suggested that the measurement should be made according to the risk assessment of the unsafe operation that the project will improve.
(5) Health and Safety: The items in which the respondents mentioned the objective of projects to prevent situations that would harm humans, the environment, or assets that are categorized by this criterion. The participants stated that the measurement should be made according to the risk assessment of the hazard to be prevented by the project.
(6) Impact on Stakeholder Satisfaction: The potential of the project to ensure the satisfaction of internal and external stakeholders is evaluated under this criterion. It was assessed that the measurement could be made with linguistic variables expressing the contribution to satisfaction.
(7) Strengthening Resilience: This criterion assesses the operational flexibility and resilience that a project would provide to a refinery, and a measurement scale with linguistic variables has mostly been proposed.
(8) Compliance with Company Strategies: It has been defined as a criterion that measures the compliance of projects with predefined company strategies.
(9) Innovation: This criterion defines the project's contribution to the company's adaptation to emerging technologies.
(10) Project Cost: It is proposed as a numerical criterion that compares the investment costs of the projects.
(11) Impact on Company Financials: Evaluate the impact of projects on company financial indicators or access to international financing.
(12) Market Domination: It is a criterion evaluating the project's impact on the company's dominance in the market and its growth.
(13) Project Maturity: It is defined as a criterion that compares the maturity of the projects at the time they are considered.
(14) Synergy Impact: It is a proposed criterion to measure the impact of the project, which is not profitable when evaluated alone, but will be profitable when carried out in partnership with other projects that benefit other sectors.
(15) Constructability: With this criterion, it is proposed to evaluate the construction resources required for the realization of the projects.

5. Fuzzy Multimoora implementation

At the beginning of the development of the fuzzy MULTIMOORA model, the criteria to be used in the method were determined based on the research data. Shaaban and Scheffran (2017) listed the main features that should be included in the criteria as follows:

(1) Data Availability: Information related to the criterion should be easily accessible.
(2) Consistency with objective: It should be able to serve the purpose for which it will be used.
(3) Independency: Criteria should not interfere in terms of content and should reflect the objective from different perspectives.
(4) Measurability: Criteria should be measurable with a numerical or linguistic scale.
(5) Simplicity: Criteria should be easy to understand by the assessors.
(6) Sensitivity: The potential to allow trend analysis is preferable.
(7) Reliability: Criteria should allow an unbiased assessment of the positive and negative sides.

In addition to the above parameters, the fact that a criterion was mentioned by at least 20% of the participants was also taken into consideration as a condition in the selection of criteria. As a result, the following six criteria were determined to be used in the model: Profitability, Regulatory Requirements, Contribution to ESG, Operational Requirements, Health and Safety, and Strengthening Resilience. The Impact on the Stakeholder Satisfaction criterion is excluded from the list since it interferes with the Contribution to ESG criterion. Compliance with Company Strategies is a combination of the other criteria in terms of its content. The remaining criteria were not used in the model since they both fell below the 20% limit and did not comply with the expected parameters such as independency, measurability, and simplicity. Considering the characteristics of the refinery projects, the inclusiveness of the six selected criteria was found to be quite high. When the criteria used in the previous studies on project portfolio selection in the literature are analyzed, it is seen that very different criteria are used. These studies have sometimes been conducted for specific project types and sometimes for projects in general. For example, Mohagheghi and Mousavi (2019) based their study on high-tech mega projects. They used their proposed MCDM method as a case study to compare the projects of a mining company. After analyzing the different selection criteria used for such projects and consulting with the main decision-makers of the company contributing to the study, they identified the following criteria: total investment cost, availability of international cooperation, technical feasibility, ecological impacts, personnel factor, and project risk factor. In another study, Mohagheghi et al. (2021) focused on the selection of large-scale construction projects that can show flexibility to changing conditions. They determined the comparison criteria by applying the systematic approach proposed by Shaaban and Scheffran (2017), which uses literature reviews and interview data with experts. In the study, project flexibility, project complexity, buffer capacity, stakeholder culture, and accessibility criteria were selected for the evaluation of project resilience. Enea and Piazza (2004) accepted project risk, project cost, environmental impact, and project duration as project selection criteria in their study. The project portfolio selection criteria obtained in this study are both more specific in terms of the sector and more inclusive as they evaluate many different aspects of projects. Since the selected criteria are mostly measured with linguistic variables, a model was developed based on the example of Balezentis et al. (2012b). The values that the criteria can take were determined in 5 layers as shown in Table 3. Defined fuzzy numbers are also valid for the importance weights which will be used as $\widetilde{w}_j$ Significance Coefficient. These weightings are implemented in Eq. (18), Eq. (22), and Eq. (23) as applied in the corresponding equations of the crisp MULTIMOORA method.

Table 3
Linguistic variables for criteria evaluation

Linguistic Variable	Fuzzy Number
Very Low	(0.00, 0.00, 0.25)
Low	(0.00, 0.25, 0.50)
Medium	(0.25, 0.50, 0,75)
High	(0.50, 0.75, 1.00)
Very High	(0.75, 1.00, 1.00)

The fuzzy numbers corresponding to each linguistic variable are assumed to be triangular fuzzy numbers and the membership functions are shown in Fig. 3. According to the membership functions, “Very Low” includes the condition that the criterion is zero, and “Very High” includes the condition that the criterion is completely fulfilled.

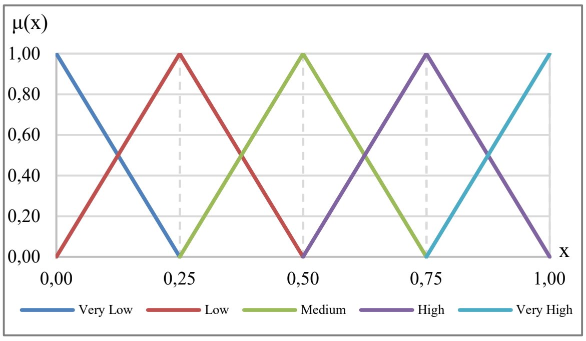

Fig. 3. Triangular membership function.

Although it is determined in the research results that Profitability and Regulatory Requirements criteria will be evaluated with numerical values, these criteria should also be expressed with linguistic variables in the developed model. For this purpose, it is assumed that the companies will determine value intervals in line with their assumptions and match the project values with the five-level evaluation scale. For example, projects with an NPV between 30-50 million USD can be assessed as “High” in the Profitability criterion, while projects with an NPV above this can be assessed as “Very High”. In this way, all criteria in the model take fuzzy number values in the same form, and the normalization process in the decision matrix is no longer required (Balezentis and Balezentis, 2016). A sample of four empirical projects is selected to demonstrate the five-step process of the model. Details of these projects are presented in Table 4.

Table 4
Project data

PROJECTS	Profitability	Regulatory Requirements	Contribution to ESG	Operational Requirements	Health and Safety	Strengthening Resilience
P1	Very High	Low	Low	Medium	Medium	Medium
P2	High	High	Medium	Medium	Low	Medium
P3	Medium	Low	Very High	Medium	Low	Medium
P4	High	Low	Low	Very High	Low	Low
Importance Weight	High	Very High	High	High	High	Medium
Measurement Parameter	NPV	Cost of not doing the project	Impact on ESG policy	Risk Assessment score	Risk Assessment score	Mitigating impact on business model risk
Type of Parameter	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial

Step 1. Formation of Decision Matrix: The decision matrix shown in Table 5 is formed in terms of fuzzy numbers that represent the linguistic variables that the projects receive in the criteria.

Table 5
Decision matrix

Projects	Profitability			Regulatory Requirements			Contribution to ESG			Operational Requirements			Health and Safety			Strengthening Resilience		
P1	0,75	1,00	1,00	0,00	0,25	0,50	0,00	0,25	0,50	0,25	0,50	0,75	0,25	0,50	0,75	0,25	0,50	0,75
P2	0,50	0,75	1,00	0,50	0,75	1,00	0,25	0,50	0,75	0,25	0,50	0,75	0,00	0,25	0,50	0,25	0,50	0,75
P3	0,25	0,50	0,75	0,00	0,25	0,50	0,75	1,00	1,00	0,25	0,50	0,75	0,00	0,25	0,50	0,25	0,50	0,75
P4	0,50	0,75	1,00	0,00	0,25	0,50	0,00	0,25	0,50	0,75	1,00	1,00	0,00	0,25	0,50	0,00	0,25	0,50

Step 2. Normalization of Decision Matrix: No normalization is required as all criteria are expressed in triangular fuzzy numbers in the decision matrix.

Step 3. Application of Importance Weights: Unlike the example of Balezentis et al. (2012b), the importance weights of the criteria are also taken into account in the calculations. While these weightings are expressed as fuzzy numbers in the Ratio System and Reference Point Approach, they are converted into crisp values by Eq. (16) in the Full Multiplicative Form. Table 6 shows the decision matrix with weightings.

Table 6
Decision matrix with weightings

Projects	Profitability			Regulatory Requirements			Contribution to ESG			Operational Requirements			Health and Safety			Strengthening Resilience		
Fuzzy Weight	0,50	0,75	1,00	0,75	1,00	1,00	0,50	0,75	1,00	0,50	0,75	1,00	0,50	0,75	1,00	0,25	0,50	0,75
Crisp Weight		0,75			0,92			0,75			0,75			0,75			0,50	
P1	0,38	0,75	1,00	0,00	0,25	0,50	0,00	0,19	0,50	0,13	0,38	0,75	0,13	0,38	0,75	0,06	0,25	0,56
P2	0,25	0,56	1,00	0,38	0,75	1,00	0,13	0,38	0,75	0,13	0,38	0,75	0,00	0,19	0,50	0,06	0,25	0,56
P3	0,13	0,38	0,75	0,00	0,25	0,50	0,38	0,75	1,00	0,13	0,38	0,75	0,00	0,19	0,50	0,06	0,25	0,56
P4	0,25	0,56	1,00	0,00	0,25	0,50	0,00	0,19	0,50	0,38	0,75	1,00	0,00	0,19	0,50	0,00	0,13	0,38

Step 4. Implementation of MULTIMOORA Analyses: Each of the analyses was performed as shown in Table 7, Table 8, and Table 9.

Table 7
Results of ratio system

Projects	a	b	c	BNP	Rank
P1	0,69	2,19	4,06	2,31	2
P2	0,94	2,50	4,56	2,67	1
P3	0,69	2,19	4,06	2,31	2
P4	0,63	2,06	3,88	2,19	4

Table 8
Results of reference point approach

Ref. Points	0,38 0,75 1,00	0,38 0,75 1,00	0,38 0,75 1,00	0,38 0,75 1,00	0,13 0,38 0,75	0,06 0,25 0,56	max d	Rank
P1	0,00	0,46	0,49	0,30	0,00	0,00	0,49	3
P2	0,13	0,00	0,30	0,30	0,19	0,00	0,30	1
P3	0,30	0,46	0,00	0,30	0,19	0,00	0,46	2
P4	0,13	0,46	0,49	0,00	0,19	0,14	0,49	3

Table 9
Results of full multiplicative form

Projects	a	b	c	BNP	Rank
P1	0,00	2,50	17,7	6,73	2
P2	0,00	5,50	33,4	12,97	1
P3	0,00	2,50	17,7	6,73	2
P4	0,00	1,40	13,2	4,89	4

Note: Results are magnified 100 times.

Step 5. Project ranking: The project rankings of the three approaches are transformed into a single project ranking with both RPM and DDG methods, and the results are comparatively obtained as shown in Table 10.

Table 10
Project ranking

Projects	Ratio System	Reference Point Approach	Full Multiplicative Form	Rank (RPM)	Rank (DDG)
P1	2	3	2	**3**	**3**
P2	1	1	1	**1**	**1**
P3	2	2	2	**2**	**2**
P4	4	3	4	**4**	**4**

Several specific points were also analyzed during the development of the model. The model was finalized according to the findings obtained. The evaluations related to these points are explained below.

5.1. Joint use of numerical and linguistic variables in fuzzy MULTIMOORA

As mentioned earlier, although the Profitability and Regulatory Requirements criteria are evaluated with numerical variables in the findings of the study, in practice, it is preferred to use these criteria by converting them into linguistic variables. Because the evaluations made with linguistic variables correspond to a fuzzy number in the range of [0-1]. However, numerical variables do not have such a limited range. When normalizing the criteria with numerical variables, the alternative that is several times larger than the other alternatives could become very advantageous. This may negatively affect the result of the final comparison. For example, in Table 11, in a two-criteria model with equal importance weights, numerical and linguistic variables are used at the same time. The first project has a higher NPV than the others, whereas the second project has the highest risk impact on operations among all projects. While the difference between the projects is very high for the Operational Requirements criterion, the same cannot be said for Profitability. Although the profitability of the first project is 10 times higher than the others, the NPV of 10 million USD represents a moderately profitable project in the company assessment. Table 12 shows the results of the model, which reflects the assumption on which this study is based and is constructed to include purely linguistic variables. As can be seen from the rankings, the first project ranked first in the first evaluation, while the second project ranked first in the second case, in line with expectations.

Table 11
Application of numerical and linguistic variables in the model

PROJECTS	Profitability	Operational Requirements	Rank of Ratio System	Rank of Reference Point Approach	Rank of Full Multiplicative Form	Rank (RPM)	Rank (DDG)
P1	10	Low	1	1	1	**1**	**1**
P2	1	Very High	2	2	2	**2**	**2**
P3	1	Low	3	2	3	**3**	**3**
P4	1	Low	3	2	3	**3**	**3**
Importance Weight	High	High					

Table 12
Application of purely linguistic variables in the model

PROJECTS	Profitability	Operational Requirements	Rank of Ratio System	Rank of Reference Point Approach	Rank of Full Multiplicative Form	Rank (RPM)	Rank (DDG)
P1	Medium	Low	2	2	2	**2**	**2**
P2	Low	Very High	1	1	1	**1**	**1**
P3	Low	Low	3	2	3	**3**	**3**
P4	Low	Low	3	2	3	**3**	**3**
Importance Weight	High	High					

5.2. Selection of reference point

In two articles by Balezentis et al., different approaches are preferred for the selection of the reference point. Keeping in mind that all criteria are beneficial, in the first article (Balezentis et al., 2012a), the reference point is taken as (1,1,1) for all criteria, while in the other (Balezentis et al., 2012b), the maximum alternative values are chosen as the reference point. In a scenario where the importance weights of the criteria are different and other project parameters are the same, these two approaches are analyzed, and different project rankings are observed. When the results shown in Table 13 and Table 14 are evaluated, it is seen that the correct approach for the reference points is the case where maximum-minimum alternative values are used.

Table 13
In the case of reference points (1,1,1)

PROJECTS	Profitability	Strengthening Resilience	Rank of Reference Point Approach
P1	Medium	Medium	1
P2	Medium	Medium	1
P3	Medium	Low	4
P4	Low	Medium	3
Importance Weight	High	Medium	

Table 14
In the case of reference points equal maximum/minimum alternative values

PROJECTS	Profitability	Strengthening Resilience	Rank of Reference Point Approach
P1	Medium	Medium	1
P2	Medium	Medium	1
P3	Medium	Low	3
P4	Low	Medium	4
Importance Weight	High	Medium	

5.3. Comparison of ranking methods

The Dominance-Directed Graph (DDG) and the Rank Position Method (RPM), which are used to obtain a single project ranking based on the rankings derived from the three approaches that make up the MULTIMOORA method, gave mostly similar results. The DDG approach is more methodical, while the RPM is more empirical and easier to apply.

6. Discussion

The MULTIMOORA method is a simple, stable, and robust MCDM method (Brauers and Zavadskas, 2012) that has been used in many different fields (Hafezalkotob et al., 2019). Therefore, as a different field application, it is used in this specific study for project portfolio selection in the refinery sector. Ten empirical projects were compared using the model developed based on the selection criteria. The project data and analysis results are presented in Table 15 and Table 16 in the order of the rankings obtained from the model.

Table 15
Case study project data

PROJECTS	Profitability	Regulatory Requirements	Contribution to ESG	Operational Requirements	Health and Safety	Strengthening Resilience
P01	High	Very High	Medium	High	Medium	Medium
P02	Very High	High	Medium	High	Medium	Medium
P03	High	High	Medium	High	Medium	Medium
P04	Medium	High	High	Medium	High	Medium
P05	High	Low	Low	High	High	High
P06	Medium	Very High	Medium	Medium	Very Low	Very Low
P07	Very High	Medium	Medium	Medium	Very Low	Very Low
P08	Medium	Low	Medium	Medium	Low	Medium
P09	Low	Very Low	Very Low	High	Medium	Medium
P10	Low	Very Low	Very Low	Medium	High	Medium
Importance Weight	High	Very High	High	High	High	Medium
Measurement Parameter	NPV	Cost of not doing the project	Impact on ESG policy	Risk Assessment score	Risk Assessment score	Mitigating impact on business model risk
Type of Parameter	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial	Beneficial

Table 16
Results of case study analysis

PROJECTS	Ratio System	Reference Point Approach	Full Multiplicative Form	Rank (RPM)	Rank (DDG)
P01	1	1	1	**1**	**1**
P02	2	1	2	**2**	**2**
P03	3	1	3	**3**	**3**
P04	3	4	3	**4**	**4**
P05	5	7	5	**5**	**5**
P06	6	5	7	**6**	**6**
P07	7	5	8	**7**	**7**
P08	8	7	6	**8**	**8**
P09	9	9	9	**9**	**9**
P10	9	9	9	**9**	**9**

When comparing projects P01 and P02, it is evident that although they share many similarities, P01 has a higher score in the Regulatory Requirements criterion, while P02 has a higher score in the Profitability criterion. As Regulatory Requirements carries the highest importance weight, P01 is considered the top priority project. Similarly, the P02 and P03 projects share the same value in all criteria except for one. In the Profitability criterion P02 project has a higher value and takes priority. It is observed that although the P03 and P04 projects seem to have different values in some criteria, they have received the same number of similar values when we group the criteria with the same importance weight. Therefore, they have been ranked equally in Ratio System and Full Multiplicative Form analyses. However, in the Reference Point Approach analysis, the P04 project falls behind the P03 project in priority due to its higher distance from the reference point in the Profitability criterion. The P05 project is ranked lower than P06 in the Reference Point Approach analysis because it has a significantly lower score in the Regulatory Requirements criterion compared to P06. However, it has been ranked higher in the other two analyses due to better values in four other criteria. Project P08 is ranked higher in the Full Multiplicative Form analysis because projects P06 and P07 scored “Very Low” in two criteria. However, as their high scores in the Profitability and Regulatory Requirements criteria gave them priority in the other two analyses, they were ranked higher than P08 in the final ranking. P09 and P10 projects are rated equally, except for the Operational Requirements and Health and Safety criteria. For these criteria, P09 is assessed “High” for Operational Requirements and “Medium” for Health and Safety. P10 has the same scores but in reverse order. As the importance weights of the Operational Requirements and Health and Safety criteria are the same and these two criteria do not affect the result of the Reference Point Approach analysis of the projects, the projects received the same ranking value.

7. Conclusion

Project portfolio selection and selection criteria will continue to be an important research topic due to changing world dynamics. The refinery sector is also affected by these important changes. This study has shown that different criteria have come to the forefront in the sector where the first priority criterion was Profitability until recently. Interviews with 20 prominent people who have worked in the refinery sector for many years and are experts in project selection, development, and realization showed that the selection criterion with the highest degree of importance is Regulatory Requirements. It has been observed that the ESG approach has been rapidly adopted recently and Contribution to ESG has started to be considered as an increasingly important criterion. Although the profitability criterion was also mentioned by everyone, it was evaluated with an equal weight of importance with Contribution to ESG, Operational Requirements, and Health & Safety. Projects aimed at increasing the company's resilience to changes have brought the Strengthening Resilience criterion to the forefront. This study aims to determine the project portfolio selection criteria and their importance weights in the oil refining sector, where billions of dollars are invested every year but not much research has been done in the literature. In addition, it also aimed to provide a reference study for this sector by providing a source that can guide practitioners in project selection. For this purpose, the obtained data is used for ranking the projects by using the fuzzy MULTIMOORA and thus a decision support tool is generated. The outcomes obtained from this study can also be applied to other MCDM methods.

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