Int. J. Nonlinear Anal. Appl.
Volume 12, Special Issue, Winter and Spring 2021 , 361-380
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/IJNAA.2021.5190

Applying fuzzy multi-objective planning technique to prioritize projects based on social responsibility and risk

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(Communicated by Madjid Eshaghi Gordji)

Abstract

Social responsibility and risk are some essential issues in projects to consider. Knowing the type of risk in each project and its impact is an important and significant issue in choosing a project or participating in tenders. Considering the increasing growth of urban communities and the need to carry out tasks, and the rising standard of living, trying to carry out projects with advanced technologies seems to be a necessity that requires modern and continuous planning to implement the relevant matters. These plans aim to increase quality and reduce costs due to the high level of demand. In the present study, a fuzzy multi-objective mathematical model has been designed to prioritize projects, minimize the risks involved in implementing each project, maximize profit margins, maximize project costs, and maximize jobs created by the project. Finally, an example appropriate to real-world problems is designed and examined to ensure the correct operation of the proposed model.

Keywords: Fuzzy multi-objective technique, Fuzzy Shannon entropy, social responsibility, risk.

1. Introduction

The first step of project-based organizations in strategic and purposeful project portfolio management is the correct selection of projects (Boyeri et al. 2018; Mohagheghi et al. 2016). Wrong choice of projects has two negative effects. On the one hand, resources are spent on unsuitable projects, and on the other hand, the organization makes less profit. If the right projects are selected, the organization will benefit more (Martino, 1995). Project selection problem is a complex decision-making process

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Received: April 2021 *Accepted:* June 2021

that is often influenced by conflicting goals. The complexity of the project selection problem is due to the large number of projects from which a project portfolio must be selected (Khalili Damghani et al., 2013). Experimental and academic researchers have also emphasized the importance of project selection and prioritization process in project portfolio management, including the studies done by Archer and Ghasemzadeh (1999) and Arto et al. (2004) (Dori et al., 2015). Organizational culture, style and structure affect how projects are carried out. The level of maturity of the project management and the company's project management system can also affect the projects. When a project is associated with external units as a mutual investment, that project is affected by more than one company. The following sections describe the organizational characteristics and structures within an organization that are likely to affect the project (PMI 2008). Considering the need to integrate financial and strategic interests, each project under uncertainty, compete with the framework of the organization's strategic goals in allocating effective resources. This attention and integration require systematic decision-making processes, which is effective in selecting portfolio projects. Recent researches have shown that it is important a systematic decision-making process including a logical framework with a series of ongoing activities in the existing stages and the use of tools and techniques and the full participation of decision-makers (Cooper et al., 2008). Given the uncertain nature of projects, it is undeniable that many projects fail to achieve the expected goals, resources, costs, scope, and time. Existence of risk in the project and its uncertainty has reduced the accuracy in proper estimation of objectives and reduces the efficiency of the project (Imani Moghaddam, Khalilzadeh, 2015). Based on this, project risk is defined as the chance of an event occurring that has the greatest possible negative effect on project objectives and is measured by terms such as probability of occurrence and outcome. Numerous definitions and interpretations of risk management have been developed by individuals and institutions with expertise in project risk management; the most comprehensive definition has been presented by Burke (2013) and the project management company. According to Burke, risk management is a process with the concept of identifying, analyzing and responding to all uncertain issues during the life of project, which includes maximizing the results of positive events and minimizing the consequences of negative events (Shahrjerdi et al., 2014). Nowadays, the problem of comprehensive and correct project cost management, including resource planning, cost estimation, budgeting and cost control, has become one of the main concerns of project managers and stakeholders. The project management, especially proper cost management, has a more prominent role due to the limitations in the event of a crisis to complete the project on time with the approved and scheduled budget. One of the main tasks of a project manager is cost management. Timely completion with anticipated cost of each project is one of the main criteria for the success, and failure to complete on time with anticipated cost of the project, will not meet the demands of the employer and the project objectives. Cost management is based on the view that costs are not created by themselves, but all costs are the product and result of management decisions that are mainly focused on how to use the organization's limited resources. The cost management attitude plays an important role in guiding managers' decisions towards creating value for all stakeholders and seeks to create a suitable and creative combination among different stakeholder sources (Danesh, 2015). The end result of all plans, activities, financial and production decisions is reflected in the company's profitability. Most of the data needed to evaluate the company's executive operations is provided directly from the profit and loss statement, which is a summary of the results of the company's operations and financial and production activities. Profitability refers to a company's ability to generate revenue and profits. Net income or profit is a measure of profitability. Investors and lenders are keen to evaluate a company's current and future profitability. Companies have to make enough profit to provide the right return for investors and lenders to raise the capital they need. If companies do not earn enough profit, they will not be able to attract the capital needed to implement various projects through shareholders or creditors (Osulian et al., 2016). The concept of corporate social responsibility is related to the role of companies in the social field. Leading organizations, as accountable organizations, take a very ethical approach to transparency and accountability to their stakeholders. These organizations have a special sensitivity and attention to social accountability and maintaining the environmental stability of the organization now and in the future and promote this view. Social responsibility is expressed in the values of these organizations. they understand and comply with local and global expectations and regulations and go beyond it through open communication with stakeholders (Crane et al., 2008; Faghani-Makrani et al., 2016). Socially responsible companies have higher social capital; Because they tend to have better relationships with stakeholders, which in turn creates security and thus reduces damage from adverse events. Investors are showing more interest in socially responsible companies and customers are more loyal to such companies. This will reduce systemic risk (Fama, French, 2007).

2. Statement of The Problem

Today, project-oriented organizations pursue their long-term goals to stay in the global competitive environment by choosing the right projects and implementing them effectively. Undoubtedly, the sustainable competitive advantage of project-based organizations is the ability to implement projects effectively and efficiently. Implementation of the project within the planned time and cost in a way that could create a profit higher than the industry standard, is the dream of project managers. To achieve this, organizations must use effective methods and tools in project management. Various researches have been done on the project selection problem. The results of these studies can be effective in improving the efficiency of projects. Performing an analysis based on the mathematical model and the method of fuzzy Shannon entropy technique can be effective for the project stakeholders as well as the future procedure of project selection. After using the Fuzzy Shanon entropy technique and implementing the decision model, important results are obtained for contractors, as follows:
1. The organization allocates its limited resources to value-added projects.
2. Only the appropriate projects of the organization are selected in the project portfolio.
3. The projects in the organization's portfolio are fully aligned with the organization's objectives and strategic business objectives.
4. Proper use of the organization's capital which leads to maintaining competitiveness and development of the organization.

3. Literature Review

Tawfiqian and Naderi (2015) analyzed the existing methods and developed a new mathematical model in the form of a complex linear programing. They designed a comprehensive experiment and compared their proposed algorithm with two existing genetic algorithms and sparse search. They have come to the conclusion that their proposed algorithm has surpassed two existing ones. Pangsari (2015) used a combination of Delphi, hierarchical analysis and TOPSIS methods. In his research, hierarchical analysis has been used to weight the criteria and TOPSIS has been used to prioritize the criteria. Mohagheghi and Mousavi and Vahdani (2016) proposed a new multi-objective decision making approach in the selection of a sustainable project portfolio, which applies fuzzy sets with interval values to account for uncertainty. They have come to conclusion that this approach can successfully address unfamiliar environments. Finally, this approach gives decision makers more flexibility in focusing on financial and non-financial criteria in the project selection process. Shafahi and Haqqani (2018) proposed a model for project selection and scheduling to implement some projects in different phases. They presented a mixed integer programming model that maximizes the net value of future investments, given the time limitations of budgets and reinvestment strategies. They concluded that in small-scale scenarios, the innovative algorithm can find the ideal value in almost all cases by the mixed integer programming method. Hesar Sorkh et al. (2021) proposed a model that determines the projects to be implemented in each period, decides on the optimal outsourcing policy, and at the same time completes the optimal programming of financial resources. They concluded that their model can be used as a strategic decision-making tool to help managers of pharmaceutical companies in analyzing different investment scenarios and project portfolio selection. Kalayatankala et al. (2021) proposed a modified intuitive fuzzy approach to select a project team, combining multi-criteria decision making with dynamic weights for each parameter. They have come to the conclusion that this method is effective in determining the most skilled candidates in terms of their ability among a group of applicants. Rodnick et al. (2021) studied on the problem of selecting improvement projects, evaluating and prioritizing projects considering a set of proposed criteria as a key criterion for continuous improvement of processes. They concluded that this method controls the main aspects of decision making using a logical method and can be implemented especially for project portfolio analysis using the latest technologies in changing environmental conditions. The studies performed on the model indices are summarized in Table (1).

Table 1. Studies on indices

study	index
Purnus A. and Bodea C.N. (2014)	a plan for project prioritization, including several criteria related to project opportunities and affecting organizational objectives (revenue, cost, return on capital, cash flow and project implementation period, and project risk estimation (cost index), (risk index)
Reginaldo F. (2015)	proposing a portfolio evaluation and balance of projects with support tools for multi-criteria decision making and with the aim of reducing internal risk and increasing profitability (profitability index).
Willomson et al. (2019)	The empirical findings demonstrate the need for an understanding based on the value of project risk management, thereby providing a more accurate view of the types of forms by which project risk management can generate value (risk index).
Mohagheghi V. et al. (2019)	It has been concluded that in recent years, not only the financial criteria, but also the social and environmental aspects of project securities have been influenced by researchers in selecting the project portfolio (employment index (social responsibility)).
Ding et al. (2019)	They presented the ideal value for the win-win distribution through negotiations in the field of price outsourcing between general contractors and multiple service providers (subcontractors) under the strategy of cooperation between the parties that characterizes the development of the oil industry (profitability index).
Analiyev and Tsiganov (2020)	It was proposed a method for a comprehensive evaluation of the project with the aim of reducing energy production costs (cost index).
Sanchez et al. (2020)	It was provided plans to reduce the risks of cost overruns in engineering projects (cost index).
Maon et al. (2021)	It was expressed the corporate social responsibility knowledge in a conceptual and integrated framework, explained the multi-stakeholder interpretive and interactive processes that shape the brand, and developed a research program in the field of corporate social responsibility commonalities (Social responsibility)

4. Research Method

The present study is applied in terms of purpose to find a solution for a problem within a community and organization. In other words, this method seeks to track and solve problems by using scientific methods and provide a suitable answer to improve the situation of society. It is a descriptive study of the transverse survey type in terms of the nature of data collection. In addition, data collection is quantitative. The implementation stages of the present study are presented in Figure 1.

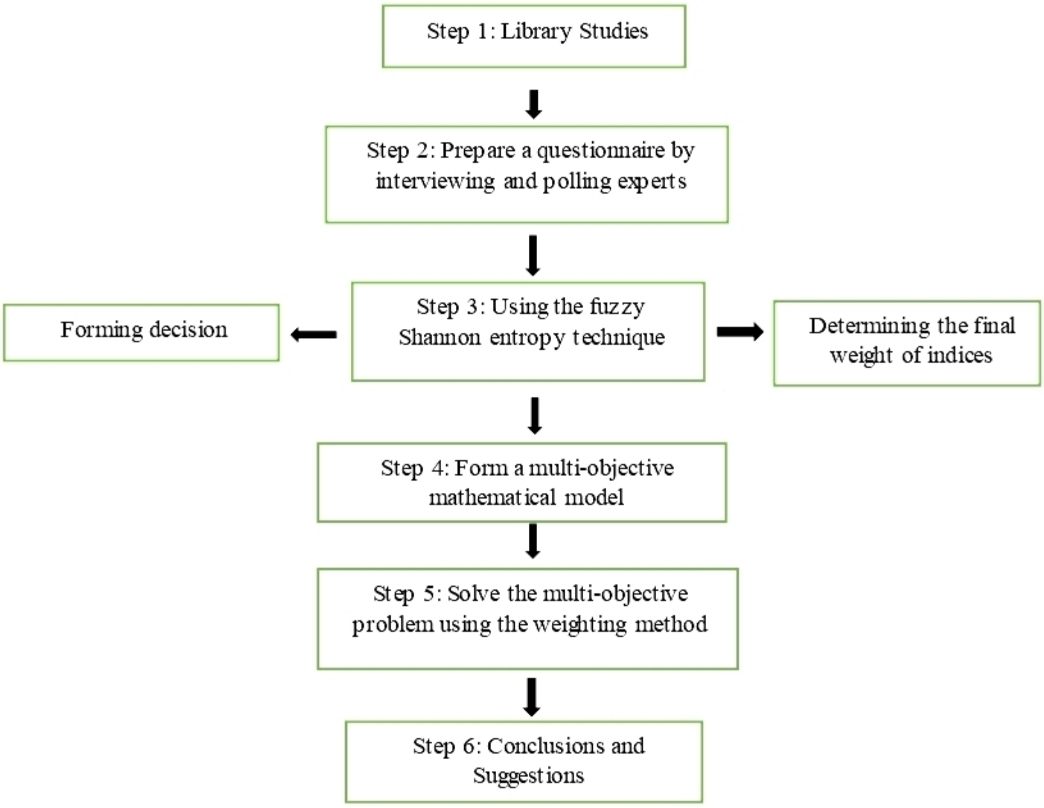

Figure (1) Steps of research method

Mathematical Model
research, first the parameters and variables in the literature were identified and then the objective functions and limitations were identified according to the variables and parameters of the problem. Finally, a multi-objective mathematical programming model based on fuzzy logic was prepared to select the project, and has been compiled. In this section of mathematical modeling, the problem of project selection considering four objective functions is presented as follows.

Sets:
N: Number of projects, $j = 1, 2, \ldots, N$
k: risks, $1, 2, \ldots, k$
t: human resource , $i = 1, 2, \ldots, t$
q: machine ,$i = 1, 2, \ldots, q$
s: raw material , $i = 1, 2, \ldots, s$
A_0: The set of projects are mutually exclusive.

Parameters:
p_{kj} : Occurrence probability of risk k in project j.

$\tilde{p}_j$: Total net profit from implementing project j alone.
$\tilde{c}_j$: The required cost project j.
$\tilde{b}_j$: The risk of implementing project j which is obtained by $\tilde{b}_j = \sum_{k=1}^{n} p_{kj}\tilde{l}_{kj}$
$\tilde{s}_j$: The number of created jobs by implementing project j.
$\tilde{h}_{ij}$: Requirement of human resource i in project $j., i = 1, 2, \ldots, t$.
$\widetilde{H}_i$: Available human resource of type i.
$\tilde{m}_{ij}$: Requirement of machine of type i in project $j., i = 1, 2, \ldots, q$.
$\widetilde{M}_i$: Available machine of type i.
$\tilde{r}_{ij}$: Requirement of raw material i in project $j.i = 1, 2, \ldots, s$.
$\tilde{l}_{kj}$: losses result from risk.
$\widetilde{R}_i$: Maximum available raw material of type i.

Variable:

x_j : It is a binary variable that if one is selected, it is equal to one and otherwise it is equal to zero.

Objective Functions and Limitations

One of the goals of project managers and experts is to maximize the net profit of projects. Based on that, the first objective function of the model is defined which is to maximize profitability based on the selected project. The first objective function is as follows:

$$max\ z_1 \cong \sum_{j=1}^{N} \tilde{p}_j x_j \tag{1}$$

The problem of cost minimization is another form of utility maximization problem. Project costs also include operating costs of project implementation, such as the cost of machinery used, the cost of manpower and the cost of raw materials, etc. Based on this, the second objective function of the model is defined, which is to minimize the cost by selecting the selected project. The second objective function is as follows:

$$min\ z_2 \cong \sum_{j=1}^{N} \tilde{c}_j x_j \tag{2}$$

Many projects that are supposed to be under control, take risks as an unrecognized event and try to control it. Risk management is done with objectives such as identifying potential risks, reducing risks, making better decisions about potential crises, and planning various projects. Based on this, the third objective function of the model is to minimize the risk based on the selected project. The third objective function is as follows:

$$min\ z_3 \cong \sum_{j=1}^{N} \tilde{b}_j x_j \tag{3}$$

One of the laws passed for contracting companies is hiring local labor to carry out projects. This increases employment and does not allow companies to use a specific workforce for all projects. Of course, this may increase costs for the company, but in return it will increase employment in the project area. The fourth objective function seeks to maximize the jobs created by implementing the selected project. The fourth objective function is as follows.

$$max\ z_4 \cong \sum_{j=1}^{N} \tilde{s}_j x_j \tag{4}$$

Limitation (5) ensure that the human resources required for the project are less or equal to the human resources available. Limitation (5) is as follows:

$$\sum_{j=1}^{N} \tilde{h}_j x_j \leq \widetilde{H}_i, \quad i = 1, 2, \ldots, t \tag{5}$$

Limitation (6) ensures that the machinery required for the project is less than or equal to the machinery available. Limitation (6) is as follows:

$$\sum_{j=1}^{N} \tilde{m}_j x_j \leq \widetilde{M}_i, \quad i = 1, 2, \ldots, q \tag{6}$$

Limitation (7) ensures that the raw materials required for the project are less than or equal to available raw materials. Limitation (7) is as follows:

$$\sum_{j=1}^{N} \tilde{r}_j x_j \leq \widetilde{R}_i, \quad i = 1, 2, \ldots, s \tag{7}$$

Limitation (8) ensures that no more than one project can be selected from a set of unique projects. Limitation (8) is as follows:

$$\sum_{j \in A_0}^{N} x_j \leq 1 \tag{8}$$

Limitation (9) identifies the highest priority projects after each implementation of the model. Limitation (9) is as follows:

$$\sum_{j=1}^{N} x_j = 1 \tag{9}$$

Finally, limitation (10) determines the type of variable used in the problem:

$$x_j \in \{0, 1\} \tag{10}$$

Since the fuzzy mechanism is used in this study, the objective functions and limitations change from fuzzy to crisp state as follows. To rank the fuzzy numbers, the ?-cut method (Yager ranking function) was used, which is defined as a set of all elements related to a range of the original set with an alpha membership degree or greater.
The efficiency of this method for solving fuzzy linear programming problems has been proven, because:
1- It maintains the linearity of the model.
2- It does not increase the number of objective functions or inequality limitations.
3- It can be applied to different membership functions.
According to the α-cut results, the fuzzy model of the problem becomes a crisp model. The crisp model of the problem is as follows:

$$max\ z_1 \cong \sum_{j=1}^{N}(\frac{p_p^j + 2p_j^m + p_j^\circ}{4})x_j \quad (11)$$

$$min\ z_2 \cong \sum_{j=1}^{N}(\frac{c_p^j + 2c_j^m + c_j^\circ}{4})x_j \quad (12)$$

$$min\ z_3 \cong \sum_{j=1}^{N}(\frac{b_p^j + 2b_j^m + b_j^\circ}{4})x_j \quad (13)$$

$$max\ z_4 \cong \sum_{j=1}^{N}(\frac{s_p^j + 2s_j^m + s_j^\circ}{4})x_j \quad (14)$$

st: for $i = 1, 2, \ldots, t$,

$$\sum_{j=1}^{N}[(1-\alpha)(\frac{h_j^\circ + h_j^m}{2})x_j + \alpha(\frac{h_j^\circ + h_j^m}{2})x_j] \leq \alpha(\frac{H_i^\circ + H_i^m}{2}) + (1-\alpha)(\frac{H_i^p + H_i^m}{2}) \quad (15)$$

$$\sum_{j=1}^{N}[(1-\alpha)(\frac{m_j^\circ + m_j^m}{2})x_j + \alpha(\frac{m_j^\circ + m_j^m}{2})x_j] \leq \alpha(\frac{M_i^\circ + M_i^m}{2}) + (1-\alpha)(\frac{M_i^p + M_i^m}{2}) \quad (16)$$

$$\sum_{j=1}^{N}[(1-\alpha)(\frac{r_j^\circ + r_j^m}{2})x_j + \alpha(\frac{r_j^\circ + r_j^m}{2})x_j] \leq \alpha(\frac{R_i^\circ + R_i^m}{2}) + (1-\alpha)(\frac{R_i^p + R_i^m}{2}) \quad (17)$$

$$\sum_{j \in A_0} x_j \leq 1 \quad (18)$$

$$\sum_{j=1}^{N} x_j = 1 \quad (19)$$

$$x_j \in \{0, 1\} \quad (20)$$

First, the membership functions of each of the objectives are written, because the objective functions are first and fourth (maximum), the membership function is the same, and the second and third objective functions (minimum), have the same membership functions.

Membership Functions of the Second and Third Objectives:

$$\mu_i(z_i(x)) = \begin{cases} 1 & Z_i \leq L_i \\ |\frac{U_i - Z_i}{U_i - L_i}| & L_i \leq Z_i \leq U_i \\ 0 & Z_i \geq U_i \end{cases} \quad (21)$$

The diagram of these membership functions (maximum) is as follows.

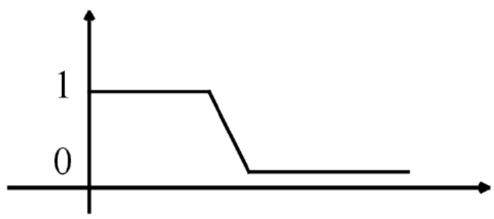

Figure (2) diagram of minimum membership functions

Membership Functions of the First and Fourth Objectives:

$$\mu_i(z_i(x)) = \begin{cases} 1 & Z_i \le L_i \\ |\frac{Z_i - L_i}{U_i - L_i}| & L_i \le Z_i \le U_i \\ 0 & Z_i \ge U_i \end{cases} \tag{22}$$

The diagram of these membership functions (minimum) is as follows.

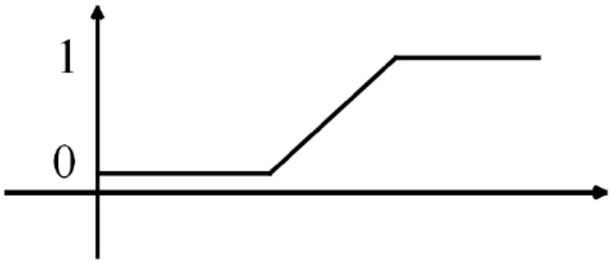

Figure (3) Diagram of Maximum Membership Functions

Accordingly, to solve the problem using the weighting method, the new objective function is as follows:

$$\begin{aligned} & max \ \sum_{i=1}^{4} \omega_i \gamma_i \\ & \gamma_i \le (\frac{Z_i - L_i}{U_i - L_i}) \qquad \forall \ i = 1, 4 \\ & \gamma_i \le (\frac{U_i - Z_i}{U_i - L_i}) \qquad \forall \ i = 2, 3 \end{aligned} \tag{23}$$

And the limitations of the problem remain the same. In the objective function of the previous step W was used in the weighting method; it is obtained through the fuzzy Shannon entropy technique. Since the fuzzy Shannon technique is used in the uncertainty environment, it is used here.

5. Fuzzy Shannon Entropy Technique

It is reasonable and logical that when the ratings of alternatives with respect to criteria are represented by Ordered fuzzy numbers, the weights of criteria should be also represented by Ordered fuzzy numbers. This means that the concept of Shannon entropy needs to be extended to fuzzy Shannon entropy based on Ordered fuzzy numbers. We will present a method of determining the weights of criteria based on Ordered fuzzy numbers using triangular Ordered fuzzy numbers (the proposed method can be easily extended to trapezoidal Ordered fuzzy numbers) (Kacprzak, 2017). Its main advantage is that it works with little data that is supposed to be reliable, and also qualitative data is assumed to be reliable, because it is obtained through surveys, etc.; And the weights used in decision-making are multi-criteria (whatever the system has used to calculate them).

It is assumed that two different decision makers with a different problem can create different weights. This is not the case with entropy-derived weights, because they do not depend on the individual but on the data. It is wrong to provide subjective weights for the criteria and then use them for people who qualify for the criteria. The only way you can do this is to use entropy-derived weights, because then they really represent the standard capacity to be evaluated. Entropy measures the discrimination or dispersion of numbers. If you add a new option, you are actually modifying the entire set of performance criteria. If we change the time period, the weight also changes. Where does "time period" come from? If it is in one criterion, the values as well as possible discrimination change again.

Now a method is proposed for determining the weight of criteria based on ordered fuzzy numbers using triangular ordered fuzzy numbers; the proposed method can be easily extended to trapezoidal ordered fuzzy numbers. Orientation of Ordered fuzzy numbers is used to distinguish between different types of criteria. This means that we use a positive triangular fuzzy number to represent the value of profit:
$A = (f_A(0), f_A(1), g_A(0))$, i.e., an ordered fuzzy number such that $0 \leq f_A(0) \leq f_A(1) \leq g_A(0))$.
Then the calculation of criteria weights based on triangular ordered fuzzy numbers can be described in the following steps.
STEP 1: Construct the fuzzy decision matrix $X = (x_{ij})$, where:

$$x_{ij} = (f_{x_{ij}}(0), f_{x_{ij}}(1), g_{x_{ij}}(0)) \tag{24}$$

is the rating of alternative A_i with respect to criterion C_j represented by a triangular ordered fuzzy number?!
STEP 2: Construct the normalized fuzzy decision matrix $Z = (z_{ij})$, where:

$$z_{ij} = \left(\frac{f_{x_{ij}}(0)}{\sum_{i=1}^{m} f_{x_{ij}}(0)}, \frac{f_{x_{ij}}(1)}{\sum_{i=1}^{m} f_{x_{ij}}(1)}, \frac{g_{x_{ij}}(0)}{\sum_{i=1}^{m} g_{x_{ij}}(0)}, \right) \tag{25}$$

If, for all$j = 1, 2, \ldots, m$ we have$f_{x_{ij}}(0) = 0$ or$f_{x_{ij}}(1) = 0$ or $g_{x_{ij}}(0) = 0$, we define $\frac{f_{x_{ij}}(0)}{\sum_{i=1}^{m} f_{x_{ij}}(0)}$ or $\frac{f_{x_{ij}}(1)}{\sum_{i=1}^{m} f_{x_{ij}}(1)}$ or $\frac{g_{x_{ij}}(0)}{\sum_{i=1}^{m} g_{x_{ij}}(0)}$ to be 0, respectively.
STEP 3: Construct the vector of fuzzy Shannon entropy $e = (e_1, e_2, \ldots, e_n)$, where:

$$e_j = \left(-\frac{1}{\ln m} \sum_{j=1}^{m} f_{z_{ij}}(0), -\frac{1}{\ln m} \sum_{j=1}^{m} f_{z_{ij}}(1), -\frac{1}{\ln m} \sum_{j=1}^{m} g_{z_{ij}}(0) \right) \tag{26}$$

And $f_{z_{ij}}(0) \ln f_{z_{ij}}(0)$ or $f_{z_{ij}}(1) \ln f_{z_{ij}}(1)$ or $g_{z_{ij}}(0) \ln g_{z_{ij}}(0)$ is defined as 0 if$f_{z_{ij}}(0) = 0$ or $f_{z_{ij}}(1) = 0$ or$g_{z_{ij}}(0) = 0$, respectively.
STEP 4: Calculate the vector of fuzzy diversification $d = (d_1, d_2, \ldots, d_n)$, where:

$$d_j = \Big(1 - f_{e_j}(0), 1 - f_{e_j}(1), 1 - g_{e_j}(0) \Big) . \tag{27}$$

STEP 5: Calculate the vector of fuzzy criteria weights $\omega = (\omega_1, \omega_2, \ldots, \omega_n)$, where:

$$\omega_j = \left(\frac{f_{d_j}(0)}{\sum_{i=1}^{n} f_{d_j}(0)}, \frac{f_{d_j}(1)}{\sum_{i=1}^{n} f_{d_j}(1)}, \frac{g_{d_j}(0)}{\sum_{i=1}^{n} g_{d_j}(0)}, \right). \tag{28}$$

If, for all$j = 1, 2, \ldots, n$ we have$f_{d_j}(0) = 0$ or$f_{d_j}(1) = 0$ or $g_{d_j}(0) = 0$, we define $\frac{f_{d_j}(0)}{\sum_{i=1}^{n} f_{d_j}(0)}$ or $\frac{f_{d_j}(1)}{\sum_{i=1}^{n} f_{d_j}(1)}$ or $\frac{g_{d_j}(0)}{\sum_{i=1}^{n} g_{d_j}(0)}$ to be 0, respectively.

6. Data Analysis

The interpretations mentioned earlier (general structure of the research, mathematical model and Shannon entropy technique) are implemented in a case study. Imam Khomeini Agro-industry in the project area is a part of Shoaybiyeh plain with an area of approximately 15300 hectares, which is limited to the northern hills of Shoaybiyeh plain from the north, to Dez river from the west, to Shatit river (Karun) from the east and to the Dehkhoda sugarcane complex from the south. This Agro-industry has several projects and over time, it has developed step by step. Now, in addition to sugar production, it has the largest MDF production unit from bagasse as well as animal feed production. It also has put the implementation of social responsibilities at the top of its agenda. Finally, with a survey of the company's experts, the decision matrix is presented in Table 3.
The use of crisp value variables will make it difficult for experts to comment, so it is clear that qualitative variables will give respondents more leeway.

Table 2. Linguistic Variables and triangular fuzzy numbers

Linguistic Variables	Triangular fuzzy numbers
Very poor (VP)	(0,1,2)
Poor (P)	(1,2,3)
Fair (F)	(4,5,6)
Good (G)	(7,8,9)
Very good (VG)	(8,9,10)

Table 3. Decision matrix arranged with ordered fuzzy numbers

Indicators / Projects	Project implementation risk	Total net profit from project implementation	Cost required for the project	Number of jobs created through project implementation
Project 1	(1,4,9)	(7,8,9)	(4,5,6)	(1,2,3)
Project 2	(1,4,9)	(4,5,6)	(1,2,3)	(1,2,3)
Project 3	(4,10,18)	(7,8,9)	(7,8,9)	(1,2,3)
Project 4	(1,4,9)	(4,5,6)	(1,2,3)	(7,8,9)
Total	(7,22,45)	(22,26,30)	(13,17,21)	(10,14,18)

Table 4. Normalized decision matrix

Indicators / Projects	Project implementation risk	Total net profit from project implementation	Cost required for the project	Number of jobs created through project implementation
Project 1	(0/14,0/18,0/20)	(0/32,0/31,0/30)	(0/31,0/29,0/30)	(0/10,0/14,0/17)
Project 2	(0/14,0/18,0/20)	(0/18,0/19,0/20)	(0/08,0/12,0/14)	(0/10,0/14,0/17)
Project 3	(0/57,0/45,0/40)	(0/32,0/31,0/30)	(0/54,0/47,0/40)	(0/10,0/14,0/17)
Project 4	(0/14,0/18,0/20)	(0/18,0/19,0/20)	(0/08,0/12,0/14)	(0/70,0/57,0/50)

Table 5. The vector of fuzzy Shannon entropy-ej, the vector of fuzzy diversification-dj, and the vector of fuzzy criteria weights-wj, defuzzified fuzzy criteria weights.

			Fixed coefficient value K	0/72
Indicators / Vectors	Project implementation risk	Total net profit from project implementation	Cost required for the project	Number of jobs created through project implementation
e_j	(0/83,0/93,0/96)	(0/97,0/98,0/99)	(0/79,0/88,0/92)	(0/68,0/83,0/90)
d_j	(0/16,0/07,0/03)	(0/03,0/01,0/01)	(0/21,0/12,0/08)	(0/32,0/17,0/10)
w_j	(0/23,0/18,0/16)	(0/03,0/05,0/06)	(0/29,0/32,0/33)	(0/44,0/44,0/43)
defuzzified fuzzy criteria weights	0/18	0/05	0/32	0/44

7. Numerical Example

The weighted fuzzy programming was proposed to design the multi-objective model; In order to do this, first the sensitivity analysis for the objective function weight, next the sensitivity analysis for the objective function coefficient, then the sensitivity analysis in the available resources and finally the sensitivity analysis in the model parameters will be done. Regarding problem solving using fuzzy logic, the values of the parameters must first be determined. For this purpose, the appropriate verbal variables are selected to determine the qualitative data of the parameters, and the fuzzy interval related to each verbal variable is determined according to the experts so that they can be converted into fuzzy numbers. Finally, the model was implemented according to the collected data using Gomez software and installed on the system (64 bits) with a time of approximately one second.

Table 6. Human resource requirements and available

Project NO.	1	2	3	4	Available
Type 1	(4,5,6)	(1,2,3)	(1,2,3)	(4,5,6)	(10,14,18)
Type 2	(7,8,9)	(7,8,9)	(4,5,6)	(8,9,10)	(26,30,34)

Table 7. Machine requirements and available

Project NO.	1	2	3	4	Available
Type 1	(1,2,3)	(1,2,3)	(4,5,6)	(4,5,6)	(10,14,18
Type 2	(4,5,6)	(7,8,9)	(1,2,3)	(7,8,9)	(19,23,27)

Table 8. Raw material requirements and available

Project NO.	1	2	3	4	Available
Type 1	(1,2,3)	(7,8,9)	(4,5,6)	(8,9,10)	(20,24,28)
Type 2	(4,5,6)	(1,2,3)	(7,8,9)	(7,8,9)	(19,23,27)

Now, eight single-objective problems must be solved in order to find the ideal value and negative ideal value. First, the problem is considered with the first objective function, once its maximum and once its minimum. After solving the maximum problem, the ideal value is 250. Now the minimum problem of first objective function is considered. This time, instead of the maximum, the minimum is set and the problem is solved again. The ideal value to this problem is 11.75. Since the objective function is the maximum, the ideal value is 250, and the negative ideal value is 11.75. The same is done for each of the other objective functions. Since the second and third objective functions are minimal, the larger value should be considered as negative ideal value and the smaller value as the ideal value. The ideal value and the negative ideal value of the objective functions for ? $= 0.5$ are presented in Table 9.

Table 9. Ideal solution and negative ideal solution of objective functions

Objective functions	Ideal value	Negative ideal value
Z_1	250	11/75
Z_2	8	250
Z_3	4/5	10/5
Z_4	12	4

Now considering the equal weights for all objective functions: (0.25. 0.25. 0.25. 0.25), and written membership functions, this becomes a single-objective problem. By solving this problem, the optimal answer is equal to 0/6016798 and $x_4 = 1$.

Now if social responsibility is not considered (function of the fourth objective), and the amount $\omega_4 = 0$ Be placed, the optimal answer is equal to: 0/7942173, With the amount $x_4 = 1$. This optimal value is different from the previous optimal answer. The results are shown in Table (10):

Table 10. Optimum values of weighted approach

approach	1	2	3	4	Objective value
weighted (without social responsibility)	0	0	0	1	0/6016798
weighted (with social responsibility)	0	0	0	1	0/7942173

The data in Table 10 show that social responsibility can directly affect the results. Now, considering different weights for the objective function, the problem is solved. Regarding the different variables that are often present in decision models, it is necessary to use sensitivity analysis to determine the effect of changes in model variables on the output and identify and determine the variables that have the least effect on the model output. Such analysis will help decision makers in a situation where the model has many variables. This analysis does not provide a complete answer to the problem but can help to better understand it as a guide. Sensitivity analysis for the weights of the objective function Now, considering different weights for the objective function, the problem is solved. The results are presented in Table 11.

Table 11. The various weights effect on objective function in weighted approach

approach	weight	Selected project	Objective value
weighted	(0/25,0/25,0/25,0/25)	4	0/6016798
weighted	(0/35,0/15,0/25,0/25)	4	0/577062
weighted	(0/15,0/35,0/25,0/25)	4	0/626297
weighted	(0/25,0/25,0/35,0/15)	4	0/7016798
weighted	(0/25,0/25,0/15,0/35)	4	0/5016798
weighted	(0/25,0/35,0/15,0/25)	4	0/584324
weighted	(0/25,0/15,0/35,0/25)	4	0/6190351

According to the results, it can be found out that the decision-maker's preferences in different objectives affect the results; it means that the answers to the problem will be different depending on which objective the decision-maker prioritizes and gives more weight to. Therefore, decision makers must make the right decision about how to assign weights to objective functions. Because incorrect preference for objectives and assigning inappropriate weights may produce inappropriate values. Now, using the fuzzy Shannon entropy technique, the diffused weights are 0.442, 0.32, 0.051, and 0.187.

Table 12. The various weights effect on objective function using fuzzy shannon entropy

approach	Weight	Selected project	Objective value
weighted	(0/187,0/051,0/32,0/442)	4	0/4706568

Sensitivity analysis for the coefficient of the objective function

Now the change in each of the objective functions is examined. Then the single-objective problem is solved with this objective function, and other ideal and negative ideal values are obtained. With changing the ideal and negative ideal values, the membership function of the first objective also changes. The results are presented in Table 13.

Table 13. The effect of changing the coefficients of the objective functions on solutions

Changed objective function	Change value	Selected project	Objective value
Without change	-	4	0/616798
profit	10+	4	0/616798
profit	10-	4	0/616798
budget	10+	4	0/616798
budget	10-	4	0/616798
risk	10+	4	0/616798
risk	10-	4	0/616798
social	10+	4	0/616798
social	10-	4	0/616798

Sensitivity analysis in available resources

In the following, the effect of resource availability on values is investigated. The results are presented in Table 14.

Table 14. The effect of resource availability on the solutions

Changed objective function	Change value	Selected project	Objective value
Without change	-	4	0/616798
Human resource type 1	+10	4	There is no answer
Human resource type 1	-10	4	0/616798
Human resource type 2	+10	4	0/616798
Human resource type 2	-10	4	0/616798
Machin type 1	+10	4	There is no answer
Machin type 1	-10	4	0/616798
Machine type 2	+10	4	0/616798
Machine type 2	-10	4	0/616798
Raw material type 1	+10	4	0/616798
Raw material type 1	-10	4	0/616798
Raw material type 2	+10	4	0/616798
Raw material type 2	-10	4	0/616798

As a result, the model is robust to changes in available resources. It means that the ideal answer and the selected project do not change by changing the coefficients of the problem.

Sensitivity analysis in model parameters (alpha value)
To solve the problem, for different $\alpha(s)$ in the initial fuzzy problem that was then crisped, $\alpha = 1$, $\alpha = 0.1$, $\alpha = 0.2$, and $\alpha = 0.3$ are put instead of $\alpha = 0.5$. The results are presented in Table 15.

Table 15. The impact of various alpha values on the problem solutions

Alpha value	Selected project	Objective value
0	4	0/616798
0/1	4	0/616798
0/2	4	0/616798
0/3	4	0/616798
0/4	4	0/616798
0/5	4	0/616798
0/6	4	0/616798
0/7	4	0/616798
0/8	4	0/616798
0/9	4	0/616798
1	4	0/616798

For all $\alpha(s)$ in tables 15, the ideal value was 0/6016798, and $X_4 = 1$. This means that in Figure 4, the graph is a straight line for different values of α. This means that this problem is also strong against changes of α.

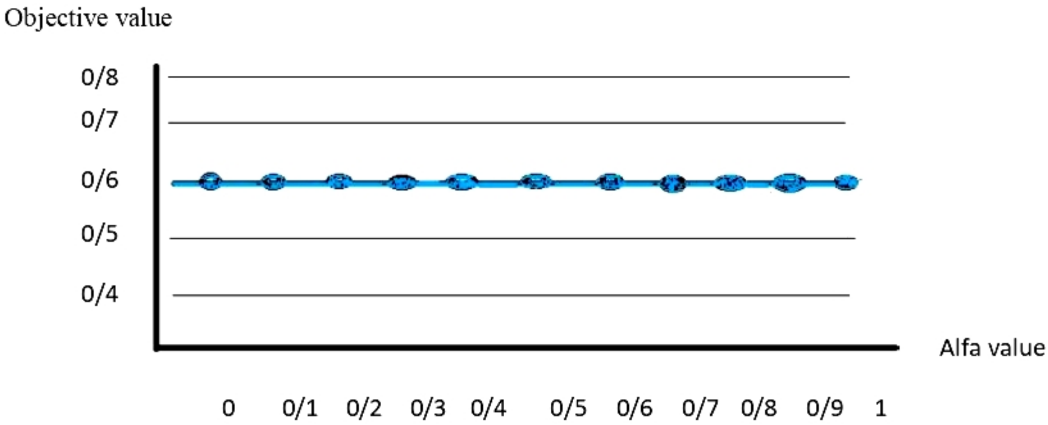

Figure (4). Objective value vs. alpha

Considering the limitations of nine models, all four projects were prioritized and the results are presented in Table 16.

Table 16. Prioritization of projects

Project NO.	Project	Priority
1	Evaluate and calculate the cost price of date products	Third
2	ISO 9001 quality management systems implementation project	Fourth
3	Develop a system of natural risks in the province	Second
4	Design and development of strategic management system of Green Tablet	First

8. Conclusion

In this research, a fuzzy multi-objective programming model was proposed to select the project. The problem model consisted of four objective functions. Objectives and parameters were considered as triangular fuzzy numbers. In order to solve the problem, first the fuzzy parameters were converted to crisp numbers using the fuzzy number ranking method. Then, the weighting method was proposed to solve the final model due to the multi-objective problem. Findings showed that social responsibility directly affects the ideal value of the objective function. The results also showed that decision makers' preferences in different objectives significantly affect the project selection problem.

In addition, limitations are important and influential factors in the process of selecting, programming and implementation of a project. One of the most influential factors in the progress of any project is the timely provision and management of resources of that project. In other words, lack of resources in the required time prevents the rapid progress of any project. Today, it is important to be aware of the status of receipts and payments during the project, which includes identifying, prioritizing and programming for resource allocation due to resource limitations in many project-oriented organizations and companies. Sensitivity analysis on resources proved that the model is robust to changes in available resources, meaning that by changing the coefficients of the problem, the ideal answer and the selected project do not change. Project budget and profitability are the first limitations of all small and large projects. Even in cultural projects where people go to work without receiving a fee, there is a shortage of staff and a lack of funding to provide supplies. Project budgeting is one of the most important tasks of project planners, and how to provide the necessary funding to advance project objectives is a very difficult task for managers. Also, the sensitivity analysis for the objective function coefficient (cost, profit, risk, employment) and also the sensitivity analysis on the model parameters indicate that the ideal value of the objective does not change with increasing the α value and the graph will be in the form of a straight line. The fuzzy model, in addition to being close to the real environment, causes managers to decide on their level of risk-taking or risk aversion based on the uncertainty degree from the real environment conditions, and select the desired project. Also, the implementation of the fuzzy model does not cause a large increase in the complexity of the calculations and the solution time. According to the extensive studies conducted in this study in order to identify important indices of project selection and also the use of decision-making model based on scientific principles, it is suggested for future tenders of the company, the project be selected using the proposed model in the research. Applying this model will lead to results such as reducing contract failures as well as improving quality problems and ultimately reducing the costs. One of the problems in the company's projects is the lack of raw materials and machinery available. Excessive use of old and limited machinery increases the cost of maintenance and repair of machinery and the cost of project implementation. Therefore, it is recommended to increase the number of available raw materials and machinery in projects, because this increases project productivity, and ultimately leads to maximum project profitability.

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