An Intuitionistic Fuzzy Decision Support for Agile Project Selection Problem

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Abstract: - In the early 1990s, organizations started to use information technology and software engineering, which encouraged the companies for employing project management methodologies to survive and then advance in competitive technologic environment. Use of project management methodologies provides efficient planning, budgeting and scheduling processes and high management quality for companies. A lot of different methodologies were developed and used to reach better ways of defining the project requirements, analyzing the problem, and implementing it in a systematic manner. In 2001, agile project management methodology came forward in response to cope with waterfall project methodology's limitations that arise from unpredictability of technology evolution, customer requirements, and unstable business environments. In this study, intuitionistic fuzzy COPRAS method, which aims to obtain a solution relative to the ideal solution, is used to rank agile project alternatives and identify the best performing one among them. Intuitionistic fuzzy sets are used to deal with loss of information and hesitation in data that may occur in operations with fuzzy numbers. The application of the proposed intuitionistic fuzzy decision-making approach is illustrated by conducting a case study.

Key-Words: - Project selection, agile, multi-criteria decision making, intuitionistic fuzzy decision making, COPRAS

Received: September 26, 2022. Revised: August 27, 2023. Accepted: September 19, 2023. Published: October 25, 2023.

1 Introduction

Recent technical advancements and organizational changes have made project management increasingly crucial to accomplishing individual goals. A project is defined as an individual's or a group's work over a specific time period toward a specified objective. Project management, which is essential for a project's success, is the use of information, skills, tools, and procedures in project activities to meet project requirements. Humans have utilized project management for a long time; it is not a novel idea [1]. In reality, modern project management started to take shape in the early 1900s. This look may be seen during the creation of Gantt charts [2]. Project management approaches have only been used by organizations since the mid-1900s [3].

To better define the project's needs, analyze the issue, and implement it in a methodical fashion, several alternative approaches were devised and implemented. Although the waterfall project management style is linear and chronological, it is mostly unsuccessful at identifying client demands, controlling costs, adapting to constantly changing project requirements, and meeting delivery deadlines. Agile project management technique was developed in 2001 in response to the limits of waterfall project methodology, which are brought on by the unpredictability of technological advancement, client demands, and erratic business situations [3].

The project team should include representatives of the project's stakeholders, evaluating and critiquing each section or iteration. The results obtained from one iteration are used to decide the next phase of the project [4]. Lean Six Sigma (LSS), is a newly developed approach, discovered with the combination of two different concepts, known as Lean and Six Sigma. Its goal is to increase shareholder value by delivering superior quality, speed, customer satisfaction and cost. Lean and Six Sigma tools and principles must be harmoniously integrated. The Six Sigma project management method focuses on accuracy and precision, while the lean project management method focuses on efficiency and speed [5].

In this study, intuitionistic fuzzy COPRAS (IFCOPRAS) method, which aims to obtain a solution relative to the ideal solution, is used to rank agile project alternatives and identify the best performing one among them. Intuitionistic fuzzy sets are used to deal with loss of information and hesitation in data that may occur in operations with fuzzy numbers. The application of the proposed intuitionistic fuzzy decision-making approach is illustrated by conducting a case study by collecting linguistic data from the experts. Four project alternatives are ranked, and seven evaluation criteria are utilized. The applied decision approach provides including intuitionistic fuzzy numbers into the decision framework for expressing experts' opinions, hence hesitation is computed.

The rest of the study is organized as follows. Section 2 outlines IFCOPRAS method. Section 4 illustrates the application of the developed methodology for project evaluation and problem. Finally, concluding remarks and future research directions are delineated in the last section.

2 Intuitionistic Fuzzy COPRAS Method

Fuzzy set theory was initially presented by Zadeh [6] to cope with the decision problems that contain uncertain and vague data. Fuzzy set theory has been applied in various research studies that provide applications in different sectors. It assumes that the membership degree of an element is a single value that is between zero and one. However, the non-membership degree of an element may not always be equal to one minus the membership degree due to the hesitation degree [7]. For that reason, Atanassov [8] proposed intuitionistic fuzzy sets (IFS), which become the extension of fuzzy sets. IFS take into account the degree of hesitation that is computed as one minus the sum of membership and non-membership degrees.

The basic notions and some operations of IFS are given as

Definition 1 [9]. Let $E \neq \emptyset$ be a given set. An IFS in E is an object Y described in

$$\tilde{Y} = \{\langle x, \mu_{\tilde{Y}}(x), \nu_{\tilde{Y}}(x)\rangle; x \in E\} \quad (1)$$

where $\mu_{\tilde{Y}}: E \to [0,1]$ and $\nu_{\tilde{Y}}: E \to [0,1]$ satisfy the condition $0 \leq \mu_{\tilde{Y}}(x) + \nu_{\tilde{Y}}(x) \leq 1$ for every $x \in E$. Hesitancy is equal to one minus the sum of membership and non-membership degrees as

$$\pi_{\tilde{Y}}(x) = 1 - (\mu_{\tilde{Y}}(x) + \nu_{\tilde{Y}}(x)) \quad (2)$$

Definition 2 [10]. Let Y and Z be two IFSs in the set E. Namely, $\tilde{Y} = \{\langle x, \mu_{\tilde{Y}}(x), \nu_{\tilde{Y}}(x)\rangle | x \in E\}$ and $\tilde{Z} = \{\langle x, \mu_{\tilde{Z}}(x), \nu_{\tilde{Z}}(x)\rangle | x \in E\}$.

The operations of summation and multiplication between $\tilde{Y}$ and $\tilde{Z}$ are defined as

$$\tilde{Y} + \tilde{Z} = \{\langle x, \mu_{\tilde{Y}}(x) + \mu_{\tilde{Z}}(x) - \mu_{\tilde{Y}}(x).\mu_{\tilde{Z}}(x), \nu_{\tilde{Y}}(x).\nu_{\tilde{Z}}(x)\rangle |\, x \in E\}$$

(3)

$$\tilde{Y}.\tilde{Z} = \{\langle x, \mu_{\tilde{Y}}(x).\mu_{\tilde{Z}}(x), \nu_{\tilde{Y}}(x) + \nu_{\tilde{Z}}(x) - \nu_{\tilde{Y}}(x).\nu_{\tilde{Z}}(x)\rangle |\, x \in E\}$$

(4)

Definition 3 [10]. For any positive integer number k, $k\tilde{Y}$ is defined as

$$k\tilde{Y} = \{\langle x, \mu_{k\tilde{Y}}(x), \nu_{k\tilde{Y}}(x)\rangle : x \in E\}, \quad (5)$$

where $\mu_{k\tilde{Y}}(x) = 1 - (1 - \mu_{\tilde{Y}}(x))^k$ and $\nu_{k\tilde{Y}}(x) = [\nu_{\tilde{Y}}(x)]^k$

Definition 4 [11]. Let $\theta_l = \langle \mu_l, \nu_l \rangle$,$\forall l$, be an intuitionistic fuzzy number. The score of θ_l is defined as follows:

$$S(\theta_l) = (\mu_l - \nu_l) \quad (6)$$

where $S(\theta_l) \in [-1,1]$

Definition 5 [12]. Let $\theta_l = \langle \mu_l, \nu_l \rangle$,$\forall l$, be an intuitionistic fuzzy number. The normalized score of θ_l is defined as

$$S^*(\theta_l) = \frac{1}{2}(S(\theta_l) + 1) \quad (7)$$

where $S^*(\theta_l) \in [0,1]$.

Decision problems in business life often require numerous criteria, which are conflicted and related to each other. Besides, crisp numbers may not always be available while collecting the data. In such circumstances, fuzzy set theory is suitable to cope with vagueness and imprecision in data. On the other hand, fuzzy set theory fails to handle the evaluation of membership and non-membership because of the lack of information, and thus hesitancy occurs. IFS theory is proposed to deal with hesitation in decision processes. In this paper, an integrated intuitionistic fuzzy decision aid framework is introduced. Weighting process is completed via IFCM tool whereas IFCOPRAS method is employed for selection procedure. The COPRAS (Complex Proportional Assessment) technique, which was initially presented by Zavadskas and Kaklauskas [13], is an MCDM (multiple criteria decision making) method that determines a solution relative to the ideal solution. The stepwise illustration of the developed framework, which is represented in Figure 1, is as

Step 1. Form a committee of experts, identify the alternatives (A_r=1,2,…,m), and the evaluation criteria C_i (i=1,2,...,n).

Step 2. Obtain the data regarding the ratings of alternatives according to the criteria, and the causal relations among the criteria.

Step 3. Compute the importance weights of criteria by following the steps of IFCM mentioned in Section 3.2.

Step 4. Normalize the importance weights employing Equation (8)

$$\varphi_i = \frac{\zeta_i}{\sum_{i=1}^{n} \zeta_i}, \forall i \quad (8)$$

where φ_i represent the normalized weight of criterion i.

Step 5. Start the selection process using IFCOPRAS method. Obtain weighted data using Equation (9)

$$\tilde{v}_{ri} = \varphi_i \tilde{t}_{ri},\ r = 1,2,\dots,m;\ i = 1,2,\dots,n \quad (9)$$

where $\tilde{t}_{ri}$ represents the rating of the rth alternative regarding ith criterion and φ_i is the weight of the ith criterion, and $\sum_{i=1}^{n} \varphi_i = 1$.

Step 6. Sum the cost and benefit criteria values.

Let $\Delta = \{1,2,\dots,h\}$ be a set of cost criteria, i.e. the minimum values refer to superior option. Calculate α_r values for each alternative employing Equation (10).

$$\alpha_r = \sum_{i=1}^{h} \tilde{t}_{ri},\ r = 1,2,\dots,m \quad (10)$$

Step 7. Let $\nabla = \{h+1, h+2,\dots,n\}$ be a set of benefit criteria, i.e. the maximum values represent superior choice. Calculate β_r values for each alternative employing Equation (11).

$$\beta_r = \sum_{i=h+1}^{n} \tilde{t}_{ri},\ r = 1,2,\dots,m \quad (11)$$

Step 8. Calculate the degree of relative weights of alternatives (γ_r) using Equation (12) [14]

$$\gamma_r = S^*(\beta_r) + \frac{\sum_{r=1}^{m} S^*(\alpha_r)}{S^*(\alpha_r) \sum_{r=1}^{m} \frac{1}{S^*(\alpha_r)}}, \qquad r = 1,2,\dots,m$$

(12)

Step 9. Determine the priority of the alternatives (λ_r) using Equation (13) and rank the alternatives in descending order.

$$\lambda_r = \frac{\gamma_r}{\gamma_{max}} * 100\%,\ r = 1,2,\dots,m \quad (13)$$

3 Case Study

In order to illustrate the application of the proposed decision making method to agile project selection problem, a case study conducted in a bank located in Istanbul, is introduced. As a result of interviews with decision-makers, four project alternatives are determined.

Determining the most appropriate agile project relies on a number of distinct factors. Benefiting from the experts opinions and the literature, seven criteria are defined as cost, project complexity, ineffective processes, communication between project members, project planning, clear objective and goals, and customer participation

A committee of three decision-makers conducted the evaluation process. A questionnaire is prepared regarding evaluation of alternatives with respect to qualitative criteria. They created a consensus and used the linguistic term set very low (VL), low (L), medium (M), high (H), very high (VH) as given in Table 1.

Table 4. Linguistic scale

Linguistic variables	IFS
Very High (VH)	<0.95,0.05>
High (H)	<0.70,0.25>
Medium (M)	<0.50,0.40>

Low (L)	<0.25,0.70>
Very Low (VL)	<0.05,0.95>

The evaluation matrix of neuromarketing technology alternatives is given in Table 2.

Table 2. Evaluation matrix

	A_1	A_2	A_3	A_4	weight
C_1	M	M	VL	M	H
C_2	M	VL	VH	H	VL
C_3	VL	M	VL	VL	H
C_4	H	M	L	L	VH
C_5	M	VL	H	M	L
C_6	M	H	VH	M	M
C_7	L	M	M	VL	H

Membership, non-membership, and hesitation values are given in Tables 3,4,5, respectively.

Table 3. Membership values

	A_1	A_2	A_3	A_4
C_1	0.5	0.5	0.05	0.5
C_2	0.5	0.05	0.95	0.7
C_3	0.05	0.5	0.05	0.05
C_4	0.7	0.5	0.25	0.25
C_5	0.5	0.05	0.7	0.5
C_6	0.5	0.7	0.95	0.5
C_7	0.25	0.5	0.5	0.05

Table 4. Non-membership values

	A_1	A_2	A_3	A_4
C_1	0.4	0.4	0.95	0.4
C_2	0.4	0.95	0.05	0.25
C_3	0.95	0.4	0.95	0.95
C_4	0.25	0.4	0.7	0.7
C_5	0.4	0.95	0.25	0.4
C_6	0.4	0.25	0.05	0.4
C_7	0.7	0.4	0.4	0.95

Table 5. Hesitation values

	A_1	A_2	A_3	A_4
C_1	0.1	0.1	0	0.1
C_2	0.1	0	0	0.05
C_3	0	0.1	0	0
C_4	0.05	0.1	0.05	0.05
C_5	0.1	0	0.05	0.1
C_6	0.1	0.05	0	0.1
C_7	0.05	0.1	0.1	0

After collecting intuitionistic fuzzy data, weighted data are obtained using Definition (2) and given in Tables 6,7,8, respectively.

Table 6. Membeship values of weighted data

	A_1	A_2	A_3	A_4
C_1	0.35	0.35	0.035	0.35
C_2	0.025	0.0025	0.0475	0.035
C_3	0.035	0.35	0.035	0.035
C_4	0.665	0.475	0.2375	0.2375
C_5	0.125	0.0125	0.175	0.125
C_6	0.25	0.35	0.475	0.25
C_7	0.175	0.35	0.35	0.035

Table 7. Non-membership values of weighted data

	A_1	A_2	A_3	A_4
C_1	0.55	0.55	0.9625	0.55
C_2	0.97	0.9975	0.9525	0.9625
C_3	0.9625	0.55	0.9625	0.9625
C_4	0.2875	0.43	0.715	0.715
C_5	0.82	0.985	0.775	0.82
C_6	0.64	0.55	0.43	0.64
C_7	0.775	0.55	0.55	0.9625

Table 8. Hesitation values of weighted data

	A_1	A_2	A_3	A_4
C_1	0.1	0.1	0.003	0.1
C_2	0.005	0	0	0.003
C_3	0.003	0.1	0.003	0.003
C_4	0.048	0.095	0.0475	0.0475
C_5	0.055	0.003	0.05	0.055
C_6	0.11	0.1	0.095	0.11
C_7	0.05	0.1	0.1	0.003

The sum of cost and benefit criteria values are calculated by employing Equations (10) and (11). Degree of relative weights as well as the priorities of the alternatives are computed using Equations (12) and (13), and the alternatives are ranked in descending order according to their priorities. Overall computational outcomes of IFCOPRAS methodology are given in Table 9.

Table 9. Overall computational outcomes

	$S^*(\alpha_r)$	$S^*(\beta_r)$	γ_r	λ_r	Rank
A_1	1.702	0.851	1.103	0.618	2
A_2	1.653	0.826	1.000	0.560	3
A_3	1.654	0.827	1.786	1.000	1
A_4	1.156	0.578	0.828	0.464	4

4 Conclusions

In this study, IFCOPRAS method, which aims to obtain a solution relative to the ideal solution, is used to rank agile project alternatives and identify the best performing one among them. Intuitionistic fuzzy sets are used to deal with loss of information and hesitation in data that may occur in operations with fuzzy numbers. The application of the proposed intuitionistic fuzzy decision-making approach is illustrated by conducting a case study. Four project alternatives are proposed, and 7 evaluation criteria are utilized. The applied decision approach provides including intuitionistic fuzzy numbers into the decision framework for expressing experts' opinions, hence hesitation is computed. Future research will focus on proposing group decision making framework.

Acknowledgement:
This work is supported by Galatasaray University Research Fund Project FBA-2022-1107.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

This work is supported by Galatasaray University Research Fund Project FBA-2022-1107.

Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.