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The combination of fuzzy electre and swot to select private sectors in partnership projects
Case study of water treatment project in Iran

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Abstract

Employer Organizations have increasingly interested in outsourcing their projects in the form of public-private partnership (PPP) due to various reasons such as compromising the resource limitations, entering new technologies to the organization and reducing risk. Choosing the private sector as one of the most basic steps in the formation of PPP is of great importance. The present study aims to introduce a hybrid model to evaluate and choose the private sector as one of the parties in PPP using a combination of SWOT-AHP analysis, as one of the most powerful tools in identifying the problem environment, and Fuzzy ELECTRE analysis to evaluate the existing candidates to participate in the partnership using the criteria resulted from SWOT analysis. In first step, criteria set by an organization, as a case, to choose appropriate private sector were identified using SWOT method during various meetings with qualified experts. Then, the best choice was selected using ELECTRE method. Finally, obtained results were compared with the PROMETHE method. The results showed the effectiveness of our proposed method to select private partnerships especially positive and negative inter-organizational and outer-organizational factors significantly influence the private sector selection.

Keywords: *Participatory projects, Selection of private sector, Swot, AHP, Fuzzy electre.*

1. Introduction

Existing infrastructures are one of the most important differential aspects of developing and developed countries [1]. Maturity of developing the vital infrastructures have enabled developed countries to maintain their growth and development. Therefore, the construction of vital infrastructures is considered among basic needs of developing countries. Vital infrastructures of a country are related to its interconnected roads, railroads, dams, power plants, sea and airlines, telecommunications, etc. Therefore, the development of infrastructures strongly depends on the development of civil projects.

A definition of a project, specifically those classified as macro civil and national projects, involves complicated and important steps. The projects, defined under the following summarized steps, are divided into two strategic and administrative activities [2]:

Strategic activities:

1- Formulation of national development strategy;

2- Planning of sectional development;

3- Project definition;

4- Technical- economical feasibility studies;

Administrative activities

5- Financing the plan;

6- Preparing a basic and detailed plan;

7- Project execution;

8- Commissioning and maintaining;

9- Enhancing management, optimization and increasing the productivity.

The strategic activities, items1-4, focus on the policies regarding project execution and strategic issues in macro management level, while administrative activities, items 5-9, are mainly related to administrative issues to create a final product of the project. Policy making and the definition of a civil project in collaboration with surveying the requirements of a project execution may be rapidly manifested, while determination of needs and definition of a project in compliance with the type of need and its elimination require accurate expertise studies. In practice, the abundance of the developing countries needs and lack of harmony between such needs and the limited resources of a country usually cause the execution of this phase to be problematic. Involvement of the private sector in the execution phase of the projects can be manifested in

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different manners such as Private Finance Initiatives (PFIs), Joint Ventures (JV), Partnership Companies, Partnership Investment, Franchises, Build-Operator-Transfer (BOT) [3]. Generally, concept of investment participation of public and private sectors in a project, known as public-private participation (PPP), refers to those investment projects where one of the subsets of the central government (and/or local government) assumes the responsibility of financing, performing and commissioning the project through participation with one or more private companies and the revenues resulting from commissioning the project are divided between each of the partners in proportion to their contributions. In other words, participation investment means two parties agree to share their resources for the production of a unique product and any probable profits and losses accrued in the course of production are shared between public and private sectors in proportion with their contributions as agreed by them. The tendency of the companies involved in Britain for carrying out the projects in the form of participation has been increasing since 1997 [4]. Australia and Britain were the pioneers in this regard and France, Germany, Ireland, Italy, Japan, Korea, Portugal, Spain, Turkey, Argentina, Brazil, South Africa and others were among other countries following this policy in 2004. Most of the projects carried out in the form of participation in these countries included designing, construction, project financing, repair and maintenance of public-owned infrastructure structures [5].

In Iran most of water sector projects have been conducted by government funding till 2005. However, limitations of resources, budget and equipments as well as the government's emphasis on the private sector partnership, water sector partnership (participatory) projects have been started since 2005. The BOO (Build Own Operate), BOT (Build Operate Transfer), BOOT (Build Own Operate & Transfer), and buyback are the most common forms of projects partnership approaches used in the construction industry in Iran [6-8].

Value for money, developing financial resources, entering technology, more effective management of the projects, growth of the contracts, recovering resources deficit, improving the interaction of public and private sectors and increasing public satisfaction are the most important advantages that persuade the public sector to define the projects as participation initiatives. On the other hand, organization development, profitability, entrance into different markets and decreasing the risk are considered as the most important factors that persuade the private sector to cooperate with the public sector. Issues such as lack of defined laws and regulations in this regard, cultural contradictions found in the field of international participations, resistance of public cumbersome laws against change and the novelty of such contracts have caused some tenacities in the course of development of such contracts. As a result, global community is continuously changing and departing from the conventional management stage toward contractual modern systems for carrying out different types of projects. Then, assignment of the projects to the private sector is an issue which is of great importance. Choosing the private sector as one of the most fundamental stages of establishment and development of participation of public and private sectors is of great significance. Proper selection will lead to effective participation and finally to production of the product of the project, while improper selection and lack of mutual understanding of the conditions of the parties not only leads to ifs and buts, but also may lead to many financial, social and political consequences. Therefore, the main purpose of this study is to present a comprehensive model for owners, mainly in public-owned sector to evaluate and assign the private sector for investment and carrying out civil projects in the country. Multiple criteria must be considered for process selection, thus; choosing a private sector has a multiple-criteria nature. Therefore, in this paper, while presenting a hybrid model, the authors have tried to help the managers of the public sector to get acquaintance of all dimensions of the issue and to make an easier decision-making process for them. The presented model is a combination of the SWOT analysis method for identification of strengths and weaknesses as well as opportunities and threats existing in this regard and Fuzzy ELECTRE to model multiple criteria for decision making. The main characteristics of the presented model are as follows:

- Using SWOT Analysis for better identification of internal and external conditions for choosing the private sector;
- Developing a field research for identification of the parameters affecting choosing the private sector;
- Integration of Fuzzy theory with ELECTRE method due to easier use of the model and cover of uncertainties existing in this regard;
- Developing a structured and organized and step by step model for better understanding.

In the following section, the literature of the research on choosing the private sector in recent studies is presented. Then, different stages of model development will be explained stage by stage. Then, the presented model will be discussed using a case study and finally the results will be discussed and some points are expressed as conclusions.

2. Review of Recent Literature

Generally, the scope of researches conducted in the last few years for developing comprehensive models for choosing the private sector to establish a private public participation is entirely limited. By limiting the case solely to the construction industry and civil projects, the conditions have become more critical resulting in a few number researchers involved in this field. Most of the models developed in this regard are focused on selection, establishment and supervision of the participation [9]. Pelton et al. (2002) suggested a model for selecting a private partner composed of four stages including initiation, screening, motivation and supervision of participation [10]. Fang et al. (2002) propose a 4-stage model including selection, establishment, maintenance and withdrawal for establishment of participation between companies of small and medium sizes [11]. Mohamed (2003) conducted an extensive review on international partnerships as Joint Venture in Australia and England [12]. They showed that the local private sector selection and comparing them with the conditions of partnership specifically in terms of risk management may significantly increase the partnership performance. In accordance with a research conducted by Sillars et al. [13] on the factors affecting of the private sector selection for participation of construction companies in US, it was proven that the selection of the smaller private sector in Joint Ventures may lead to more promising market growth than larger companies. Moreover, they emphasized the cultural coincidence of contracting parties in partnership for project success. Chen and Tseng [14] determined the resources of the private sector as one of the most effective factors affecting selecting private sector as one of the participating parties. Tang et al. [15] suggested a model for evaluation of main success factors affecting the public and private participation. In the model suggested by them, the relationship of selection of participating parties with main success factors has been shown. In addition, they have acknowledged the remarkable role played by proper selection of the private sector for assignment of the projects in the construction industry. Kumaraswamy and Anvuur [16] developed a model for optimization of public private partnership team. Their model is based upon the appraisal of participating parties on the basis of the balance of the quality of last performance of the parties, technical capabilities, tolerability and relative criteria. Ye and Li [17] developed a model for selection of the participating party in virtual companies on the basis of the group decision-making method. Application of a range of numbers for compensation of lack of data in this regard was one of the innovations of the model developed by them.

By reviewing researches conducted in this regard, it is concluded that:

1. There have been few models for selection process of private party selection. Thus, developing more models is necessary.
2. The proposed models have conceptualized the nature and their function may be changed by changing the presuppositions made earlier.
3. Since the numbers of affecting criteria in this regard are varied, no proper method or approach has been proposed for evaluation of all criteria.
4. Despite the multi-criteria nature of issues regarding selection of the parties involved in the participations, few individuals have used multi-criteria decision-making methods as a suitable approach for modeling such issues.
5. Linguistic variable are the most useful approaches to obtain the experts opinions where uncertainty about input data is high and the decision makers could not distinguish between the rate of criteria. For working with linguistic terms of the model, the authors applied fuzzy set theory and combined it with multi-criteria-decision making method. This combined approach is new that has not been reported elsewhere.

Participation projects are new phenomenon in Iran which necessitates conducting applied researches in this regard to identify all unknown dimensions of such contracts and the previously reported problems. Therefore, the present article aims to provide a suitable context for more easier selection of the private sector by public sector by presenting an organized and structured model. By using SWOT Analysis, the authors have tried to become acquainted with all criteria affecting the selection of the private sector and make an easier selection process for decision-makers using one of the multi-criteria decision-making (ELECTRE) and integrating it with Fuzzy theory.

3. The Model Description

Multiple-criteria decision-making (MCDM) is the most applicable tool in the selection and evaluation process especially in the construction industry. Several studies have been conducted in these areas in various fields such as project selection [18,19], contractor selection [20, 21], risk assessment [22, 23] [22], supplier selection [24, 25], plant location selection [26], material selection [27, 28], etc. Different methods have been developed for the traditional decision-making problems, such as TOPSIS method [29, 30], VIKOR method [23, 31, 32], PROMETHEE method [33, 34], ELECTRE method proposed the extended TOPSIS method with various attributed values respectively, such as interval numbers, triangular fuzzy numbers, and trapezoidal fuzzy numbers etc. [22, 35-39].

Considering the previous studies, we used a hybrid-based model to evaluate and select the private sector for assignment of the projects. At a broader view, the model presented in the present research consists of different methods such as SWOT analysis, the Analytical Hierarchy Process (AHP) and ELECTRE method.

However, in this method the ratings and the weights of the selection criteria are known precisely and thus are inadequate for dealing with the imprecise or vague nature of linguistic assessment [40].

Combining MCDM approaches with the fuzzy theory is an accepted viewpoint which can properly deal with dark and vague conditions of the construction industry in the decision making phase. [41].

In fuzzy ELECTRE, linguistic preferences can easily be converted to fuzzy numbers [42].In other words, decision makers utilize fuzzy numbers instead of single values in the evaluation process of the ELECTRE [43].

In first step, the criteria of strength, weakness, opportunities and threats involved in the projects assignment to the private sector are firstly considered based on the contractors' point of view. The AHP method is applied for weighing the criteria to determine the weights and rating their importance. In this way, a realistic approach resulting from classification of the criteria is provided for the decision-makers and they should evaluate the probability of occurrence of each criterion. In the last stage, using the views made by the experts as well as using the output from the previous stage, the Fuzzy ELECTRE method is used for evaluating and scoring the suggested choices.

4. Applicable Principles

4.1. Fuzzy set

The Fuzzy set of $\tilde{a}$ in the reference set of X is indicated as $\mu_{\tilde{a}}(x)$, so that one natural number within the [0, 1] range is attributed to each member of x from X set where $\mu_{\tilde{a}}(x)$ is a membership function corresponding to x member in $\tilde{a}$ set.

4.2. Fuzzy Number

Fuzzy numbers refer to those which a definite membership function is attributed to instead of a specified value being defined for them and trapezoidal Fuzzy Number $\tilde{a}=(a_1,a_2,a_3,a_4)$ is specifically defined as shown in Eq. (1). The form of trapezoidal Fuzzy number is as shown in Fig. 1.

$$\mu_{\tilde{a}}(x)=\begin{cases} 0 & x<a_1 \\ \dfrac{x-a_1}{a_2-a_1} & a_1\le x\le a_2 \\ 1 & a_2\le x\le a_3 \\ \dfrac{x-a_4}{a_4-a_3} & a_3\le x\le a_4 \\ 0 & x>a_4 \end{cases} \tag{1}$$

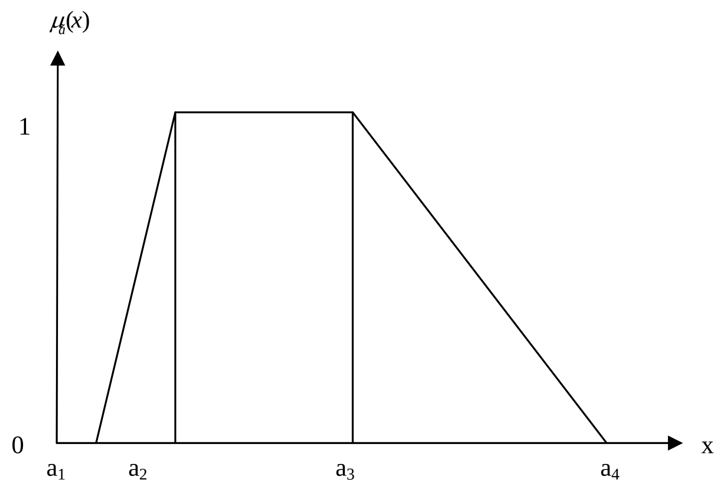


Fig. 1 Trapezoidal fuzzy number $\tilde{a}$

4.3. Comparison of fuzzy numbers

We used Torques method for comparison of Fuzzy numbers. Values of $\sigma(\tilde{m})$ and $\bar{x}(\tilde{m})$ are calculated for the Fuzzy numbers (Eq. 2).

$$\bar{x}(\tilde{m})=\frac{\int x\mu_{\tilde{m}}(x)dx}{\int \mu_{\tilde{m}}(x)dx} \qquad \sigma(\tilde{m})=\left[\frac{\int x^2\mu_{\tilde{m}}(x)dx}{\int \mu_{\tilde{m}}(x)dx}-\bar{x}(\tilde{m})\right]^{1/2} \tag{2}$$

If Fuzzy number is trapezoidal, the equations will be defined as follows (Eq. 3):

$$\tilde{x}(\tilde{m})=\frac{\left(-m_1^2-m_2^2+m_3^2+m_4^2-m_1m_2+m_3m_4\right)}{3\left(-m_1-m_2+m_3+m_4\right)}$$

$$\sigma(\tilde{m})=\left(\left[\frac{1}{m_2-m_1}\left(\frac{m_2^4}{4}-\frac{m_1m_2^3}{3}+\frac{m_1^4}{12}\right)+\frac{1}{3}\left(m_3^3-m_2^3\right)+\frac{1}{m_4-m_3}\left(\frac{m_4^4}{12}-\frac{m_3^2m_4}{3}+\frac{m_2^4}{4}\right)\right]\Big/\left(\frac{1}{2}\left(-m_1-m_2+m_3+m_4\right)\right)-\frac{\left(-m_1^2-m_2^2+m_3^2+m_4^2-m_1m_2+m_3m_4\right)}{3\left(-m_1-m_2+m_3+m_4\right)}\right) \tag{3}$$

For a comparison of two Fuzzy Numbers, Eq. (4) is used as follows:

$$\begin{aligned} &if \quad x(\tilde{m}) > x(\tilde{v}) \Rightarrow \tilde{m} > \tilde{v} \\ &if \quad x(\tilde{m}) = x(\tilde{v}), \sigma(\tilde{m}) < \sigma(\tilde{v}) \Rightarrow \tilde{m} > \tilde{v} \end{aligned} \quad (4)$$

5. Model Stages

A summary of the function resulted by the proposed model is shown in Fig. 2. The stages of suggested models are as follows:

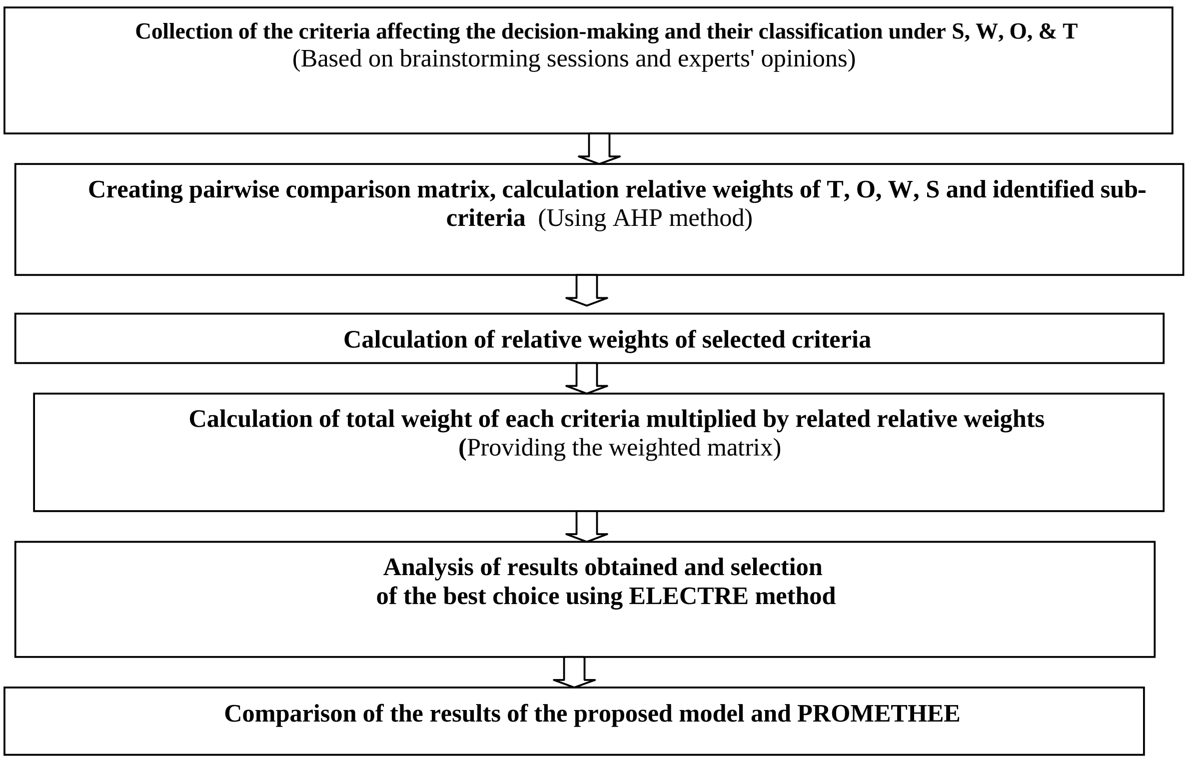


Fig. 2 Step of proposed method

5.1. SWOT Analysis

Different organizations and institutes have to formulate different strategies for achieving their long-term goals. In this regard, different approaches are applied at strategic management processes [44] and SWOT analysis is the most popular powerful tool to formulate the strategies of organizations [45]. It was developed for the first time by Albert S. Humphrey as a strategic planning tool for investment in different fields such as the construction industry. By evaluation of Strengths (S) and Weaknesses (W) (context inside organization) as well as Opportunities (O) and Threats (T) (context outside organization) and taking into consideration two-by-two of these criteria, different strategies in compliance with organization goal may be adopted. [46].

To identify the opportunities, threats, weaknesses and strengths of participation or assignment of the projects in the construction industry to the private sector, about 48 criteria classified under different groups were identified using a case study. A committee, composed of seven experts, was formed for evaluation and adjustment of the above criteria. The members of this committee are experienced engineers (more than 10 years of working experience) and active in different fields related to the owner, consultant, plan management and contractor. They were required to identify five criteria of great importance through brain-storming sessions where they examined the criteria identified in each group of classifications related to strengths, weaknesses, opportunities and threats. After holding working sessions (nearly 22 hours), this group classified 18 criteria in four groups as Strengths (S), Weaknesses (W), Opportunities (O) and Threats (T). It is mentioned that these criteria were prepared and finalized taking into consideration the conditions applicable in the construction industry in Iran. The results obtained by the working group are presented in Table (1).

Table 1 SWOT criteria

Main Criteria	Sub-criteria (Level 2)	Description
S	S1: Completion of projects according to the approved schedule	Supervision according to the available schedule for projects
	S2: Organizations' support for assigning the private sector the projects	-
	S3: Effective cost management by experts	Supervision and control of the significance of the added value
	S4: Taking risks in assigning projects	Considering the functional notions of risk in contracts
	S5: Showing flexibility in assigning projects	Availability of different specialties and combination of specialties
W	W1: Lack of regulations on transference	Novelty of regulations on transference of projects to the private sector
	W2: High dependency of organization on the private sector	Lack of expertise, experience, and technology matching the needs of the public sector and budget shortage
	W3: Weakness in controlling projects by government entities	Absence of real interest and loss due to respect for personal interests
O	O1: Shortage of liquidity in the private sector	Shortage of liquidity and budget for implementing projects
	O2: Experience of the private sector with some certain projects	Transferring risk of changes and such in the case of certain projects
	O3: Fame and credit gained by the private sector in implementing projects	Gaining credit and transferring fame from the private sector to the organization
	O4: Equipment and resources of the private sector	Use of the equipment and technology owned by the private sector in the organization
	O5: Use of skilled human force provided by the private sector (party)	Possibility of using experiences and forces in proportion to the project size
T	T1: Lack of tendency of the private sector to compete on wining projects	Lack of supports from the government organization and intervention in the transferred projects
	T2: Multiplicity of expensive projects and budget shortage	-
	T3: Type and contents of contracts transferred to the private sector	Ambiguities associated with paragraphs of new regulations and codes
	T4: Confidentiality of government information and lack of easy access to data	Lack of easy access from the private sector to data and results of projects of public organizations
	T5: Lack of administrative stability in the employer's organization and the private sector	Lack of knowledge of the employer and private sector of mutual responsibilities

5.2. Weighting criteria

For easier evaluation of the projects' characteristics to be assigned to the private sector, the identified criteria are defined under two levels: Main criteria (Level DPOUR1) included in the criteria are related to Strengths (S), Weaknesses (W), Opportunities (O), and Threats (T) and Level 2 consists of sub-criteria existing in each group. In this stage, the AHP method is used for weighing the criteria. The Analytical Hierarchy Process (AHP) is one of the most comprehensive multi-criteria decision-making systems proposed by Saati [47] as a method for solving the decision-making related problems. Using binary comparisons for better understanding is one of the advantages of this method. One of the advantages of the AHP method is a parameter referred to as rate of incompatibility. According to the relations developed for this factor, the rate of incompatibility of a decision is calculated and then it may be judged accordingly. In general, an acceptable rate of incompatibility depends on the decision-maker, but Professor Sa'ati believes that if the rate of incompatibility is greater than 0.1, the judgments have to be reviewed.

5.3. Evaluation of choices

In this paper, the fuzzy ELECTRE I method is considered which was proposed by Hatami-Marbini and Tavana [48]. In other words, for evaluation of the choices, the views made by the experts are collected taking into consideration the outputs from SWOT analysis and the outputs related to the weights calculated in the previous stage (AHP method) are used. This method was developed for the first time by Roy 1968 [49].

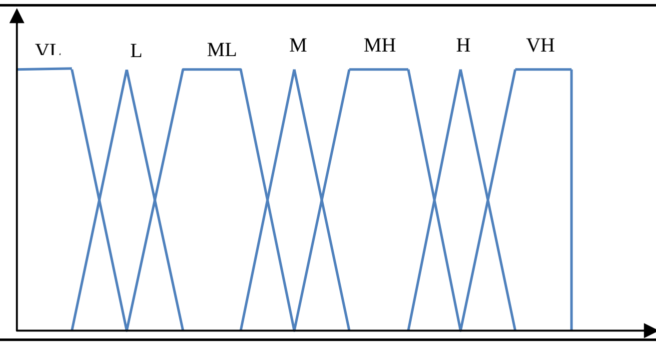
The adopted approach consists of the following stages:

Stage 1. Definition of linguistic variables: As explained before, in the present article, linguistic variables are used for modeling the views made by the experts due to more facilitation and harmonization with the context. In general, Fuzzy numbers are applied for using the linguistic parameters.

There are several fuzzy numbers in the construction industry; the most frequent of them are triangular and trapezoidal fuzzy numbers [50]. Linguistic parameters and corresponding Fuzzy numbers are presented in Table 2.

Table 2 Information related to the linguistic variables [48]

Linguistic terms (weights)	**Generalized interval-valued trapezoidal fuzzy numbers**
Very low (VL)	(0,0,0.1,0.2)
Low (L)	(0.1,0.2,.02,0.3)
Medium low (ML)	(0.2,0.3,0.4,0.5)
Medium (M)	(0.4,0.5,0.5,0.6)
Medium high (MH)	(0.5,0.6,0.7,0.8)
High (H)	(0.7,0.8,0.8,0.9)
Very high (VH)	(0.8,0.9,1,1)



Stage 2. Group Decision-making: Since most of the important decisions are made by a team of experts, in case the Fuzzy rate of the Kth decision-maker is $\tilde{x}_{ijk} = (a_{ijk}, b_{ijk}, c_{ijk}, d_{ijk})$, the final Fuzzy rate taking into consideration each criterion is presented by $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij}, d_{ij})$.

Qualitative opinions of all experts are obtained as quantitative fuzzy numbers according to Table 1 and using the following equation, the final fuzzy number equal to the final decision maker is created to perform calculations of the next related steps using Electre method.

$$\tilde{x}_{ij} = \left(\min_k \{a_{ijk}\}, \frac{1}{k}\sum_{k=1}^{K} b_{ijk}, \frac{1}{k}\sum_{k=1}^{K} c_{ijk}, \max_k \{d_{ijk}\} \right) \quad (5)$$

The product of the above operation will be a matrix for Fuzzy decision and it is presented as follows:

$$\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{2n} & \tilde{x}_{2n} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix}$$

Stage 3. Formation of Weighed Decision Matrix: In case $W = \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix}$ stands for matrix of the weights of SWOT criteria, Fuzzy decision matrix will be the product of W multiplied by $\tilde{D}$.

$$\tilde{V} = [\tilde{v}_{ij}]_{m\times n} = \tilde{D} \times W \qquad i = 1,2,\ldots,m$$
$$\tilde{v}_{ij} = \tilde{x}_{ij} \otimes w_j \qquad j = 1,2,\ldots,n \quad (6)$$

Stage 4. Formation of Concordance and Discordance Matrices: Concordance and Discordance Matrices formation in the ELECTRE method refer to calculation of the number of criteria where the kth choice has priority over the lth choice (called Concordance matrix) as well as calculation of the number of criteria where the kth choice has no priority over the lth choice (called Discordance matrix). The authors have paid attention to the type of criteria of O, W, S and T and it is an innovation. The identity the weaknesses and threats of organization is negative. Then, the approach adopted by the authors in the development of concordance and discordance matrices for evaluation of the choices based on these matrices was completely opposite. In other words, the choices of the least score under classification of weakness and threat criteria have more priority. Concordance matrix (C) and Discordance matrix (D) are formed as follows:

If $\tilde{m}_{kj}$ stands for the Fuzzy number related to j criterion and k choice:

$$C_{kl} = \left\{ j \middle| \tilde{m}_{kj} \geq \tilde{m}_{lj} \right\} \quad (7)$$

$$c_{kl} = \sum_{j \in C_{kl}} w_j \quad (8)$$

$$D_{kl} = \left\{ j \middle| \tilde{m}_{kj} < \tilde{m}_{lj} \right\} \quad (9)$$

$$d_{kl} = \frac{\max_{j \in D_{kl}} \left| \tilde{m}_{kj} - \tilde{m}_{lj} \right|}{\max_{j} \left| \tilde{m}_{kj} - \tilde{m}_{lj} \right|} \quad (10)$$

$$C=\begin{bmatrix} - & c_{12} & \cdots & c_{1m} \\ c_{21} & - & \cdots & c_{2m} \\ \vdots & \vdots & - & \vdots \\ c_{m1} & c_{m2} & \cdots & - \end{bmatrix} \qquad D=\begin{bmatrix} - & d_{12} & \cdots & d_{1m} \\ d_{21} & - & \cdots & d_{2m} \\ \vdots & \vdots & - & \vdots \\ d_{m1} & d_{m2} & \cdots & - \end{bmatrix}$$

Stage 5. Formation of Boolean Matrix: In the ELECTRE method, for a final comparison, Boolean Matrices of B and H are calculated using Equations (11), (12), (13) and (14).

According to the results of the previous step and using the members of matrices C and D in equations 11 and 12, $\bar{c}$ and $\bar{d}$ values are calculated to create matrices H and B. Members of matrices H and B are obtained comparing the members of matrices C and D and $\bar{c}$ and $\bar{d}$ values according to equations 13 and 14.

At last, for the final selection, the final dominance matrix of Z is formed where $z_{ij}=b_{ij}\times h_{ij}$. If in a line, all drays are one, they are selected with the highest priority; otherwise those choices having more dray of one are to be prioritized.

$$B=\begin{bmatrix} - & b_{12} & \cdots & b_{1m} \\ b_{21} & - & \cdots & b_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ b_{m1} & b_{m2} & \cdots & - \end{bmatrix} \qquad H=\begin{bmatrix} - & h_{12} & \cdots & h_{1m} \\ h_{21} & - & \cdots & h_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ h_{m1} & h_{m2} & \cdots & - \end{bmatrix} \qquad Z=\begin{bmatrix} - & z_{12} & \cdots & z_{1m} \\ z_{21} & - & \cdots & z_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ z_{m1} & z_{m2} & \cdots & - \end{bmatrix}$$

$$\bar{c}=(\sum_{l=1}^{m}\sum_{k=1}^{m}c_{kl})/m(m-1) \qquad (11)$$

$$\bar{d}=(\sum_{l=1}^{m}\sum_{k=1}^{m}d_{kl})/m(m-1) \qquad (12)$$

$$\begin{aligned} &if \quad c_{ij}\geq\bar{c} \quad \Rightarrow \quad b_{ij}=1 \\ &if \quad c_{ij}<\bar{c} \quad \Rightarrow \quad b_{ij}=0 \end{aligned} \qquad (13)$$

$$\begin{aligned} &if \quad d_{ij}\geq\bar{d} \quad \Rightarrow \quad h_{ij}=1 \\ &if \quad d_{ij}<\bar{d} \quad \Rightarrow \quad h_{ij}=0 \end{aligned} \qquad (14)$$

6. Case Study

In this step, a real case study is presented to make a comprehensive description. The government wants to choose a private sector in a water treatment project in Iran where three private companies were initially qualified as candidate for the projects. Therefore, to assign the organization's project to one of them; A_1, A_2 and A_3, the suggested model is implemented to make the best decision.

The characteristics of company (A1):

The company has good experience (about 12 years), good financial capabilities, modern equipment, and moderate human resources. The company has experienced several projects smaller than the proposed one and prefers to get a constant strategy in facing new opportunities; so the company is cautious.

The characteristics of company (A2):

The company has very good experience (about 35 years), good financial capabilities and various financial resources in other markets, modern equipment, and good skilled human resources. The company is known for executing projects in-time and with high quality. The company has good flexibility for participating in a joint venture.

The characteristics of company (A3):

The company has limited experience (about 5 years), moderate financial capabilities, old equipment and limited human resources. The company has experienced some big size projects and is able to tolerate various risks and eager enough to participate in a joint venture.

This stage of our study is classified as follows:

The weights of each criterion and sub-criterion calculated in the second step of the model are presented in Fig. 3. This process was performed through creating pairwise comparison matrix (Table 3) using the AHP method to calculate the weights of criteria presented in Tables 4 and5.

In addition, each choice is rated by three decision-makers in accordance with the linguistic variable as specified in Table 2. Final results obtained in this stage are presented in Tables 4 and 5.

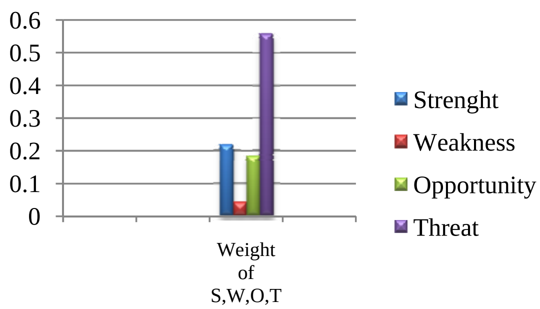
Left figure shows the relative weight of main SWOT criteria compared to each other. The threats and strengths (strength points) are heavier than other criteria and therefore are more important in determining the final option. This means that the option having a greater ability to deal with threats using its strengths can be recognized as the best option. Right figure shows the relative weight of all sub-criteria related to main criteria compared to each other, and in fact, is a guide to prioritizing sub-criteria to increase (strengths-opportunities) or decrease (weaknesses-threats) each of them.

Table 3 Preferences values for pairwise comparisons and pairwise comparison matrix for calculating weights of main criteria and sub-criteria

	S1	S2	S3	S4	S5		T1	T2	T3	T4	T5		S	W	O	T
S1	1	9	3	5	5	T1	1	3	7	9	5	S	1	5	1/3	1/5
S2	1/9	1	1/7	1/5	1/3	T2	1/3	1	5	7	3	W	1/5	1	1/7	1/9
S3	1/3	7	1	3	3	T3	1/7	1/5	1	3	½	O	3	7	1	1/3
S4	1/5	5	1/3	1	2	T4	1/9	1/7	1/3	1	1/5	T	5	9	3	1
S5	1/5	3	1/3	1/2	1	T5	1/5	1/3	2	5	1					
	O1	O2	O3	O4	O5		W1	W2	W3				value	Preferences		
O1	1	5	7	3	9	W1	1	1/3	1/5				9	Fully preferred		
O2	1/5	1	3	1/3	5	W2	3	1	1/3				7	Extremely		
O3	1/7	1/3	1	1/5	3	W3	5	3	1				5	Strongly		
O4	1/3	3	5	1	7								3	Mildly preferred		
O5	1/9	1/5	1/3	1/7	1								1	Equal preference		
													2,4,6,8	Preferences		

Table 4 Weight of criteria and consistency index for SWOT criteria

Criteria	Weight of	Consistency index
S	0.218	0.04
W	0.041	0.03
O	0.183	0.053
T	0.558	0.043



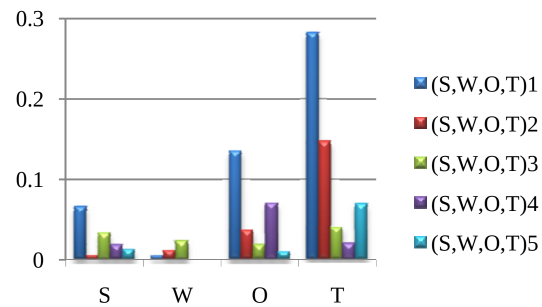


Fig. 3 Weight values for selected criteria

Table 5 Evaluation of alternatives with respect to the DMs' opinions

Criteria	Alternative	D1	D2	D3	Criteria	Alternativ	D1	D2	D3
S1 (.497)	A1	H	H	MH	W1 (.106)	A1	M	M	ML
	A2	VH	VH	VH		A2	MH	M	M
	A3	VH	VH	H		A3	MH	MH	MH
S2 (.036)	A1	M	ML	M	W2 (.26)	A1	MH	MH	MH
	A2	VH	H	VH		A2	H	MH	MH
	A3	H	H	H		A3	H	MH	H
S3 (.246)	A1	VH	H	VH	W3 (.633)	A1	H	H	H
	A2	MH	H	MH		A2	H	VH	H
	A3	H	H	H		A3	H	H	H
S4 (.132)	A1	MH	MH	H	S5 (.088)	A1	M	M	M
	A2	VH	VH	VH		A2	MH	M	MH
	A3	H	VH	H		A3	M	M	MH
Criteria	Alternative	D1	D2	D3	Criteria	Alternativ	D1	D2	D3
T1 (.507)	A1	H	H	H	O1 (.503)	A1	H	MH	H
	A2	H	MH	H		A2	VH	VH	VH
	A3	MH	MH	MH		A3	MH	MH	M

T2 (.263)	A1	MH	MH	MH	O2 (.134)	A1	H	H	H
	A2	M	MH	M		A2	VH	H	H
	A3	M	M	M		A3	H	MH	MH
T3 (.072)	A1	MH	H	MH	O3 (.068)	A1	MH	MH	MH
	A2	H	H	H		A2	MH	MH	MH
	A3	H	H	MH		A3	MH	M	MH
T4 (.035)	A1	H	H	H	O4 (.26)	A1	VH	H	H
	A2	MH	MH	MH		A2	VH	VH	H
	A3	H	MH	MH		A3	H	H	H
T5 (.123)	A1	M	M	M	O5 (.035)	A1	MH	M	M
	A2	M	M	M		A2	MH	MH	MH
	A3	MH	M	MH		A3	ML	M	M

For simplicity, sub-criteria were equalized by the main criteria of S, W, O and T presented the relative weights as calculated on the basis of the AHP method. For example, the view made by decision-maker 1 on choice 1 under S criterion is calculated as follows: $H \times W_{S1} + M \times W_{S2} + VH \times W_{S3} + MH \times W_{S4} + M \times W_{S5}$

where, W_{Sj} stands for relative weights of each sub criteria.

The fuzzy equivalent matrix for each of the decision-makers is determined based on Table 2 and its results are presented in Table 6. For example, the method of calculating the result of the first decision maker for A1 option and S criterion is computed as follows: (.66,.76,.798,.873)=

0.497*(0.7,0.8,0.8,0.9)+0.036*(0.4,0.5,0.5,0.6)+0.246*(0.8,0.9,1,1)+0.132*(0.5,0.6,0.7,0.8)+0.088*(0.4,0.5,0.5,0.6)

Taking Eq. (6) into account, the final decision matrix is weighed (Table 7).

Table 6 Final decision making matrix

	Alternative	S	W	O	T
DM1	A1	(.66,.76,.798,.873)	(.615,.715,.741,.841)	(.705,.805,.842,.916)	(.596,.696,.73,.83)
	A2	(.769,.869,.969,.979)	(.678,.778,.789,.889)	(.769,.869,.969,.979)	(.577,.677,.681,.781)
	A3	(.723,.823,.872,.922)	(.678,.778,.789,.888)	(.568,.668,.729,.829)	(.495,.595,.658,.758)
		S	W	O	T
DM2	A1	(.628,.728,.745,.845)	(.615,.715,.741,.841)	(.575,.675,.732,.832)	(.61,.71,.737,.837)
	A2	(.736,.836,.899,.936)	(.679,.779,.868,.905)	(.756,.856,.942,.966)	(.502,.602,.683,.783)
	A3	(.736,.836,.899,.936)	(.626,.726,.763,.862)	(.542,.642,.705,.805)	(.476,.576,.63,.73)
		S	W	O	T
DM3	A1	(.583,.687,.761,.837)	(.594,.694,.731,.831)	(.676,.776,.783,.883)	(.596,.696,.73,.83)
	A2	(.769,.869,.969,.979)	(.615,.715,.741,.841)	(.73,.83,.89,.94)	(.577,.677,.681,.781)
	A3	(.682,.782,.79,.89)	(.678,.778,.789,.888)	(.498,.598,.618,.718)	(.474,.573,.647,.747)
		S	W	O	T
Final decision making	A1	(.583,.725,.768,.873)	(.594,.708,.738,.841)	(.575,.752,.786,.916)	(.596,.701,.732,.837)
	A2	(.736,.858,.946,.979)	(.615,.757,.799,.905)	(.73,.852,.934,.979)	(.502,.652,.681,.783)
	A3	(.682,.814,.854,.936)	(.626,.761,.78,.888)	(.498,.636,.684,.829)	(.474,.581,.645,.758)

Tabel 6 Final decision making weighted matrix

	S	W	O	T
A1	(.127,.158,.167,.19)	(.0244,.029,.03,.0345)	(.105,.138,.144,.168)	(.333,.391,.41,.467)
A2	(.16,.187,.21,.213)	(.025,.031,.033,.037)	(.134,.156,.171,.179)	(.28,.364,.38,.437)
A3	(.149,.177,.186,.2)	(.026,.031,.032,.036)	(.091,.116,.125,.152)	(.264,.324,.36,.423)

Table 7 Final decision making weighted matrix

	S	W	O	T
A1	(.127,.158,.167,.19)	(.0244,.029,.03,.0345)	(.105,.138,.144,.168)	(.333,.391,.41,.467)
A2	(.16,.187,.21,.213)	(.025,.031,.033,.037)	(.134,.156,.171,.179)	(.28,.364,.38,.437)
A3	(.149,.177,.186,.2)	(.026,.031,.032,.036)	(.091,.116,.125,.152)	(.264,.324,.36,.423)

In this stage, Concordance and Discordance matrices are formed in accordance with Eqs. (7-10). The results are presented in Tables 8 and 9.

Boolean Matrices are determined based on Eqs. (11-14) and at last the final dominance matrix is formed for prioritization of the choices. The result of this operation is presented in the Tables (10-12).

Table 9 Disconcordance Matrix

	A1	A2	A3
A1	-	0.041	0.224
A2	0.959	-	0.041
A3	0.776	0.6	-

Table 8 Concordance Matrix

	A1	A2	A3
A1	-	0.4	1
A2	1	-	1
A3	0.67	0.5	-

Table 11 Boolean Matrix (G)

	A1	A2	A3
A1	-	0	0
A2	1	-	0
A3	1	1	-

Table 10 Boolean Matrix (H)

	A1	A2	A3
A1	-	0	1
A2	1	-	1
A3	0	0	-

7. Discussion

Partnership projects are among the popular approaches because governments not only need to perform some new projects to meet the populations' needs, but they are also facing an inability in supplying various resources for carrying out projects with respect to their resource limitations. Although the partnership project is a useful strategy, there are some challenges in its development. The main consideration is to pick up the best private sectors among some candidates. There have been few systematic models developed for private sectors selection. For addressing this shortcoming, we propose a step-by-step approach as well as apply two tools including fuzzy set theory and an MADM approach to develop a novel model with more friendly-use interface. We compared the outputs of the proposed model in solving the numerical example with the PROMETHEE method. PROMETHEE is one of the multi criteria decision making approaches presented by Brans [33]. Table 12 shows the obtained results from the two approaches.

Table 12 a comparison of the results of the proposed model and PROMETHEE(verification of the proposed model)

Alternative	Φ^+	Φ^-	$\Phi = \Phi^+ - \Phi^-$	Promethee	Electre
A1	-0.00144	0.028184	-0.02963	3	2
A2	0.015795	0.002256	0.013539	1	1
A3	0.018329	0.00509	0.013239	2	2

With regard to the results of table (12), PROMETHEE chose A2 as the best alternative and was ranked A3 and A1 respectively.

Since the effective criteria such as financial ability, experience, equipments, ability to perform partnership projects, etc in the A2 option have higher weights than other options, this option is selected as the best choice for partnership.

The proposed model which has applied ELECTRE as a selection tool is capable enough to select the best candidate. When decision makers want to rank all alternatives, they can change the selection tool.

8. Conclusions

The present paper proposes a novel model for private sector selection for participation in projects based on the owners' point of view. With reference to the abundant demands of developing countries as well as the limited resources of governments, expanding the projects assigned to private and public sectors as one of the participating parties is the most basic and fundamental step involved in forming and carrying out a successful participation. The main purpose of this paper is to present a structured model to assist the owners for evaluation and selection of the private sector appropriate with the criteria required by concerned individuals. By implementation the SWOT-AHP method, the opportunities and threats were extensively identified and the strengths and weaknesses of the organization were evaluated to determine some criteria for covering the threats and weaknesses and exploiting the opportunities. Using the Fuzzy ELECTRE method may develop a systematic model for evaluation of different criteria and this method was used in the construction industry. Finally, the suggested model was implemented in a case study. Our findings showed that the ELECTRE method is an effective approach for choosing the best alternative, therefore; the authors recommend this method in choosing the best private sector among different candidates.

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