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Project manager selection in SSP by applying Delphi method and fuzzy linguistic

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ABSTRACT

The main objective of this research is to develop ananalytical hybrid methodology for project manager selection problem in order to identify criteria for project manager selection by an extension of Delphi method, to evaluate a candidate by a new group multi criteria decision making (GMCDM) model based on fuzzy set theory, and develop a model based on linguistic extension of fuzzy for ranking candidates.The models were validated using a case studyof project manager selection in SSP for a project manager position.Firstly, this study developed a structured method for criteria selection. The use of a structured criteria selection method encourages experts to focus on explicit and functional criteria, rather than to use inappropriate criteria. As a contribution to the knowledge, this study extended the classical Delphi technique through using the results of relevant literature review and discussion with experts to identify the selection criteria. Secondly, this study developed a linguistic extension for evaluation. Decisionmakers cannot express judgment inaccurate numerical terms and use oflinguistic labels makes decision judgment more reliable and informative for decisionmaking.

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INTRODUCTION

As in many decision problems, personnel selection problem is very complex in real life. Individuals in many conditionsmostly prefer to show their feelings with verbal phrasing.When decision makers do not want or are not able to represent their preferences in form of quantitative evaluations, Fuzzy Linguistic evaluation can be used for qualitative evaluations. In fuzzy linguistic evaluation linguistic variables (Siler and Buckley, 2005)are expressed in words or sentences (not numbers). For example, in personnel selection, communication skill is a criterion that can be considered as a linguistic variable. Its linguistic values are poor, fair, good. By a fuzzy triangular number each linguistic value can be represented. For changing the verbal expressions into numerical ones fuzzy linguistic models is suitable(Güngör *et al*., 2009). Therefore, some multicriteria methods based on fuzzy relations are used for dealing quantitatively with imprecision in the expression of the importance of each criterion.Some studies were conducted with the purpose of solving personnel selection problem within the boundaries of objective criteria in fuzzy environment (Capaldo and Zollo, 2001; Chen and Cheng, 2005; Drigas *et al*., 2004; Karsak, 2001).According to previous literature research, thisresearch attempts to developa newproject manager selection model by using thelinguistic variables in a group environment.

In the case of project manager selection decision making, the majority of developed models in literature focused more on the decision making tools rather than providing a valid method for criteria selection (Kelemenis *et al*., 2011). The neglect of an appropriate and systematic criteria selection technique might be presented inaccurately in the final decision and consequently, the validity of MCDM method will be reduced(Yeh, 2003). Thus, adding a systematic method for the criteria selection is required.Therefore, the above mentioned gaps in literature indicates a need for further studies focused on criteria selection, group decision making, and fuzzy linguistic, in project manager selection problem.Theaim of this research is to develop a hybrid analytical model for project manager selection problem. In order to fulfill this objective, the following sub objectives must be fulfilled:

1. To identify criteria for project manager selection by developing a new systematic model.
2. To develop a group multicriteria decisionmaking (GMCDM) model based on fuzzy set theory for candidate evaluation in project manager selection problem.
3. To develop a new linguistic extension of fuzzymeasures and fuzzy integrals for project manager selection.

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The analytical method is used in this study. The research conceptually covers multicriteria decision making view in personnel selection problem. Personnel selection is one phase of human resources management and this research do not include the other phases. This section has identified the research objective.

MATERIALS AND METHODS

Decision making theory:

Decision making is the process of selecting a possible course of action from all the available alternatives(Zeleny, 1981). The task of decision making is intimately associated with every area of human life. In fact, the ability to make rational decisions is a unique human characteristic. People have continuously devices means and ways to enlarge their abilities to cope with the growing complexity of their decision making problems. It is true that the task of decision making is an indispensable part of our daily routine works. It also accepts that most of the decision making problems do incorporate a multiple criteria rather than a single criterion. That is, for many such problems, the decision maker wants to attain more than one objective or goal in selecting the course of action while satisfying the constraints dictated by the available resources.

Figueira *et al*.(2005) has classified the whole set of decision making problems, based upon two dimensions: the nature of outcomes (stochastic versus deterministic), and the nature of constrains (whether they are explicit or implicit).In addition to the above two dimensions, there may be other dimensions as well. One may consider the number of decision makers as a dimension (a single decision maker versus a group of decision makers). Another important dimension may be the number of criteria (single criterion versus multiple criteria).

It is not difficult to acknowledge the fact that most of the decision making problems encountered by us involve a finite or infinite number of alternatives and finite number of criteria(Belton and Stewart, 2002). These criteria are, in general, conflicting in nature. Criteria are said to be *conflicting* if the full satisfaction of one will result in impairing or precluding the full satisfaction of the other(s). Based upon these multitudes of criteria, we, as decision makers, choose the "best" alternative from a pool of the alternatives. In the literature, this type of problems characterized by multiple criteria is termed as multiple criteria decision making(henceforth referred as MCDM) problems.

Multiple attribute decision making (MADM):

A MADM problem can also be in a few words expressed in a matrix format. Let there be m (finite) number of criteria $C_1, C_2, \cdots, C_m$ and n (finite and predetermined) number of alternatives $A_1, A_2, \cdots, A_n$. these alternatives may be physical objects (e.g., different houses, cars, etc.) or may be simply plans of action (e.g., possible routes for a new highway or marketing strategies). Here, the criteria need not be expressed by means of mathematical functions. Let x_{ij} denotes the evaluation score of the alternative A_i on the criterion C_j. Then the matrix takes the form(Triantaphyllou, 2000):

D =

	C_1	C_2	$\cdots$	C_m
A_1	x_{11}	x_{12}	$\cdots$	x_{1m}
A_2	x_{21}	x_{22}	$\cdots$	x_{2m}
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$
A_n	x_{n1}	x_{n2}	$\cdots$	x_{nm}

The matrix D is called a decision matrix. Our primary concern is about (i) choosing the best alternative for the decision maker or (ii) ranking the alternatives in order of preference. A MADM problem may have few alternatives or many alternatives. Various MADM methods have been developed according to various preference information.

Group decision making:

A group decision making will be referred to a set of interdependent individuals who view themselves as a group and who have the common goal of producing a decision. What distinguishes group from individual decision making is the existence of more than one information source and perspective that must be combined to arrive at a collective decision.In real world decision making problems, the number of decision makers is not one, but many. The problem of seeking consensus in group decision making (GDM) has been extensively studied in multi criteria problems. The Delphi technique and the Nominal Group Technique (NGT) are the most famous approach in group decision making(Hwang and Lin, 1987).

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The Delphi technique:

The Delphi technique (Delbecq *et al*., 1975)is a set of procedures for eliciting and refining the opinions of a group of people without their being required to hold face to face meetings. Some distinct and compelling reasons for selecting the Delphi technique for use with GDM can be made:

1. The Delphi provides a means of obtaining structure input without the requirement of a face to face meeting.
2. The Delphi technique is inexpensive compared to convening a panel in one location for a series of meetings.
3. It is inherently a simplifying device since consensus is attempted for as well as the clarification of views.
4. Respondents receive feedback and are allowed to alter initial positions in successive rounds or passes.

A panel of experts is carefully selected and then asked to address an issue in written form. The initial responses are likely to spread over a wide range. A follow up questionnaire is sent to the respondents with a summary of the distribution of the initial response. Participants are then asked to consider previous answers or remarks, respond to this new information and revise opinion as they see fit. This procedure is continued until a consensus of opinion is reached, or until no further progress toward a consensus is evident. However, experience has shown that convergence usually occurs at the second iteration(Okoli and Pawlowski, 2004).

Linguistic variables:

Linguistic variable is a variable that contains values that are words. These amounts are expressed in the form of expressions. In other words, variables that are not numbers and its value are words and phrases. For example, "Height" is a linguistic variable that can include values such as very low, low, medium, high, very high, etc. Fuzzy numbers can be used to display linguistic variables. It is suitable to represent the degree of subjective judgment in qualitative aspect by using linguistic variables than in crisp value by using numbers. In conditions where decision problems are very complicated or not clearly explained to be described appropriately, the concept of a linguistic variable is very useful by using conventional quantitative expressions (Herrera *et al*., 2009).

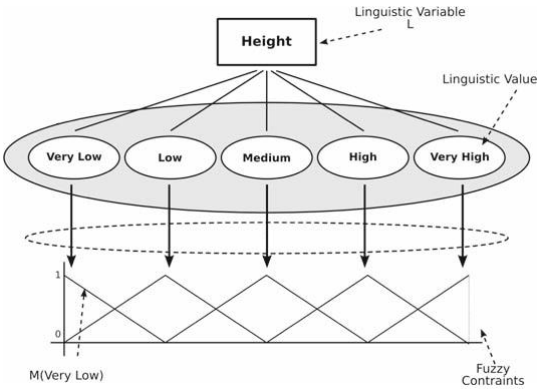

Fig. 1: Five linguistic terms and their corresponding fuzzy numbers

A variable that its values are linguistic labels is a linguistic variable. These linguistic terms can be words or sentences (Siler and Buckley, 2005). For example, communication skill is a linguistic variable when its linguistic values are poor, fair, good. Each linguistic value can be represented by a fuzzy number which can be assigned to a membership function. As an example, Linguistic variable for W_{ij} consists five element. $W_{ij} = \{VU, U, F, I, VI\}$, where VU = Very Unimportant, U = Unimportant, F = Fair, I = Important, VI = Very Important. There are many different way to define membership function in literature. The triangular shape membership functions which are most often used are used in this study. The linguistic values of W_{ij} are shown in Table1:

Table 01: Linguistic variables for the weightings

Linguistic term	Triangular fuzzy number
Very Important (VI)	(0.75, 1.0, 1.0)
Important (I)	(0.5, 0.75 , 1.0)
Fair (F)	(0.25, 0.5, 0.75)
Unimportant (U)	(0, 0.25, 0.5)
Very Unimportant (VU)	(0 ,0 , 0.25)

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This section explored the literature related personnel selection problem. From the decision science point of view, many scholars have dealt with the personnel selection problem. To handle this decision making problem, they combined techniques from operational research with artificial intelligence fields. Expert systems, fuzzy linguistic variables, neural networks and multi criteria decision making techniques used as methodology.

RESULTS AND DISCUSSION

Theresearch methodologies of this study consist of some stages. First, in new systematic criteria eliciting method, after literature review and three rounds of data gathering, the hierarchical structure of criteria for personnel selection is constructed. Second, linguistic evaluation is used to calculate the weights of criteria. Third, with aggregating method the linguistic values are transferred to crisp values. Todemonstrate the ability of proposed new model, the results of a case study are also presented in four stages.The result of first stage is the hierarchical structure of criteria for selecting project manager. The result of second stage is the weights of criteria and the rates of candidates in linguistic terms. The result of the third stage is crisp data consist of the weights of criteria and the rates of candidates. And the results of the fourth stage are the utility values for each candidate for ranking.

Project manager selection in SSP:

ShakhesSannatPuya (SSP) was established in 1993 and its mission was the localization of automotive parts and development of Saypa parts supply chain. Its premier staff was a group of Saypa employees who worked in Localization Department. Supplying material and automotive parts and complexes to Saypa group and local and global market, through effective management of supply process from design to assembly and recognition and promotion of supply chain competitive advantageous up to global levels in order to achieve strategic goals of Saypa group.

In order to accomplish the targets of the organization for improving the Project manager selection system, and making a logical tie between evaluation system and other systems, such as promotions and rewards, and providing customers' satisfaction (people), SSP conducts the Project manager selection based on the following criteria:

1- Observance of the regulations and discipline, 2- Team working orientation, 3- Job responsibility, 4- Efforts to enhance job skill and knowledge, 5- Innovation, creativity and flexibility, 6- Respect for clients and colleagues, 7- Efficient use of resources and facilities, 8- Hardworking, perseverance and on-tune decision making, 9- Forecasting affairs, commands and consequences, 10- Attention to moral values, 11- Commitment for the allocated job, 12- Intellectual and physical efforts improve job conditions, 13- Acquired skills and abilities, 14- Trust ability, 15- potential hazards from the work.

These criteria are identical in all the departments of the organization and the score of each criterion equals two, so that at the end the total score equals 30. All personnel are evaluated with the same criteria. It is a Top-Down evaluation model and is performed annually.

Using Delphi for the elicit selection criteria:

The evaluations made by the experts rely on their individual competence and are subjective. Therefore, it is more appropriate to present the data by fuzzy numbers instead of crisp numbers. The researcher uses literature and experts comments to develop an initial listing of recognized usability criteria. The research participants will be divided based on each department (SSP has four departments and two units), and study will be conducted in relation to each department.

Stage 1:

The professionals involved in the Delphi process were identified in three ways: personal knowledge, literature review and project databases. This study was carried out in the framework of the personal knowledge and research project. Twenty-one persons were selected as a professional group research according to the president of SSP organization opinion based on their experiences and education in order to determine the criteria, weights, and assessors' viewpoint weights. Professional group included: Four deputies of departments, two units managers, and fifteen experts. The professional group degrees were: two doctors of philosophy, ten masters and nine bachelors.

Stage 2:

All the members of the professional group were interviewed personally and were informed of the objectives, nature, and the process of Project manager selection, and they were asked to determine criteria affecting the competency for Project manager selection.

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Stage 3:

based on feedbacks attained from includes 130 criteria collected from different departments. Later on the professionals were asked to consider all the criteria of different departments and select appropriate criteria for the project managers in their own departments. In fact, they are actually encouraged to gain understanding regarding other's viewpoints and try to leap to work out a more accurate judgment.

Stage 4:

The results of stage 2, was collected and accurately analyzed. Criteria with less degree of importance were omitted and those close in the meaning, and definitions were mixed. Then criteria for project managers were classified and distributed in the professional group for third time, to ask them determine the criteria for their own departments.

Stage 5:

The data collected from the preceding step analyzed. Effective assessment criteria for managers, determined for each department.

Stage 6:

Criteria determined from the previous step were distributed to each department's professional group to seek weights of criteria based on linguistic terms.

Stage 7:

Stage 6 was repeated frequently, until the consensus is reached on the criteria list by the panel members for project managers.

Identification of evaluation criteria weights:

Panel members were asked to determine the importance of criteria weights and the importance of assessor's viewpoints' weights by using linguistic terms as shown in Table 2. The professional group (comprising six professional from deputy of training and optimizing energy consumption) use the linguistic weighting variables to assess the importance of the criteria for project managers that present In Tables 2. The first column shows the 33 evaluation managers' criteria and other columns show the professionals' linguistic rating based on each criterion.

Table 02: The importance of the project manager's criteria weight

Criteria		Decision makers				
	D_1	D_2	D_3	D_4	D_5	D_6
C_1	VH	ML	VH	VH	VH	H
C_2	VH	L	H	VH	VH	VH
C_3	H	L	VH	H	H	H
C_4	VH	L	MH	VH	MH	H
C_5	VH	L	MH	H	VH	VH
C_6	VH	MH	VH	VH	H	MH
C_7	VH	VH	MH	VH	MH	H
C_8	VH	H	VH	H	H	VH
C_9	VH	ML	VH	VH	VH	H
C_{10}	VH	ML	MH	VH	H	H
C_{11}	VH	M	H	H	MH	VH
C_{12}	VH	VL	MH	VH	ML	H
C_{13}	VH	L	VH	VH	H	VH
C_{14}	VH	VH	H	VH	H	H
C_{15}	VH	VH	H	VH	H	H
C_{16}	VH	VL	VH	VH	MH	H
C_{17}	VH	ML	H	VH	H	MH
C_{18}	VH	L	VH	VH	VH	H
C_{19}	VH	L	VH	VH	VH	VH
C_{20}	VH	L	H	VH	H	VH
C_{21}	VH	M	M	H	ML	H
C_{22}	VH	L	VH	VH	MH	M
C_{23}	VH	M	VH	VH	H	VH
C_{24}	VH	L	VH	VH	H	VH
C_{25}	VH	VL	MH	VH	VH	VH
C_{26}	VH	VH	MH	VH	MH	MH
C_{27}	VH	VL	M	VH	ML	MH
C_{28}	VH	ML	ML	VH	ML	M

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C_{29}	VH	VH	H	VH	H	ML
C_{30}	VH	L	H	VH	MH	H
C_{31}	VH	M	VH	VH	H	H
C_{32}	VH	H	H	H	MH	VH
C_{33}	VH	VH	MH	VH	MH	H

The linguistic evaluations were converted into triangular fuzzy numbers as defined in Table 3. All the weight measures were defuzzified into crisp numbers. The resulting criteria weights from the professional team are summarized and shown in Table 3.

Table 3: Defuzzification of manager's criteria weight and result

Criteria	Weight	Criteria	Weight	Criteria	Weight
C_1	0.0318	C_{12}	0.0242	C_{23}	0.0331
C_2	0.0308	C_{13}	0.0308	C_{24}	0.0308
C_3	0.0289	C_{14}	0.0348	C_{25}	0.0291
C_4	0.0274	C_{15}	0.0348	C_{26}	0.0327
C_5	0.0291	C_{16}	0.0285	C_{27}	0.0219
C_6	0.0327	C_{17}	0.0312	C_{28}	0.0327
C_7	0.0327	C_{18}	0.0308	C_{29}	0.0219
C_8	0.0348	C_{19}	0.0314	C_{30}	0.0285
C_9	0.0318	C_{20}	0.0295	C_{31}	0.0312
C_{10}	0.0295	C_{21}	0.0242	C_{32}	0.0308
C_{11}	0.0308	C_{22}	0.0291	C_{33}	0.0314

Candidate rating by fuzzy group decision making:

Al, A2, A3' and A4 alternatives are allocated to four project managers candidate being assessed by four different assessors (boss, colleague, inferior, employee him/herself). In the previous sections the evaluation criteria, criteria weights, and assessors' viewpoint weights were identified. In the algorithm, the assessors presented preferences for each alternative based on each attribute according to linguistic terms such as: (Very Poor, Poor, Medium Poor, Fair, Medium Good, Good, and Very Good) for project managers selection. The elements of the Table 4 shows the linguistic rating based on each criterion for one of assessors.

Table 04: The ratings for the four candidates by the first assessor

Criteria	A_1	A_2	A_3	A_4	Criteria	A_1	A_2	A_3	A_4
C_1	MG	G	F	G	C_{18}	MG	MG	G	G
C_2	G	G	F	VG	C_{19}	MG	MG	G	MG
C_3	MG	MG	MG	G	C_{20}	MG	MG	G	G
C_4	G	MG	G	VG	C_{21}	MG	MG	G	VG
C_5	G	G	G	G	C_{22}	MG	MG	G	F
C_6	MG	MG	VG	F	C_{23}	MG	MG	G	F
C_7	G	G	G	MG	C_{24}	MG	MG	G	G
C_8	MG	MG	VG	VG	C_{25}	MG	G	MG	G
C_9	MG	F	G	G	C_{26}	G	MG	G	F
C_{10}	G	F	VG	G	C_{27}	G	VG	MG	F
C_{11}	MG	F	VG	F	C_{28}	MG	G	MG	G
C_{12}	G	*F*	VG	*G*	C_{29}	MG	MH	VG	G
C_{13}	MG	*MG*	MG	*VG*	C_{30}	MG	G	G	G
C_{14}	G	*MG*	MG	*MG*	C_{31}	MG	MG	VG	VG
C_{15}	G	*F*	VG	*VG*	C_{32}	MG	G	G	G
C_{16}	MG	*F*	VG	*VG*	C_{33}	G	G	VG	VG
C_{17}	G	*G*	G	*VG*					

Project manager selection by fuzzy aggregation:

The linguistic evaluation for candidates rating shown in Table 4 was converted into triangular fuzzy numbers to construct the fuzzy decision making. Then the vertex method is used for transfer fuzzy numbers to crisp numbers. The transformation values of fuzzy ratings of the four candidates by the first assessor as shown in Table 5.

Table 05: The ratings for the four candidates by the first assessor

Criteria	A_1	A_2	A_3	A_4	Criteria	A_1	A_2	A_3	A_4
C_1	0.700	0.867	0.500	0.867	C_{18}	0.700	0.700	0.867	0.867
C_2	0.867	0.867	0.500	0.967	C_{19}	0.700	0.700	0.867	MG
C_3	0.700	0.700	0.700	0.867	C_{20}	0.700	0.700	0.867	0.867
C_4	0.867	0.700	0.867	0.967	C_{21}	0.700	0.700	1.000	VG
C_5	0.867	0.867	0.867	0.867	C_{22}	0.700	0.700	0.867	0.500
C_6	0.700	0.700	0.967	0.500	C_{23}	0.700	0.700	0.867	0.500
C_7	0.867	0.867	0.867	0.700	C_{24}	0.700	0.700	0.867	0.867

C_8	0.700	0.700	0.967	0.967	C_{25}	0.700	0.867	0.700	0.867
C_9	0.700	0.500	0.867	0.867	C_{26}	0.867	0.700	0.867	0.500
C_{10}	0.867	0.500	0.967	0.867	C_{27}	0.867	0.967	0.700	0.500
C_{11}	0.700	0.500	0.967	0.500	C_{28}	0.700	0.700	0.700	0.867
C_{12}	0.867	0.500	0.967	0.867	C_{29}	0.700	0.700	0.967	0.867
C_{13}	1.000	0.700	0.700	0.500	C_{30}	0.700	0.867	0.867	0.867
C_{14}	1.000	0.700	0.700	*0.800*	C_{31}	0.700	0.700	0.967	0.967
C_{15}	0.867	0.500	0.967	0.967	C_{32}	0.700	0.867	0.867	0.867
C_{16}	0.700	0.500	0.967	0.967	C_{33}	0.867	0.867	0.967	0.967
C_{17}	0.867	0.867	0.867	0.967					

Considering the proper value of decision maker weights of each assessor and also the ratings for each candidate results must be mixed to find the final ranking for the four candidates. Table 6 shows the final ranking after aggregating the results.

Table 06: Aggregation based on results for candidates

	A_1	A_2	A_3	A_4	Criteria	A_1	A_2	A_3	A_4
$\sum$	1.3232	0.7275	2.0068	1.9427	*Rank*	3	4	1	2

Alternative with the highest value is the first rank, and the lowest represents the last rank. The ordinal ranks of four alternatives (candidates for project manager position) are attained as follows:

$A_3>>A_4>>A_1>>A_2$

Therefore, A_3 is the optimal candidate.

Personnel selection problem is considered as a multi criteria group decision making problem. According to the objectives of this study, the suggested methodology must have some characteristics:

1. It is able to elicit and aggregate relevant experts' opinion about the hierarchical structure consist of criteria and sub criteria with a systematic criteria selection method.
2. It is able to find criteria importance and candidates rating by effective using linguistic terms in a group environment based on decision making preferences. Then these results must be combined together for final ranking.
3. It is able to investigate the best candidates ranking.

Therefore, a hybrid methodology was required to fit the above characteristics. This methodology is based on using pertinent literature, Delphi method, discussion, fuzzy linguistic variables, fuzzy triangular numbers, vertex method.After reporting the case study results, a discussion was done. Comments are related to three innovations of the methodology. The advantages and superiority of the proposed approach versus previous methods available in literature, was shown in the discussion section. The discussion showed that fuzzy linguistic may play an important role in the analysis and in the final decision.

Conclusions:

The focus of this research was to contribute the concept of personnel selection by developing a decision methodology which integrates group decision making, and fuzzy linguistic evaluation. The contribution of this research was to develop a group fuzzy MCDM model that evaluates candidates by linguistic variables. This research has made a significant contribution to the personnel selection problem. Multiple criteria decision making has not been extensively applied in the field of personnel selection.The suggested methodology has been validated through a case study by the project manager selection of a project based company in Iran. Thus, case study has empirically verified the feasibility of study and in order to ensure that the decision making procedure is significantly correct. Furthermore the comparative study has utilized to compare the results of new proposed model with previous models.Theresults demonstrated that there are significant difference between the results of proposed model and other personnel selection models.

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