Using Fuzzy MCDM Model to Select Middle Managers for Global Shipping Carrier-based Logistics Service Providers

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Abstract: - The main purpose of this paper is to develop a fuzzy multiple criteria decision-making (MCDM) model to select middle managers for the global shipping carrier-based logistics service providers (GSLPs). At first, some concepts and methods used to develop a fuzzy MCDM model are introduced. Secondly, to effectively select middle managers for GSLPs, five steps of fuzzy MCDM algorithms are proposed. Finally, a step-by-step numerical example is illustrated by using the proposed fuzzy MCDM approach. The illustrated example shows the proposed approach can successfully accomplish our goal of this study.

Key-Words: - Middle managers; Shipping; Logistics service provider; Fuzzy MCDM

1 Introduction

The keen competition has arisen among container shipping carriers (CSCs), which they must emphasize upon making greatly efforts to meet customers' requirements. To provide total logistics solutions [15] for customers, the logistics services in the shipping logistics chains are expanded by the CSCs. The focus of container shipping logistics management is increasing, more and more companies are searching for the usage of third-party logistics service providers (3PLs) due to the fact that the 3PLs provide more customized services and many different functional services [22]. As a result, the global shipping carrier-based logistics service providers (GSLPs) are emerged to grow fast in the recent decade.

However, how to make shipping logistics systems to operate and how to output performance to be efficient and effective for GSLPs? We know that the four management functions - planning, organizing and staffing, leading, and controlling - could be applied to deal with this matter [13]. In here, many scholars (e.g., Robbins et al. [24]; Aaker [1]; Stock and Lambert [26]) agree that 'the people' are one of the most important elements in any organization. Hence, the evaluation of the organizational people is an important issue to deal with the management functions.

Robbins et al. [24] divided organizational people into non-managerial employees and managers. In here, the managers are usually classified as top, middle, and first-line managers. Among these three categories, the middle ones are very important for GSLPs due to the fact that the proper middle ones not only can perform the projects well toward the organizational goals, but also can employ each kind of managerial skills to modulate the operational process of organization. Hence, selecting those middle ones who holding various managerial competencies [14] to compete against their competitors is critical for GSLPs.

To evaluate the selection problems researchers have used many intelligent techniques [23], such as the soft computing, and operational research etc. Since the selection of middle ones is critical to the organization development; however, experience has shown that it is no easy matter. The decision for selecting middle ones poses a multi-criteria problem. It involves a multiplicity of complex considerations and poses a unique characteristic of multiple criteria decision-making (MCDM) [4, 9, 10, 17, 20]. The evaluation criteria of managerial competencies of middle ones are usually subjective in nature and often changing with the decision-making conditions, which creates the fuzzy and uncertain nature among the criteria and the importance weights of the criteria. Further, there are situations in which information is incomplete or imprecise or views that are subjective or endowed with linguistic characteristics creating a fuzzy decision-making environment [9]. The author, therefore, adopts the fuzzy set theory [27], combing with MCDM method (e.g., Chou [5]; Ding [9-11]) as an evaluation tool to improve the quality of this study. In addition, the current papers of Ding's studies [9-11] used the fuzzy MCDM models to evaluate the selection problems, e.g. strategic partner selection, the identification of core competence. We seized the merits and scientific concepts of Ding's studies to propose a fuzzy MCDM model to select the middle managers in the logistics industry. In the light of this, a fuzzy MCDM model is used to select middle ones for the human resources management (HRM) department of GSLPs.

In summary, the aim of this paper is to develop a fuzzy MCDM model to improve the quality of decision-making in selecting middle ones for GSLPs. The following section presents the research methods. Next section proposes a fuzzy MCDM algorithm. In the fourth section, a numerical study is illustrated. Finally, conclusions are made in the last section.

2 Research Methodologies

In this section, some concepts and methods used in this paper are briefly introduced.

2.1 Triangular fuzzy numbers and the algebraic operations

A fuzzy number A [12] in real line $\Re$ is a triangular fuzzy number if its membership function $f_A : \Re \to [0,1]$ is

$$f_A(x) = \begin{cases} (x-c)/(a-c), & c \le x \le a \\ (x-b)/(a-b), & a \le x \le b \\ 0, & otherwise \end{cases} \tag{1}$$

with $-\infty < c \le a \le b < \infty$. The triangular fuzzy number can be denoted by (c, a, b).

According to extension principle [27], let $A_1 = (c_1, a_1, b_1)$ and $A_2 = (c_2, a_2, b_2)$ be triangular fuzzy numbers, the algebraic operations of any two triangular fuzzy numbers A_1 and A_2 can be expressed as

- Fuzzy addition:
  $A_1 \oplus A_2 = (c_1 + c_2, a_1 + a_2, b_1 + b_2)$,
- Fuzzy subtraction:
  $A_1 \ominus A_2 = (c_1 - b_2, a_1 - a_2, b_1 - c_2)$,
- Fuzzy multiplication:
  (i) $k \otimes A_2 = (kc_2, ka_2, kb_2), k \in \Re, \ k \ge 0$;
  (ii) $A_1 \otimes A_2 \cong (c_1c_2, a_1a_2, b_1b_2),$
  $c_1 \ge 0, \ c_2 \ge 0$,
- Fuzzy division:
  (i) $(A_1)^{-1} = (c_1, a_1, b_1)^{-1}$
  $\cong (1/b_1, 1/a_1, 1/c_1), c_1 > 0$;
  (ii) $A_1 \varnothing A_2 \cong (c_1/b_2, a_1/a_2, b_1/c_2),$
  $c_1 \ge 0, c_2 > 0.$

2.2 Linguistic values

In fuzzy decision environments, two preference ratings can be used. They are fuzzy numbers and linguistic values (LVs) characterized by fuzzy numbers [28]. Depending on practical needs, DMs may apply one or both of them. In this paper, the weighting set and preference rating set are used to analytically express the LV and describe how important and how good of the involved criteria, sub-criteria and alternatives against various sub-criteria above the alternative level are. In this paper, the weighting set is defined as *W* = {*VL*, *L*, *M*, *H*, *VH*} and rating set as *S* = {*VP*, *P*, *F*, *G*, *VG*}; where *VL*=Very Low, *L*=Low, *M*=Medium, *H*=High, *VH*=Very High, *VP*=Very Poor, *P*=Poor, *F*=Fair, *G*=Good, and *VG*=Very Good. In this paper, we define the LVs of *VL*=*VP*=(0, 0, 0.2), *L*=*P*=(0, 0.2, 0.4), *M*=*F*=(0.3, 0.5, 0.7), *H*=*G*=(0.6, 0.8, 1), and *VH*=*VG*=(0.8, 1, 1), respectively.

2.3 Graded mean integration representation method

To match the fuzzy MCDM algorithm developed in this paper, and to solve the problem of defuzzification powerfully, the graded mean integration representation (GMIR) method, proposed by Chen and Hsieh [3], is employed to defuzzify the fuzzy numbers.

Let $A_i = (c_i, a_i, b_i), i = 1, 2, \ldots, n,$ be n triangular fuzzy numbers. By the GMIR method, the GMIR value of A_i can be denoted by

$$P(A_i) = \frac{c_i + 4a_i + b_i}{6} \tag{2}$$

Suppose $P(A_i)$ and $P(A_j)$ are the GMIR values of the triangular fuzzy numbers A_i and A_j, respectively. Define:

- $A_i > A_j \Leftrightarrow P(A_i) > P(A_j)$,
- $A_i < A_j \Leftrightarrow P(A_i) < P(A_j)$,
- $A_i = A_j \Leftrightarrow P(A_i) = P(A_j)$.

2.4. Distance measure method

To match the fuzzy MCDM algorithm developed in this paper, the modified geometrical distance (GD) approach, proposed by Hsieh and Chen [19], is used to measure the distance of two fuzzy numbers.

Let $A_i = (c_i, a_i, b_i)$ and $A_j = (c_j, a_j, b_j)$ be fuzzy numbers. Then, the modified GD value can be denoted by

$$\Delta_M(A_i, A_j) = \left\{ \frac{1}{4} \begin{bmatrix} (c_i - c_j)^2 + 2(a_i - a_j)^2 \\ + (b_i - b_j)^2 \end{bmatrix} \right\}^{1/2} \quad (3)$$

3 The fuzzy MCDM Model

A systematic model of the fuzzy MCDM algorithm is proposed in this section. The steps to be taken are described below.

3.1 Development of hierarchical structure

A hierarchy structure is the framework of system structure. It can not only be utilized to study the interaction among the elements involved in each layer but also help decision-makers (DMs) to explore the impact of different elements against the evaluated system. The concepts of hierarchical structure analysis with three distinct layers, i.e. criteria layer, sub-criteria layer, and alternatives layer, are used in this paper. In this paper, there are k criteria (i.e., C_t, $t = 1, 2, \ldots, k$), $n_1 + \cdots + n_t + \cdots + n_k$ sub-criteria (i.e., $C_{11} \cdots C_{1n_1} \cdots C_{t1} \cdots C_{tn_t} \cdots C_{k1} \cdots C_{kn_k}$), and m alternatives (i.e., A_i, $i = 1, 2, \ldots, m$) in the hierarchical structure.

As regards to the evaluation criteria and sub-criteria, the author referred some literature, which are made known in academic and management publications [2, 6-8, 11, 13, 14, 16, 18, 22, 24-26]. Then, the criteria and sub-criteria of managerial traits, skills, capabilities, and competencies are preliminarily discussed with scholars and senior managers of department of HRM of GSLPs by the author. Finally, five criteria in the first hierarchy and twenty-five sub-criteria in the second hierarchy are suggested and their codes are shown in parentheses. In this paper, all criteria and sub-criteria are subjective. Moreover, these criteria with sub-criteria are all discussed by experts and reviewed by literature, hence, the criteria and sub-criteria are closely related to the four management functions. In addition, there are five sub-criteria for each criterion due to the fact that the experts suggest that the importance weights can be easy to measure in the future development and survey.

(1) Conceptual competency and administrative management capability (C_1). This criterion includes 'container shipping logistics knowledge and understanding of specific contexts on organizational development and their work processes (C_{11}),' 'container shipping logistics planning on service, cost, time, risk, quality, process management etc. (C_{12}),' 'monitoring and controlling of container shipping logistics activities (C_{13}),' 'cross cultural consideration and skills (C_{14}),' and 'tactical strategies thinking (C_{15}).'

(2) Communication competency (C_2). This criterion includes 'skills and experience in verbal and intermediary communication (C_{21}),' 'encouragement of participative management among employees (C_{22}),' 'ability of negotiation and analysis (C_{23}),' 'conflict of reconciliation (C_{24}),' and 'facilitation and presentation skills (C_{25}).'

(3) Interpersonal competency (C_3). This criterion includes 'leadership (C_{31}),' 'ability of coordination (C_{32}),' 'ability of team work and managing team (C_{33}),' 'skill of customer focus and customer concern (C_{34}),' and 'developments of inbound and outbound interpersonal networks (C_{35}).'

(4) Information of personal characteristics (C_4). This criterion includes 'acting with integrity and awareness of business ethics (C_{41}),' 'ability of self-motivation (C_{42}),' 'be patient with customers (C_{43}),' 'ability to build new relationships (C_{44}),' and 'education and past experience (C_{45}).'

(5) Container shipping logistics professional competency (C_5). This criterion includes 'the know-how of information technology and information system (IT/IS) (C_{51}),' 'insights into success factors of container shipping logistics-related activities (C_{52}),' 'ability to problem-solving and decision-making (C_{53}),' 'deep knowledge of cost, profit, and customer satisfaction (C_{54}),' and 'action-oriented on shipping logistics services (C_{55}).'

3.2 Estimation of fuzzy weights of all criteria and sub-criteria and fuzzy ratings of all alternatives versus all sub-criteria

The weights of all criteria are greatly influenced the final selection of fuzzy MCDM problem. The weights of criteria reflected the DM's subjective preference. The weights not only can express the explanation ability and reliability of the decision-making problem but also can represent actual conditions of decision-making and improve the quality of decision-making. Hence, the arithmetic mean method is used to obtain the average fuzzy weights of all criteria and sub-criteria as well as the fuzzy ratings of alternatives versus all subjective sub-criteria in this paper. The linguistic values of the weighting set and preference rating set, mentioned in the Section 2.2, are assisted in obtaining the fuzzy weights and fuzzy ratings. This is done as follows.

Let $W_{th} = (c_{th}, a_{th}, b_{th})$, $t = 1, 2, \ldots, k$; $h = 1, 2, \ldots, n$, be the weight given to criterion C_t by the h^{th} DM. Then, the average fuzzy weight of C_t can be represented as

$$W_t = \frac{1}{n} \otimes \left(W_{t1} \oplus W_{t2} \oplus \cdots \oplus W_{tn}\right) \cong (c_t, a_t, b_t), \tag{4}$$

where $c_t = \frac{1}{n}\sum_{h=1}^{n} c_{th}$, $a_t = \frac{1}{n}\sum_{h=1}^{n} a_{th}$, $b_t = \frac{1}{n}\sum_{h=1}^{n} b_{th}$.

Let $W_{tjh} = (c_{tjh}, a_{tjh}, b_{tjh})$, $t = 1, 2, \ldots, k$; $j = 1, 2, \ldots, p_t$; $h = 1, 2, \ldots, n$, be the weight given to sub-criterion SC_{tj} by the h^{th} DM. Then, the average fuzzy weight of SC_{tj} can be represented as

$$W_{tj} = \frac{1}{n} \otimes \left(W_{tj1} \oplus W_{tj2} \oplus \cdots \oplus W_{tjn}\right) \cong (c_{tj}, a_{tj}, b_{tj}), \tag{5}$$

where $c_{tj} = \frac{1}{n}\sum_{h=1}^{n} c_{tjh}$, $a_{tj} = \frac{1}{n}\sum_{h=1}^{n} a_{tjh}$,

$b_{tj} = \frac{1}{n}\sum_{h=1}^{n} b_{tjh}$.

Let $S_{itjh} = (c_{itjh}, a_{itjh}, b_{itjh})$, $i = 1, 2, \ldots, m$; $t = 1, 2, \ldots, k$; $j = 1, 2, \ldots, p_t$; $h = 1, 2, \ldots, n$, be the rating assigned to alternative A_i by the h^{th} DM for sub-criterion SC_{tj}. Then, the average fuzzy rating of alternative A_i can be represented as

$$S_{itj} = \frac{1}{n} \otimes \left(S_{itj1} \oplus S_{itj2} \oplus \cdots \oplus S_{itjn}\right) \cong (c_{itj}, a_{itj}, b_{itj}), \tag{6}$$

where $c_{itj} = \frac{1}{n}\sum_{h=1}^{n} c_{itjh}$, $a_{itj} = \frac{1}{n}\sum_{h=1}^{n} a_{itjh}$,

$b_{itj} = \frac{1}{n}\sum_{h=1}^{n} b_{itjh}$.

3.3 Calculation of fuzzy ideal and anti-ideal solutions

The FMCDM algorithm based on the ideal and anti-ideal concepts [21] is used in this paper. The logic of ideal and anti-ideal solutions is based on the concept of relative closeness in compliance with the shorter (longer) the distance of alternative *i* to ideal (anti-ideal), the higher the priority can be ranked.

Firstly, to ensure compatibility between fuzzy ratings of subjectively positive criteria (or sub-criteria) and negative criteria (or sub-criteria), the average fuzzy superiority values must be converted to dimensionless indices. The fuzzy ideal values with minimum values in negative sub-criteria or maximum values in positive sub-criteria should have the maximum rating. Based on the principle stated as above, let $\psi_{tj} = \max_i \{b_{itj}\}$, $\zeta_{tj} = \min_i \{c_{itj}\}$, then the normalized average fuzzy superiority value ρ_{itj}^a of alternative A_i for sub-criterion SC_{tj} can be defined as:

(1) For the positive sub-criterion SC_{tj} (the sub-criteria that have positive contribution to the objective, e.g., benefit sub-criterion):

$$\rho_{itj}^a = (\chi_{itj}, \varphi_{itj}, \kappa_{itj}) = \left(\frac{c_{itj}}{\psi_{tj}}, \frac{a_{itj}}{\psi_{tj}}, \frac{b_{itj}}{\psi_{tj}}\right) \tag{7}$$

(2) For the negative sub-criterion SC_{tj} (the sub-criteria that have negative contribution to the objective, e.g., cost sub-criterion):

$$\rho_{itj}^a = (\chi_{itj}, \varphi_{itj}, \kappa_{itj}) = \left(\frac{\zeta_{tj}}{b_{itj}}, \frac{\zeta_{tj}}{a_{itj}}, \frac{\zeta_{tj}}{c_{itj}}\right) \tag{8}$$

Subsequently, by using the GMIR method mentioned in Section 2.3, the GMIR value can be express as $P(\rho_{itj}^a)$. The fuzzy ideal value FI_{tj}^+ and fuzzy anti-ideal value FAI_{tj}^- of each sub-criterion above the alternatives layer can be judged and determined by comparing with these representation values $P(\rho_{itj}^a)$. Then,

(1) if $P(\rho_{xtj}^a) = \max_i P(\rho_{itj}^a)$, then the fuzzy ideal value $FI_{tj}^+ = \rho_{xtj}^a$, (9)

(2) if $P(\rho_{ytj}^a) = \min_i P(\rho_{itj}^a)$, then the fuzzy anti-ideal value $FAI_{tj}^- = \rho_{ytj}^a$. (10)

Finally, we integrate the fuzzy ideal/anti-ideal values into the fuzzy ideal/anti-ideal solutions. Define the fuzzy ideal solution I^+ and fuzzy anti-ideal solution AI^- as

$$I^+ = (FI_{11}^+, FI_{12}^+, \ldots, FI_{t1}^+, \ldots, FI_{tp_t}^+, \ldots, FI_{k1}^+, \ldots, FI_{kp_k}^+), \tag{11}$$

and

$$AI^- = (FAI_{11}^-, FAI_{12}^-, \ldots, FAI_{t1}^-, \ldots, FAI_{tp_t}^-, \ldots, FAI_{k1}^-, \ldots, FAI_{kp_k}^-). \quad (12)$$

3.4 Computation of the distance of different alternatives versus the fuzzy ideal/anti-ideal solutions

As mentioned in Section 3.2, let W_t and W_{tj}, $t = 1, 2, \ldots, k;\quad j = 1, 2, \ldots, p_t$, are the average fuzzy weights of criteria C_t and sub-criteria SC_{tj}, respectively. Then the normalized integration weights of the sub-criteria SC_{tj} can be obtained by using the GMIR method in Section 2.3, denoted by:

$$\Phi_{tj}^* = \frac{P(W_t)}{\sum_{t=1}^{k} P(W_t)} \times \frac{P(W_{tj})}{\sum_{j=1}^{p_t} P(W_{tj})}, \quad (13)$$

$$0 \le \Phi_{tj}^* \le 1, \quad \sum \Phi_{tj}^* = 1.$$

Then, compute the distance of different alternatives versus I^+ and AI^- which were denoted by D_i^+ and D_i^-, respectively. Define

$$D_i^+ = \sqrt{\sum_{t=1}^{k} \sum_{j=1}^{p_t} \left[(\Phi_{tj}^*)^2 \times (\Delta_M (FI_{tj}^+, \rho_{itj}^a))^2 \right]}, \quad (14)$$

$$i = 1, 2, \ldots, m,$$

$$D_i^- = \sqrt{\sum_{t=1}^{k} \sum_{j=1}^{p_t} \left[(\Phi_{tj}^*)^2 \times (\Delta_M (FAI_{tj}^-, \rho_{itj}^a))^2 \right]}, \quad (15)$$

$$i = 1, 2, \ldots, m,$$

where $\Delta_M(\bullet)$ can be obtained by using the equation (3) mentioned in Section 2.4.

3.5 Calculation of the relative approximation value of different alternatives versus ideal solution and ranking the alternatives

The relative approximation value (i.e. the relative closeness) of different alternatives A_i versus fuzzy ideal solution I^+ can be calculated, which can be denoted as

$$RC_i^* = \frac{D_i^-}{D_i^+ + D_i^-}, \ i = 1, 2, \ldots, m, \quad (16)$$

It is obvious, $0 \le RC_i^* \le 1$, $i = 1, 2, \ldots, m$. Suppose alternative A_i is an ideal solution (i.e. $D_i^+ = 0$), then $RC_i^* = 1$. Otherwise, if A_i is an anti-ideal solution (i.e. $D_i^- = 0$), then $RC_i^* = 0$. The nearer the value RC_i^* close to 1 implies a closer alternative A_i come near the ideal solution. That is, the maximum value of RC_i^*, then the all alternatives can be ranked. Finally, the best alternative can be selected.

4 The Numerical Illustration

In this section, a numerical example of evaluating middle managers selection for a GSLP company is illustrated to demonstrate the computational process of the proposed fuzzy MCDM model, step by step, as follows.

Step 1. Assume that a GSLP company needs to select a middle manager. Three candidates of middle managers (i.e., *A*, *B*, and *C*) are chosen after preliminary screening for further evaluation. The HRM department has been formed a committee of three DMs (i.e., *X*, *Y*, and *Z*) to evaluate the best choice among three candidates. Five criteria and twenty-five sub-criteria are suggested in the Section 3.1.

Step 2. Three DMs use the LVs (mentioned in the Section 2.2) of weighting sets and rating sets to evaluate the importance weights and performance values, respectively. Then, according to the equations (4), (5), and (6), the results of the importance weights and the performance values can be shown in Table 1 and Table 2, respectively.

Step 3. Calculate the fuzzy ideal solution and anti-ideal solution. In our case, all sub-criteria are positive; hence, the performance values of three candidates in Table 2 do not be normalized. Then, by using the equations (9) and (10), the fuzzy ideal/anti-ideal values can be determined by using the data of Table 3, as shown in Table 3.

Finally, these fuzzy ideal and anti-ideal values can be transformed to the fuzzy ideal solution I^+ and fuzzy anti-ideal solution AI^- by using the equations (11) and (12). That is

I^+ = [(0.733, 0.933, 1), (0.733, 0.933, 1), …, (0.467, 0.667, 0.8), …, (0.3, 0.433, 0.633), …, (0.667, 0.867, 1), … , (0.733, 0.933, 1), …, (0.367, 0.567, 0.7), (0.567, 0.767, 0.9)].

AI^- = [(0, 0.133, 0.333), (0, 0, 0.2), …, (0.467, 0.667, 0.8), …, (0.2, 0.333, 0.533), …, (0.367, 0.5, 0.633), … , (0.467, 0.667, 0.8), …, (0.267, 0.4, 0.533), (0, 0, 0.2)].

Step 4. Compute the distance of three candidates versus the fuzzy ideal solution and fuzzy anti-ideal solution. In our case, firstly, by using the equation (13), we can obtain the normalized integration weights of all sub-criteria, the results can be shown in Table 4.

Secondly, by using the equations (3), (14), and (15), we can obtain the distance of three candidates versus fuzzy ideal and anti-ideal solutions, respectively. The results can be shown in Table 5.

Table 1. The fuzzy weights of all criteria and sub-criteria

Criteria / Sub-criteria	DMs	LVs	Fuzzy weights	Criteria / Sub-criteria	DMs	LVs	Fuzzy weights
C_1	*X*	*H*	(0.733, 0.933, 1)	C_{31}	*X*	*H*	(0.3, 0.5, 0.7)
	Y	*VH*			*Y*	*L*	
	Z	*VH*			*Z*	*M*	
C_2	*X*	*M*	(0.4, 0.6, 0.8)	C_{32}	*X*	*VH*	(0.633, 0.833, 0.9)
	Y	*M*			*Y*	*M*	
	Z	*H*			*Z*	*VH*	
C_3	*X*	*VH*	(0.633, 0.833, 0.9)	C_{33}	*X*	*M*	(0.5, 0.7, 0.9)
	Y	*VH*			*Y*	*H*	
	Z	*M*			*Z*	*H*	
C_4	*X*	*H*	(0.6, 0.8, 1)	C_{34}	*X*	*L*	(0.2, 0.4, 0.6)
	Y	*H*			*Y*	*H*	
	Z	*H*			*Z*	*L*	
C_5	*X*	*H*	(0.567, 0.767, 0.9)	C_{35}	*X*	*M*	(0.567, 0.767, 0.9)
	Y	*VH*			*Y*	*VH*	
	Z	*M*			*Z*	*H*	
C_{11}	*X*	*M*	(0.633, 0.833, 0.9)	C_{41}	*X*	*H*	(0.5, 0.7, 0.9)
	Y	*VH*			*Y*	*M*	
	Z	*VH*			*Z*	*H*	
C_{12}	*X*	*L*	(0.1, 0.3, 0.5)	C_{42}	*X*	*M*	(0.567, 0.767, 0.9)
	Y	*L*			*Y*	*H*	
	Z	*M*			*Z*	*VH*	
C_{13}	*X*	*VH*	(0.667, 0.867, 1)	C_{43}	*X*	*VH*	(0.467, 0.667, 0.8)
	Y	*H*			*Y*	*M*	
	Z	*H*			*Z*	*M*	
C_{14}	*X*	*M*	(0.467, 0.667, 0.8)	C_{44}	*X*	*VH*	(0.667, 0.867, 1)
	Y	*M*			*Y*	*H*	
	Z	*VH*			*Z*	*H*	
C_{15}	*X*	*H*	(0.733, 0.933, 1)	C_{45}	*X*	*M*	(0.2, 0.4, 0.6)
	Y	*VH*			*Y*	*M*	
	Z	*VH*			*Z*	*L*	
C_{21}	*X*	*M*	(0.5, 0.7, 0.9)	C_{51}	*X*	*VH*	(0.633, 0.833, 0.9)
	Y	*H*			*Y*	*VH*	
	Z	*H*			*Z*	*M*	
C_{22}	*X*	*L*	(0.2, 0.4, 0.6)	C_{52}	*X*	*H*	(0.3, 0.5, 0.7)
	Y	*H*			*Y*	*L*	
	Z	*L*			*Z*	*M*	
C_{23}	*X*	*M*	(0.567, 0.767, 0.9)	C_{53}	*X*	*VH*	(0.633, 0.833, 0.9)
	Y	*VH*			*Y*	*M*	
	Z	*H*			*Z*	*VH*	
C_{24}	*X*	*H*	(0.5, 0.7, 0.9)	C_{54}	*X*	*VH*	(0.633, 0.833, 0.9)
	Y	*M*			*Y*	*VH*	
	Z	*H*			*Z*	*M*	
C_{25}	*X*	*H*	(0.733, 0.933, 1)	C_{55}	*X*	*H*	(0.6, 0.8, 1)
	Y	*VH*			*Y*	*H*	
	Z	*VH*			*Z*	*H*	

Table 2. The performance values of three candidates versus all sub-criteria

Sub-criteria	DM	LVs			Performance values		
		A	*B*	*C*	*A*	*B*	*C*
C_{11}	*X*	*P*	*G*	*P*	(0.1, 0.233, 0.433)	(0.733, 0.933, 1)	(0, 0.133, 0.333)
	Y	*VP*	*VG*	*VP*			
	Z	*F*	*VG*	*P*			
C_{12}	*X*	*VP*	*VG*	*VP*	(0.2, 0.267, 0.467)	(0.733, 0.933, 1)	(0, 0, 0.2)
	Y	*G*	*G*	*VP*			
	Z	*VP*	*VG*	*VP*			
C_{13}	*X*	*P*	*P*	*P*	(0.2, 0.333, 0.533)	(0.2, 0.333, 0.533)	(0.2, 0.333, 0.533)
	Y	*G*	*G*	*G*			
	Z	*VP*	*VP*	*VP*			
C_{14}	*X*	*F*	*G*	*P*	(0.567, 0.767, 0.9)	(0.667, 0.867, 1)	(0.267, 0.467, 0.6)
	Y	*G*	*G*	*P*			
	Z	*VG*	*VG*	*VG*			
C_{15}	*X*	*VP*	*VG*	*VP*	(0.467, 0.6, 0.733)	(0.733, 0.933, 1)	(0, 0.067, 0.267)
	Y	*VG*	*VG*	*VP*			
	Z	*P*	*G*	*P*			
C_{21}	*X*	*G*	*G*	*G*	(0.467, 0.667, 0.8)	(0.467, 0.667, 0.8)	(0.467, 0.667, 0.8)
	Y	*VG*	*VG*	*VG*			
	Z	*P*	*P*	*P*			
C_{22}	*X*	*G*	*VG*	*VP*	(0.4, 0.6, 0.8)	(0.733, 0.933, 1)	(0, 0.067, 0.267)
	Y	*G*	*G*	*VP*			
	Z	*P*	*VG*	*P*			
C_{23}	*X*	*F*	*F*	*F*	(0.3, 0.5, 0.7)	(0.3, 0.5, 0.7)	(0.2, 0.333, 0.533)
	Y	*F*	*F*	*VP*			
	Z	*F*	*F*	*F*			
C_{24}	*X*	*P*	*P*	*P*	(0.1, 0.233, 0.433)	(0.367, 0.567, 0.7)	(0, 0.133, 0.333)
	Y	*F*	*F*	*P*			
	Z	*VP*	*VG*	*VP*			
C_{25}	*X*	*VP*	*G*	*VP*	(0.467, 0.6, 0.733)	(0.667, 0.867, 1)	(0.467, 0.6, 0.733)
	Y	*G*	*G*	*G*			
	Z	*VG*	*VG*	*VG*			
C_{31}	*X*	*F*	*F*	*VP*	(0.3, 0.433, 0.633)	(0.3, 0.433, 0.633)	(0.2, 0.333, 0.533)
	Y	*VP*	*VP*	*P*			
	Z	*G*	*G*	*G*			
C_{32}	*X*	*G*	*G*	*G*	(0.567, 0.767, 0.9)	(0.733, 0.933, 1)	(0.567, 0.767, 0.9)
	Y	*VG*	*VG*	*VG*			
	Z	*F*	*VG*	*F*			
C_{33}	*X*	*P*	*P*	*P*	(0.267, 0.467, 0.6)	(0.533, 0.733, 0.8)	(0, 0.067, 0.267)
	Y	*P*	*VG*	*VP*			
	Z	*VG*	*VG*	*VP*			
C_{34}	*X*	*VP*	*VG*	*VP*	(0.2, 0.333, 0.533)	(0.733, 0.933, 1)	(0.2, 0.333, 0.533)
	Y	*G*	*G*	*G*			
	Z	*P*	*VG*	*P*			
C_{35}	*X*	*VP*	*VG*	*P*	(0.1, 0.167, 0.367)	(0.367, 0.5, 0.633)	(0, 0.133, 0.333)
	Y	*F*	*F*	*P*			
	Z	*VP*	*VP*	*VP*			
C_{41}	*X*	*G*	*G*	*VP*	(0.567, 0.767, 0.9)	(0.667, 0.867, 1)	(0.367, 0.5, 0.633)
	Y	*F*	*G*	*F*			
	Z	*VG*	*VG*	*VG*			
C_{42}	*X*	*F*	*G*	*F*	(0.567, 0.767, 0.9)	(0.733, 0.933, 1)	(0.1, 0.233, 0.433)
	Y	*VG*	*VG*	*VP*			
	Z	*G*	*VG*	*P*			

Table 2. The performance values of three candidates versus all sub-criteria (Continued)

Sub-criteria	DM	LVs			Performance values		
		A	*B*	*C*	*A*	*B*	*C*
C_{43}	*X*	*VG*	*VG*	*VG*	(0.267, 0.467, 0.6)	(0.733, 0.933, 1)	(0.267, 0.4, 0.533)
	Y	*P*	*VG*	*P*			
	Z	*P*	*G*	*VP*			
C_{44}	*X*	*P*	*VG*	*P*	(0.1, 0.233, 0.433)	(0.367, 0.5, 0.633)	(0, 0.133, 0.333)
	Y	*F*	*F*	*P*			
	Z	*VP*	*VP*	*VP*			
C_{45}	*X*	*P*	*P*	*VP*	(0.267, 0.4, 0.533)	(0.267, 0.4, 0.533)	(0.267, 0.333, 0.467)
	Y	*VP*	*VP*	*VP*			
	Z	*VG*	*VG*	*VG*			
C_{51}	*X*	*F*	*VG*	*F*	(0.467, 0.667, 0.8)	(0.733, 0.933, 1)	(0.467, 0.667, 0.8)
	Y	*VG*	*G*	*VG*			
	Z	*F*	*VG*	*F*			
C_{52}	*X*	*G*	*G*	*G*	(0.6, 0.8, 1)	(0.6, 0.8, 1)	(0.2, 0.333, 0.533)
	Y	*G*	*G*	*VP*			
	Z	*G*	*G*	*P*			
C_{53}	*X*	*VP*	*VG*	*P*	(0.2, 0.333, 0.533)	(0.733, 0.933, 1)	(0, 0.133, 0.333)
	Y	*G*	*VG*	*P*			
	Z	*P*	*G*	*VP*			
C_{54}	*X*	*VG*	*VG*	*VG*	(0.367, 0.567, 0.7)	(0.367, 0.567, 0.7)	(0.267, 0.4, 0.533)
	Y	*P*	*P*	*P*			
	Z	*F*	*F*	*VP*			
C_{55}	*X*	*F*	*F*	*VP*	(0.1, 0.3, 0.5)	(0.567, 0.767, 0.9)	(0, 0, 0.2)
	Y	*P*	*G*	*VP*			
	Z	*P*	*VG*	*VP*			

Table 3. Fuzzy ideal/anti-ideal values

Sub-criteria	Fuzzy ideal values	Fuzzy anti-ideal values	Sub-criteria	Fuzzy ideal values	Fuzzy anti-ideal values
C_{11}	(0.733, 0.933, 1)	(0, 0.133, 0.333)	C_{34}	(0.733, 0.933, 1)	(0.2, 0.333, 0.533)
C_{12}	(0.733, 0.933, 1)	(0, 0, 0.2)	C_{35}	(0.367, 0.5, 0.633)	(0, 0.133, 0.333)
C_{13}	(0.2, 0.333, 0.533)	(0.2, 0.333, 0.533)	C_{41}	(0.667, 0.867, 1)	(0.367, 0.5, 0.633)
C_{14}	(0.667, 0.867, 1)	(0.267, 0.467, 0.6)	C_{42}	(0.733, 0.933, 1)	(0.1, 0.233, 0.433)
C_{15}	(0.733, 0.933, 1)	(0, 0.067, 0.267)	C_{43}	(0.733, 0.933, 1)	(0.267, 0.4, 0.533)
C_{21}	(0.467, 0.667, 0.8)	(0.467, 0.667, 0.8)	C_{44}	(0.367, 0.5, 0.633)	(0, 0.133, 0.333)
C_{22}	(0.733, 0.933, 1)	(0, 0.067, 0.267)	C_{45}	(0.267, 0.4, 0.533)	(0.267, 0.333, 0.467)
C_{23}	(0.3, 0.5, 0.7)	(0.2, 0.333, 0.533)	C_{51}	(0.733, 0.933, 1)	(0.467, 0.667, 0.8)
C_{24}	(0.367, 0.567, 0.7)	(0, 0.133, 0.333)	C_{52}	(0.6, 0.8, 1)	(0.2, 0.333, 0.533)
C_{25}	(0.667, 0.867, 1)	(0.467, 0.6, 0.733)	C_{53}	(0.733, 0.933, 1)	(0, 0.133, 0.333)
C_{31}	(0.3, 0.433, 0.633)	(0.2, 0.333, 0.533)	C_{54}	(0.367, 0.567, 0.7)	(0.267, 0.4, 0.533)
C_{32}	(0.733, 0.933, 1)	(0.567, 0.767, 0.9)	C_{55}	(0.567, 0.767, 0.9)	(0, 0, 0.2)
C_{33}	(0.533, 0.733, 0.8)	(0, 0.067, 0.267)			

Table 4. The normalized integration weights of all sub-criteria

Sub-criteria	Normalized weights	Sub-criteria	Normalized weights	Sub-criteria	Normalized weights	Sub-criteria	Normalized weights
C_{11}	0.0539	C_{23}	0.0456	C_{35}	0.0465	C_{52}	0.0207
C_{12}	0.0131	C_{24}	0.0417	C_{41}	0.0489	C_{53}	0.0454
C_{13}	0.0506	C_{25}	0.0512	C_{42}	0.0347	C_{54}	0.0448
C_{14}	0.0383	C_{31}	0.0371	C_{43}	0.0407	C_{55}	0.0418
C_{15}	0.0502	C_{32}	0.0396	C_{44}	0.0524		
C_{21}	0.0474	C_{33}	0.0462	C_{45}	0.0232		

C_{22}	0.0179	C_{34}	0.0261	C_{51}	0.0510	

Table 5. Distance of three candidates versus fuzzy ideal and anti-ideal solutions

Alternatives	D_i^+	D_i^-
A	0.004185	0.001695
B	0	0.006437
C	0.009525	0

Step 5. Calculate the relative closeness values of three candidates versus ideal solution and rank the alternatives. By using the equation (16), the relative closeness values of three candidates versus ideal solution can be obtained:

$RC_A^* = 0.001695/(0.004185 + 0.001695) = 0.2883$,

$RC_B^* = 0.006437/(0 + 0.006437) = 1$,

$RC_C^* = 0/(0.009525 + 0) = 0$,

Based on the proposed algorithm, the illustrative example shows the ranking order of RC_i^* for three candidates is *B*, *A*, and *C*, respectively. The most suitable middle manager is focused on the candidate *B*.

5 Conclusions

The proper middle managers not only can perform the projects well toward the organizational goals, but also can employ each kind of managerial skills to modulate the operational process of organization. The evaluation of selecting middle managers is critical for the HRM department of GSLPs. Since the decision for middle managers selection poses a fuzzy MCDM problem; hence, the aim of this paper is to develop a fuzzy MCDM model to select middle managers for GSLPs.

To effectively select middle managers, a systematically fuzzy MCDM algorithm is proposed. At first, the employment of Zadeh's fuzzy set theory and linguistic values, the Chen and Hsieh's GMIR method the Hsieh and Chen's modified GD approach, and ideal and anti-ideal concepts are applied in the fuzzy MCDM algorithm. Secondly, a hierarchical structure with five criteria, twenty-five sub-criteria is constructed. Finally, a step by step example is illustrated to study the computational process of the fuzzy MCDM model. In addition, the proposed approach has successfully accomplished our goal.

Furthermore, the proposed model not only releases the limitation of crisp values, but also facilitates its implementation as a computer-based decision support system in a fuzzy environment. In addition, the proposed fuzzy MCDM model is not run solely middle managers; however, every decision maker or beneficiary can apply this fuzzy-based MCDM model. Although the proposed algorithm presented in this paper is designed for evaluating middle managers, however, it can also be applied to selection problems such as projects, partners, and many other areas of management decision problems.

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