International Journal of the Physical Sciences Vol. 6(3), pp. 610-619, 4 February, 2011
Available online at http://www.academicjournals.org/IJPS
DOI: 10.5897/IJPS10.686
ISSN 1992 - 1950 ©2011 Academic Journals

Full Length Research Paper

Middle managers selection for third-party logistics service providers

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Accepted 12 January, 2011

Since the selection of middle managers is critical to the development of organizations for third-party logistics service providers (3PLs), how do the organizations of 3PLs select and recruit competent middle managers? The decision-making for middle managers selection poses a multi-criteria problem and faces a fuzzy environment. Hence, the aim of this paper is to develop a fuzzy multiple criteria decision-making (MCDM) model, to select middle managers for 3PLs. At first, some concepts and methods used to develop a fuzzy MCDM model are introduced. Secondly, to effectively select middle managers for 3PLs, three steps of a fuzzy MCDM algorithm are proposed. Finally, a step-by-step numerical example is illustrated by using the proposed fuzzy MCDM approach. The illustrated example shows that the proposed method can successfully accomplish the study's goal.

Key words: Middle managers, third-party logistics service provider, fuzzy MCDM.

INTRODUCTION

With the growing improvement of technology and the rapid change of economic environment, many enterprises encounter enormously, increasing risks and uncertainties that are greater than before. The keen competition and many changes have arisen. Facing the tendency towards fast developments on the economy, the usage of computers and electronic communications in business transactions and the acute competitions on international markets, some violent changes have came into existence on the customers' behavior. For meeting customers' requirements, to ensure the re-purchase intention and to develop the new customers, the trends of outsourcing of logistics services have emerged from the requirements of effectiveness. As a result, it would reduce the cost and increase the efficiency by applying the outsourced activities for an enterprise. Hence, the third-party logistics service providers (3PLs) are sprung up all over the world as a result of being fastidious about the effectiveness and convenience of customers.

The focus of supply chain management is increasing, more and more companies are searching for the usage of 3PLs due to the fact that the 3PLs provide more customized services and many different functional services (Murphy and Poist, 2000). There would be an opportunity to use the 3PLs surrounded by upstream, midstream and downstream of companies among the supply chain. On the other hand, more specialized services provided by 3PLs can be taken to find out the solutions of purchasing materials and distributing finished products for their companies. The companies would be kept under the intimate partnership with the 3PLs due to the fact that they could integrate the whole supply chain. That is, the non-core logistics activities are being outsourced to the 3PLs (Stock and Lambert, 2001); hence, the companies can emphasize on their core activities of competitive advantage.

However, how to make the logistics systems operate, and how to integrate the coordination of logistics activities to be efficient and effective is paramount. We know that

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the management can be applied to deal with those matters. DuBrin (2006) referred to organizing and staffing as one of the four management functions, while the other three are planning, leading and controlling. To accomplish these goals, all non-managerial employees and managers would use the input resources and perform the four management functions. Then, the output performance could be finally surveyed, and at the same time, the managers can view whether or not the usage of input resources and the transformation process of management functions are efficient, or whether the goals attainments are effective in the management systems.

Robbins et al. (2008) indicated that the three characteristics of an organization are goals, people and structure. Aaker (1995) pointed out that structures, systems, people, culture and strategies are the five components of an organization. Stock and Lambert (2001) had noted that the main component of an effective logistics organization is the people. Most scholars agree that the people are one of the most important elements in any organization. As such, organizational people can be divided into non-managerial employees and managers. Robbins et al. (2008) indicated that the former ones 'work directly on a job or task and have no responsibility for overseeing the work of others,' while on the other hand, the latter ones are people who 'directly oversee the activities of other people in the organization.' The managers are usually classified as top, middle and first-line managers. The top ones, for example, president, chief executive officer (CEO) etc., are responsible for policies formulation and the decision-making of the organizational direction, while the first-line ones (for example supervisor, taskmaster, etc.) are those people who directly conduct the daily activities. With regard to the middle ones (for example, unit chief, department head, project manager etc.), they are responsible for switching the organizational goals to specific details that first-line managers will devote to the accomplishment. Among these three categories, the middle ones are very important for 3PLs due to the fact that lack of managerial competency for a department head would result in the arrearage of enterprise development in the future. The proper middle ones can not only perform the projects well toward the organizational goals, but also can employ each kind of managerial skills to modulate the operational process of the organization. Therefore, in this paper, the issue of middle managers has been investigated due to the fact that they relate to the successful business and future development of enterprises.

Since the punctilious selection of middle managers is critical to the development of organization, how do organizations select and recruit competent managers? Do the organizations ensure that they get competent and skillful people? To perform the management functions more effectively, it really depends on recruiting capable people who possess a number of specific skills or capabilities. Therefore, it is important to select those middle managers holding various managerial competencies (Fang et al., 2010) to compete against their competitors. However, the department of human resources management (HRM) should be well-down to this task.

As mentioned already, the evaluation of middle managers selection is crucial; however, experience has shown that it is not an easy matter. The decision for middle managers selection poses a multi-criteria problem. It involves a multiplicity of complex considerations and poses a unique characteristic of the multiple criteria decision-making (MCDM). The evaluation criteria of managerial competencies of middle managers are usually subjective in nature and often change with the decision-making conditions, which creates the fuzzy and uncertain nature among the criteria and the important 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 (Ding, 2005). The authors, therefore, adopts the fuzzy set theory (Zadeh, 1965), in combination with MCDM method (Ahmad et al., 2010; Anisseh et al., 2009; Ardil and Sandhu, 2010; Chou, 2010a, 2010b, 2010c; Ding, 2009, 2010; Sreekumar and Mahapatra, 2009) as an evaluation tool to improve the quality of this study. In the light of this, a fuzzy MCDM model of soft computing is used to evaluate selection of middle managers for the HRM department of 3PLs.

In summary, the aim of this paper is to develop a fuzzy MCDM model to improve the quality of decision-making in evaluating selection of middle managers for 3PLs. Subsequently, the study presents the research methods and then proposes a fuzzy MCDM algorithm. Afterwards, a numerical study is illustrated and conclusions are thus made.

RESEARCH METHODS

Here, some of the research methods are briefly introduced.

Triangular fuzzy numbers and the algebraic operations

A fuzzy number *A* (Dubois and Prade, 1978) in real line $\Re$ is a triangular fuzzy number if its membership function, $f_A : \Re \rightarrow [0, 1]$, is

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

with $-\infty < c \le a \le b < \infty$. The triangular fuzzy number can be denoted by (*c, a, b*). According to the extension principle (Zadeh, 1965), let $A_1 = (c_1, a_1, b_1)$ and $A_2 = (c_2, a_2, b_2)$

be fuzzy numbers, then the algebraic operations of any two fuzzy numbers, A_1 and A_2, can be expressed as:

(i) Fuzzy addition, ⊕: $A_1 \oplus A_2 = (c_1 + c_2, a_1 + a_2, b_1 + b_2)$.

(ii) Fuzzy subtraction, ⊖: $A_1 \ominus A_2 = (c_1 - b_2, a_1 - a_2, b_1 - c_2)$.

(iii) Fuzzy multiplication, ⊗: $k \otimes A_2 = (kc_2, ka_2, kb_2), \quad k \in \Re, \; k \geq 0$;

$A_1 \otimes A_2 \cong (c_1c_2, a_1a_2, b_1b_2), \quad c_1 \geq 0, \; c_2 \geq 0$.

(iv) Fuzzy division, ⊘: $(A_1)^{-1} = (c_1, a_1, b_1)^{-1} \cong (1/b_1, 1/a_1, 1/c_1), \quad c_1 > 0$;

$A_1 \oslash A_2 \cong (c_1/b_2, \; a_1/a_2, \; b_1/c_2), \quad c_1 \geq 0, \; c_2 > 0$.

Linguistic values

In fuzzy decision environments, two preference ratings can be used. They are fuzzy numbers and linguistic values characterized by fuzzy numbers (Zadeh, 1975, 1976). Depending on the practical needs, decision-makers (DMs) may apply one or both of them. In this paper, the weighting set and rating set are used to analytically express the linguistic values and describe how important and good the involved criteria, sub-criteria and alternatives against the various sub-criteria above the alternative level are.

In this paper, the weighting set *W* = {*VL*, *L*, *M*, *H*, *VH*} and the appropriateness rating set *S* = {*VP*, *P*, *F*, *G*, *VG*} are used, 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. Both sets are used to evaluate the weights of all criteria and sub-criteria, as well as the fuzzy ratings of alternatives against various sub-criteria above the alternative level. We define *VL* = *VP* = (0, 0, 0.25), *L* = *P* = (0, 0.25, 0.5), *M* = *F* = (0.25, 0.5, 0.75), *H* = *G* = (0.5, 0.75, 1) and *VH* = *VG* = (0.75, 1, 1). These triangular fuzzy numbers are referred to in Ghyym (1999).

Ranking method

For matching the following fuzzy MCDM algorithm developed in this paper, a systematic method based on the concepts of integral value (Liou and Wang, 1992) was used to rank the final ratings. Let $f_A^L(x) = (x-c)/(a-c), c \leq x \leq a,$ and $f_A^R(x) = (x-b)/(a-b), a \leq x \leq b,$ be the left and right membership function of fuzzy number *A*, respectively. Suppose that g_A^L and g_A^R are the inverse function of f_A^L and f_A^R, respectively, then $g_A^L(y) = c + (a-c)y$ and $g_A^R(y) = b + (a-b)y$ can be obtained, respectively. Define the left and right integral values of *A* as:

$I^L(A) = \int_0^1 g_A^L(y)dy = (c+a)/2$ and

$I^R(A) = \int_0^1 g_A^R(y)dy = (a+b)/2$, respectively.

Then, the ranking value $R(A_i)$ of fuzzy numbers A_i is defined as:

$$R(A_i) = \beta I^R(A_i) + (1-\beta) I^L(A_i), \quad 0 \leq \beta \leq 1. \tag{1}$$

The value β can be referred to as the DM's risk attitude index. If β<0.5, β=0.5, and β>0.5, respectively, it implies that the DM is a risk-averter (pessimism), risk-neuter (moderatism) and risk-lover (optimism), respectively. The value β can be determined by two procedures. First, the DM gives the value β at the data output stage (Kim and Park, 1990), for example, β=0.2, 0.5, 0.75. However, it is difficult to apply this procedure directly in multiple DMs problem. Hence, Chang and Chen (1994) suggested that it is reasonable to evaluate β through the evaluation data conveyed by the DMs at the data input stage. In this paper, the method developed by Chang and Chen (1994) is cited to find the total risk attitude index β. The ranking of the fuzzy numbers, A_i and A_j, is defined based on the following rules:

(i). $A_i > A_j \Leftrightarrow R(A_i) > R(A_j)$;

(ii). $A_i < A_j \Leftrightarrow R(A_i) < R(A_j)$; and

(iii). $A_i = A_j \Leftrightarrow R(A_i) = R(A_j)$.

Let $A_i = (c_i, a_i, b_i)$ and $i = 1, 2, \ldots, n,$ be *n* fuzzy numbers. The ranking value of the fuzzy number A_i can be obtained as:

$$R(A_i) = \beta[(a_i + b_i)/2] + (1-\beta)[(c_i + a_i)/2].$$

Then based on the ranking rules described, the ranking of the *n* fuzzy numbers can be effectively determined.

THE PROPOSED FUZZY MCDM ALGORITHM

Here, a systematic model of the fuzzy MCDM algorithm is proposed. The steps to be taken are thus described.

Step 1 (Development of the hierarchical structure)

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

As regards the evaluation criteria and sub-criteria, the authors referred to some literature, which were made known in academic and management publications (Chen et al., 2008; Crawford, 2005; Crawford and Nahmias, 2010; DuBrin, 2006; Fang et al., 2010; Fisher, 2010; Giunipero et al., 2005; Harison and Boonstra, 2009; Lewis et al., 2010; Liao, 2005; Murphy and Poist, 2000; Robbins et al., 2008; Siu, 1998; Stevenson and Starkweather, 2010; Stock and Lambert, 2001). Then, the criteria and sub-criteria of managerial traits, skills, capabilities and competencies are preliminarily discussed with scholars and senior managers of the department of

HRM of 3PLs by the authors. Finally, five criteria in the first hierarchy and twenty-eight sub-criteria in the second hierarchy are suggested and their codes are shown in parentheses:

(i) Conceptual competency and administrative management capability (C_1). This criterion includes six sub-criteria, that is, logistics knowledge and understanding of specific contexts on organizational development and their work processes (C_{11}), logistics planning on cost, time, risk, quality, scope, process management, etc (C_{12}), empowerment (C_{13}), monitoring and controlling of logistics activities (C_{14}), cross cultural consideration and skills (C_{15}) and strategic thinking (C_{16}).
(ii) Communication competency (C_2). This criterion includes five sub-criteria, that is, skills and experience in verbal levels and intermediary communication at multiple levels (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}).
(iii) Interpersonal competency (C_3). This criterion includes five sub-criteria, that is, 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}).
(iv) Information of personal characteristics (C_4). This criterion includes five sub-criteria, that is, 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}).
(v) Logistics professional competency (C_5). This criterion includes seven sub-criteria, that is, the logistics managerial know-how of information technology and information system (IT/IS) (C_{51}), insights into risks and success factors of logistics-related processes (C_{52}), ability to problem-solving and decision-making (C_{53}), deep knowledge of cost and profit (C_{54}), knowledge of the project construction work (C_{55}), insights into logistics integration (C_{56}) and action orientation (C_{57}).

Step 2 (Computation of aggregating evaluation ratings of all alternatives)

The detail steps can be done and summarized as follows. That is, let $w_{tq} = (c_{tq}, a_{tq}, b_{tq}),\ 0 \le c_{tq} \le a_{tq} \le b_{tq} \le 1,$ $t = 1, 2, \ldots, k;\quad q = 1, 2, \ldots, n,$ be the weight given to criterion C_t by the q^{th} DM. Then, the weight of C_t can be represented as $W_t = (c_t, a_t, b_t),$

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

Let $w_{tjq} = (c_{tjq}, a_{tjq}, b_{tjq}),\ 0 \le c_{tjq} \le a_{tjq} \le b_{tjq} \le 1,$ $t = 1, 2, \ldots, k;\quad j = 1, 2, \ldots, n_t;\quad q = 1, 2, \ldots, n,$ be the weight given to criterion C_{tj} by the q^{th} DM. Then, the weight of C_{tj} can be represented as $W_{tj} = (c_{tj}, a_{tj}, b_{tj}),$

where $$c_{tj} = \frac{1}{n}\sum_{q=1}^{n} c_{tjq},\ a_{tj} = \frac{1}{n}\sum_{q=1}^{n} a_{tjq},\ b_{tj} = \frac{1}{n}\sum_{q=1}^{n} b_{tjq}.$$

Let $m_{itjq} = (c_{itjq}, a_{itjq}, b_{itjq}),\ 0 \le c_{itjq} \le a_{itjq} \le b_{itjq} \le 1,$ $i = 1, 2, \ldots, m;\quad t = 1, 2, \ldots, k;\quad j = 1, 2, \ldots, n_t;$ $q = 1, 2, \ldots, n,$ be the appropriateness rating assigned to alternative A_i by the q^{th} DM for criterion C_{tj}. Then, the appropriateness rating of alternative A_i can be represented as

$M_{itj} = (c_{itj}, a_{itj}, b_{itj}),$ where

$$c_{itj} = \frac{1}{n}\sum_{q=1}^{n} c_{itjq},\ a_{itj} = \frac{1}{n}\sum_{q=1}^{n} a_{itjq},\ b_{itj} = \frac{1}{n}\sum_{q=1}^{n} b_{itjq}.$$

The aggregation appropriateness rating of alternative A_i for the n_t sub-criteria under criterion C_t $(t = 1, 2, \ldots, k)$ can be denoted as:

$$R_{it} = \frac{1}{n_t} \otimes \left[(M_{it1} \otimes W_{t1}) \oplus (M_{it2} \otimes W_{t2}) \oplus \cdots \oplus (M_{itj} \otimes W_{tj}) \oplus \cdots \oplus (M_{itn_t} \otimes W_{tn_t}) \right] \quad (2)$$

Because $M_{itj} = (c_{itj}, a_{itj}, b_{itj})$ and $W_{tj} = (c_{tj}, a_{tj}, b_{tj}),$ we can denote $R_{it} \cong (Y_{it}, Q_{it}, G_{it})$, where $Y_{it} = \sum_{j=1}^{n_t} c_{itj}\, c_{tj} / n_t,\ Q_{it} = \sum_{j=1}^{n_t} a_{itj}\, a_{tj} / n_t,$ $G_{it} = \sum_{j=1}^{n_t} b_{itj}\, b_{tj} / n_t,$ for $i = 1, 2, \ldots, m;\quad t = 1, 2, \ldots, k.$

Furthermore, the final aggregation appropriateness rating of alternative A_i can be denoted as:

$$F_i = \frac{1}{k} \otimes \left[(R_{i1} \otimes W_1) \oplus (R_{i2} \otimes W_2) \oplus \cdots \oplus (R_{it} \otimes W_t) \oplus \cdots \oplus (R_{ik} \otimes W_k) \right] \quad (3)$$

Because $W_t = (c_t, a_t, b_t),$ we can denote $F_i \cong (Y_i, Q_i, G_i)$, where $Y_i = \sum_{t=1}^{k} Y_{it}\, c_t / k,$ $Q_i = \sum_{t=1}^{k} Q_{it}\, a_t / k,$ $G_i = \sum_{t=1}^{k} G_{it}\, b_t / k,$ for $i = 1, 2, \ldots, m.$

Step 3 (Choice of optimal alternative)

Let $A = (c, a, b)$ be the importance weight or appropriateness rating obtained by using the aggregation method proposed in Step 2. Based on the method developed by Chang and Chen (1994), the value of $\gamma=(a-c)/[(a-c)+(b-a)]$ can be considered as the DMs' total risk attitude index for someone's important weight or appropriateness rating. Hence, for the fuzzy MCDM algorithm presented in this paper, the total risk attitude index β of all the DMs can be obtained by:

$$\beta = \frac{\beta_x + \beta_y + \beta_z}{(k \times n) + (n \times \sum_{t=1}^{k} n_t) + (m \times n \times \sum_{t=1}^{k} n_t)}$$, where

$$\beta_x = \sum_{t=1}^{k} \sum_{q=1}^{n} \frac{a_{tq} - c_{tq}}{(a_{tq} - c_{tq}) + (b_{tq} - a_{tq})}$$,

$$\beta_y = \sum_{t=1}^{k} \sum_{j=1}^{n_t} \sum_{q=1}^{n} \frac{a_{tjq} - c_{tjq}}{(a_{tjq} - c_{tjq}) + (b_{tjq} - a_{tjq})}$$, and

$$\beta_z = \sum_{i=1}^{m} \sum_{t=1}^{k} \sum_{j=1}^{n_t} \sum_{q=1}^{n} \frac{a_{itjq} - c_{itjq}}{(a_{itjq} - c_{itjq}) + (b_{itjq} - a_{itjq})}$$.

Finally, by using these equations, we can calculate the left integral value, right integral value and the entire DMs' risk attitude index β. Based on the ranking method and the use of Equation (1), the final ranking values of the *m* alternatives can be obtained; and then the optimal alternative can be selected.

THE NUMERICAL ILLUSTRATION

Here, a numerical example of evaluating middle managers selection for a 3PL company is studied to demonstrate the computational process of the proposed fuzzy MCDM algorithm, step by step, as follows.

Step 1: An assumption that a 3PL company needs to select a middle manager. Three middle managers (*X*, *Y*, *Z*, respectively) are chosen after preliminary screening for further evaluation. The HRM department has formed a committee of three DMs, that is, *A*, *B*, *C*, respectively, to evaluate the best choice among three candidates. Five criteria and twenty-eight sub-criteria are suggested in step 1 of the proposed fuzzy MCDM algorithm.

Step 2: Three DMs made use of the linguistic values of weighting set to evaluate the importance weights of all criteria and sub-criteria. For example, the three DMs that evaluated the importance of C_1 with linguistic values are *M*, *M*, *H*, respectively. Then, according to Step 2 of the proposed fuzzy MCDM algorithm, the importance weight of C_1 is (0.333, 0.583, 0.833). To sum up, the results of the importance weights of all criteria and sub-criteria can be shown in Table 1. Similarly, the appropriateness ratings of three candidates versus all sub-criteria can be obtained by Step 2 of the proposed fuzzy MCDM algorithm. However, the results are shown in Table 2.

Step 3: By using equation β of Step 2 of the proposed fuzzy MCDM algorithm, we can obtain the three DMs' total risk attitude index β = 0.5056, where β_x = 9, β_y = 52 and β_z = 119.5, respectively. The risk-bearing attitude of the DMs trends is positive, based on the procedure of data input stage. Furthermore, by using Equation (1) of the ranking method, the left integral values, right integral values and final ranking values can be obtained. The results are shown in Table 3. The ranking order of the three candidates is *Y*, *X* and *Z*. Therefore, it is obvious that the optimal selection is candidate *Y*.

Conclusions

The usages of 3PLs are increasing all over the world due to the fact that the non-core logistics activities outsourced those of professionalized companies. However, how to make the logistics systems operate, and how to integrate the coordination of logistics activities to be efficient and effective is paramount. Most scholars have noted that the main component of an effective logistics organization is non-managerial employees and managers. Among the managers, the middle level managers are very important for 3PLs due to the fact that lack of managerial competency for a department head would result in the arrearage of enterprise development in the future. The proper middle ones can not only perform the projects well toward the organizational goals, but can also employ each kind of managerial skills to modulate the operational process of the organization. Therefore, the issue of middle managers is investigated in this paper.

Since the selection of middle managers is critical to the development of organization, how do the organizations of 3PLs select and recruit competent managers? The decision for middle managers selection poses a multi-criteria problem. It involves a multiplicity of complex considerations and poses a unique characteristic of multiple criteria decision-making (MCDM). The evaluation criteria of the managerial competencies of middle managers are usually faced by an ambiguous and uncertain nature. Hence, the selection of middle managers is confronted with a fuzzy decision-making environment. In light of this, the aim of this paper is to develop a fuzzy MCDM model to select middle managers for 3PLs.

To effectively select middle managers for 3PLs, a systematically fuzzy MCDM model is proposed. At first, a hierarchy structure is developed. Then, we calculate the final aggregation ratings of all other alternatives. In addition, a ranking method based on the concepts of integral value is used to rank the final ratings. Finally, a step by step numerical example is illustrated to study the computational process of the fuzzy MCDM algorithm. Furthermore, this paper with its methodologies developed can be employed as a practical tool for business application. 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.

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

Criteria / Sub-criteria	DM	Linguistic values	Fuzzy weights	Criteria / Sub-criteria	DM	Linguistic values	Fuzzy weights
C_1	*A*	*M*	(0.333, 0.583, 0.833)	C_{32}	*A*	*VH*	(0.583, 0.833, 0.917)
	B	*M*			*B*	*VH*	
	C	*H*			*C*	*M*	
C_2	*A*	*H*	(0.5, 0.75, 0.917)	C_{33}	*A*	*H*	(0.5, 0.75, 1)
	B	*VH*			*B*	*H*	
	C	*M*			*C*	*H*	
C_3	*A*	*M*	(0.417, 0.667, 0.917)	C_{34}	*A*	*M*	(0.167, 0.417, 0.667)
	B	*M*			*B*	*M*	
	C	*H*			*C*	*L*	
C_4	*A*	*M*	(0.25, 0.5, 0.75)	C_{35}	*A*	*M*	(0.583, 0.833, 0.917)
	B	*M*			*B*	*VH*	
	C	*M*			*C*	*VH*	
C_5	*A*	*H*	(0.667, 0.917, 1)	C_{41}	*A*	*L*	(0.083, 0.333, 0.583)
	B	*VH*			*B*	*L*	
	C	*VH*			*C*	*M*	
C_{11}	*A*	*M*	(0.167, 0.333, 0.583)	C_{42}	*A*	*M*	(0.167, 0.417, 0.667)
	B	*M*			*B*	*M*	
	C	*VL*			*C*	*L*	
C_{12}	*A*	*H*	(0.25, 0.5, 0.75)	C_{43}	*A*	*H*	(0.333, 0.583, 0.833)
	B	*L*			*B*	*L*	
	C	*M*			*C*	*H*	
C_{13}	*A*	*VH*	(0.583, 0.833, 0.917)	C_{44}	*A*	*M*	(0.333, 0.583, 0.75)
	B	*M*			*B*	*VH*	
	C	*VH*			*C*	*L*	
C_{14}	*A*	*M*	(0.417, 0.667, 0.917)	C_{45}	*A*	*M*	(0.5, 0.75, 0.917)
	B	*H*			*B*	*H*	
	C	*H*			*C*	*VH*	
C_{15}	*A*	*L*	(0.167, 0.417, 0.667)	C_{51}	*A*	*VH*	(0.417, 0.667, 0.833)
	B	*H*			*B*	*M*	
	C	*L*			*C*	*M*	
C_{16}	*A*	*M*	(0.167, 0.333, 0.583)	C_{52}	*A*	*VH*	(0.583, 0.833, 1)
	B	*VL*			*B*	*H*	
	C	*M*			*C*	*H*	
C_{21}	*A*	*M*	(0.5, 0.75, 0.917)	C_{53}	*A*	*M*	(0.417, 0.667, 0.833)
	B	*VH*			*B*	*M*	
	C	*H*			*C*	*VH*	
C_{22}	*A*	*H*	(0.417, 0.667, 0.917)	C_{54}	*A*	*H*	(0.667, 0.917, 1)
	B	*M*			*B*	*VH*	
	C	*H*			*C*	*VH*	

Table 1. Contd.

	A	VH			A	VH	
C_{23}	B	VH	(0.583, 0.833, 0.917)	C_{55}	B	VH	(0.667, 0.917, 1)
	C	M			C	H	
	A	L			A	H	
C_{24}	B	H	(0.167, 0.417, 0.667)	C_{56}	B	H	(0.583, 0.833, 1)
	C	L			C	VH	
	A	M			A	VH	
C_{25}	B	H	(0.5, 0.75, 0.917)	C_{57}	B	VH	(0.667, 0.917, 1)
	C	VH			C	H	
	A	M					
C_{31}	B	M	(0.167, 0.417, 0.667)				
	C	L					

Table 2. The appropriateness ratings of three candidates versus all sub-criteria.

Sub-criteria	DM	Linguistic values			Fuzzy ratings		
		X	Y	Z	X	Y	Z
	A	P	G	P			
C_{11}	B	VP	VG	VP	(0.083, 0.25, 0.5)	(0.667, 0.917, 1)	(0, 0.167, 0.417)
	C	F	VG	P			
	A	VP	VG	VP			
C_{12}	B	G	G	VP	(0.167, 0.25, 0.5)	(0.667, 0.917, 1)	(0, 0, 0.25)
	C	VP	VG	VP			
	A	P	P	P			
C_{13}	B	G	G	G	(0.167, 0.333, 0.583)	(0.167, 0.333, 0.583)	(0.167, 0.333, 0.583)
	C	VP	VP	VP			
	A	F	G	P			
C_{14}	B	G	G	P	(0.5, 0.75, 0.917)	(0.583, 0.833, 1)	(0.25, 0.5, 0.667)
	C	VG	VG	VG			
	A	VP	VG	VP			
C_{15}	B	VG	VG	VP	(0.25, 0.417, 0.583)	(0.667, 0.917, 1)	(0, 0.083, 0.333)
	C	P	G	P			
	A	P	VG	P			
C_{16}	B	VP	VP	P	(0.167, 0.333, 0.583)	(0.417, 0.583, 0.75)	(0, 0.167, 0.417)
	C	G	G	VP			
	A	G	G	G			
C_{21}	B	VG	VG	VG	(0.417, 0.667, 0.833)	(0.417, 0.667, 0.833)	(0.417, 0.667, 0.833)
	A	G	G	G			
C_{21}	B	VG	VG	VG	(0.417, 0.667, 0.833)	(0.417, 0.667, 0.833)	(0.417, 0.667, 0.833)
	C	P	P	P			

Table 2. Contd.

C_{22}	*A*	*G*	*VG*	*VP*	(0.333, 0.583, 0.833)	(0.667, 0.917, 1)	(0, 0.083, 0.333)
	B	*G*	*G*	*VP*			
	C	*P*	*VG*	*P*			
C_{23}	*A*	*F*	*F*	*F*	(0.25, 0.5, 0.75)	(0.25, 0.5, 0.75)	(0.167, 0.333, 0.583)
	B	*F*	*F*	*VP*			
	C	*F*	*F*	*F*			
C_{24}	*A*	*P*	*P*	*P*	(0.083, 0.25, 0.5)	(0.333, 0.583, 0.75)	(0, 0.167, 0.417)
	B	*F*	*F*	*P*			
	C	*VP*	*VG*	*VP*			
C_{25}	*A*	*VP*	*G*	*VP*	(0.417, 0.583, 0.75)	(0.583, 0.833, 1)	(0.417, 0.583, 0.75)
	B	*G*	*G*	*G*			
	C	*VG*	*VG*	*VG*			
C_{31}	*A*	*F*	*F*	*VP*	(0.25, 0.417, 0.667)	(0.25, 0.417, 0.667)	(0.167, 0.333, 0.583)
	B	*VP*	*VP*	*P*			
	C	*G*	*G*	*G*			
C_{32}	*A*	*G*	*G*	*G*	(0.5, 0.75, 0.917)	(0.667, 0.917, 1)	(0.5, 0.75, 0.917)
	B	*VG*	*VG*	*VG*			
	C	*F*	*VG*	*F*			
C_{33}	*A*	*P*	*P*	*P*	(0.25, 0.5, 0.667)	(0.5, 0.75, 0.833)	(0, 0.083, 0.333)
	B	*P*	*VG*	*VP*			
	C	*VG*	*VG*	*VP*			
C_{34}	*A*	*VP*	*VG*	*VP*	(0.167, 0.333, 0.583)	(0.667, 0.917, 1)	(0.167, 0.333, 0.583)
	B	*G*	*G*	*G*			
	C	*P*	*VG*	*P*			
C_{35}	*A*	*VP*	*VG*	*P*	(0.083, 0.167, 0.417)	(0.333, 0.5, 0.667)	(0, 0.167, 0.417)
	B	*F*	*F*	*P*			
	C	*VP*	*VP*	*VP*			
C_{41}	*A*	*G*	*G*	*VP*	(0.5, 0.75, 0.917)	(0.583, 0.833, 1)	(0.333, 0.5, 0.667)
	B	*F*	*G*	*F*			
	C	*VG*	*VG*	*VG*			
C_{42}	*A*	*F*	*G*	*F*	(0.5, 0.75, 0.917)	(0.667, 0.917, 1)	(0.083, 0.25, 0.5)
	B	*VG*	*VG*	*VP*			
	C	*G*	*VG*	*P*			
C_{43}	*A*	*VG*	*VG*	*VG*	(0.25, 0.5, 0.667)	(0.667, 0.917, 1)	(0.25, 0.417, 0.583)
	B	*P*	*VG*	*P*			
	C	*P*	*G*	*VP*			
C_{44}	*A*	*P*	*VG*	*P*	(0.083, 0.25, 0.5)	(0.333, 0.5, 0.667)	(0, 0.167, 0.417)
	B	*F*	*F*	*P*			
	C	*VP*	*VP*	*VP*			

Table 2. Contd.

C_{45}	*A* *B* *C*	*P* *VP* *VG*	*P* *VP* *VG*	*VP* *VP* *VG*	(0.25, 0.417, 0.583)	(0.25, 0.417, 0.583)	(0.25, 0.333, 0.5)
C_{51}	*A* *B* *C*	*F* *VG* *F*	*VG* *G* *VG*	*F* *VG* *F*	(0.417, 0.667, 0.833)	(0.667, 0.917, 1)	(0.417, 0.667, 0.833)
C_{52}	*A* *B* *C*	*G* *G* *G*	*G* *G* *G*	*G* *VP* *P*	(0.5, 0.75, 1)	(0.5, 0.75, 1)	(0.167, 0.333, 0.583)
C_{53}	*A* *B* *C*	*VP* *G* *P*	*VG* *VG* *G*	*P* *P* *VP*	(0.167, 0.333, 0.583)	(0.667, 0.917, 1)	(0, 0.167, 0.417)
C_{54}	*A* *B* *C*	*VG* *P* *F*	*VG* *P* *F*	*VG* *P* *VP*	(0.333, 0.583, 0.75)	(0.333, 0.583, 0.75)	(0.25, 0.417, 0.583)
C_{55}	*A* *B* *C*	*F* *P* *P*	*F* *G* *VG*	*VP* *VP* *VP*	(0.083, 0.333, 0.583)	(0.5, 0.75, 0.917)	(0, 0, 0.25)
C_{56}	*A* *B* *C*	*G* *VP* *G*	*VG* *VG* *VG*	*VP* *P* *P*	(0.333, 0.5, 0.75)	(0.75, 1, 1)	(0, 0.167, 0.417)
C_{57}	*A* *B* *C*	*P* *F* *VP*	*G* *G* *VP*	*P* *F* *VP*	(0.083, 0.25, 0.5)	(0.333, 0.5, 0.75)	(0, 0.167, 0.417)

Table 3. Ranking value of the three candidates.

Candidates	Right integral values	Left integral values	Final ranking values	Ranking order
X	0.3639	0.1349	0.2507	2
Y	0.4836	0.2080	0.3473	1
Z	0.265	0.0851	0.1763	3

REFERENCES

Aaker DA (1995). Strategic Market Management (4th ed.). Singapore: John Wiley & Sons, Inc.

Ahmad I, Abdullah A, Alghamdi A (2010). Towards the selection of best neural network system for intrusion detection. Int. J. Phys. Sci., 5(12): 1830-1839.

Anisseh M, Yusuff RbM, Shakarami A (2009). Aggregating group MCDM problems using a fuzzy Delphi model for personnel performance appraisal. Sci. Res. Essays, 4(5): 381-391.

Ardil E, Sandhu PS (2010). A soft computing approach for modeling of severity of faults in software systems. Int. J. Phys. Sci., 5(2): 74-85.

Chang PL, Chen YC (1994). A fuzzy multi-criteria decision making method for technology transfer strategy selection in biotechnology. Fuzzy Sets Syst., 63(2): 131-139.

Chen P, Partington D, Wang JN (2008). Conceptual determinants of construction project management competence: A Chinese perspective. Int. J. Project Manage., 26(6): 655-664.

Chou CC (2010a). An integrated quantitative and qualitative FMCDM model for location choices. Soft Comput., 14(7): 757-771.

Chou CC (2010b). Application of FMCDM model to selecting the hub location in the marine transportation: A case study in southeastern Asia. Math. Comput. Model., 51(5/6): 791-801.

Chou CC (2010c). Application of a fuzzy MCDM model to the evaluation

of plant location. Int. J. Innov. Comp. Inf. Control, 6(6): 2581-2594.
Crawford L (2005). Senior management perceptions of project management competence. Int. J. Project Manag., 23(1): 7-16.
Crawford L, Nahmias AH (2010). Competencies for managing change. Int. J. Project Manage., 28(4): 405-412.
Ding JF (2005). Using fuzzy MCDM to select partners of strategic alliances for liner shipping. Inf. Sci., 173(1-3): 197-225.
Ding JF (2009). Fuzzy MCDM approach for selecting strategic partner: an empirical study of a container shipping company in Taiwan. Int. J. Innov. Comp. Inf. Control, 5(4): 1055-1068.
Ding JF (2010). Critical factors influencing customer value for global shipping carrier-based logistics service providers using fuzzy AHP approach. Afr. J. Bus. Manage., 4(7): 1299-1307.
Dubois D, Prade H (1978). Operations on fuzzy numbers. Int. J. Syst. Sci., 9(6): 613-626.
DuBrin AJ (2006). Essential of Management (7th ed.). Singapore: Thomson South-Western.
Fang CH, Chang ST, Chen GL (2010). Competency development among Taiwanese healthcare middle manager: A test of the AHP approach. Afr. J. Bus. Manage., 4(13): 2845-2855.
Fisher E (2010). What practitioners consider to be the skills and behaviours of an effective people project manager. Int. J. Project Manage., (Article in Press).
Ghyym SH (1999). A semi-linguistic fuzzy approach to multi-actor decision-making: Application to aggregation of experts' judgments. Ann. Nucl. Energy, 26(12): 1097-1112.
Giunipero LC, Denslow D, Eltantawy R (2005). Purchasing/supply chain management flexibility: Moving to an entrepreneurial skill set. Ind. Market. Manag., 34(6): 602-613.
Harison E, Boonstra A (2009). Essential competencies for technochange management: Towards an assessment model. Int. J. Inf. Manage., 29(4): 283-294.
Kim K, Park KS (1990). Ranking fuzzy numbers with index of optimism. Fuzzy Sets Syst., 35(2): 143-150.
Lewis R, Yarker J, Donaldson-Feilder E, Flaxman P, Munir F (2010). Using a competency-based approach to identify the management behaviours required to manage workplace stress in nursing: A critical incident study. Int. J. Nurs. Stud., 47(3): 307-313.
Liao YJ (2005). Applying fuzzy theory to the study of evaluating key competencies of managers in high technology manufacturing industries. Master thesis, National Taiwan Ocean University, Taiwan.
Liou TS, Wang MJJ (1992). Ranking fuzzy numbers with integral value. Fuzzy Sets Syst., 50(3): 247-255.
Murphy PR, Poist RF (2000). Third-party logistics: Some user versus provider perspectives. J. Bus. Logist., 21(1): 121-133.
Robbins SP, DeCenzo DA, Coulter M (2008). Fundamentals of Management: Essential Concepts and Applications (7th ed.). Singapore: Pearson Education, Inc.
Siu V (1998). Managing by competencies - A study on the managerial competencies of hotel middle managers in Hong Kong. Int. J. Hosp. Manage., 17(3): 253-273.
Sreekumar M, Mahapatra SS (2009). A Fuzzy multi-criteria decision making approach for supplier selection in supply chain management. Afr. J. Bus. Manage., 3(4): 168-177.
Stevenson DH, Starkweather JA (2010). PM critical competency index: IT execs prefer soft skills. Int. J. Project Manage., 28(7): 663-671.
Stock JR, Lambert DM (2001). Strategic Logistics Management (4th ed.). New York: McGraw-Hill Companies.
Zadeh LA (1965). Fuzzy sets. Inf. Control, 8(3): 338-353.
Zadeh LA (1975-1976). The concept of a linguistic variable and its application to approximate reasoning, Part 1, 2 and 3. Inf. Sci., 8(3): 199-249, 8(4): 301-357; 9(1): 43-80.