



An integrated fuzzy-lp approach for a supplier selection problem in supply chain management

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ABSTRACT

In supply chain management process, the firm select best supplier takes the competitive advantage to other companies. Thus, supplier selection is an important issue and with the multiple criteria decision-making approach, the supplier selection problem includes both tangible and intangible factors. This paper is aimed to present an integrated fuzzy and linear programming approach to the problem. Firstly, linguistic values expressed in trapezoidal fuzzy numbers are applied to assess weights and ratings of supplier selection criteria. Then a hierarchy multiple model based on fuzzy set theory is expressed and fuzzy positive and negative ideal solutions are used to find each supplier's closeness coefficient. Finally, a linear programming model based on the coefficients of suppliers, buyer's budgeting, suppliers' quality and capacity constraints is developed and order quantities assigned to each supplier according to the linear programming model. The integrated model is illustrated by an example in a textile firm.

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1. Introduction

Supplier selection is one of the critical activities for firms to gain competitive advantage and achieve the objectives of the whole supply chain. On average, manufacturers' purchases of goods and services constitute up to 70% of product cost and in high-technology firms, purchased materials and services represent up to 80% of total product cost (Ghodsypour & O'Brien, 2001). To manage this strategically important purchasing function effectively, appropriate method and criteria have to be chosen for the problem.

Supplier selection is a multiple criteria decision-making (MCDM) problem affected by several conflicting factors such as price, quality and delivery. A study carried out by Dickson based on a questionnaire sent to 273 purchasing agents identified 23 different commonly used criteria for supplier selection problem. Out of the 23 factors, Dickson concluded that quality, delivery and performance history are the most important criteria (Dickson, 1966). Table 1 summarizes criteria appeared in literature since 1966.

Over the years, several techniques have been developed to solve the problem efficiently. Analytic hierarchy process (AHP), analytic network process (ANP), linear programming (LP), mathematical programming, multi-objective programming, data envelopment analysis (DEA), neural networks (NN), case-based reasoning (CBR) and fuzzy set theory (FST) methods have been applied in literature. Also, the integration of different methodologies has been developed in literature and the integration takes the advantages of var-

ious methods' strengths and complements their weaknesses. Ghodsypour and O'Brien (1998) applied an integration of AHP and LP to consider both tangible and intangible factors. Ha and Krishnan (2008) developed a hybrid method including AHP, DEA and NN methodologies. Moreover, Faez, Ghodsypour, and O'Brien (2006) presented an integrated fuzzy case-based reasoning and mathematical programming model.

In practice, decision-making in supplier selection problem includes a high degree of fuzziness and uncertainties. Fuzzy set theory (FST) is one of the effective tools to handle uncertainty and vagueness. Kumar et al. developed a "fuzzy multi-objective integer programming vendor selection problem" (f-MIP_VSP) model and in the proposed model, various input parameters have been treated as vague with a linear membership function of fuzzy type (Kumar, Vrat, & Shankar, 2006). Also, to overcome the vagueness of information, Ghodsypour et al. developed a fuzzy multi-objective linear model and for the first time applied an asymmetric fuzzy decision-making technique to enable the decision-makers to assign different weights to various criteria (Amid, Ghodsypour, & O'Brien, 2006).

Chen et al. applied linguistic values to assess the ratings and weights of supplier selection criteria and then used a hierarchy multiple criteria decision-making (MCDM) model based on fuzzy set theory (FST). By calculating the candidate suppliers' distances to the fuzzy positive and negative ideal solutions (FPIS & FNIS), a closeness coefficient is defined to determine the ranking order of all suppliers (Chen, Lin, & Huang, 2006).

Basically, there are two kinds of supplier selection problem as multiple sourcing and single sourcing. In single sourcing, one supplier can satisfy all the buyer's needs and the management needs

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Nomenclature

CC_i	closeness coefficients of each supplier	p_i	unit price of i th supplier
X_i	order quantity for i th supplier	P	company's maximum acceptable unit price respect to allocated budget for purchasing this order (9.2 in the model)
D	total demand (5000 in the model)	C_i	capacity of i th supplier
q_i	defect quality rate of i th supplier		
Q	company's maximum acceptable defect quality rate (4 in the model)		

to make only one decision, which supplier is the best, whereas in multiple sourcing, as no supplier can satisfy all the buyer's requirements, more than one supplier has to be selected (Ghodsypour & O'Brien, 1998).

Chen et al. (2006) developed model based on fuzzy set theory is suitable for single sourcing problem. In this paper, a fuzzy and linear programming integrated model has been developed to solve multiple sourcing supplier selection problems. As Chen's model, linguistic values expressed in trapezoidal fuzzy numbers are used to assess weights and ratings of supplier selection criteria. Fuzzy positive and negative ideal solutions are obtained from weights and rating assigned by decision-makers. By using vertex method, the distances between alternative suppliers and fuzzy positive and negative ideal solutions are calculated. Then, a linear programming model is built using budgeting, quality, capacity constraints and coefficients of each supplier obtained from the distances calcu-

lated. Finally, order quantities assigned to each supplier according to the results of the linear model.

The paper is organized as follows: first we present the basic definitions and notations of the fuzzy numbers and computational procedure of the method in Section 2. Then next section, the proposed method is illustrated with an example in a textile firm. Finally, last section contains the conclusion and the future direction of research in the context of fuzzy set theory.

2. Basic definitions and proposed method

Definition 2.1. A positive trapezoidal fuzzy number \tilde{n} can be defined as (n_1, n_2, n_3, n_4) shown in Fig. 1 and the membership function $\mu_{\tilde{n}}(x)$ is defined as;

$$\mu_{\tilde{n}}(X) = \begin{cases} 0, & x < n_1, \\ \frac{x-n_1}{n_2-n_1}, & n_1 \leq x \leq n_2, \\ 1, & n_2 \leq x \leq n_3, \\ \frac{x-n_4}{n_3-n_4}, & n_3 \leq x \leq n_4, \\ 0, & x < n_4. \end{cases} \quad (1)$$

For a trapezoidal number if $n_2 = n_3$ then the number is called as a triangular fuzzy number. Also a crisp number k can be expressed as a trapezoidal number, (k, k, k, k) .

Definition 2.2. A matrix \tilde{D} is called as a fuzzy matrix if at least one element is a fuzzy number (Buckley, 1985).

Definition 2.3. Let $\tilde{m} = (m_1, m_2, m_3, m_4)$ and $\tilde{n} = (n_1, n_2, n_3, n_4)$ be two trapezoidal fuzzy numbers. Then the distance between them can be calculated by using the vertex method as (Chen et al., 2006)

$$d_v(\tilde{m}, \tilde{n}) = \sqrt{\frac{1}{4}[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2 + (m_4 - n_4)^2]}. \quad (2)$$

Table 1
Supplier selection criteria literature research.

Selection Criteria	A	B	C	D	E	F	G	H	I	J
Price	X	X	X	X	X	X	X	X		
Quality	X			X	X		X	X	X	
Delivery	X	X		X	X		X	X		
Warranties and claims	X	X								
After sales service	X	X	X	X					X	
Technical support		X	X					X		
Training aids	X	X		X						
Attitude	X		X	X						
Performance history	X			X				X		
Financial position	X	X		X				X	X	
Geographical location	X			X				X		
Management and organization	X			X						
Labor relations	X			X						
Communication system	X			X				X		X
Response to customer request		X						X		
E-commerce capability					X	X				
JIT capability										
Technical capability	X			X					X	
Production facilities and capacity	X			X			X	X		
Packaging ability	X			X						
Operational controls	X			X						
Ease-of-use		X	X							
Maintainability		X	X							
Amount of past business	X	X		X						
Reputation and position in industry	X	X	X	X				X		X
Reciprocal arrangements	X			X						
Impression	X	X	X	X						
Environmentally friendly products					X					
Product appearance						X				
Catalog technology						X				
Relationship closeness									X	X
Conflict resolution									X	X
Political Stability								X		
Economy								X		
Terrorism								X		

A, Dickson (1966); B, Lehmann & O'Shaughnessy (1974); C, Abratt (1986); D, Weber, Current, & Benton (1991); E, Min & Galle (1999); F, Stavropoulos (2000); G, Ghodsypour & O'Brien (2001); H, Chan & Kumar (2007); I, Chen et al. (2006); J, Lin & Chang (2008).

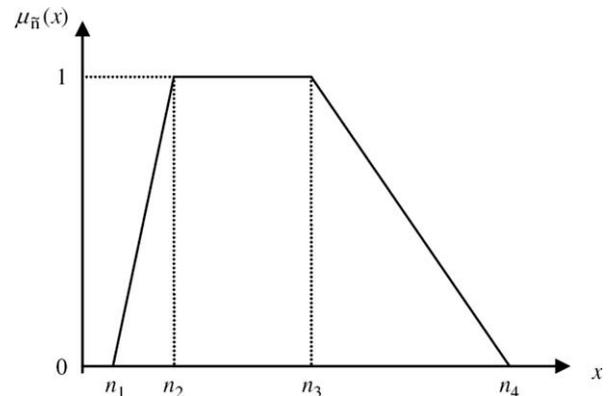


Fig. 1. Trapezoidal fuzzy number \tilde{n} .

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