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Supplier Evaluation and Selection in SCM using Fuzzy AHP

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Abstract. Nowadays, selecting the best suppliers has strategic importance in this competitive environment for companies. Supplier selection consists of both qualitative and quantitative criteria, so it is considered as a multi-criteria decision-making (MCDM) problem. There are many investigations about supplier selection and many publications have been issued since now, but they have not separated qualitative and quantitative criteria for evaluating suppliers and allocating orders. Hence, we propose an integrated model that evaluates suppliers and allocates order to them. In the first step, we evaluate suppliers by qualitative criteria such as financial structure, services and loyalty with Fuzzy analytical hierarchy process (FAHP) and gain their weights. Meantime, the fuzzy logic and triangular fuzzy numbers are utilized to handle ambiguity of human judge. In the second step, for evaluating suppliers and allocating orders with quantitative criteria such as cost, defect rate, and delay considering company's demands and suppliers' limitations a multi objective linear programming (MOLP) is formulated. This model consists of four objective functions: minimizing defect, delay, and costs. For influencing the suppliers' weights which are achieved from qualitative evaluation by FAHP, an objective function is defined to maximize the overall weights of suppliers. A case study is applied to illustrate the stages of Supplier selection, evaluation and order allocation.

Keywords: Supplier selection, Fuzzy set, Multi criteria decision making, AHP, Multi objective linear-Programming

1. Introduction

Variation in demands for production enforces organization to outsource their activities. Primary problem in supply chain is control and coordinate this activities. Supplier selection process is one of the significant parts of service and product management for many enterprises within supply chain. In manufacturing companies the raw materials and component parts can equal up to 70% of the product cost. In such conditions the purchasing unit can affect in cost reduction. Supplier evaluation is one of the most fundamental issues of purchasing management. Choosing an appropriate supplier considerably reduces cost, causes to competitive advantage and increases the level of customer satisfaction. Therefore organizations to achieve their strategic goals, should establish an appropriate relationship with their suppliers. Actually, the process of supplier selection and evaluation is multi-criteria decision making; that is, in supplier selection many criteria may be considered during this process; therefore, supplier selection and evaluation is a multi-criteria problem which includes both tangible and intangible criteria, some of which may conflict. Fundamentally supplier selection and evaluation can be divided to two categories:
(1) *Single sourcing*. Constraints are not considered in the supplier selection process. In other words, all suppliers can satisfy the buyer's requirements of demand, quality, delivery, etc. The buyer only needs to make one decision, which supplier is the best. (2) *Multiple sourcing*. Some limitations such as supplier's capacity, quality, and delivery are considered in the supplier selection process. In other words, no one supplier can satisfy the buyer's total requirements and the buyer needs to purchase some part of demand

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from one supplier and the other part from another supplier to compensate for the shortage of capacity or low quality of the first supplier. In these circumstances buyers need to make two decisions: which suppliers are the best, and how much should be purchased from each selected supplier?

2. Proposed model

This study proposed a systematic model to evaluate suppliers with criteria and to allocate optimal orders (Figure1). This proposed model wants to help managers in decision making. In the first step, after categorizing raw materials, services and Identifying suppliers, the criteria for evaluating supplier are defined. Then, criteria are separated to two groups: qualitative and quantitative. For evaluating suppliers with qualitative criteria Fuzzy AHP is applied. For evaluating supplier and allocating resources with quantitative criteria, after defining goals and constraints the multi objective linear programming is used where one of the objective functions is formulated considering performance scores of suppliers that were gained with FAHP.

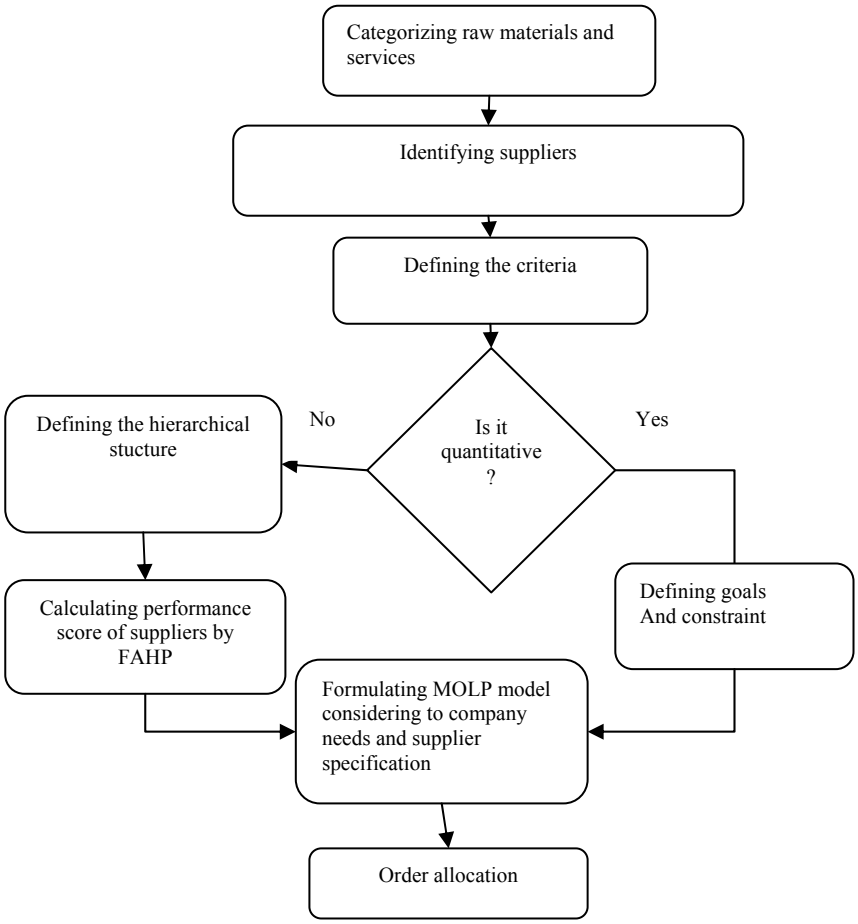

Figure1- proposed model

2.1. Evaluating suppliers with FAHP

2.1.1. Establishing hierarchy process

For evaluating suppliers with qualitative criteria, the hierarchy structure is established that consist of three levels (Figure2). Level one is the goal which wants to evaluate suppliers and select the best supplier. Level two shows the criteria that suppliers are evaluated with them. Finally, the level three is the suppliers or our alternative.

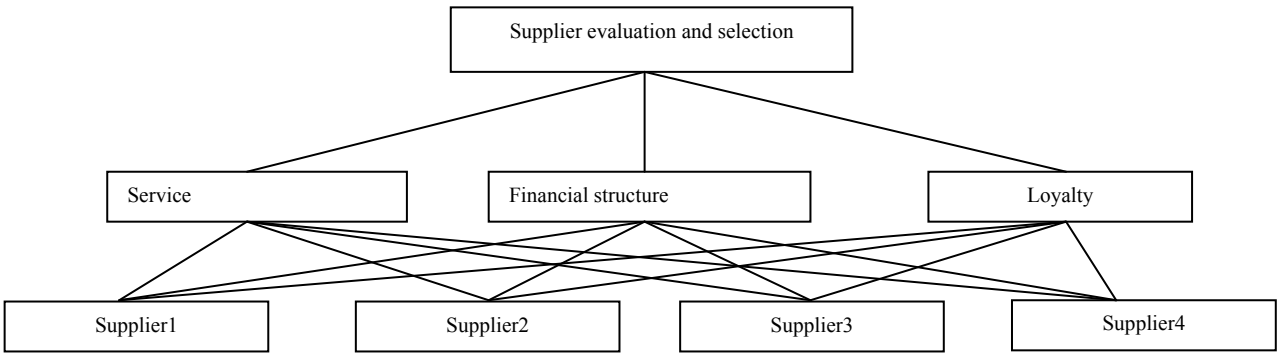

Figure2.

2.1.2. Calculating the weight of criteria

For calculating the weight of criteria FAHP has been used. AHP provides a framework to cope with multiple criteria situations. It can be easily understood and applied by operating managers.[imp]. With FAHP criteria are evaluated with pair wise comparison and criteria are evaluated based on goals. Furthermore a pair wise comparison matrix is established and with FAHP the weight of criteria are calculated. For evaluating criteria and supplier we used triangular fuzzy number.

2.1.3. FAHP Chang's step

After gathering information from supplier and quality documents the criteria for supplier evaluation have to extract and weight. We use Delphi method for these purposes. For weighting the criteria we proposed Chang's FAHP.

3. MOLP modeling

In this research we proposed a multi objective linear programming for orders allocation. In the first step, score of each supplier is calculated by FAHP, and then in the second step a MOLP model provides a solution for orders allocation to suppliers. Making a decision usually requires many objectives consideration and certain constraints, such as supplier's defect ratio, capacity and requirement on acceptance defect. In this research we have four objective functions:

4. Case study

The proposed method was applied for supplier evaluation and order allocation in PAKABCO technical and engineering corporation that act in civil fields in Iran. In the latest project they needed to buy a kind of valve for this we applied proposed model .the basic hierarchy of the decision problem was constructed based on the experts' suggestions was derived from Delphi approach. That is, each expert was asked to identify possible factors that could somehow affect the final decision through several surveys, questionnaires and discussions until a consensus was reached in this research wanted from experts to judge as a group. Also, the criteria used in the hierarchy were obtained and checked through the discussion process using Delphi approach and based on the suggestions from the references in.

With Chang's FAHP the criteria were weighted for important degree of criteria linguistic variable and TFN are defined (table 3) and then with Chang's algorithm criteria weight were gained that shown in table 4.The result shows that the consistency ratio of pair wise matrix is .04 that less than .1 and is acceptable. The overall score of each supplier has been shown in table 5.

Table3- triangular fuzzy scale

Linguistic scale	Triangular fuzzy scale
Just equal	(1,1,1)
Equally important	(1/2,1,3/2)
Weakly important	(1,3/2,2)
Strongly more important	(3/2,2,5/2)
Very strong more important	(2,5/2,3)
Absolutely more important	(5/2,3,7/2

Table 4 – criteria weights

Criteria	weight
service	0.1377
Financial structure	0.71

Loyalty	0.1522

Table5-Supplier overall score	S1	S2	S3	S4
	0.055	0.486	0.438	0.020

5. Order allocation to suppliers

After ranking suppliers and achieving their overall score In this stage by considering to corporation demands(table 7) and the supplier information that shown in table 6 With MOLP orders are allocated to suppliers with model that was established previously.

Table 5- suppliers' specifications

	S1	S2	S3	S4
supplier defect ratio	.035	.03	.032	.037
capacity of supplier	6000	6000	6500	5500
supplier delay ratio in delivery	0.37	0.27	0.23	.33
register and order cost for supplier	900	600	700	750
Supplier overall score	0.055	0.486	0.438	0.020

Table 6-Corporation Demands	
Demand	15000
acceptance defect	.04

So the model is displayed as follow:

$$minf1(x) = .37x1 + .27x2 + .23x3 + .33x4$$
$$minf2(x) = .035x1 + .03x2 + .032x3 + .037x4$$
$$maxf3(x) = .055x1 + .486x2 + .438x3 + .02x4$$
$$minf4(x) = 900x1 + 600x2 + 700x3 + 750x4$$

S.t.

$$X1 \leq 6000$$
$$X2 \leq 6000$$
$$X3 \leq 6500$$
$$X3 \leq 6500$$
$$.035x1 + .03x2 + .032x3 + .037x4 \leq .04(x1 + x2 + x3 + x4)$$
$$x1 + x2 + x3 + x4 \geq 15000$$
$$x1, x2, x3, x4 \geq 0$$

Finally with LINGO 11 software the model was solved and results were displayed in table 11

6. Conclusion

Organizations to achieve their strategic objectives, should establish an appropriate relationship with their suppliers. Therefore Supplier evaluation is a fundamental step of supply chain management and a multi criteria decision making problem. This study, proposed a systematic model to evaluate suppliers, uses TFN to express linguistic values that consider the subjective judgments of evaluators and then apply fuzzy multiple criteria decision-making approach to synthesize the decision making. The combined model of FAHP and MOLP has been proposed in this study. Little attention is given in the literature to decisions on the appropriate selection of suppliers, and on assigning order quantities to these suppliers, in the case of multiple sourcing, with multiple criteria and with supplier's capacity constraints. In supplier selection process considering qualitative factors is increased when the attention through supplier partnership was increased. AHP can be very useful in involving several decision-makers with different conflicting objectives

to arrive at a consensus decision. FAHP was used to weighting suppliers with qualitative criteria. The result of FAHP is used in MOLP model.

7. Reference

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