Presentation of a Consolidated Model for Evaluation and Selection of Suppliers and the Purchasing Decisions in Supply Chain Network

Foad Eshghi [1], Mohammad Khorasani Amoli [2]

[1.] M.S. in Agricultural Economics, Iran
[2.] Member of Scientific Board, Department of Management, Shomal University, Iran
Fesh.foad@gmail.com

Abstract: Due to the essential role of suppliers in determining the criteria of quality, cost and services to achieve the goals of supply chain, the issue of evaluation and selection of suppliers and the purchasing decisions in regarded as one of the most important activities of purchase managers in a supply chain. The issue of the evaluation and selection of suppliers is as a multi-criteria problem in which the goals contrast to each other and depending on the purchase situation, the goals find different importance and priority. First, through Hierarchical Analysis Technique (AHP) with consideration of both quantitative and qualitative criteria, a collection of the parameters of the selected suppliers was defined; then, a multi-objective linear programming model with multiple goals and a set of systemic limitations is formulated and it is applied in order to allocate the optimal ordering value to the selected suppliers. In this paper, initially, the literature is reviewed and then a multi-objective linear programming model is presented with effective flexibility to evaluate and select the potential suppliers and the process of their purchasing decisions which creates some understanding and awareness about their future purchasing strategies and finally, the best selected suppliers as well as the purchasing plan of each of them during each period are determined.
[Eshghi F, Khorasani Amoli M. **Presentation of a Consolidated Model for Evaluation and Selection of Suppliers and the Purchasing Decisions in Supply Chain Network.** *J Am Sci* 2012;8(12):666-670]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 92

Keywords: evaluation and selection of the suppliers, supply chain, the ordered system, Hierarchical Analysis Process, Multi-Criteria Decision-Making, Multi-Objective linear programming

1. Introduction

In practice, several criteria are used for decision making of suppliers' selection in a company, such as the proposed price of the quality sector, on-time delivery, after-sale services, response to the change in the order or location of suppliers and change in financial situation of suppliers. Seemingly, the selection of the suppliers is a multi-criteria problem which includes both quantitative and qualitative criteria. This paper establishes a balance between different goals of options' selection which is more compatible with the complexity and nature of decision-making environment of the reality. In most decision-making problems, multiple goals and factors are generally proposed and the decision maker attempts to select the best option among the several available options. To evaluate the suppliers, it is necessary to consider different criteria and factors which are actually the input data for evaluation and their input is suppliers' sorting which regarding to it, it can be addressed to select the suppliers.

The importance of the contractors' evaluation can be sought in the process of contractors' reduction. This issue can be important from different aspects, such as using of the best suppliers, decrease in total cost of the produced product, decrease in the management cost of the suppliers, the potential to create the development of suppliers in order to evaluate and select the suppliers.

Consequently, one of the most important tasks of purchasing is to evaluate and select the suppliers. Philip Crowsby, a quality specialist, expresses that a fundamental section of quality problems of a company is resulted from weak selection and management of the supply basis. Therefore, a correct decision about the supplier selection can decrease and eliminate a large section of the future problems (Monezka, 1998).

Although the main concept of the proposed procedure can be used for each organization with a purchasing task; however, its performance for each interested organization is very specific. As a result, each of the organizations should define some intellectual criteria and limitations for it. Of important survival factors in today's competitive environment, is to decrease yield production costs.

The selection of appropriate of suppliers can significantly decrease the purchasing costs and increase the competition capability of the organization. Since in most industries, the cost of raw materials and the product constituents includes a fundamental section of the finished value of the product. Perhaps, a supplier can keep satisfied the buyers of all equipments and facilities. Under such conditions, the purchasing management is obligated

to make two kinds of decisions (Ting and Cho, 2008):

1- Which of the suppliers should be considered?
2- How much is the order value allocated to each of the selected suppliers?

AHP technique regards both quantitative and qualitative criteria to select the suppliers and the hierarchical structure using of AHP is developed to define a set of the volunteer suppliers. As a result, a multi-objective linear programming model (MOLP) with three optimization goals (total costs of purchase, the quality and reliability of achievements) and a series of systemic limitations are formulated and it is solved to obtain the optimal ordered value and to select the best suppliers until by the minimum cost, the optimal order value would be allocated to the selected suppliers. In 2001, Dr. Qodsipour performed a comprehensive study about a number of quantitative techniques to select the suppliers which includes linear programming (LP), mixed integer programming (MIP), goal-based programming (GP), multi-objective programming (MOP) and non-linear programming (NLP). For quantification of qualitative data based on managerial judgments in multi-criteria decision-making environment, some of researchers (Bhutta and Hug, 2002; Liu and Hai, 2005; Hou and Sou, 2006; Saen, 2007) used AHP procedure to determine the priority in suppliers' selection. Also, other researcher such as Choy (2002), Chen (2006), Bevilacqua (2006), Amid (2006), Florez-Lopez (2007), Chan and Kumar (2007) presented inventory attitudes which are based on Artificial Intelligence (AI) techniques such as nervous networks and fuzzy logic (Ting and Cho, 2008). In order this method to be perfectly applied, they are shown for real life situations, especially when the evaluation of suppliers is sensitive and the decision-makers make different judgments. Among statistical models, the model presented by Ronen (1988) and the simulation model presented by Thompson (1996) can be referred which due to the complexity of methods, they have a little application in selection of suppliers. There are some models in order to consider quantitative and qualitative criteria simultaneously which Ramzi et al's papers can be referred in which different models are referred in detail in the recent papers. According to De Boer (2001), problem solving of the suppliers' selection includes the following four steps:

1- Definition of the problem.
2- Formulation of criteria
3- Pre-qualification of appropriate suppliers.

Final selection of suppliers

2. Material and Methods

AHP Method

The Analytic Hierarchy Process (AHP) was developed in the early 1970's by Thomas Saaty to solve prioritization problems. Satty claims that the AHP serves as a framework for people to structure their own problems and provide judgments based on knowledge, reasons or feelings to derive a set of priorities considered as an optimal solution to a decision problem (Saaty, 1980; Saaty, 1994). Today the AHP has gained wide popularity and acceptance throughout the world. It has been considered that AHP is one of the powerful tools to help individual as well as group decision makers to convert linguistic assessment to quantitative scales.

To evaluate the suppliers, it is necessary to consider some criteria and factors. In fact, the inputs of the suppliers' storing which using of it, it can be addressed to select the suppliers. Up to now, different factors are considered by the authors of papers which are often presented based on the experiences of buyers in relation to the suppliers. In primary studies in this respect which are performed by Dickson, he has presented nearly 23 distinct criteria for decision-making in relation to the suppliers' selection. Later, it was shown by Weber and Desai that the problem of the suppliers' selection is virtually multi-objective and on the other hand, paying attention to more than one criterion can cause to success the evaluation and selection of suppliers (Dickson, 1996; and Weber and Desai, 1996).

Hierarchical structure of the supplier selection

The main dimension and criteria applied in order to select the supplier with the study of performed papers and brain storm technique are obtained by the managers in purchase sector. After the hierarchy related to the criteria was determined, the decision – makers will evaluate the elements by couple comparisons. The couple comparisons is a process which is performed in relation to the importance priority, superiority and similarity of two elements regarding to their higher-level elements.

Then , the priorities are combined based on low-level judgments which finally , the general weight in relation to each alter native regarding to the hierarchical tree based on each criterion is obtained. The priorities related to weight loss are farther considered in a combined AHP- MOLP model as a weight goal function for alternative. Finally, the suppliers are automatically selected who have achieved the maximum comprehensive scores in AHP process.

There for, the presented model is a combined model which simultaneously with considering the Decision–Making criteria, it wants to

present the best answer in terms of minimization of total costs for the decision–maker.
The method in this paper is perfectly general and comprehensive and it can be implemented for each case and for each company. But the details of the process of the suppliers, selection and the allocation of optimal ordered value to them may be different from one case to the other.

Symbols and Assumptions used in this paper

For model development, we use some symbols and hypotheses which are shown in table1.

- Daily consumption for each period is randomized and it is normally distributed.
- The management determines the required confidence level for each of the periods.
- The initial inventory value of each period is known for the inventory management.
- The selected suppliers are able to supply several periods required by the purchasing sector.
- The costs of transportation and ordering of each unit are calculated by mean of these costs during three past months, which can be obtained by buyer-supplier reports, respectively.

Table 1. Symbols and parameters applied in MOLP model (Ting and Cho, 2008)

Parameter	Definition
x_{ij}	The value of jth item order from ith supplier Parameter
c_{ij}	The cost of each unit of jth purchase minus from ith supplier
d_{ij}	Mean of defaults or the proportion of jth faults minus from ith supplier
t_{ij}	Mean of jth delay time minus from ith supplier
p_{ij}	The price of each jth unit minus from ith supplier
f_{ij}	Cost for each jth unit minus from ith supplier
o_{ij}	Cost for ordering each jth unit minus from ith supplier
B_j	Purchasing budget for supplying jth sector
D_j	The value of product demand for jth sector
S_{ij}	Maximum value of jth supply minus from ith supplier
q_{ij}	Mean percentage of jth sector's faults from ith suppliers
Q_j	Maximum ratio of the acceptable fault of jth sector from ith supplier
L_j	Waiting time of jth sector from ith supplier
A_j	Mean value of consumption for jth sector
Z_j	jth safety factor
SD_j	Standard deviation of consumption value of jth sector
I_j^o	Initial inventory value of jth sector
Z_1, Z_2, Z_3	The values of goal amounts
W_1, W_2, W_3	The weights of goal functions of Z_1, Z_2, Z_3
Z_1^*, Z_2^*, Z_3^*	Minimum values of Z_1, Z_2, Z_3 are obtained by optimal solution

Formulation of model and introduction of model limitations

The proposed MOLP model includes three goals and a series of systemic limitations such as the limitation of purchase budget, product demand, capacity of suppliers, quality control and inventory control.

Total costs of purchase considered in MOLP model includes not only the product price but also it includes the costs for transportation and ordering. Three goal function of this model include:

1**. Purchase costs**: first goal function of MOLP model is to minimize total costs of purchasing:

$$\min Z_1 = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij} x_{ij} \qquad (1)$$

Whereas the purchasing cost of each unit equals to the sum unit price, the cost for each unit's transportation and the ordering cost for each unit.

$$c_{ij} = p_{ij} + f_{ij} + o_{ij} \qquad (2)$$

2. Quality: the second goal function of this model is to minimize total values of faults returning the goods:

$$\min Z_2 = \sum_{i=1}^{m}\sum_{j=1}^{n} d_{ij} x_{ij} \qquad (3)$$

3. Reliability of delivery: Third goal function of this model is to minimize the deviations from delivery date:

$$\min Z_3 = \sum_{i=1}^{m}\sum_{j=1}^{n} t_{ij} x_{ij} \qquad (4)$$

In this model Z_1, Z_2, Z_3 are the values of target functions; W_1, W_2, W_3 are the weights of target function of Z_1, Z_2, Z_3 ; Z_1^*, Z_2^*, Z_3^* are

minimum values of Z_1, Z_2, Z_3 resulted from the ideal answer; Z_1^*, Z_2^*, Z_3^* are maximum values of Z_1, Z_2, Z_3 resulted from non-ideal answers and λ is the maximum deviations from the minimum values of Z_1^*, Z_2^*, Z_3^* (in percent).

The available limitations in this model (MOLP) include

1. Constraints related to purchasing budget:

$$\sum_{i=1}^{m} p_{ij} x_{ij} \le B_j$$
$$j = 1,2,...,n \qquad (5)$$

2. Constraints related to product demand:

$$\sum_{i=1}^{m} x_{ij} \ge D_j \qquad j = 1,2,...,n \qquad (6)$$

3. Constraints related to the capacity of suppliers:

$$x_{ij} \le S_{ij} \qquad (7)$$
$$i = 1,2,...,m \; , \; j = 1,2,...,n$$

MOPL model:
Minimum model:

$$Min\ Z = \lambda \qquad (8)$$

Subject To:

$$\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij} x_{ij} + \frac{\lambda(Z_1^+ - Z_1^{++})}{\omega_1} \le Z_1^+ \qquad (9)$$

$$\sum_{i=1}^{m}\sum_{j=1}^{n} d_{ij} x_{ij} + \frac{\lambda(Z_2^+ - Z_2^{++})}{\omega_2} \le Z_2^+ \qquad (10)$$

$$\sum_{i=1}^{m}\sum_{j=1}^{n} t_{ij} x_{ij} + \frac{\lambda(Z_3^+ - Z_3^{++})}{\omega_3} \le Z_3^+ \qquad (11)$$

3. Results

In this paper, multi-criteria decision-making model and multi-objective decision-making are presented for evaluation and selection and programming of the suppliers. All multi-criteria selection and evaluation problems of suppliers are not only appropriate to select the suppliers but they are applied to allocate the optimal ordering value among the selected suppliers among the selected suppliers based on the number of key criteria such as the costs of quality and delivery credit and etc. for these suggestion two-step decision-making procedure is developed in this paper:

1. First step is that initially, a hierarchical structure in developed to select the suppliers through AHP considering both qualitative and quantitative criteria and then determining a series of the volunteer suppliers.

2. Second step is that a multi-objective programming model with three goals and a series of systemic limitations are formulated in order to help the management, allocation of the optimal ordering value to the volunteer suppliers. Meanwhile, MOLP model was remodeled as a LP model.

Corresponding Author:
Foad Eshghi
M.S. in Agricultural Economics, Iran
E-mail: Fesh.foad@gmail.com

References

1. Amid, A., Ghodsypour, S.H. and O'Brien, C. (2006), "Fuzzy multiobjective linear model for supplier selection in a supply chain", International Journal of Production Economics, Vol. 104, pp. 394-407.
2. Araz, C. and Ozkarahan, I. (2007), "Supplier evaluation and management system for strategic sourcing based on a new multicriteria sorting procedure", International Journal of Production Economics, Vol. 106, pp. 585-606.
3. Bhutta, K.S. and Huq, F. (2002), "Supplier selection problem: a comparison of the total cost of ownership and analytic hierarchy process approaches", Supply Chain Management: An International Journal, Vol. 7, pp. 126-35.
4. Chen, C.T., Lin, C.T. and Huang, S.F. (2006), "A fuzzy approach for supplier evaluation and selection in supply chain management", International Journal of Production Economics, Vol. 102, pp. 289-301.
5. De Boer, L. and van der Wegen, L. (2003), "Practice and promise of formal supplier selection: a study of four empirical cases", Journal of Purchasing and Supply Management, Vol. 9, pp. 109-18.
6. Dickson, G. W. (1966). "An analysis of vendor selection system and decisions" Journal of purchasing. Vol. 2, No. 1, pp.28-41
7. Ghodsypour & O'brin, 1998 A Decision support system for supplier selection using and intergrated andalytic Hirorhy process and linear programming "international journal of production Economics pp 199-212.

8. Liao, Z. and Rittscher, J. (2007), “A multi-objective supplier selection model under stochastic demand conditions”, International Journal of Production Economics, Vol. 105, pp. 150-9.
9. Liu, F.H. and Hai, H.L. (2005), “The voting analytic hierarchy process method for selecting suppliers”, International Journal of Production Economics, Vol. 97, pp. 308-17.
10. Monozka R. Trent R and R.Hand ield. (1998), "purchasing and supply chain management" south western college, Cincinnati, Ohio USA
11. Kurtila, Mikko, Pesonen, Mauno, Kangas, Jyrki and Kajanus, Miika "Utilizing the analytic hierarchy process (AHP) in SWOT analysis - a hybrid method and its application to a forest - certification case", Forest Policy Economics, 1 April, (2000), 41-52.
12. Saen, R.F. (2007), “A new mathematical approach for supplier selection: accounting for non-homogeneity is important”, Applied Mathematics and Computation, Vol. 185, pp. 84-95.
13. Ting, S-C. and Cho, DI. (2008), “An integrated approach for supplier selection and purchasing decisions“, Supply Chain Management: An International Journal 13/2 ,pp. 116–127
14. Weber, C. A. and Desai, A. (1996). “Determination of paths to vendor market efficiency using parallel co-ordinates representation: a negotiation tool fpr buyers.” European Journal of operational Research, Vol.90, No. 1, pp. 142-155.

08/20/2012