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APPLICATION OF COPRAS METHOD FOR SUPPLIER SELECTION

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Abstract

Evaluation of alternative suppliers and selection of the most appropriate has always been viewed as the most important responsibility of logistics management. Although a large number of mathematical approaches are proposed to evaluate and select the alternative suppliers, this paper explores the applicability and capability of recently developed method i.e. complex proportional assessment (COPRAS) for supplier selection. The methodology of COPRAS method for the supplier performance evaluation for a firm that manufactures agricultural and construction equipment was given and the results were compared with those derived by the past researchers.

Keywords: *supplier selection, COPRAS, decision making.*

1. INTRODUCTION

In today's highly competitive and interrelated manufacturing environment, the effective selection of suppliers is very important to the success of a manufacturing firm. Many manufacturing firms have given increased attention to strategic supplier selection in an effort to reduce the number of suppliers to support JIT manufacturing [1]. Supplier selection decisions are an important component of production and logistics management for many companies [2].

Supplier selection is a multi-criteria decision making problem involving a set of different and opposite criteria. Information and communication technology, financial position, flexibility in meeting customer needs, reputation and position in industry, attitude, flexibility, packaging ability, management and organization, geographical location, production facilities and capacity, personnel capability, warranties and claim policies, repair service, payment options, parity, cost can be considered as main criteria that influence the supplier selection of a given product in a supply chain management.

Various multi-criteria decision-making (MCDM) methods and different optimization techniques have been proposed to aid the supplier selection process. Decision analysis is concerned with those situations where a decision maker has to choose the best alternative among several candidates while considering a set of conflicting criteria [3]. In order to evaluate the overall effectiveness of the candidate alternatives, rank and select the most appropriate (the best) supplier, the primary objective of an MCDM method is to identify the relevant supplier selection problem criteria, assess the alternatives information relating to those criteria and develop methodologies for evaluating the significance of criteria.

Bayazit [4] explored the use of ANP methodology as a method for supplier selection. Šimunović et al. [5] applied AHP method for the purpose of systematic evaluation and selection o of suppliers. Liu et al [1] proposed and demonstrated the use of data envelopment analysis (DEA) in evaluating the overall performances of suppliers in a manufacturing firm. Kwang [6] proposed a combined scoring method with fuzzy expert systems approach to perform the supplier assessment. Feng et al. [7] presented a stochastic integer programming approach for simultaneous selection of tolerances and suppliers based on the quality loss function and process capability indices. Linear programming as one of the techniques of operational research, integrated with other methods, is applied in the papers [8, 9]. Shyur and Shih [10] proposed a hybrid MCDM model using ANP and TOPSIS methods for strategic supplier selection. Wadhwa and Ravindran [11] presented multi-objective optimization methods including weighted objective, goal programming and compromise programming. Venkata Rao [12] presented a logical procedure for solving the vendor selection problem in a supply chain environment with multiple objectives which is based on a combined AHP and genetic algorithm method. Kumar and Roy [13] proposed hybrid modeling approach by using AHP and artificial neural network to assess supplier performance. An extensive review of MCDM methids for supplier evaluation and selection is given by Ho et al. [14].

As seen from literature, many MCDM methods have been proposed for solving supplier selection problem. However, there is need for a systematic and simple mathematical approach for efficient and effective evaluation of competitive suppliers. In this paper, an attempt is made to explore the applicability and capability of recently developed MCDM method, i.e. complex proportional assessment (COPRAS) method for selection of the most appropriate supplier. Till date, COPRAS method has very limited application in the logistics domain.

2. COPRAS METHOD

The preference ranking method of complex proportional assessment (COPRAS) method was developed by Zavadskas et al. [15]. In this method, the influence of maximizing and minimizing criteria on the evaluation result is considered separately. The selection of the best alternative is based considering both the ideal and the anti-ideal solutions. The main procedure of COPRAS method includes several steps [3].

Step 1: Set the initial decision matrix, *X*.

$$X = \left[x_{ij}\right]_{m \times n} = \begin{bmatrix} x_{11} \; x_{12} \ldots x_{1n} \\ x_{21} \; x_{22} \ldots x_{2n} \\ \ldots \; \ldots \; \ldots \; \ldots \\ x_{m1} \; x_{m2} \ldots x_{mn} \end{bmatrix} \quad (1)$$

where x_{ij} is the assessment value of i-th alternative in respect to j-th criterion, m is the number of alternatives and n is the number of criteria.

Step 2: Normalization of the decision matrix by using the following equation:

$$R = \left[r_{ij}\right]_{m \times n} = x_{ij} / \sum_{i=1}^{m} x_{ij} \quad (2)$$

Step 3: Determination of the weighted normalized decision matrix, D, by using the following equation:

$$D = \left[y_{ij}\right]_{m \times n} = r_{ij} \cdot w_j, \, i = 1,\ldots,m, \; j = 1,\ldots,n \quad (3)$$

where r_{ij} is the normalized performance value of i-th alternative on j-th criterion and w_j is the weight of j-th criterion.

The sum of weighted normalized values of each criterion is always equal to the weight for that criterion:

$$\sum_{i=1}^{m} y_{ij} = w_j \quad (4)$$

Step 4: In this step the sums of weighted normalized values are calculated for both the beneficial and non-beneficial criteria by using the following equations:

$$S_{+i} = \sum_{j=1}^{n} y_{+ij}, \, S_{-i} = \sum_{j=1}^{n} y_{-ij} \quad (5)$$

where y_{+ij} and y_{-ij} are the weighted normalized values for the beneficial and non-beneficial criteria, respectively.

Step 5: Determination the relative significances of the alternatives, Q_i, by using the following equation:

$$Q_i = S_{+i} + \frac{S_{-min} \cdot \sum_{i=1}^{m} S_{-i}}{S_{-i} \cdot \sum_{i=1}^{m} \left(S_{-min} / S_{-i}\right)}, \, i = 1,\ldots,m \quad (6)$$

where S_{-min} is the minimum value of S_{-i}.

Step 6: Calculation of the quantitative utility, U_i, for i-th alternative by using the following equation:

$$U_i = \frac{Q_i}{Q_{max}} \cdot 100\% \quad (7)$$

where Q_{max} is the maximum relative significance value.

As a consequence of Eq. 6, utility values of the candidate alternatives range from 0% to 100%.The greater the value of U_i, the higher is the priority of the alternative. Based on alternative's utility values a complete ranking of the competitive alternatives can be obtained.

3. SUPPLIER SELECTION AND DISCUSSION OF THE RESULTS

In this paper a case study presented by Liu et al. [1] was considered. The authors demonstrated the supplier performance evaluation using DEA method for a firm that manufactures agricultural and construction equipment. The multi-criteria decision making problem with the goal (the supplier selection), criteria and alternatives is shown in Figure 1.

As could be seen from Figure 1, five criteria for the best supplier selection were proposed i.e. price, quality, delivery performance, distance and supply variety. Also, multi-criteria decision making problem involves assessment and ranking of 18 alternatives (suppliers). Price and distance to the category of "non-beneficial" criteria, and smaller assessment values are preferred. On the other hand quality, delivery performance and supply variety are "beneficial" criteria and higher values are preferred. The data for the assessment of alternatives are given in Table 1.

The application of COPRAS method for ranking of alternative suppliers begins with normalization of decision matrix. Firstly by using Eq. 2 the normalized decision matrix is obtained (Table 2).

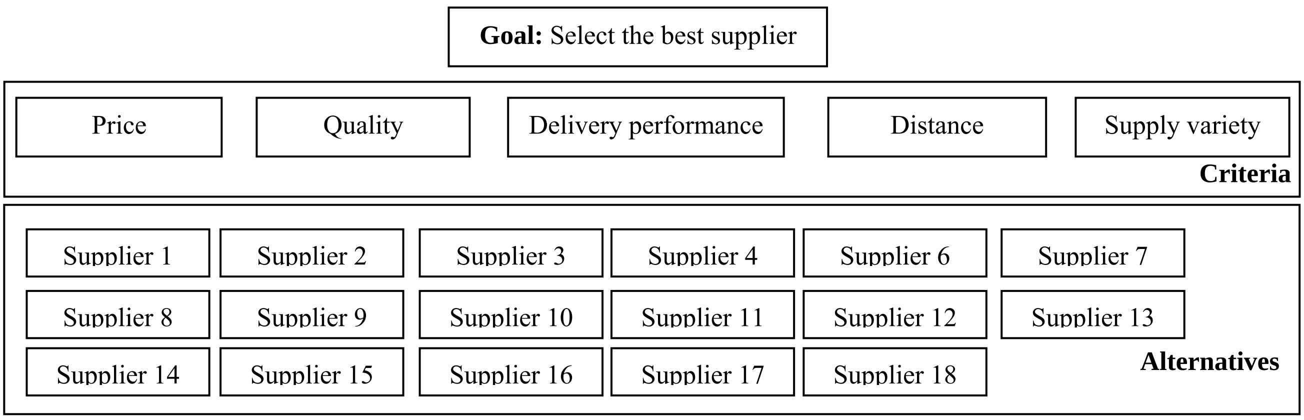

Fig. 1 Structure of MCDM problem for the supplier selection

Table 1. Decision matrix for supplier selection problem

	Price ($)	Quality (%)	Delivery performance (%)	Distance (miles)	Supply variety
Goal	Min	Max	Max	Min	Max
Supplier 1	100	100	90	249	2
Supplier 2	100	99.79	80	643	13
Supplier 3	100	100	90	714	3
Supplier 4	100	100	90	1809	3
Supplier 5	100	99.83	90	238	24
Supplier 6	100	96.59	90	241	28
Supplier 7	100	100	85	1404	1
Supplier 8	100	100	97	984	24
Supplier 9	100	99.91	90	641	11
Supplier 10	100	97.54	100	588	53
Supplier 11	100	99.95	95	241	10
Supplier 12	100	99.85	98	567	7
Supplier 13	100	99.97	90	567	19
Supplier 14	100	91.89	90	967	12
Supplier 15	80	99.99	95	635	33
Supplier 16	100	100	95	795	2
Supplier 17	80	99.99	95	689	34
Supplier 18	100	99.36	85	913	9

Table 2. Normalized decision matrix for supplier selection problem

	Price ($)	Quality (%)	Delivery performance (%)	Distance (miles)	Supply variety
Goal	Min	Max	Max	Min	Max
Supplier 1	0.0568	0.0560	0.0547	0.0193	0.0069
Supplier 2	0.0568	0.0559	0.0486	0.0499	0.0451
Supplier 3	0.0568	0.0560	0.0547	0.0554	0.0104
Supplier 4	0.0568	0.0560	0.0547	0.1404	0.0104
Supplier 5	0.0568	0.0559	0.0547	0.0185	0.0833
Supplier 6	0.0568	0.0541	0.0547	0.0187	0.0972
Supplier 7	0.0568	0.0560	0.0517	0.1090	0.0035
Supplier 8	0.0568	0.0560	0.0590	0.0764	0.0833
Supplier 9	0.0568	0.0560	0.0547	0.0497	0.0382
Supplier 10	0.0568	0.0547	0.0608	0.0456	0.1840
Supplier 11	0.0568	0.0560	0.0578	0.0187	0.0347
Supplier 12	0.0568	0.0559	0.0596	0.0440	0.0243
Supplier 13	0.0568	0.0560	0.0547	0.0440	0.0660
Supplier 14	0.0568	0.0515	0.0547	0.0750	0.0417
Supplier 15	0.0455	0.0560	0.0578	0.0493	0.1146
Supplier 16	0.0568	0.0560	0.0578	0.0617	0.0069
Supplier 17	0.0455	0.0560	0.0578	0.0535	0.1181
Supplier 18	0.0568	0.0557	0.0517	0.0709	0.0313

The decision maker express or define the ranking i.e. significance (relative importance) of criteria by assigning weighting coefficients. It may be added here that relative importance of criteria may be expressed either with ordinal (qualitative) or cardinal (quantitative) level data, or a mix of both. Using the AHP method, Venkata Rao [2] determined the significance of each criterion, i.e. criteria weighting coefficients as: w_{price}=0.1361, $w_{quality}$=0.4829, $w_{delivery\ performance}$ =0.2591, $w_{distance}$=0.0438 and $w_{supply\ variety}$=0.0782. For the comparison purpose the same weighting coefficients are considered.

By using Eq. 3 the weighted normalized decision matrix is obtained (Table 3). As mentioned earlier, the purpose of normalization is to obtain dimensionless values of different supplier selection criteria so that all these criteria can be compared.

By applying Eq. 5 sums of weighted normalized values are calculated for all criteria. Subsequently, relative significance (priority) of each alternative was obtained by using Eq. 6 (Table 4).

Finally, by using Eq. 7, quantitative utility for each alternative was calculated upon which the final ranking was obtained (Table 5).

From Table 5, the ranking of the alternative suppliers is observed as 10-17-15-8-6-5-13-11-12-9-2-18-16-14-3-4-1-7. Hence the best choice is supplier 10. Supplier 17 is the second choice and the third choice is supplier 15 and these results match with those of Liu et al. [1]. The last ranked alternative is supplier 7. Venkata Rao [2] obtained a ranking of the alternative suppliers as 10-17-15-6-5-8-13-11-12-9-2-1-16-14-3-18-4-7 while solving the problem using the TOPSIS method. Figure 2 compares the ranking performance

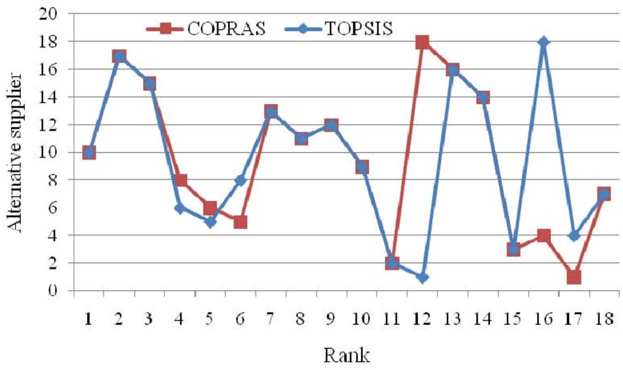

Fig. 2 Comparative rankings of CORPAS and TOPSIS

of COPRAS method with respect to TOPSIS method by Venkata Rao [2]. The results do not show much difference between COPRAS and TOPSIS method except in the rankings of the middle rated alternatives. It can be observed that supplier 10 received the highest attention by all methods, hence may be regarded as the most appropriate.

In some cases it may be advantageous to develop and maintain high quality relationships with several suppliers in order to maximize profitability, minimize risk and achieve competitive advantage. As noted by Liu et al. [1], with a smaller number of suppliers, the company will be able to develop better partnerships with suppliers which in turn can result in reduced order processing costs. Considering present case study it seems that it would beneficial to develop long term relationships with suppliers 10, 17 and 15. Liu et al. [1] had suggested that five vendors, i.e., 1, 10, 12, 15, and 17 were efficient, the remaining vendors were inefficient, and vendors 2 and 14 were most inefficient.

Table 3. Weighted normalized decision matrix for supplier selection problem

	Price ($)	Quality (%)	Delivery performance (%)	Distance (miles)	Supply variety
Goal	Min	Max	Max	Min	Max
Supplier 1	0.0077	0.0271	0.0142	0.0008	0.0005
Supplier 2	0.0077	0.0270	0.0126	0.0022	0.0035
Supplier 3	0.0077	0.0271	0.0142	0.0024	0.0008
Supplier 4	0.0077	0.0271	0.0142	0.0061	0.0008
Supplier 5	0.0077	0.0270	0.0142	0.0008	0.0065
Supplier 6	0.0077	0.0261	0.0142	0.0008	0.0076
Supplier 7	0.0077	0.0271	0.0134	0.0048	0.0003
Supplier 8	0.0077	0.0271	0.0153	0.0033	0.0065
Supplier 9	0.0077	0.0270	0.0142	0.0022	0.0030
Supplier 10	0.0077	0.0264	0.0158	0.0020	0.0144
Supplier 11	0.0077	0.0270	0.0150	0.0008	0.0027
Supplier 12	0.0077	0.0270	0.0154	0.0019	0.0019
Supplier 13	0.0077	0.0271	0.0142	0.0019	0.0052
Supplier 14	0.0077	0.0249	0.0142	0.0033	0.0033
Supplier 15	0.0062	0.0271	0.0150	0.0022	0.0090
Supplier 16	0.0077	0.0271	0.0150	0.0027	0.0005
Supplier 17	0.0062	0.0271	0.0150	0.0023	0.0092
Supplier 18	0.0077	0.0269	0.0134	0.0031	0.0024

Table 4. Relative significance of alternatives

Q_i	0.0423	0.0436	0.0425	0.0424	0.0482	0.0484	0.0411	0.0493	0.0447
Supplier	1	2	3	4	5	6	7	8	9
Q_i	0.0570	0.0453	0.0448	0.0469	0.0427	0.0515	0.0430	0.0518	0.0431
Supplier	10	11	12	13	14	15	16	17	18

Table 5. Utility values and ranking of the candidate alternatives

U_i	74.22	76.47	74.55	74.34	84.62	84.99	72.07	86.42	78.34
Supplier	1	2	3	4	5	6	7	8	9
U_i	100.00	79.39	78.64	82.20	74.93	90.39	75.44	90.85	75.68
Supplier	10	11	12	13	14	15	16	17	18

An analysis and comparision with previous results suggest that COPRAS method can be successfully applied for dealing with complex supplier selection problems.

The COPRAS and TOPSIS methods are mathematically simple to moderately complex to understand. Although both methods can be relatevely easy applied using EXCEL worksheet, the implementation i.e. calculation/computation time of COPRAS method requires less time and effort. The ease of implementation of COPRAS method in EXCEL worksheet, enables efficient use of this method for solving complex supplier selection problems which involve assessment of a number of alternatives over a number of criteria, and also with different types of criteria.

4. CONCLUSION

Evaluation of alternative suppliers, ranking and selection of the most appropriate involves consideration of numeruos and conflicting criteria. Application of different multi-criteria decision making methods to the problem of supplier selection helps to make a more objective and reliable decisions. In the formulation and solving procedure of supplier selection problems multi-criteria decision making methods often involve active participation of decision makers. This is particularly related to formulation of criteria relative importance as well as to analysis, ranking and selection of the final solution, i.e. best alternative. Throught the use of specialized software packages many different multi-criteria decision making methods can be easily applied.

Although different multi-criteria decision making methods have already been proposed by the past researchers to address the problem of supplier evaluation and selection, it is still not clear which method is the best for a given problem. It seems that the ease of understanding an method is a primary concern in the choice of whether (or not) it is used.

This paper explores the applicability and capability of recently developed COPRAS method while solving complex supplier selection decision-making problem, involving cardinal criteria. The decision maker can easily apply COPRAS method for the formulation of a reduced performance criterion which is directly proportional to the relative effect of the compared criteria values.

Regarding the COPRAS methodology and and comparision with previous results, it is clear that this approach has good competitive potential for wider application. Further investigation will include comparisons of COPRAS method with other multi-criteria decision making methods for supplier selection.

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