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A decision support system for selecting best supplier for multiple criteria decision making problems using entropy weight method and COPRAS Method

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Abstract
Supplier selection is one of the significant aspects of any supply chain. The incorrect decision on supplier selection affects not only the specific buyer but also the entire supply chain. The selection of good supplier may lead to reduce purchasing risk, maximize overall value to the purchaser and to establish reliable long-term relationships between buyers and suppliers. In fact, supplier selection is a multi-criteria decision making problem which includes both qualitative and quantitative factors. In this paper a methodology has been proposed by integrating Entropy Weight Method (EWM) and Complex Proportional Assessment of alternatives called COPRAS with a view to resolving the uncertainty while selecting the best one among various alternatives. A case study has been conducted in a manufacturing company to demonstrate the proposed methodology.

Keywords: supplier selection, multiple criteria decision making (MCDM), entropy weight method (EWM), complex proportional assessment of alternatives (COPRAS)

1. Introduction
Supplier selection is one of the major tasks of any purchase department which involves the acquisition of required materials and equipment for an organization. Generally, the decision of supplier selection depends upon a various number of criteria. Mainly, cost is the foremost criteria considered while choosing a supplier, others such as product quality of the material, delivery time, information, 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 can be considered as other criteria that influence the supplier selection of a given product in a supply chain management.

2. Literature Review
Selecting suppliers and service providers through competitive bid ding processes is a vital activity for most operating organizations and manufacturers. In today's competitive markets, companies have understood the importance of selecting proper suppliers who can supply their requirement with their desired quality and in a scheduled time. Therefore, businesses try to measure the performance of their suppliers to select the best supplier to gain supply chain surplus. Consequently, supplier selection is a key factor of the procurement process. Basically, selecting a proper supplier is considered as a non-trivial task. To achieve this goal, the majority of the decision makers empirically evaluate and select suppliers.
The Entropy method can be used not only to quantitatively estimate data quantity, but also to calculate objectively the relative weight of information. Entropy was originally intended to imply a physical phenomenon of numerator turbulence degree or the probability scale under a specified condition. If entropy values are lower, the numerator degrees are more proportional, implying as close to perfect entropy as possible. Conversely, if entropy values are higher, the numerator degrees have a more irregular inflection. Therefore, entropy weight method was introduced to obtain the relative weight of each attribute. Additionally, in information theory, entropy can be used to measure expected information content of a certain message.
In the literature there are many applications of COPRAS method, COPRAS method for assessing building life cycles to select the best alternative [1]. Determined the effective variant of a dwelling maintenance work and performance with this method [2]. Used COPRAS method for developing a housing credit access model, determined the appropriate maintenance contractors for apartment blocks [3]. Proposed COPRAS method for designing and refurbishment of building [4]. Used this method for selecting the best contractor for the construction of a trade and entertainment center [5]. Evaluated contractors for the replacement of windows in Vilnius Gediminas Technical University main building [6]. Selected the best construction alternative with COPRAS method [7]. Determined the market value of real estate with help of COPRAS method [8]. Proposed to use COPRAS method for evaluating road design alternatives, further they used COPRAS method for evaluating the sustainability of residential areas in Vilnius City and determined sustainable city compactness by using COPRAS method [9]. Used COPRAS method to select a building's life cycle [10].

3. COPRAS Method
The COPRAS (COmplex Proportional ASsessment) was firstly introduced by Zavadskas, Kaklauskas and Sarka in 1994. This method compares the alternatives and determines their priorities under the conflicting criteria by taking into account the criteria weights. It assumes direct and proportional dependences of the significance and utility degree (priority) of the alternatives. The preference ranking method of complex proportional assessment (COPRAS) method was developed by Zavadskas [11]. 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 [12].

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

$$X = [x_{ij}]_{m*n} = \begin{bmatrix} x_{12} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

Where *xij* 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:

$$R = [r_{ij}]_{m*n} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}$$

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

$$D = [y_{ij}]_{m*n} = r_{ij} . w_{ij} \text{ , } (i = 1, \ldots, m \text{ and } j = 1, \ldots, n)$$

Where rij is the normalized performance value of i-th alternative on j-th criterion and wj 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:

$$\sum_{i=1}^{m} y_{ij} = w_{ij}$$

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:

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

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, *Qi*, by using the following equation:

$$Q_i = S_{+i} + \frac{min_i \, S_{-i} \sum_{i=1}^{m} S_{-i}}{S_{-i} \sum_{i=1}^{m} min_i \, S_{-i} / S_{-i}}$$

Where S_{-min} is the minimum value of S_{-i}.
Step 6: Calculation of the quantitative utility, *Ui*, for i-th alternative by using the following equation:

$$U_i = \frac{Q_i}{Q_{max}} . 100\%$$

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

As a consequence of equation, utility values of the 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.

4. Illustrative Example

A numerical example is illustrated in this section, a manufacturing company that wants to select a suitable supplier for raw material supply. In the present problem there are five suppliers (S1, S2, S3, S4 & S5) and five criteria (C1, C2, C3, C4 & C5) in which C1 & C3 is cost attribute, the smaller value being consider and remaining is benefit attribute, therefore the greater values being consider. Initial information about the supplier and criteria is given is table 1.

Table 1: Initial Decision Matrix

	C1	C2	C3	C4	C5
A1	90	90	95	70	55
A2	80	85	90	85	90
A3	80	85	85	90	69
A4	60	80	85	85	83
A5	70	80	80	75	75

Table 2: Normalized matrix & weight calculation

	C1	C2	C3	C4	C5
A1	0.2368	0.2143	0.2184	0.1728	0.1478
A2	0.2105	0.2024	0.2069	0.2099	0.2419
A3	0.2105	0.2024	0.1954	0.2222	0.1855
A4	0.1579	0.1905	0.1954	0.2099	0.2231
A5	0.1842	0.1905	0.1839	0.1852	0.2016
$\sum_{i=1}^{n}(p_{ij}.lnp_{ij})$	-0.8366	-0.8573	-0.8587	-0.8338	-0.8329
k	-0.7213	-0.7213	-0.7213	-0.7213	-0.7213
e_j	0.6034	0.6183	0.6194	0.6015	0.6008
$d_j = 1 - e_j$	0.3966	0.3817	0.3806	0.3985	0.3992
$w_j = \frac{1-e_j}{\sum_{j=i}^{n} 1-e_j}$	0.2027	0.1951	0.1945	0.2037	0.2040

Table 3: Weighted normalized decision matrix

	C1	C2	C3	C4	C5
A1	0.048	0.042	0.042	0.035	0.030
A2	0.043	0.039	0.040	0.043	0.049
A3	0.043	0.039	0.038	0.045	0.038
A4	0.032	0.037	0.038	0.043	0.046
A5	0.037	0.037	0.036	0.038	0.041

Table 4: Index value, performance value & ultimate ranking of alternatives

	S+	S-	Qi	Ui	Rank
A1	0.107	0.090	0.1763	82	5
A2	0.132	0.083	0.2071	96	2
A3	0.123	0.081	0.2002	93	4
A4	0.125	0.070	0.2148	100	1
A5	0.116	0.073	0.2016	94	3

5. Conclusions

Evaluation of alternative suppliers, ranking and selection of the most appropriate involves consideration of numerous 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.

A numerical illustration is presented utilizing the COPRAS method for supplier selection problem. Finally, a solution for COPRAS method combined with entropy weight method shown with help of tables of above section. With reference to the table no. 4, we, conclude that Supplier A4 is the most suitable supplier for the manufacturing firm, with the help table no. 4 we can say that the rank order of suppliers is A4>A2>A5>A3>A1.

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