

Supplier Selection Using MCDM Method in TV Manufacturing Organization

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Abstract

The aim of this study was to provide an analytical tool to evaluate and select the best supplier(s)/vendor(s) in fuzzy environment for Television (TV) manufacturing organization. A hierarchy through which decision makers can bring about a comparison among the suppliers was worked out and software for the same was developed. The methodology for selection was based upon multiple criteria decision making/multiple attribute decision making (MCDM/MADM) method using technique for order preference by similarity to ideal solution (TOPSIS). MCDM approach and application of TOPSIS proved to be a powerful technique for rapid, performance evaluation, comparative assessment and selection of supplier(s). Biasness in decision making process was avoided using weights for DM's based on their proficiency in the problem under consideration. The suppliers were evaluated and selected on the basis of criteria/attributes (quality, delivery, price, and suggestion acceptance) and weights were assigned (0.5, 0.3, 0.1, and 0.1) to them. The ranking/selection order of ten suppliers (alternatives) was determined as C4, C5, C10, C7, C2, C6, C1, C8, C9, and C3. Although the study concentrates on TV manufacturing organization, however the methodology can be adopted by any organization if the criteria and alternatives are clearly defined. Results have provided valuable suggestions to suppliers on how to improve each criterion so that they could bridge the gap between actual and aspired performance values in the future. The decision-aiding software was implemented in C language to automate the supplier(s) selection process.

Index terms— supplier(s) selection, decision matrix, MCDM, MADM, TOPSIS, purchasing.

1 I.

INTRODUCTION In today's highly competitive environment, it is impossible for an organization to successfully produce low-cost, high-quality products without help/involvement of suppliers. Supplier selection or its evaluation is a common problem for acquiring the necessary raw materials (semi-finished/finished materials) to support the outputs of organizations. Supplier evaluation and selection involve decisions that are critical to the profitability, growth and survival of manufacturing organizations in the increasingly competitive global scenario. Such decisions are often complex, because they require the identification consideration and analysis of many tangible factors.

The decision problem involves tradeoffs between multiple criteria that are often qualitative. In recent years, many methods have gained considerable acceptance for judging different proposals [1,2,3].

2 II.

3 GENERAL METHODS OF SUPPLIER SELECTION

Most commonly used methodologies for solving the supplier selection problem are as follows:

? Total cost approach: In the total cost approach, the quoted price of each vendor was taken as the starting point and then each constraint being considered as replaced by a cost factor and the business was awarded to the vendor with the lowest unit total cost [12,17,25]. ? Multiple attribute utility theory (MAUT): MAUT is a vendor selection technique most useful in dealing with international vendor selection, as it is capable of handling multiple conflicting attributes inherent in international vendor selection [14,19,21]. ? Multi-objective programming: It is an additional flexibility of multi-objective approach which allows a varying number of vendors into the solution and provides suggested volume allocation by vendor. However, the process of obtaining solution through this method is complex [7,10,20]. ? Total cost of ownership (TCO): TCO is a methodology and philosophy. It looks beyond the price of purchase to include many other purchase-related costs. The TCO models are further classified by usage such as vendor selection and vendor evaluation [6,9,15]. ? Analytic hierarchy process (AHP): It is considered to be a good approach and can be used in a multifactor decision-making environment, especially when subjective and/or qualitative considerations have to be incorporated. It also provides a structured approach or to determines the scores and weights for the different criteria to be used in decision making [5,11,13,16].

Different mathematical, statistical and game theoretical models have been proposed to solve the vendor/supplier selection problem. De Boer et al. (2001), Weber et al. (1991) and many others (see Tahriri, 2008) have reviewed the methodology of supplier/vendor selection. I performance, for example, Tamm & Golhar (1991), and Ellram (1990) had identified, 13 and 18 criteria for supplier selection respectively, however, price, quality, lead-time, technical service and delivery reliability have been considered as the five primary criteria used in the supplier selection problem.

On the other hand Dickson (1966) had identified 23 different criteria in vendor selection process and quality was given an extreme importance.

Present studies, presents a real-life problem from a developing-country. Since MCDM (Hwang & Yoon, 1981) provides an effective framework for supplier comparison based on the evaluation of multiple conflict criteria, therefore, MCDM method in supplier selection has been applied in this paper, which provides decision maker's with a method to systematically analyze the effects of policy decisions on the relevant criteria in supplier selection decisions.

The objective of the study was therefore, (i) to integrate multidimensional issues in an MCDM framework that may help decision makers to develop clear insights and make intelligent decisions, (ii) to assess supplier performance for suitability of approved suppliers.

The procedure covers all the approved suppliers who were supplying raw material and semifinished/finished components to the manufacturing company except for foreign suppliers/contractors.

The responsibility for implementing the supplier selection procedure lied mainly with Head-Product Planning. Suppliers rating system was evolved in such a way that it was a continuous process. A rating was done on six months supplies by the supplier(s) by considering various aspects, such as quality, delivery, price, and suggestion acceptance.

4 III. FORMULATION OF MCDM SUPPLIER SELECTION MODEL

In most large organizations supplier selection process is done empirically. In this paper, we deal with the problem of supplier selection where buyers order quantities from different suppliers in a multiple sourcing network. The supplier selection, which inherently involves conflicting criteria, has not been dealt with as a multi attribute problem frequently.

In the present study, on supplier selection problem, quality, delivery (time), price, and suggestion acceptance as the four attributes/objectives functions were selected.

The MCDM problem was solved using the multiple attribute decision making (MADM)-technique for order preference by similarity to ideal solution (TOPSIS) technique.

MCDM refers to making decisions in the presence of multiple, usually conflicting, criteria. Problems for multiple criteria decision making are common occurrences in everyday life. The problems of MCDM are widely diverse and share the following common characteristics:

? Each problem has multiple objectives/attributes. A decision maker must generate relevant objectives/attributes for each problem setting. ? Multiple criteria usually conflict with each other.

? Each objective/attribute has a different unit of measurement.

Solutions to these problems are either to design the best alternative or to select the best one among the specified finite alternatives. The problems of MCDM can be broadly classified into two categories viz., Multiple attribute decision making (MADM), and Multiple objective decision making (MODM) [27,28]. In actual practice this classification is well fitted in two facets of the problem solving viz., MADM is for selection (evaluation) and MODM for design.

The distinguishing feature of the MADM is that there are usually a limited number of predetermined alternatives. The alternatives have associated with them a level of the achievement of the attributes (which may not necessarily be quantifiable) based on which the final decision is to be made. The final selection of the alternative is made with the help of inter-and intraattribute comparisons. The comparisons may involve explicit or implicit tradeoff.

5 IV. FORMULATION OF MCDM SUPPLIER SELECTION MODEL

Consider a manufacturing organization has suppliers for evaluation and selection. However, owing to operational and resource constraints, it is unable to consider all suppliers simultaneously. Hence, the management is faced with a decision problem. As discussed earlier, MCDM philosophy is broadly classified into two categories: MADM and MODM.

There are three features of MADM method: should have a set of quantifiable objectives; should possess a set of well-defined constraints; and should have a process to obtain some trade off information between the stated and unstated objectives.

The methodology of TOPSIS is a MADM process, which is expressed in matrix form. TOPSIS method evaluates the decision matrix ' D ' of a $m \times n$ matrix which contain ' m ' number of alternatives associated with ' n ' number of criteria (or attributes).

The element ij of the 'D' matrix indicates the Different researchers have employed MCDM methodology and its various techniques for supplier's selection process [1,2,24]. The technique of TOPSIS (of MADM) hitherto, has not been employed for supplier selection as this mainly refers to a selection process where objectives/attributes are conflicts. However, in the present study TOPSIS has been employed for supplier selection process as quality, delivery, price, and suggestion acceptance criteria were also in a sort of conflict in nature. In the present studies suppliers have been ranked/selected according to the weights of the criteria given by the decision maker's of the organization.

a) The TOPSIS model TOPSIS is a method for cardinal preference to attributes. Hwang and Yoon (1981) developed this technique based upon the concept that the chosen alternative should have the shortest Euclidean distance from the ideal solution and farthest from the negativeideal solution.

Assuming that each attribute takes the monotonically increasing (or, decreasing) utility; then it is easy to locate the 'ideal' solution which is composed of all best attribute values attainable, and the 'negativeideal' solution composed of all worst attribute values attainable. One approach is to take an alternative which has the (weighted) minimum Euclidean distance to the ideal solution in a geometrical sense [27]. Dasarathy (1976) used this similarity measure in clustering multidimensional data arrays. This method is simple and yields an indisputable preference order of solution.

6 b) Algorithm for TOPSIS model

The general structure of the MCDM model is that of a heuristically evolved procedure that can provide support to decision makers. The steps are described below.

Step 1: List the set of suppliers to be evaluated and selected by the organization. Identify all the intrinsic and extrinsic factors that may influence the organization while it is evaluating the suppliers. Generate a matrix 'D' having size $m \times n$. This is known as decision matrix.

Step 2: Obtain the information from the decision maker's or users on the relative importance of criteria. Assign weights to each of the criteria given by the decision maker's, is then accommodated to the decision matrix. It is usually given by a set of (preference) weights, which is normalized to sum 1. In case of n criteria, a set of weights is(1) (2)

Step 3: Construct the normalized decision matrix: Normalization may be essential to facilitate the computational problems inherent to the presence of different units in decision matrix. The advantage of normalization is that all the criteria are measured in dimensionless units so that inter-attribute comparison is possible.

The normalization procedure does not lead to equal minimum and maximum values for all attributes, so straightforward comparison is therefore difficult. An element ij r of the normalized decision matrix R can be calculated as follows:

(
So that all criteria's have the same unit length of vector.

(4) Supplier Selection Using MCDM Method in TV Manufacturing Organization Global Journal of Researches in Engineering Volume XII Issue v v v I Version I 3 (G) n j C C C C 2 1 ? = mn mj m m in ij i i n j n ij m i x x x x x x x x x x x x x x A A A DV is equal to RW : ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? ? = mn mj m m in ij i i n ij v v v v v v v v v v V 2 1 2 1 1 12 11

Step 4: Construct the weighted normalized decision matrix: This matrix 'V' can be calculated by multiplying each column of the matrix R with its associated weight j w .

(5)

Negative-ideal solution, (6) where:

The ideal solution is a hypothetical solution for which all attribute values correspond to the maximum attribute values (most preferable alternative). The negative-ideal solution is a hypothetical solution for which all attribute values correspond to the minimum attribute values (least preferable alternative).

Step 6: Calculate the separation measure: Calculate $+iS$ and $-iS$ (where $i=1$ to m) from ideal and negative-ideal solutions (step 5), respectively.

Separation measure is nothing but the n -dimensional Euclidean distance. The separation of each alternative for ideal and negative-ideal solution can be measured by Euclidean distance:(7)(8)

where: $+iS$ and $+iC = 1$ if $+ = A_i$ and $+iC = 0$ if $+ \neq A_i$. An alternative i is closer to $+A$ as $+iC$

approaches to 1.

Step 8: Rank the preference order: Rank the alternatives according to the descending order of $+iC$. c) Criteria employed in evaluation and selection (rating) of suppliers

The suppliers were evaluated based on the following criteria:

(a)Quality: A six monthly statement of rejections was generated by computerized system for the rejections during the supplies of the last six months which gave the percentage of rejections for the received material. Head-Quality Assurance allocated marks in the quality column of suppliers rating format.

Quality rating (Quality verification) was done on the basis of inspection stages: Incoming inspection and Inprocess inspection stages.

? Incoming inspection: It is based on quantity delivered versus quantity accepted for a given consignment, it was calculated as follows:

where: C =Consignment and N =Number of consignments received in a month.

? Inprocess inspection: In this category, quality rating was determined based on the feedback from assembly shop after the materials have been used up. Information on shop rejection on account of manufacturing defects was provided by the shop to electronic data processing (EDP) every month. To calculate the quality rating the same formula as given above (see Incoming inspection) was applied. where: $=q$ Quality rating for a particular month, 1

Q =Quantity used without problems,

7 2

Q =Quantity used under deviation, $3Q$ =Quantity used after rework in shop, Q =Total quantity used in the month, N =Number of the months. Rating for quality was limited to 0.5 weights given by decision maker's.

where: $m_i j j v j j v A_i j i j i$,....., 2, 1) . (min), . (max ' = ? ? = + { } + + + + = n j v v v v

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+ + + =) ... (3 2 1 1 then, $N C \text{ Sum } QR \div =$

) ((b)Delivery: A quarterly statement on receipts was generated for each material supplied by the suppliers during the period and was compared with the where: $=q$ quality rating for a particular month, 1 Q =Quantity accepted,

8 ebruary

9 F

Step 5: Determine ideal and negative-ideal solutions from step 4: Let the two artificial alternatives and be defined as: Ideal solution, the quarter. Based on this statement, Head-Planning and Purchase allocated marks in the delivery column of supplier rating format, which were intimated to EDP. Delivery rating was calculated based on scheduled delivery versus actual delivery. In case, purchase required to be postponed or preponed for delivery of consignment from the date specified in purchase order, a request approved by Head-Planning and Purchase was sent to EDP and the amended delivery schedule was taken into consideration for calculating delivery rating. Weights allocated for delivery rating were 0.3 and calculated as follows:

A=If delivery was on the scheduled date or within a week prior to the schedule-0.3

B=If delivery schedule was not met and supplies were delayed, the ratings were as per Table ??.

Table ?? : Delivery rating points.

(c)Price: Every six months a comparative statement of each supplier price with the rates of other suppliers was prepared or in case of a single source, comparison with organization norms were made by purchase and planning department and given to its Head who inturn allocated marks in price column in the supplier rating format and sent it to EDP.

Price rating (PR) was calculated based on the ratio of the quoted price over standard price. Until a standard price was worked out, the lowest price quoted was used as a substitute. The maximum price rating was 0.1 weights and calculated as follows:

EDP systems worked out the progress to accommodate all these inputs in order to implement the supplier rating system.

(d)Suggestion acceptance: To overcome the rejection and improve the quality, various suggestions were given to suppliers by quality assurance/planning and purchase department and a check was kept on implementation of those suggestions and marks were allocated to a particular supplier in the supplier rating format.

Suggestion acceptance was calculated on the basis of suggestions made during supplier's visits, their implementation in the future supplies or in infrastructure changes suggested were checked during future visits. Weights allocated for suggestion acceptance were 0.1.

were determined in consultation with the purchasing manager. The inclusion of more objectives though would pose no theoretical problems; however, it would increase computational time (i.e., an increased number of non-inferior solutions to be generated) and increased complexity of the output (i.e., more solutions and more tradeoffs to be analyzed) might create implementation problems. The practical implications of these potential problems are another area for future research.

? Organization can provided valuable suggestions to suppliers on how to improve each criterion so that they could bridge the gap between actual and aspired performance values in the future. ? Study carried out in the TV manufacturing organization prove the practical feasibility of the model TOPSIS for the suppliers ranking/selection problem.

? Finally, the model TOPSIS has been used, as a conscious exercise, within the manufacturing organization to make a choice between suppliers on the basis of very relevant criteria, so that capital can be committed to feasible, as well as profitable ventures.

14 (G)

Rank Supplier ^{1 2}



Figure 1: Fig. 1 :

1	11	12	...	...	...
2	21	22	...	2	2
...	...	...	...	...	...
...	... 1	... 2		...	...
	1	2			

$$w = (w_1, w_2, \dots, w_j)$$

Figure 2:

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where:

Attributes, 1 C : Quality,

Suggestion acceptance.

Note that

alternatives we will choose from to make our decision,
 $j, \dots, 1 =$
 to make a good decision, $i ; = 1, ?, n , j w$: the weights
 a decision maker place on each criterion; $ij f$: the
 performance scores of each choice, measured in terms
 of the criteria. Note that the five elements can evolve

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 ers/Alternatives,
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m ; i C : the set of criteria with which we need

Figure 3: Table 2 :

1 S		48	28	7	8
S	2	49	26	7	7
S	3	33	26	7	8
S	4	48	25	7	7
S	5	46	25	7	8
S	6	47	25	8	8
S	7	47	25	7	8
S	8	47	27	8	7
S	9	39	27	7	8
10 S		46	22	6	5

Figure 4:

3

VII.

Figure 5: Table 3 :

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[Bard ()] 'A comparison of AHP process with multi-attribute utility theory: A case study'. J F Bard . *IIIE Transaction* 1992. 24 (5) p. .

[Ghodsypour and O'brien ()] 'A decision support system for supplier selection using an integrated analytical hierarchy process and linear programming'. S H Ghodsypour , C O'brien . *International Journal Production Economics* 1998. p. .

[Weber ()] *A decision support system using multi-criteria techniques for vendor selection*, C A Weber . 1990. Columbus, OH. College of Business, The Ohio State University (Ph.D. Dissertation)

[Sreekumar and Mahapatra (2009)] 'A fuzzy multi-criteria decision making approach for S 0.2098 supplier selection in supply chain management'. S S Sreekumar , S S Mahapatra . *African Journal of Business Management* April 2009. 3 (4) p. .

[Kumar et al. ()] 'A multiobjective interval programming approach for supplier selection problem in a supply chain'. M Kumar , P Vrat , R Shankar . *Proceedings of the International Conference on E-Manufacturing: An Emerging Need for 21st Century World Class Enterprises*, (the International Conference on E-Manufacturing: An Emerging Need for 21st Century World Class Enterprises Bhopal, India) 2002. IEI. p. .

[De Boer et al. ()] 'A review of methods supporting supplier selection'. L De Boer , E Labro , P Morlacchi . *European Journal of Purchasing and Supply Management* 2001. 7 p. .

[Tahriri et al. ()] 'A review of supplier selection methods in manufacturing industries'. F Tahriri , M R Osman , A Ali , R M Yusuff . *Suranaree Journal Science Technology* 2008. 15 (3) p. .

[Dickson ()] 'An analysis of vendor selection systems and decisions'. G W Dickson . *Journal of Purchasing* 1966. 2 p. .

[Karpak and Kasuganti ()] 'An application of visual interactive goal programming: A case in supplier selection decisions'. K Karpak , R R Kasuganti . *Journal of Multi-Criterion Decision Making* 1999. 8 p. .

[Ghodsypour and O'brien ()] 'An integrated method using the analytical hierarchy process with goal programming for multiple sourcing with discounted prices'. S H Ghodsypour , C O'brien . *Proceedings of the 14th International Conference on Production Research*, (the 14th International Conference on Production Research Osaka, Japan) 1997.

[Monckza and Trecha ()] 'Cost-based supplier performance evaluation'. R M Monckza , S J Trecha . *Journal of Purchasing and Materials Management* 1988. 24 (1) p. .

[Degraeve and Roodhooft ()] 'Effectively selecting suppliers using total cost of ownership'. Z Degraeve , F Roodhooft . *Journal of Supply Chain Management* 1999. 35 (1) p. .

[Harding ()] 'How to calculate total purchase cost'. M L Harding . *Hospital Material Management Quarterly* 1998. 19 (4) p. .

[Min ()] 'International supplier selection: A multi-attribute utility approach'. H Min . *International Journal of Physical Distribution and Logistics Management* 1994. 24 (5) p. .

[Stamm and Golhar ()] 'JIT purchasing: Attribute classification and literature review'. C L Stamm , D Y Golhar . *Production Planning and Control* 1993. 4 p. .

[Tsiporkova and Boeva ()] 'Multi-step ranking of alternatives in a multi-criteria and multiexpert decision making environment'. E Tsiporkova , V Boeva . *Information Sciences* 2006. 176 (18) p. .

[Kahraman et al. ()] 'Multicriteria supplier selection using fuzzy AHP'. C Kahraman , U Cebeci , Z Ulukan . *Logistics Information Management* 2003. 16 (6) p. .

[Cohon ()] *Multiobjective programming and planning*, J L Cohon . 1978. New York: Academic Press.

[Hwang et al. ()] 'Multiple attribute decision making, methods and applications, A state-of-the-art survey'. C L Hwang , K ; Yoon , M Kunzi , HP . *Lecture notes in economics and mathematical systems (Managing Editors: Beckmann, (Berlin/Heidelberg/New York) 1981. Springer-Verlag.*

[Hwang and Masud (ed.) ()] *Multiple objective decision making-methods and applications: A state-of-art survey*, C L Hwang , A S M Masud . Collaboration with Paidy, S.R. and Yoon, K. (ed.) 1979. Berlin/Heidelberg/New York: Springer-Verlag.

[Dasarathy ()] 'SMART: Similarity measure anchored ranking technique for the analysis of multidimensional data analysis'. B V Dasarathy . *IEEE Transition on Systems, Man, and Cybernetics* 1976. 6 (10) p. .

[Vahdani et al. ()] 'Supplier selection by balancing and ranking method'. B Vahdani , M Zandieh , A Alem-Tabriz . *Journal of Applied Sciences* 2008. 8 (19) p. .

- [Bhutta and Huq ()] 'Supplier selection: A comparison of the total cost of ownership and analytical hierarchy process approaches'. K S Bhutta , F Huq . *Supply Chain Management-An International Journal* 2002. 7 (3) p. .
- [Von and Webber ()] 'The effects of attribute ranges on weights in multi-attribute utility measurements'. N Von , M Webber . *Management Science* 1993. 39 (8) p. .
- [Ellram ()] 'The supplier selection decision in strategic partnerships'. L M Ellram . *Journal of Purchasing and Materials Management* 1990. 26 p. .
- [Weber and Current ()] 'Theory and methodology: A multi-objective approach to vendor selection'. C A Weber , J R Current . *European Journal Operational Research* 1993. 68 p. .
- [Ellram ()] 'Total cost of ownership: elements and implementation'. L M Ellram . *International Journal of Purchasing and Materials Management* 1993. 29 (2) p. .
- [Porter ()] *Tying down total cost. Purchasing*, A M Porter . 1993. 21 p. .
- [Mohantry and Deshmukh ()] 'Use of analytic hierarchic process for evaluating sources of supply'. R P Mohantry , S G Deshmukh . *International Journal of Physical Distribution and Logistics Management* 1993. 23 (3) p. .
- [Weber et al. ()] 'Vendor selection criteria and methods'. C A Weber , J R Current , W C Benton . *European Journal of Operational Research* 1991. 50 p. .