

Supplier Evaluation and Ranking using Digraph and Matrix Approach

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ABSTRACT

In present globalised competitive environment, supplier selection process becomes vital for the success of any manufacturing organization. In this situation, supplier selection is one of the most important functions to be handled by the purchasing department. Since supplier selection process is a multi-criterion problem, it becomes very complicated and it requires a trade-off between the qualitative and quantitative factors. Many authors have discussed different models and techniques for and evaluating and rating suppliers. In this paper digraph and matrix approach, a multi attributes decision making (MADM) technique is applied to solve the supplier selection problem. A numerical example also demonstrated for better understanding..

Keywords

Supplier selection, digraph and matrix approach.

1.INTRODUCTION In TQM, the supplier contribution and supplier relationship have been studied as key contributing factors to attain the quality. In supply chain management, buyer-supplier relationship is critical one to achieve the strategic goals of a company. In manufacturing industries, the cost raw materials and components constitutes major portion in the total product cost. Thus, to reduce the cost and to improve the quality of the product, quality raw material and quality components are required with low cost. Various surveys say that this can be achieved only by enhancing best supplier rating and supplier selection method. In early days, cost of the product was given the more priority than quality. So the supplier selection was an easy task. Now quality become the most critical factor and is given top most priority for any selection process. Apart from the quality, many other critical factors such as cost, time of delivery, service, reliability, are also play a vital role in supplier selection process. Hence, supplier selection process becomes crucial and a multi attribute decision making problem. Felix T. S. Chan and Hing Kai Chan[1] gave the elaborative list of factors which includes delivery, cost, assurance of supply, flexibility, cost, reliability, perceived risk, technological issues and environmental issues. This list of factors are not exhaustive and also this number of factors being varied according to the specific company strategies. As the number of factors and their influence on the companys' goal vary, a suitable methodology has to be incorporated in order to trade off between the factors and the goal. Presently, many tools and techniques like AHP, ANP, TOPSIS, DEA (Data Envelop Analysis), are being incorporated for the supplier selection process.

Elaborative literature survey is given in the next section

Ali Ekici[2] developed a mixed integer non-linear programming model to find the least-cost cyclic ordering policy for the buyer. They proposed the model to solve the problem by enumerating over all possible supplier combinations. Ghazal Assadipour & Jafar Razmi,[3] have considered the problem of inventory lot-sizing and supplier selection for an assembly system. In their model they assumed the supplier available capacities as ambiguous dynamic parameter. The dynamic parameters such as demand, suppliers' available capacities, prices, and holding and shortage costs are also considered in their model. Mehmet Sekip Altug and Garrettvan Ryzin [4] considered a multi-supplier, single-manufacturer supply chain where each supplier sells a different component at varying quality levels. They also proposed a mechanism, in which the quality, price, schedules and revenue sharing are considered. Wan Lung Ng, [5] proposed a weighted linear program for the multi-criteria supplier selection problem. They also included the advantages of the DEA non-parametric approach and ranking the relativity of importance of criteria. He presents a transformation technique which enables the weighted linear program to be solved without optimization and can be implemented with a spreadsheet package. Hamed Fazlollahtabar et al[6] provided an approach which integrate the supplier selection shipment allocations, including number of tangible and intangible criteria within a time horizon. Mohsen Jafari Songhori et al[7] have provided a comprehensive and systematic approach that embraces both quantitative and qualitative criteria. They also included different transport alternatives and order allocation decisions encompassing multiple discrete time periods. They also demonstrated case study for the proposed framework and exhibited the efficiency of the procedures and algorithms. P.K. Humphreys, et al[8] integrated environmental factors into the supplier selection factors like quality, flexibility for evaluating supplier performance. They also provided a support tool to integrate environmental criteria into their supplier selection process. Nagraj (Raju) et al[9] provided a model specifically to couple the product choice and vendor selection. Further they have analyzed selection of supplier for the specific model and providing offer to the supplier for the supply of versatility components. Alireza Alinezad et al [10] developed an integrated multiple criteria fuzzy decision-making approach to apprise the performance of alternative suppliers. In the approach, QFD (quality function deployment) was used to arrive the customer requirement and Fuzzy AHP was used to determine ratings and weightage of the customer requirements. Reza Farzipoor Saen[11] has developed a new data envelopment analysis methodology for supplier

selection in which he included both undesirable outputs and imprecise data and she has demonstrated a numerical example to illustrate his method. Javad Soroora et al [12] developed a smart module for the selection of best supplier by integrating fuzzy logic, AHP, and QFD. It is a hybrid autonomous model which evaluate the suppliers without direct human intervention. Cevriye Gencer, Didem Gu'rpınar [13], and Jafar Razmi & Hamed Rafiei [14] were applied ANP model for the supplier selection problem for the different environmental conditions. Felix T. S. Chan & Hing Kai Chan [15] developed an AHP model for selection of suppliers in the fast changing fashion market in the apparel industry.

2. Digraph And Matrix Approach

Digraph and matrix approach is widely used in various fields of science and Technology.

Rao and Gandhi [16] applied digraph and matrix methods for failure causes of a machine tool. Grover et al. [17] used the same approach to evaluate the total quality management environment of an industry. Paramasivam V. et al [18] applied digraph and matrix approach for equipment selection problem. Venkatasamy and Agrawal [19] applied this to evaluate the automotive vehicle by considering the characteristics of the vehicle. The detailed survey on the application of digraph and matrix approach reveals that this approach is a universal one which can be suited to any manufacturing process or system problems involving attributes of qualitative as well as quantitative nature.

Methodology

The step by step procedure of the digraph and matrix methodology is as follows.

2.1 Identify the supplier selection attributes for the given manufacturing organization. The number of attributes depends on the real situation of the organization. Number of attributes may be identified based on the number of alternative suppliers and goal of the organization. Adnan Aktepe and Suleyman ERSOZ [19], have tabulated the large number of supplier selection attributes which are considered for various circumstances by various authors. For the illustration purpose four important attributes Quality, On time delivery, Price and Service are considered in the numerical example.

2.2 Develop the digraph considering all supplier selection attributes. The digraph contains the number of nodes equal to the number of selection attributes decided in the step 1 and edges showing the relative importance between the attributes. The fig 1. shows a supplier selection attributes digraph in which A1, A2, A3, A4 are the supplier selection attributes and edges e12, e21, e13, e31, etc are the relative importance between attributes with respect to the selected problem objective. Magnitude of the attributes value and relative importance between the attributes are also decided in this step. The values of the relative importance are assigned by referring the table 1. The attributes values must be quantitative values. If there is any qualitative value, they must be converted into quantitative values by fuzzy theory. Digraph is constructed in order to know the problem complexity at a glance. If the problem attributes are large in number, the digraph looks complex.

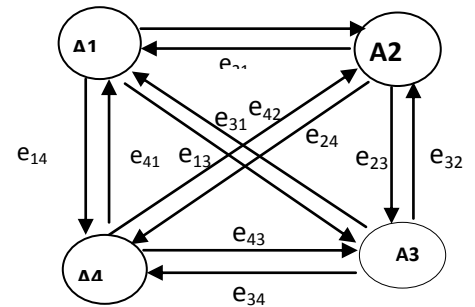


Fig.1 supplier selection attributes digraph.

Table 1. Relative importance between attributes

Class description	Relative importance of attributes	
	r _{ij}	r _{ji} = 10 - r _{ij}
Two attributes are of equal importance	5	5
One attributes is slightly more important than the other	6	4
One attributes is more important than the other	7	3
One attributes is much more important than the other	8	2
One attributes is extremely more important than the other	9	1
One attributes is exceptionally more important than the other	10	0

2.3 After the construction of the digraph, a supplier selection matrix is arrived (Fig.2). This matrix is nothing but the one to one representation of the digraph. In the matrix all the attributes values are represented (A1, A2, A3, A4) by the diagonal elements and the relative importance values are represented by the off diagonal elements (e12, e21, e13, e31, ...). Matrix with any dimension can be solved easily by using the soft tools.

$$Per(s) = \begin{bmatrix} A_1 & e_{12} & e_{13} & e_{14} \\ e_{21} & A_2 & e_{23} & e_{24} \\ e_{31} & e_{32} & A_3 & e_{34} \\ e_{41} & e_{42} & e_{43} & A_4 \end{bmatrix}$$

Fig.2 supplier selection attributes matrix.

2.4 Followed by the matrix representation, a permanent function is derived (Eqn.1). This permanent function is a standard function used in combinatorial mathematics. This permanent function is differing from the determinant by having all positive terms unlike determinant having alternatively positive and negative terms. The permanent for matrix is represented as below. Interpretation to the permanent function is clearly given by R.VenkataRao and

O.P. Gandhi [16], Grover et al [17]. V. Paramasivam et al[18], The permanent function is interpreted as follows:- The supplier selection attributes function contains terms arranged in (M+1).i.e 4+1=5 groupings and these groupings represent the measures of 4 attributes and the relative importance loops. The first grouping represents the measures of M(5) attributes. As there is no selfloop in the digraph, second grouping is absent. The third grouping contains 2-attribute relative importance loops and measures of (M-2) attributes. Each term of the fourth grouping represents a set of 3-attribute relative importance loop or its pair and measures of (M-3) attributes. The fifth grouping contains two subgroupings. The terms of the first subgrouping are a set of two 2-attribute relative importance loops and the measures of (M-4) attributes. Each term of the second subgrouping is a set of 4-attribute relative importance loop or its pair and the measures of (M-4) attributes.

delivery and service as attributes and is given in fig.3.

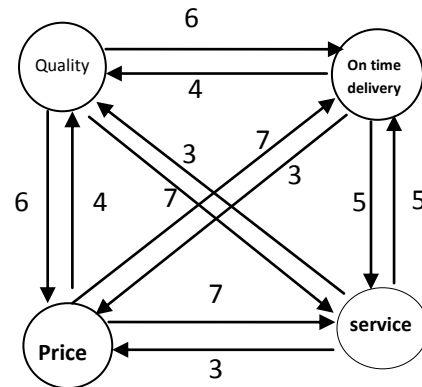


Fig.3supplier selection digraph for the given example

$$Per(V) = \prod_{i=1}^m A_i + \sum_{j=1}^m \sum_{k=1}^m \sum_{l=1}^m (e_{ij}e_{jk}e_{li}) A_i A_j A_k + \sum_{j=1}^m \sum_{k=1}^m \sum_{l=1}^m (e_{ij}e_{jk}e_{li} + e_{ik}e_{jl}e_{li}) A_i A_j A_k + ((\sum_{j=1}^m \sum_{k=1}^m \sum_{l=1}^m (e_{ij}e_{jk}) + e_{li}e_{li}) A_m) + \sum_{j=1}^m \sum_{k=1}^m \sum_{l=1}^m (e_{ij}e_{jk}e_{li}e_{li} + e_{ik}e_{jl}e_{li}e_{li}) A_m + \sum_{j=1}^m \sum_{k=1}^m \sum_{l=1}^m (e_{ij}e_{jk}) (e_{ik}e_{li}e_{li} + e_{li}e_{li}e_{li}) + \sum_{j=1}^m \sum_{k=1}^m \sum_{l=1}^m (e_{ij}e_{jk}e_{li}e_{li}e_{li} + e_{li}e_{li}e_{li}e_{li}e_{li})$$

2.5 Assign the values for attributes and the values for the relative importance of the selected alternative suppliers in the permanent function. Assigning these values for all alternative suppliers provides a numerical value for each alternative. These values are supplier selection indices which are arranged in descending order. The supplier who has the higher index value is the best among the alternatives.

3. NUMERICAL EXAMPLE

3.1 Selection of supplier selection attributes

In order to illustrate the methodology, a numerical example given in this section. For this example attributes and its values are taken from the article of Wei-Ning Pi and Chinyao Low[21] which is reproduced in the table2.

Table2:-Normalized values of attributes- source article Wei-Ning Pi and Chinyao Low[21]

Supplier	Quality	On-time delivery	Price	Service
A	1.80	1.00	100	90
B	1.50	6.00	110	72
C	1.00	2.00	118	65
D	1.40	6.00	108	95

3.2 Supplier selection digraph

As per the methodology described above a supplier selection digraph is constructed by considering quality, price, on time

3.3 Supplier selection matrix.

Supplier selection matrix can be obtained for each alternative suppliers by substituting the values of attributes from the table. 2 and values of relative importance from table 3. For the illustration purpose an example matrix is given in fig.4

$$Per(s) = \begin{bmatrix} 1.8 & 7 & 6 & 7 \\ 3 & 1 & 3 & 4 \\ 4 & 7 & 100 & 7 \\ 3 & 6 & 3 & 90 \end{bmatrix}$$

Fig.4.Supplier selection matrix for the given example

Table 3. Relative importance between the supplier selections attributes

	Quality	On-time delivery	Price	Service
Quality	1	7	6	7
On-time delivery	3	1	3	4
Price	4	7	1	7
Service	3	6	3	1

3.4 Supplier selection index.

Supplier selection index can be calculated manually by substituting the values of attributes and relative importance between the attributes. If the matrix is a large one, manual calculation is difficult and the error may occurs. So software tool is developed in MATLAB which reduces the calculation time drastically and also nullify the error. In this case study soft tool is employed for calculating the indices and the same is tabulated and the alternative suppliers are also be ranked based on their index value (Table 4).

Table4.Supplier selection indices and ranking.

Supplier	Index value	Supplier ranking

A	262150	III
B	312480	II
C	232225	IV
D	384150	I

5. CONCLUSION

The digraph matrix approach is suggested for supplier selection from a large number of alternative suppliers can be applied to any multi attribute decision making problems. The proposed approach considers the influence of attributes and the influence of relation between the attributes for the selection problem. It is a general approach which can be considered to any supplier selection problem involving any number of qualitative and quantitative attributes. As the problem can be represented in matrix form, computation becomes much easier and the size of matrix i.e the number of attributes will not give any error in calculation.

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