VENDOR SELECTION IN SUPPLY CHAIN USING RELATIVE RELIABILITY RISK EVALUATION

[1]RUPA SUNIL BINDU, [2] B. B. AHUJA

[1] Assoc. Prof., Department of Mechanical Engineering, DYPCOE, Akurdi, Pune, India-411044

[2] Prof.and Head, Department of Production Engineering, Govt. College of Engg., Pune, India-411005

ABSTRACT

Vendor is an important constituent in the supply chain and supply chain management is truly vendor management. Performance evaluation based vendor selection is a decision of strategic importance to an industry. This paper introduces the concept of relative reliability risk assessment especially for new vendors, where information availability is inadequate to calculate reliability. The paper deals with multiple attributes of vendor to which Analytical Hierarchy Process is applied using verbal assessments for relative measurements. The technique used for assigning weights is the entropy method. Final value of Relative Reliability Risk Index (R^3I) is calculated. The concept of Alternatives Functionality Graph is introduced. A real life case study considering Multiple Attribute Decision Making (MADM) with proposed method is illustrated.

Keywords: Reliability, Analytical Hierarchial Process (AHP), Relative Reliability Risk Index (R^3 I), Alternative Functionality Graphs (AFGs), Multiple Attribute Decision Making (MADM), Win-Win type of relationship.

1. INTRODUCTION

The selection of right vendor for an organization should not only meet customer requirements, bring profit to the firm, but also help in fulfilling various criteria such as cost, delivery, quality objectives and technical specifications. It is needed to develop a systematic vendor selection process for identifying and prioritizing relevant criteria and to evaluate the trade offs between technical, economic and performance criteria, as brought out by Lamberson et al. [01].

The method used should also reduce time in vendor selection and develop consensus decision making. Computer assisted decision making methods have been evolved, by Moore and Fearon [02]. Measuring the performance of vendors and the analysis of criteria for selection has been the focus of various researchers since 1960, Dickson [03], Weber et al. [04]. In Vendor selection problem, various decision-making situations involve high degree of fuzziness and uncertainties. Fuzzy set theory for problem modeling and solution was proposed by Zadeh [05]. Bellman and Zadeh [05], introduced fuzzy set theory in Multiattribute Decision Making as an approach to effectively deal with the inherent impression, vagueness and subjectiveness of the human decision making process. AHP based strategic sourcing model is developed for effective vendor selection by Bindu et al. [06].

Vendor selection as mentioned in the perspective by Bindu et al. [07] is having a direct impact on the efficiency and responsiveness of the entire supply chain. Although many multi-criteria decision making methods, are available to select the final vendor from the set of available vendors, the data to calculate reliability of vendors may not be available, in case of new vendors. Therefore it is proposed to relatively assess the reliability of new alternative vendors and then screen out those that seem to have unacceptable level of rank. Performance is a measure of reliability and the functionality indication, as concluded by Weber et al. [04] refers to the performance of the vendor. Therefore a relative approach is followed in calculating R^3I using the Analytical Hierarchy Process.

Vol. 16 No.2 June , 2010 pp [145 – 152]

ISSN: 1817-3195 / E-ISSN: 1992-8615

2. PROPOSED METHOD

A four tier method is proposed to calculate Relative Reliability Risk Index (R^3I). In step 1, the function structure i.e. Vendor Evaluation attributes is established. After establishment of the function structure, the Analytical Hierarchy Process by Saaty et al. [08], is applied so as to relatively rate the main functions of the function structure as shown in step 2 of the Figure 1. After the comparisons have been made, we obtain the priorities. Application of AHP is done using a C-Language programme by Bindu et al. [06] to calculate consistency ratio. Any number of main functions can be compared and a measure of inconsistencies during the comparisons is provided which gives a good measure of the relative ratings and provides a check whether the comparison should be performed again. In step 3, using these priorities, the Alternatives Functionality Graphs (AFGs) are drawn. AFG indicates the relative measure of functionality fulfillment with respect to each of the available alternatives. In step 4, weights are assigned to the functions, using entropy method. This method is preferred because it does not require the decision maker to affix the weight; instead weights are calculated using the information obtained from the decision matrix obtained after applying AHP. It rules out any chance of prejudice or manipulation to assign weights by the decision maker. Even if the weights have already been assigned by the decision maker, they can be combined with the weights obtained using this method. The application of AHP leads to normalized priorities in the decision matrix, which are then used to extract information for input to the entropy method in step 4. The schematic representation of the different steps used in the four tier method, is shown in Figure1.

The main function or goal is to select a vendor. Keeping in view, attributes of vendor performance are Costs (C), Reliability of Quality and Service (R), Buyer-Supplier–Relationship (B-S-R) and Factors for Foreign Vendors (FFD). Each of these four main functions can have a number of auxiliary functions.

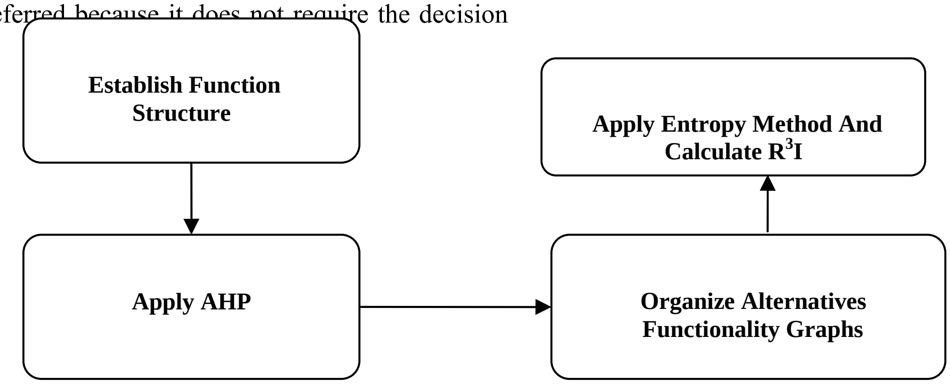


Figure 1 : Four Distinct Steps in the Methodology

3. ANALYTICAL HIERARCHY PROCESS

The Analytical Hierarchy Process by Saaty [09], is a powerful multiattribute decision making tool. This tool effectively uses insight based soft information from the decision makers in the form of relative values. Main objective forms the highest level of the hierarchy. The lower level is represented by the criteria and so on. The bottommost hierarchy is occupied by the alternatives available. Refer Figure 2. After establishing the level structure, comparison matrices are formed and comparisons of lower level criteria are made with respect to the property at the upper level.

In the illustrative real life case study here, AHP method is used for selecting a vendor. XYZ industry wants to award purchase contract to a most appropriate vendor from a list of alternative vendors. There are six alternative vendors. The criteria on which the selection depends are four i.e. Cost (C), Reliability of service and quality (R), Buyer-Supplier Relationship (B-S-R) and Factors for Foreign vendors (FFD).

We compare all the six alternative vendors' w.r.t. each criterion, at the level above it. There would be four comparison matrices for these comparisons as shown in the Tables 1, 2, 3 and 4 respectively.

Vol. 16 No.2 June , 2010 pp [145 – 152]

ISSN: 1817-3195 / E-ISSN: 1992-8615

Table 1: Inconsistency = 0.06

Cost	A	B	C	D	E	F	Priorities
A	1	5	3	3	2	1/3	0.233
B	1/5	1	1/3	2	1/3	1/4	0.061
C	1/3	3	1	3	1/3	1/4	0.103
D	1/3	1/2	1/3	1	1/5	1/5	0.047
E	1/2	3	3	5	1	1/2	0.190
F	3	4	4	5	2	1	0.365

Table 2: Inconsistency = 0.03

Reliability	A	B	C	D	E	F	Priorities
A	1	5	3	5	½	3	0.0271
B	1/5	1	1/3	1	1/5	1/2	0.053
C	1/3	3	1	3	1/4	3	0.145
D	1/5	1	1/3	1	1/5	1/2	0.053
E	2	5	4	5	1	5	0.396
F	1/3	2	1/3	2	1/5	1	0.082

Table 3: Inconsistency = 0.04

Buyer-Supplier - relations hip	A	B	C	D	E	F	Priorities
A	1	1/3	1/2	1	1/2	1/2	0.082
B	3	1	3	5	2	3	0.352
C	2	1/3	1	3	1/2	2	0.157
D	1	1/5	1/3	1	1/3	1/3	0.061
E	2	1/2	2	3	1	3	0.229
F	2	1/3	1/2	3	1/3	1	0.119

Table 4: Inconsistency = 0.02

Factors for foreign vendors	A	B	C	D	E	F	Priorities
A	1	1	2	2	2	1	0.219
B	1	1	2	1/2	1/5	1/2	0.115
C	1/2	1/2	1	1/2	1/2	1/5	0.072
D	1/2	2	2	1	2	1	0.185
E	1/2	5	2	1/2	1	1/2	0.171
F	1	2	5	1	2	1	0.239

The priorities are calculated and shown in the comparison matrices. These matrices are used to calculate the final priorities for the available alternatives. With each matrix, there is associated a consistency ratio (CR), which gives the measure of consistency in the comparisons made. CR should be less than or equal to 0.1 for the results to be acceptable, else the comparison should be undertaken again.

In the method it is proposed to calculate R^3 I to calculate the priorities of the alternatives w.r.t. criteria, but we do not compare the criteria w.r.t. the objective. This is because the criteria those are available with us are the main functions from the function structure. It would be inadvisable to compare the functions that are basic or fundamental to the system, using the pair wise comparison matrix, because all the main functions may seem to be equally important. Instead, we use entropy method to calculate the weights of the functions with us.

Vol. 16 No.2 June , 2010 pp [145 – 152]

ISSN: 1817-3195 / E-ISSN: 1992-8615

4. ENTROPY METHOD

After application of AHP, using tables 1 to 4, the priority matrix obtained is shown in Table 5 below. This will be treated as our decision matrix.

Table 5: Decision Matrix

Main Functions j = 1 to k ↓	Vendor i = 1 to n →					
	A	B	C	D	E	F
Cost	0.233	0.061	0.103	0.047	0.190	0.365
Reliability	0.027	0.053	0.145	0.053	0.396	0.082
B-S-R	0.082	0.352	0.157	0.061	0.229	0.119
F F D	0.218	0.114	.072	0.184	0.171	0.239

The weights for the four functions considered have been calculated using the information from the decision matrix and the entropy method. The entropy method is Multi Attribute Decision Making method, as stated by Hwang [10]. This method has been adopted as a part of calculating R^3 I, because it may be inappropriate for a decision maker to compare functions relatively from the function structure.The information contents of the normalized values of the attributes can be measured using entropy values. The entropy V_j of the set of normalized outcomes of attribute j is given by

$$V_j = -\beta \sum_{i=1}^{n} (l_{ij} * \ln (l_{ij})) \quad \text{for all } j \text{ (} j=1 \text{ to } k \text{ represents attributes) \& (} i=1 \text{ to } n \text{ represents alternatives)} \qquad (1)$$

$$\beta = \text{constant} = 1 / \ln (n) \; ; \; l_{ij} = \text{Normalized element of the decision matrix} \qquad (2)$$

If there are no preferences available, the weights are calculated using the equation,

$$W_j = E_j / (\sum_{j=1}^{k} E_j) \quad \text{and} \quad E_j = (1 - V_j) \qquad (3)$$

If the decision maker has the weights available before hand i.e. W_e, then it can be combined with the weights calculated above, resulting in new weights that are W_{new}

$$W_{new} = (W_e * W_j) / (\sum_{j=1}^{k} W_e * W_j) \qquad (4)$$

The weights for the four functions considered have been calculated using the information from the matrix and the entropy method is utilized to calculate the same. The weights obtained after the application of the method are shown in Table 6. Normalization of decision matrix is not required since the sum of the priorities for any attribute j is 1 (Table 5). Having calculated the weights and priorities, we obtain R^3 I, (Table 7) using the following equation.

$$R^3 I_i = \sum_{j=1}^{k} (l_{ij} * W_j) \quad \text{for all } i \qquad (5)$$

Vol. 16 No.2 June , 2010 pp [145 – 152]

ISSN: 1817-3195 / E-ISSN: 1992-8615

5. SAMPLE CALCULATIONS

1) β = constant = 1 / ln (n) ; n = No. of the alternatives

β = constant = 1 / ln (6)

β = 1/ (1.79)

β = 0.55811

2) $V_j = -\beta \sum_{i=1}^{n} (l_{ij} * \ln (l_{ij}))$ for all j (j =1 to k represents attributes) & (i=1 to n represents alternatives)

$V_1 = -\beta * [l_{11}*\ln(l_{11}) + l_{21}*\ln(l_{21}) + l_{31}*\ln(l_{31}) + l_{41}*\ln(l_{41}) + l_{51}*\ln(l_{51}) + l_{61}*\ln(l_{61})]$

$V_1 = -0.55811* [0.233*\ln (0.233) + 0.061*\ln (0.061) + 0.103*\ln (0.103) + 0.047*\ln(0.047) + 0.190*\ln (0.190) + 0.365*\ln (0.365)]$

$V_1 = 0.87688$

3) $E_1 = (1 - V_1)$

$E_1 = (1 - 0.87688)$

$E_1 = 0.12314$

4) $W_j = E_j / (\sum_{j=1}^{k} E_j)$

$W_1 = (E_1 / (E_1+E_2+E_3+E_4)$

$W_1 = (0.12314 / (0.1231+0.1533+0.0932+0.03767)$

$W_1 = 0.30225$

5) $\sum_{j=1}^{k} W_j = (W1+W_2+W_3+W_4)$

$\sum W_j = (0.30225+0.3764+0.2288+0.09249)$

$\sum W_j = 0.99999$

6) $R^3 I_i = \sum_{j=1}^{k} (l_{ij} * W_{j})$ for all i

$R^3 I_1 = [(l_{11}*W_1) + (l_{12}*W_2) + (l_{13}*W_3) + (l_{14}*W_4)]$

$R^3 I_1 = [(0.233*0.3023) + (0.027*0.3764)+(0.082*0.2288)+(0.218*0.09249)]$

$R^3 I_1 = 0.21091$

6. RESULTS

We can see from Table 7, that vendor E has the best R^3 I among all the available vendors. Also the vendors which may be screened out are those that have low R^3 I value, which are B & D.The ordinal ranks are also shown in Table 7.

Vol. 16 No.2 June , 2010 pp [145 – 152]

ISSN: 1817-3195 / E-ISSN: 1992-8615

Table 6: Weights for the Attributes

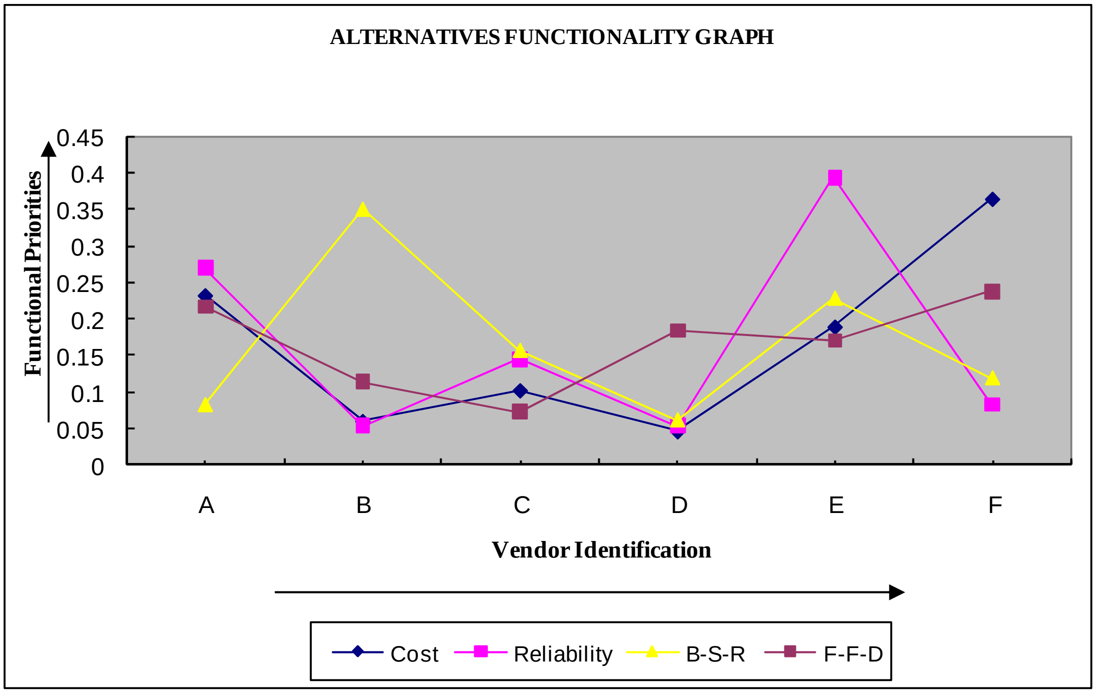
1	Cost	0.3023
2	Reliability	0.3764
3	Buyer-Supplier Relationship	0.2288
4	Factors For Foreign Vendors	0.09249

Table 7: R^3 I and Ranks for Vendors – Vendor Selection

	A	B	C	D	E	F
R^3 I	0.211	0.129	0.188	0.065	0.274	0.190
Rank	2	5	4	6	1	3

7. ALTERNATIVE FUNCTIONALITY GRAPHS

AFGS are graphs between the functional priorities calculated by AHP and the alternatives. This approach towards evaluating alternatives helps identify the strengths and weaknesses of all the alternatives, function wise. Unfortunately systematic methods are not always used in industries as stated by Chakraborty et al. [11] and Garg et al.[12]. Also a huge vendor data base comprising of a large number of alternatives may produce a complex situation to recognize the strengths and weaknesses as regards each function in the function structure as illustrated by Bindu et al.[13]. AFGs are means to represent the strengths and weaknesses of alternatives after the comparison using AHP has been performed. The AFG for the above case study is shown below. X axis represents vendors A to F respectively. This figure is meant to depict a clear picture of the strengths and weaknesses of different vendor alternatives with respect to the functions.



Vol. 16 No.2 June , 2010 pp [145 – 152]

ISSN: 1817-3195 / E-ISSN: 1992-8615

8. CONCLUSION

This paper reviewed reliability and proposed a method for calculating relative index to compare vendor alternatives with a view to enter in a most favorable purchase relationship with appropriate supplier leading to an effective and responsive supply chain. The method helps to obtain ordinal rankings of the available choices and is illustrated with the help of case study of a real industrial problem. The methodology involves application of the analytic hierarchy process to relatively compare the choices and the entropy method for obtaining the weights of the functions considered. The idea of alternatives functionality graphs is introduced and the results of application on the example are discussed.

9. SCOPE FOR FUTURE WORK

Presently industries are using ERP softwares like SAP for vendor performance rating which serves as basis for outsourcing decisions. SAP incorporates performance rating scales. The feedback from Quality Audit system is used as an input to SAP. However Quality Audit can be carried out only of the existing vendors of an industry. When new vendors approach the industry for business , no performance data of these new vendors is available . Only some subjective data can be available , based on which one can not take correct decisions. The method discussed provides an appropriate tool for ranking new vendor alternatives for outsourcing. Existing methods do not consider all important vendor attributes like Buyer-Supplier Relationship and attributes for foreign vendors . The model discussed can include maximum no. of vendor performance attributes and can be customized for particular industry. Future work can also include validation of this methodology using other examples from industry.

10. ACKNOWLEDGEMENT

The authors would like to thank anonymous referees for their valuable and constructive comments and suggestions that have led to a significant improvement on an earlier version of this note.

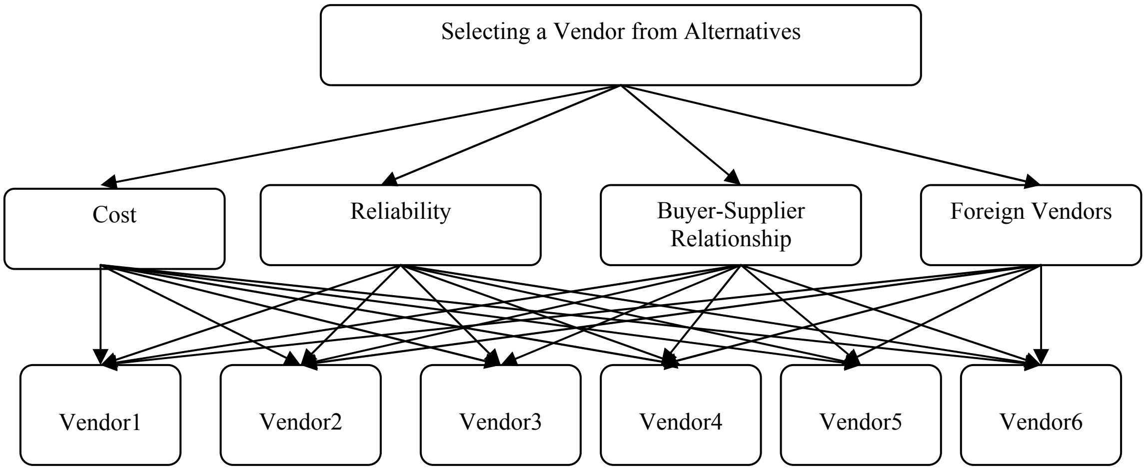


Figure 2: Hierarchy Structure showing different Levels of Hierarchy

Vol. 16 No.2 June , 2010 pp [145 – 152]

ISSN: 1817-3195 / **E-ISSN**: 1992-8615

REFERENCES

[1]. Lamberson, L.R., Diederivh, D., Wuoriu, J., "Quantitative vendor evaluation", Journal of purchasing and Materials Management, 1976, pp.19-28.
[2]. Moore, D. L., Fearon, H.E., "Computer Assisted Decision making in Purchasing", Journal of Purchasing, Vol. 9/4, 1972, pp.5-25.
[3]. Dickson, W., "An analysis of vendor selection systems and decisions", Journal of Purchasing, Vol. 2, 1966, pp. 5-17.
[4]. Weber, C.A., Current, J.R., Benton, R, "Vendor Selection Criteria and Methods", European Journal of Operational Research, Vol.50 (2), 1991,pp.2-18.
[5]. Zadeh, L.A., "Fuzzy sets, Information and Control", 1965, pp.338-353.
[6]. Rupa Bindu,.B.B.Ahuja., "AHP Based Strategic Sourcing – A Novel Integration for Vendor Selection", Proc. of the International conference on Issues and Challenges in Supply Chain Management, B.H.U., Varanasi, U.P. 2008.
[7]. Rupa Bindu, Prashant More., "SCM in India- A Perspective", Proc. of the International Conference on Manufacturing and Management, Vellore, India, 2004.
[8]. Yoram Wind, Thomas L.Saaty., "Marketing Applications of the Analytical Hierarchy Process", JSTOR (Journal of scientific tools in operation research), Management Science, Vol.26, No.7, July 1980, pp. 641-658.
[9]. Saaty, Thomas L.," Decision making for Leaders", 2001, Pittsburgh,.
[10]. Hwang, C.L., Yoon, K., "Multiple Attributes Decision Making Methods and Applications", 1981, Springer Berlin, Heidelberg,.
[11]. Dr.Shankar Chakraborty and Dr.Diganta Taha., "A Supply Chain Management Module for Integrated functioning of a Manufacturing Organization", Manufacturing Technology Today, 2005, pp. 15-18.
[12]. Dixit, Garg, S.G., Deshmukh.,"Vendor Relations in Managing faster Supply Chain", Proc. of World Conference on SCM, Delhi, India 1999.
[13]. Rupa S. Bindu. "Analysis of Supply Chain Performance through Scor Model", Proc.of the International Conference on Dynamic Role of Management in Global Economy, Ludhiana, Punjab, 2005.

Vol. 16 No.2 June , 2010 pp [145 – 152]

ISSN: 1817-3195 / **E-ISSN**: 1992-8615