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AHP And QFD Methodology For Supplier Selection

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Abstract. Supplier selection is a multi-criteria decision-making problem and vital issue in supply chain management (SCM). Supplier selection highly depends on experts' assessments. To increase the quality, flexibility and reduce the lead time, total cost is the strategic objectives of the industries. To fulfil these objectives there is a need to capture the 'voice' of the customer. As the company acts as customer in supplier selection process so it's 'voice' of the customer should be captured. In this paper, quality function deployment (QFD) and Analytic Hierarchy Process (AHP) multi-criteria group decision making approach have been used to evaluate the supplier. Further HOQ (House of Quality) is used to determine the need of the industries from the suppliers and AHP method is used to evaluate and compare the suppliers with each other and to make the final selection of supplier to achieve goal.

Keywords: Supply chain management, Supplier selection, Decision-making techniques, Quality Function Deployment

1. Introduction

In increasingly competitive and globalised world markets, industries are constantly under pressure to find ways to cut material and production costs. As a qualified and reliable supplier is a key element and a vital source in reducing production and material costs, evaluation and selection of the suppliers is an important component of supply chain. Supplier selection becomes a strategic decision when the purchasing organizations attempt to establish a long-term and win-win business relationship with its suppliers. Companies Dependence on the suppliers to provide goods and services, which were formerly managed in-house, has increased gradually in order to specialize and improve. Within the logistic chain, waste of material can be reduced by developing a long term relationship with the suppliers. For long term buyer-supplier relation, industry should have a small number of suppliers. A firm's growth and competiveness depends on the decision making criteria along with choice of right supplier. As the suppliers are very important for SCM(Supply Chain Management) there selection is also important responsibility of the purchasing manager and purchasing department. As purchasing function is gaining more and more importance in SCM the purchasing decisions are becoming vital as these decisions if go wrong can impact severely. Due to globalization, vast usage of internet, changing customer taste and trends, the decision making phase should be as short as possible and more importantly it should be correct. Operations research techniques like problem structuring approaches, mathematical programming and data mining technique s are few methods that may help in supplier selection decisions.

This paper attempts to bring out a relationship between criteria for supplier selection and the final decision of supplier selection. Here the customer is the companies or industries procuring the raw material or services for routine operation. Thus the company and supplier relation can be encapsulated in' house of quality' model. The combined outcome of both the methodologies is presented in the paper. Both the methodologies are explained in brief and subsequently AHP QFD methodology is explained.

2. Literature Review

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Dickson et. al. (1966) [1] validated 23 criteria for assessing supplier's performance. He observed that price was not the most important factor. He found that the ability of each supplier to meet required quality was the most important criterion. Weber e al.(1991) [2] referred examined Dickson's work by reviewing published articles between 1966 1nd 1990 and found that 47 out of 74 articles used multiple criteria for selection process. He stressed that Just-in-time(JIT) components such as quality, delivery, net price, geographical location and production facilities and capacity have the utmost priority for the companies. Lee et al.(2001) [3] proposed supplier selection and management system(SSMS) including purchasing strategy system, supplier selection system and supplier management system and showed its application in a real supply chain. Gholamian and Ghomi et al.(2006) [4] found that the recent methods used is swarm intelligence methods namely ant colony and particle optimization method to cater multi-objective problems. William ho et al.(2010) [5] reviewed 78 journal articles and found that DEA approach is most widely used and AHP-GP integrated approach is most popular. Chakraborty et al.(2011) [6] used particle swarm optimization based fuzzy neural network for qualitative data in achieving more precise supplier selection. Singh.A.R et al.(2013) [7] employed a Fuzzy-AHP method to determine the relative importance of the criteria and to assign the weight to the criteria. These in turn helped to indentify the preferences of purchasers in selecting t suppliers in the context of Indian manufacturing industry.

3. Proposed Method

3.1 QFD (Quality Function Deployment): QFD was developed in Japan in the late 1960s by Professors Shigeru Mizuno and Yoji Akao.Iit is derived from six Chinese/ Japanese characters:

(a) Hin shitsu: Qualities, features or attributes, (b) Ki no: function, (c) Ten kai: deployment.

It translates customer requirements, based on marketing research and benchmarking data, into an appropriate number of engineering targets to be met by a new product design. It is used also for determining the priority of the tasks. Results of QFD are merely a guideline of determining the priorities hence its association with AHP is must to reach a decision. Steps involved in building house of quality are,

Step 1. Identification of the customer needs. The voice of customer remains at the base of the QFD process.

Step 2 . Identification of technical needs. Technical needs are characteristics that describe the customer needs in the designer language. These must be measurable because the result is controlled (checked) and compared with the target objectives.

Step 3. The link between the customer needs and the technical needs. The customer needs must be written in the left column and the technical ones on the top. The purpose of this matrix is to show if the final technical needs cover the customer needs.

Step 4. Addition of the competitive evaluation and of the sale key points. In this stage the importance of every customer need is evaluated and the competitor's products and services are the ones which cover these needs and are also researched.

Step 5. Evaluation of technical needs of the competitive products and services and establishment of targets. This stage happens usually on the base of information added or products tested. These evaluations are compared with the competitive evaluation of the customer's needs in order to determine the disparities between the customer's needs and the technical ones.

Step 6. Selection of the technical needs to be modified in the process In this stage there are identified the technical requirements which have a strong link with the customer needs, that are considered sale key points. In the rest of the process, the customer voice will be taken into account.

3.2 Analytic Hierarchy Process (AHP): AHP was introduced by Thomas Saaty (1980) it is an effective tool for dealing with complex decision making, and may aid the decision maker to set priorities and make the best decision. By reducing complex decisions to a series of pair wise comparisons, and then synthesizing the results, the AHP helps to capture both subjective and objective aspects of a decision.

In addition, the AHP incorporates a useful technique for checking the consistency of the decision maker's evaluations, thus reducing the bias in the decision making process. Steps involved in AHP are,

Step 1 The complex problem is decomposed into smaller sub problems with goal hierarchy at top, followed by criteria sub criteria at lower levels and at the bottom decision variables.

Step 2 Saaty gave a nine point scale (table 1). Decision matrix is constructed and the priority score is determined. For an equal assessment numerical value 1is assigned and for moderately more important 3 is assigned, for strongly more 5 is assigned and 7 for very strongly, for extremely more important 9 is assigned. 2,4,6,8 are assigned for intermediate values of importance.

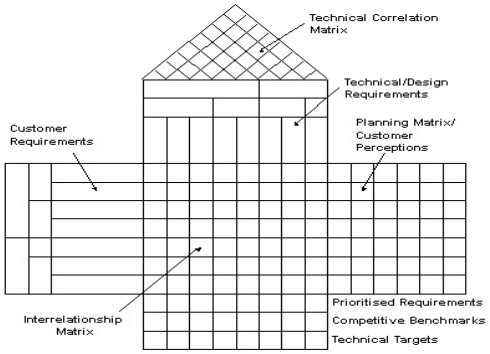

Fig 1 House of Quality

Table 1. Table of relative scores.

Value of ajk	Interpretation
1	j and k are equally important
3	j is slightly more important than k
5	j is more important than k
7	j is strongly more important than k
9	j is absolutely more important than k
2,4,6,8	Intermediate values of importance

If a decision matrix is made for n criteria and m alternatives then,

$$D = \begin{pmatrix} d_{11}\ d_{12} \ldots d_{1n} \\ d_{21}\ d_{22} \ldots d_{2n} \\ \cdot \quad \cdot \quad \cdot \quad \cdot \\ \cdot \quad \cdot \quad \cdot \\ \cdot \quad \cdot \quad \cdot \quad \cdot \\ dm1\ dm2 \ldots dmn \end{pmatrix}$$

The ith alternative in respect to the jth criteria is given by{dij},

Step3 To set the relative priorities with respect to next higher level, pair wise comparison is done. The comparison matrix so formed takes the form There are n criteria then n(n-1)/2 comparisons are to be done and the condition aij=wi/wj =1/aij and a11=1 with k=1,2,….,n is satisfied. aij in the comparison matrix shows the degree of preference of ith criteria over jth criteria. As the comparison between two criteria is easy in comparison at an overall weight assignment here weight determination of criteria is more reliable.

$$\begin{pmatrix} a_{11}\ a_{12} \ldots a_{1n} \\ a_{11}\ a_{12} \ldots a_{1n} \\ \cdot \ \cdot \qquad \cdot \\ a_{11}\ a_{12} \ldots a_{1n} \end{pmatrix} \qquad \begin{pmatrix} w_1/w_1 & w_1/w_2 \ldots & w_1/w_n \\ w_2/w_1 & w_2/w_2 \ldots & w_2/w_n \\ \cdot & \cdot & \cdot \\ w_n/w_1 & w_n/w_2 \ldots & w_n/w_n \end{pmatrix}$$

Step4 for checking the consistency of decision maker's judgment in consistency index or consistency ration is calculated using the equation CI=(λmax-n)/(n-1). As the CI nears zero, the consistency increases. The relevant index should be lower then.0.1otherwise steps and 3 should be repeated.

Step 5 the comparison matrix is to be normalized by dividing each column by the sum of the entries of that column. The matrix so obtained will have sum of the entire elements in that column as 1.

Step 6 to obtain the relative weight of the criteria Eigen value of the n normalized matrix should be calculated. The equation A.W= λmax. W should be verified, Where, A is pair wise comparison matrix, W

is Eigen vector, λmax max is highest Eigen value. The alternative with the highest coefficient value is chosen as the best alternative

3.3 AHP QFD Methodology Steps are:

Step 1 Identify the WHATs

Step 2 Determining the HOWs

Step 3 Determine the Weights of WAHTs using AHP

Step 4 Prepare the relationship Matrix

Step5 Calculate the Weights of HOWs

Step6 Compute the individual scores for each supplier using AHP

Step 7 finally ranking the suppliers

This paper proposes combined AHP and QFD methodology for supplier selection decision. In the conventional HOQ process the company hears the 'voice' of the customer i.e. identify the need of customer. The need of customer is external variables and to meet these requirements of customer when design parameters or specifications are changed, it forms the internal variables. In supplier selection the company takes the place of customer. The company establishes the features required by it thus deciding the internal variables. The company then finds the supplier attributes which are considered as external variables, impacting most on the desired features by the company. Now just review a case regarding research paper:

4. Case Study:

A medium scale industry producing TMT bars is selected. AHP –QFD method is applied for the supplier selection:

Steps 1 Identify the WHATS, Quality, delivery cost and performance history is the characteristics finalized by the company for the suppliers.

Step 2 From the review of the literature on Supply Chain Management the various criteria were chosen out of which the finalized five criteria's are (1) Experience, (2) Technical Capability, (3) Quality system certification, (4) Geographical position, (5) Raw material procurement.

Step 3 Determine the Weights of WHATs using AHP

As per the scale of table 1 the team compared the criteria and matrix show below is prepared

Table 2 Comparison Matrix

	Quality	Delivery	Performance history	Cost
Quality	1	3	5	7
Delivery	0.33	1	2	3
Performance history	0.2	0.5	1	3
cost	0.14	0.33	0.33	1

Table 3. Normalized Matrix

Criteria	Quality	Delivery	Performance history	Cost	Sum	Priority Vector
Quality	0.6	0.63	0.6	0.5	2.33	0.58
Delivery	0.2	0.20	0.24	0.21	0.85	0.21
Performance history	0.12	0.10	0.12	0.21	0.55	0.14
cost	0.08	0.07	0.04	0.08	0.27	0.07
Sum	1.00	1.00	1.00	1.00	4.00	1.00

λmax= 4.08,Consistency index (CI) =2.92%, Consistency Ratio (CR) =3.25%. The consistency ratio is less than 10% so within limits.

Step 4 Using the linguistic variable High, Medium and low the impact of each HOW on each WHAT is recorded and marking them as 9, 3, and 1 respectively.

Step 5 The relative weights of the HOWs are calculated from the House of Quality. From the scores it is revealed that technical capability and quality system certification are the major criteria followed by experience.

Step 6 the four suppliers are compared on every criteria using AHP and individual scores are computed. Individual scores are shown in table below:

Table 4. Relationship matrix

	HOWS					
WHATS	**Importance**	**Experience**	**Technical Capability**	**Quality system certification**	**Geographical Position**	**Raw material procurement**
Quality	**0.58**	**M**	**H**	**H**		
Delivery	**0.21**	**L**	**M**		**M**	**L**
Performance history	**0.14**	**H**		**M**		
cost	**0.07**	**L**			**L**	**H**

Table 5. House of Quality (Weights of HOWs)

		HOWS					
WHATS	**Importance**	**Experience**	**Technical Capability**	**Quality system certification**	**Geographical Position**	**Raw material procurement**	**Total**
Quality	**0.58**	**1.74**	**5.22**	**5.22**			**12.18**
Delivery	**0.21**	**0.21**	**0.63**		**0.63**	**0.21**	**1.68**
Performance history	**0.14**	**1.26**		**0.42**			**1.68**
cost	**0.07**	**0.07**			**0.07**	**0.63**	**0.77**
Total		**3.28**	**5.85**	**5.64**	**0.7**	**0.84**	**16.31**
Relative weight		**20.11%**	**35.86%**	**34.58%**	**4.29%**	**5.15%**	

Table 6. Supplier's scores for each Criteria

	Supplier1	**Supplier 2**	**Supplier 3**	**Supplier 4**
Experience	**0.43**	**0.23**	**0.17**	**0.16**
Technical Capability	**0.47**	**0.15**	**0.3**	**0.08**
Quality system certification	**0.38**	**0.24**	**0.24**	**0.14**
Geographical position	**0.18**	**0.22**	**0.38**	**0.22**
Raw material procurement	**0.45**	**0.2**	**0.21**	**0.14**

Step 7 Multiply the individual scores of the suppliers with relative weights of criteria to obtain the ranks of the suppliers. The ranking of the suppliers in the order are S1, S3, S2, and S4.

5. Conclusion

In this paper, supplier selection is based on experience, technical capacities, quality system and raw material procurement. Strategic supplier selection is based on integrated approach of AHP and QFD. 'Voice' of the company is captured through QFD and AHP method is used to rank the suppliers on the basis of criteria and how far they are impacted by each alternative. This paper gives some review portion in AHP & QFD.

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