International Conference on Mechanical, Industrial and Materials Engineering 2015 (ICMIME2015)
11-13 December, 2015, RUET, Rajshahi, Bangladesh.

Paper ID: IE-23

Best Supplier Selection Using Analytical Hierarchy Process (AHP) of a Furniture Industry in Bangladesh

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Abstract

Supplier selection is one of the most important functions of Supply Chain Management. In this competitive global world markets, companies are under pressure to find ways to minimize production and material costs in order to survive and sustain their competitive position in their respective markets. Since a qualified supplier is a main element and a good resource for a buyer in reducing such costs, evaluation and selection of the potential suppliers has become an important function of supply chain management. Supplier should be compared based on their impact on the supply chain surplus and total cost. Supplier selection decision should not be driven based solely on the price. Many other characteristics such as lead time, reliability, quality also affect the total cost of doing business with a supplier. In such a case, multi criteria decision making tool may be used. In this study, a multi criteria decision making tool known as Analytical Hierarchy Process (AHP) has been used for solving such a multi criteria supplier selection problem. In this paper we apply Analytical Hierarchy Process (AHP) to select the best supplier of a furniture industry in Bangladesh.

Keywords: Supply chain management, Analytical Hierarchy Process (AHP), Multi criteria decision.

1. Introduction

In modern supply chain management suppliers are considered not only a supplier of raw materials rather they are considered as a part of that organization. The supplier evaluation process not only helps defending the shortage of materials for production but also helps in maintaining the buyer-seller relationship and many other business aspects. In early times cost was the prime priority. Minimizing cost and maximizing revenue through value addition of suppliers and other management aspects such as, quality management, distributions, competitive pricing etc. are to be incorporated as the criteria of supplier selection [1] But now a days supply quality, supply lead time, supplier reliability, supplier flexibility etc. are considered as important along with cost. Selecting the right supplier significantly reduces purchasing costs, improves competitiveness in the market and enhances end user satisfaction [2]. Thus supplier selection is the evaluation of different criteria and various supplier attributes, it can be considered as a multiple criteria decision making (MCDM) problem. Since these are qualitative terms a quantitative conversion is needed for comparison among alternatives. Different approaches are available for these purposes. Analytical Hierarchy Process (AHP) is a multi-criteria decision-making tool that has been used in almost all the applications related with decision-making [3]. AHP, developed by Saaty, addresses how to determine the relative importance of a set of activities in a multi-criteria decision problem. It uses a multi-level hierarchical structure of objectives, criteria, sub-criteria, and alternatives. The relevant data are derived by using a set of pairwise comparisons. These comparisons are used to obtain the weights of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion [4]. In our study we incorporate eight criteria-Quality, Pricing, Lead Time, Supply Capability, Payment Term, Country of Origin, Uncertain Demand Capability and Conduct Media. We compare among four alternative suppliers with respect to these eight criteria.

2. Literature review

Analytical hierarchy process (AHP) is a mathematical tool for taking decisions in case of multiple constraint function. It is a mathematical approach for converting qualitative terms into quantitative measure. This tool is used by business organizations and researchers for such type of decisions. This tool is also extensively used for supplier selection in business organizations. Özkan et al. [5] used the AHP to choose the best supplier for computer and printer purchasing for General Directorate of Land Registry with respect to 4 main criteria and 16 sub criteria. They compare between the alternatives and the criteria and select best supplier by rating them. Dain et al. [6] proposed a five step AHP model to the supplier selection decision for strategic development of lean suppliers at a large German industrial company. They established a pre-filter based on Spekman (1989) in order to reduce the number of detailed supplier evaluations if suppliers meet the minimum requirements for supplier development. Tanmoy et al. [7] proposed a novel heuristic approach as an optimization technique to solve the multi criteria decision making problem for supplier selection. The initial solution of the problem had been achieved using AHP and thereafter the quality of the solution is improved using the proposed heuristic technique. Damle et al. [8] used a pair wise comparison among three alternative suppliers based on three criteria. They used four pair of quality for their comparison. Mustafa [9] used fuzzy AHP for supplier selection problem. The Fuzzy AHP model had been utilized to solve the supplier selection problem of a manufacturing company, to determine the best supplier among 3 alternatives. These alternative suppliers had been inspected with respect to 5 criteria namely; quality, origin of the raw material, cost, delivery time, and after sales services. In Fuzzy AHP model, the pair wise comparisons of both criteria and the alternatives were performed through the linguistic variables, which were represented by triangular numbers. Shahroodi et al. [10] used six criteria for supplier selection for a manufacturing firm. Narendra et al. [11] had used Analytical Hierarchy Process (AHP) and Weighted Sum Model (WSM) for supplier selection of Coke Energy Ltd. India. Firstly, the weights of criteria had been calculated by using AHP, and then by implementing Weighted Sum Model (WSM), assessment of suppliers had been done. In our model we use eight criteria as mentioned above for selection of supplier for a furniture company-Hatil Complex Ltd. of Bangladesh. These criteria's are very important for a firm. We then compare among the alternative suppliers with respect to these criteria.

3. Methodology

Analytic Hierarchy Process (AHP), since its invention, has been a tool at the hands of decision makers and researchers; and it is one of the most widely used multiple criteria decision-making tools. This is an Eigen value approach to the pair-wise comparisons. It provides a means of measure the quantitative as well as qualitative performances. The AHP method is based on three principles:

a) Identifying problem and structure of the model
b) Comparative judgment of the alternatives and the criteria
c) Relative weight evaluation

In the first step, a complex decision problem is structured as a hierarchy. AHP initially breaks down a complex multi-criteria decision-making problem into a hierarchy of interrelated decision criteria, decision alternatives. The second step is the comparison of the alternatives and the criteria. The pairwise judgment starts from the second level and finishes in the lowest level, alternatives. In each level, the criteria are compared pairwise according to their levels of influence and based on the specified criteria in the higher level. In AHP, multiple pairwise comparisons are based on a standardized comparison scale of nine levels.

It should be noted that the quality of the output of the AHP is strictly related to the consistency of the pairwise comparison judgments. First the consistency index (CI) needs to be estimated. This is done by adding the columns in the judgment matrix and multiply the resulting vector by the vector of priorities (i.e., the approximated eigenvector) obtained earlier. This yields an approximation of the maximum eigenvalue, denoted by $\lambda_{\max}$. The consistency ratio CR is obtained as the ratio of the CI and the random index (RI) [12].

$$CR = CI / RI \tag{1}$$

Table 1. Random index (RI) for the factors used in the decision making process

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

If C.R. ≤ 0.10, the calculation of relative criteria importance (alternative priority) is considered acceptable. In the opposite case, the decision maker has to analyze the reasons for unacceptably high evaluation inconsistency. (Saaty, 1980).

4. Supplier Selection with AHP

In this study, we consider eight criteria for four suppliers. The eight criteria are marked in the following way:

C_1 - Quality
C_2 - Pricing
C_3 - Lead Time
C_4 - Supply Capability
C_5 - Payment Term

C_6 - Country of Origin
C_7 - Uncertain Demand Capability
C_8 - Conduct Media
Now, the importance of attributes could be assigned as presented in the table 2.

Table 2. The criteria attribute comparison

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	weight
C_1	1	2	3	4	4	5	5	7	0.3384
C_2	0.5	1	2	2	2	3	3	4	0.1910
C_3	0.33	0.5	1	1	1	2	2	3	0.1182
C_4	0.25	0.5	1	1	1	1	1	2	0.0846
C_5	0.25	0.5	1	1	1	1	1	2	0.0846
C_6	0.20	0.33	0.5	1	1	1	1	1	0.0658
C_7	0.20	0.33	0.5	1	1	1	1	1	0.0658
C_8	0.14	0.25	0.33	0.5	0.5	1	1	1	0.0515

$$\lambda_{max} = 8.108 \qquad CI = \frac{\lambda_{max} - n}{n-1} = 0.0154 \qquad CR = \frac{CI}{RI} = 0.011 < 0.10 (acceptable)$$

The alternative suppliers could be marked in the following way:
A_1 - Supplier no. 1
A_2 - Supplier no. 2
A_3 - Supplier no. 3
A_4 - Supplier no. 4
The corresponding alternatives comparison matrices for each attribute and their respective priorities are presented in tables 3-10.

Table 3. Matrix of alternative relative importance compared to C_1 (Quality) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	2	3	0.5	0.2575
A_2	0.5	1	2	0.25	0.1486
A_3	0.33	0.5	1	0.16	0.0788
A_4	2	4	6	1	0.5151

$$\lambda_{max} = 4.0301 \qquad CI = \frac{\lambda_{max} - n}{n-1} = 0.01 \qquad CR = \frac{CI}{RI} = 0.01 < 0.10 (acceptable)$$

Table 4. Matrix of alternative relative importance compared to C_2 (Pricing) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	0.5	2	0.33	0.1517
A_2	2	1	4	0.5	0.2971
A_3	0.5	0.25	1	0.16	0.0757
A_4	3	2	6	1	0.4754

$$\lambda_{max} = 4.0303 \qquad CI = \frac{\lambda_{max} - n}{n-1} = 0.0101 \qquad CR = \frac{CI}{RI} = 0.01 < 0.10 (acceptable)$$

Table 5. Matrix of alternative relative importance compared to C_3 (Lead Time) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	0.33	2	0.5	0.1517
A_2	3	1	6	2	0.4754
A_3	0.5	0.16	1	0.25	0.0757
A_4	2	0.5	4	1	0.2971

$$\lambda_{max} = 4.0303 \qquad CI = \frac{\lambda_{max} - n}{n-1} = 0.0101 \qquad CR = \frac{CI}{RI} = 0.01 < 0.10 (acceptable)$$

Table 6. Matrix of alternative relative importance compared to C_4 (Supply Capability) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	2	0.33	1	0.1818
A_2	0.5	1	0.16	0.5	0.0906
A_3	3	6	1	3	0.5458
A_4	1	2	0.33	1	0.1818

$$\lambda_{\max} = 4 \qquad CI = \frac{\lambda_{\max} - n}{n-1} = 0 \qquad CR = \frac{CI}{RI} = 0 < 0.10(\textit{acceptable})$$

Table 7. Matrix of alternative relative importance compared to C_5 (Payment Term) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	3	2	1	0.3472
A_2	0.33	1	0.5	0.33	0.1071
A_3	0.5	2	1	0.5	0.1984
A_4	1	3	2	1	0.3472

$$\lambda_{\max} = 4.0203 \qquad CI = \frac{\lambda_{\max} - n}{n-1} = 0.0068 \qquad CR = \frac{CI}{RI} = 0.0076 < 0.10(\textit{acceptable})$$

Table 8. Matrix of alternative relative importance compared to C_6 (Country of Origin) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	0.5	0.33	2	0.1517
A_2	2	1	0.5	4	0.2971
A_3	3	2	1	6	0.4754
A_4	0.5	0.25	0.16	1	0.0757

$$\lambda_{\max} = 4.0303 \qquad CI = \frac{\lambda_{\max} - n}{n-1} = 0.0101 \qquad CR = \frac{CI}{RI} = 0.0113 < 0.10(\textit{acceptable})$$

Table 9. Matrix of alternative relative importance compared to C_7 (Uncertain Demand Capability) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	0.5	0.5	0.33	0.1205
A_2	2	1	1	0.5	0.2328
A_3	2	1	1	0.5	0.2328
A_4	3	2	2	1	0.4139

$$\lambda_{\max} = 4.0236 \qquad CI = \frac{\lambda_{\max} - n}{n-1} = 0.0079 \qquad CR = \frac{CI}{RI} = 0.0089 < 0.10(\textit{acceptable})$$

Table 10. Matrix of alternative relative importance compared to C_8 (Conduct Media) attribute

	A_1	A_2	A_3	A_4	Weight
A_1	1	2	3	3	0.4464
A_2	0.5	1	2	2	0.2728
A_3	0.33	0.5	1	1	0.1404
A_4	0.33	0.5	1	1	0.1404

$$\lambda_{\max} = 4.021 \qquad CI = \frac{\lambda_{\max} - n}{n-1} = 0.007 \qquad CR = \frac{CI}{RI} = 0.0079 < 0.10(\textit{acceptable})$$

Now, all alternatives are multiplied by the weight of the single decision criteria and then the obtained results are summarized in the following table. The alternative with the highest value obtained is A_4 (Supplier no. 4) that is the optimal alternative.

Table 11. Synthesized data of supplier selection

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	Total
Weight	0.3384	0.1910	0.1182	0.0846	0.0846	0.0658	0.0658	0.0515	
A_1	0.2575	0.1517	0.1517	0.1818	0.3472	0.1517	0.1205	0.4464	
Weight * A_1	0.0871	0.0290	0.0179	0.0154	0.0294	0.0100	0.0079	0.0230	0.2197
A_2	0.1486	0.2971	0.4754	0.0906	0.1071	0.2971	0.2328	0.2728	
Weight *A_2	0.0503	0.0567	0.0562	0.0077	0.0091	0.0195	0.0153	0.0140	0.2288
A_3	0.0788	0.0757	0.0757	0.5458	0.1984	0.4754	0.2328	0.1404	
Weight *A_3	0.0267	0.0145	0.0089	0.0462	0.0168	0.0313	0.0153	0.0072	0.1669
A_4	0.5151	0.4754	0.2971	0.1818	0.3472	0.0757	0.4139	0.1404	
Weight *A_4	0.1743	0.091	0.0351	0.0154	0.0294	0.0050	0.0272	0.0072	**0.3846**

From the above table it can be concluded that supplier no. 4(A_4) gives a fair result than the other 3 suppliers. So supplier no. 4 (A_4) is the best supplier. Comparatively supplier no. 3(A_3) gives the worst result. So the worst supplier is supplier no. 3 (A_3).

9. Conclusion

The AHP process incorporates both intangible qualitative criteria along with tangible quantitative criteria. In this paper, AHP process is used to determine the best supplier for purchasing raw materials in a Furniture Industry. Using AHP technique, we find that the alternative A_4 is determined as the best supplier alternative, while A_2 is determined as second best alternative and A_3 is the worst alternative. The AHP technique can further be applied in more critical vendor selection problem by involving more conflicting criteria and sub-criteria such as risk management, supplier profile, supplier reputation etc. However, in this paper, AHP technique is used for supplier selection problems, other multi criteria decision making techniques such as fuzzy AHP, Technique for Order Preference by Similarly to Ideal Solution (TOPSIS), Fuzzy Analytic Network Process (ANP) etc. can also be used and compared with the obtained results.

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