

Supplier Selection in Construction Industry using AHP Integrated with TOPSIS Method: A Case study

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ABSTRACT: In construction industry, various parties constituting the supply chain come together for the completion of a single project. The companies which can manage their supply chain efficiently will outperform in the global market. Supplier is a key component of supply chain since construction materials constitute over 50% of the total cost of a project. So selecting the right supplier is an important strategic decision which should be well defined. Also various criterias which affect the supply chain management were studied and their importance in supplier selection were studied through Questionnaire survey. On the basis of the RRI values, the various factors which play an important role in supplier selection in construction industry were also studied. The effect of supplier selection using the Multi Criteria Decision Making technique, AHP integrated with TOPSIS method is studied by implementing it in a real working environment. The study results showed that AHP integrated with TOPSIS method is an efficient technique for choosing the best supplier of raw materials which is most suitable for a particular construction project depending on the priority of criterias or demands of the organization.

KEYWORDS: Construction industry, MCDM, AHP, TOPSIS, supplier selection, criterias

I. INTRODUCTION

The term “Supply Chain Management” implies the integration of activities to procure raw materials, transform them into intermediate goods and final products, and delivers to the customer. In today’s highly competitive environment, an effective supplier selection process is very important to the success of any construction organization. The cost of raw materials and component parts constitutes the main cost of a product, such that in some cases it can account for over 50% of the total project cost. In such circumstances decision making of purchasing management can play a key role in cost reduction. In supply chain the coordination between manufacturers and suppliers is the most important and critical link in the channel of distribution. Once a supplier becomes part of a well-managed and established supply chain, this relationship will have a lasting effect on the competitiveness of the entire supply chain. Because of this, supplier selection problem has become one of the most important issues for establishing an effective supply chain system. Selection of the right supplier is a complicated process by the fact that numerous criteria must be considered in the decision making process. Researches also indicates that supplier selection process has direct impact on performance of an organization. As the organization becomes more and more dependent on their suppliers, the direct and indirect consequences of poor decision making becomes more critical. The nature of their demand may be complex and unstructured.

So supplier selection can be considered as a Multi Criteria Decision Making problem. Multi Criteria Decision Making (MCDM) or Multi Attribute Decision Making (MADM) is a branch of decision making which deals with problems under the effect of number of decision criteria. There are many MADM methods available. Each method has its own characteristics. These techniques may be used to find out the best alternative or may be also used to find out the relative importance of various alternatives under consideration.

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II. RELATED WORK

MCDM techniques when applied helps the selection of optimum supplier in relatively short time on the basis of the required criteria desired by the purchaser. Traditionally, selection of suppliers was often based on the criterion of price. The cheapest supplier is usually selected without taking into consideration the additional costs or other criterias this supplier may introduce in the chain of the purchasing organization. Various authors have clearly defined the need of considering more than one criteria to select the optimum supplier. Also many authors have studied and described number of criterias which affect supplychain management in construction industry. They also have cited the importance of using MCDM techniques in reduction of cost and increase in the sales. Optimum suppliers are chosen on basis of final rank obtained after applying MCDM techniques.

III. METHODOLOGY

In the first phase the problem of supplier selection was defined and on the basis of the literature review done, various criteria related to the supplier selection problems are identified and listed. The next phase was data collection. In this study, the data collection methods adopted are by using questionnaire survey and personal interview. In the phase of questionnaire survey, questionnaires will be distributed among the purchase managers of different construction firms and the respondents are asked to rank the criteria's in the questionnaire according to their priority using Likert scale. Key Criteria's were then chosen for the study. The suppliers were then evaluated on the basis of these key criteria's chosen using AHP integrated with TOPSIS method using the data obtained from the proposed case study. The important steps involved in AHP integrated with TOPSIS method are:

- 1: Define criteria and sub-criteria that are most affecting in supplier selection problem.
- 2: Construct pairwise comparison matrix of criteria (Using AHP).
- 3: Determination of criteria weights (Using AHP).
- 4: Evaluation of alternatives (normalized decision matrix) using TOPSIS method.
- 5: Determine positive and negative ideal solution using TOPSIS.
- 6: Determination of best alternative. (Using TOPSIS method).
- 7: Select the best alternative.

IV. CRITERIAS USED FOR THE STUDY

Traditionally cost and quality were only criterias considered for the selection of right supplier. But now, few more interactive and interdependent selection criterias have been increasingly used by the manufacturers. Thirty nine criterias which affect the supplier selection were considered for the study on the basis of the literatures reviewed were:

- Price
- Quality
- Delivery time
- Repair service
- Warranties
- Safety
- History
- Reliability
- Environment degradation
- Position
- Management
- Technical knowledge
- Payment terms

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- Commitment
- Attitude
- Long term relation
- Experience
- Testing certificate
- Financial position
- Geographic location
- Innovation
- Customer satisfaction
- Proper communication
- Urgent delivery
- Service time
- Discount
- After sales service
- Mode of delivery
- Product durability
- Hazard
- Billing accuracy
- Product development
- Process improvement
- Desire
- Honesty
- Inventory
- Flexibility
- Culture
- Quality standards

V. DATA COLLECTION

Questionnaire has been used as the main method of data collection for this study to allow for feedback from a large number of respondents, where it is impractical to collect feedback using other more resource intensive methods. The scale used for the measurement is Likert scale.

Likert value	Indication
1	Not at all important
2	Slightly important
3	Moderately important
4	Very important
5	Extremely important

Table 1. Five point Likert Scale

Likert scale is used by the respondents to express their opinions or views towards the importance of the criteria. Therefore a five-point Likert scale (shown in Table 1) is used for recording the perceptions of respondents. Data was collected from 39 companies.

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VI. DATA ANALYSIS

Cronbach's alpha is the most commonly used when you have multiple Likert questions in a survey/questionnaire that form a scale and you wish to determine if the scale and the questionnaire is reliable. After the collection of Questionnaires required for the study, data was analysed using the Statistical Package for Social Science (SPSS). A Cronbach Alpha value of 0.939 was obtained and hence the response obtained can be concluded as highly reliable

VII. RELATIVE RANKING INDEX OF CRITERIAS USED IN THE STUDY

The criterias were ranked on the basis of the response obtained from Questionnaire survey using Relative Ranking Index (RRI) method. The RRI technique is used for comparison between the importance levels of variables and derived from the Likert scales which represent the level of importance of variables chosen by respondents which need to be transformed into a Relative Rank Index that has a value of one or less. The RRI can be calculated using the following equation:

$$RRI = \frac{1}{nN} (\sum_{i=1}^n l_i x_i) \dots \dots \dots (1)$$

Where, i- 1,2.....n, l_i =Likert scale (l_1 is the least important and l_n is the most important) and x_i = the frequency of the i^{th} response.

22 Criterias with RRI value of 0.675 or more were considered as Key criterias used for the further study.

VIII. IMPLEMENTATION OF AHP INTEGRATED WITH TOPSIS METHOD IN THE PROPOSED CASE STUDY

For the implementation of AHP integrated with TOPSIS method in the given case study, two sets of data were collected. This data was further used to evaluate the supplier alternatives of various materials. Three supplier alternatives for raw materials, cement, sand, steel and coarse aggregate were chosen for the study. Data was collected through personal interview with the purchase manager/ store keeper of the proposed site. Suppliers were evaluated and compared based on a 9 point Saaty's scale (Table 2). In the first set of data, each suppliers were evaluated on the basis of each of the key criterias considered for the study. The second set of data were pair wise comparison matrices wherein each suppliers were compared with each other for each individual criterias. The matrices were also found to be consistent in the consistency check.

After the input data required for the implementation of AHP integrated with TOPSIS method were collected, the method was implemented.

IX. RESULTS AND DISCUSSION

The final result obtained after applying the MCDM technique in the given case study is shown in Table 2. The best alternatives were chosen for each of the four raw materials -: Cement, Sand, Steel and Coarse aggregate.

Material	Best alternative chosen
Cement	Supplier 1
Steel	Supplier 1
Sand	Supplier 1
Coarse aggregate	Supplier 1

Table 2. Results obtained

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So for each material, considering the organization/ construction company's priority and importance for each of the key criteria, the best alternative was chosen. Thus the application of Multi Criteria Decision Making techniques helps in choosing the right supplier with due consideration of a number of criterias. Overall cost, time and efficiency of supplier selection process can be improved, hence making it suitable for practical application in construction industry.

X. CONCLUSION

In this work, 39 criterias which affects the supplier selection process were identified and the effect and relative importance of these criterias on the supplier selection process was studied by conducting a Questionnaire survey. The key criterias chosen for the further study were identified using Relative Ranking Index method. AHP integrated with TOPSIS method was implemented using the data obtained from a real working environment. For all the four materials considered, Supplier 1 was found to be the best supplier when applied to the cement, sand, steel and coarse aggregate suppliers. Hence, it can be concluded that AHP integrated with TOPSIS technique can be effectively executed in construction industry to find out the best supplier with due consideration to various criterias and their priorities which can enable the efficient and smooth functioning of supply chain. Advantages of applying this method are that it overcomes most of the disadvantages of AHP and TOPSIS methods and it is more accurate compared to both the methods. Disadvantages of AHP integrated with TOPSIS method is that it is a time consuming and complex technique.

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