An Analytical Hierarchy Process (AHP) Based Approach for Supplier Selection: An Automotive Industry Case Study

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Abstract: **The purchasing function directly affects the competitive ability of an organization in the competitive business environment. Purchasing managers need to periodically evaluate supplier performance in order to retain those suppliers who meet their requirements. The importance of incorporating multiple attributes such as quality, on-time delivery, price and service, into vendor evaluation are well established in the literature. Supply chain management (SCM) has emerged as an increasingly important approach to improving the performance of manufacturing systems. SCM is an integrated approach to increase the effectiveness of the logistics chain by improving cooperation between the partners in the supply chain. The paper proposed a structured model for evaluating vendor selection using the analytical hierarchy process (AHP). The supplier selection problem consists of analyzing and measuring the performance of a set of suppliers in order to rank and select them for improving the competitiveness of the whole supply chain system. As many conflicting factors should be taken into account in the analysis, the problem can be tackled using multi-criteria models and methods. A live case study of an automotive industry for supplier evaluation and selection is also presented to demonstrate the functional application of the model.**

Keywords: **Analytical hierarchy process (AHP), pair-wise comparison, supply chain management, vendor selection.**

I. INTRODUCTION

Purchasing function has become vital in determining the profitability and survival of business organizations; it has been receiving considerable attention [1]. The increasing importance of supplier selection decisions is forcing organizations to re-think their purchasing and evaluation strategies because a successful purchasing decision directly depends on selecting the "right" vendor. Usually, quality is a critical concern for most manufacturers while purchasing. The need for high-quality suppliers has always been an important issue for many manufacturing organizations. The purchase price is also a highlighted consideration for the purchasing organization due to its impact on the product cost, but the purchase price is not all of the cost associated with the material receipt [3]. Additional costs are required by the purchasing organization to correct the deficiencies when a supplier fails to meet quality and delivery requirements. Hence, the purchasing department must consider the full-part cost instead of a unit-price-oriented cost. Monczka and Trecha [4] provided a cost-based supplier performance evaluation system to evaluate key supplier performance. Service quality from the supplier is also very important to the manufacturer. Improving service quality is considered an essential strategy for success and survival in today's competitive situation.

This paper proposes a decision support system to aid in optimal selection of supplier companies for a business initiative in the automotive manufacturing environment. The present work describes four main factors (Quality, cost, flexibility, reliability) and about 13 sub-factors for the vendor selection. The proposed decision support system uses analytic hierarchy process algorithm to provide a quick and optimal selection of supply chain partners.

II. LITERATURE REVIEW

Methodologies for supplier evaluation have included conceptual, empirical and modeling approaches. Cost, quality and delivery performance are the three most important criteria that need to be considered for supplier evaluation in the initial work. The conceptual research primarily emphasizes the strategic importance of supplier evaluation and the trade-offs among cost, quality and delivery performance. The empirical research mainly focuses on studying the relative importance of various supplier attributes such as price, quality and delivery performance [7]. Although the conceptual and empirical research both stress the strategic importance of supplier evaluation and the consideration of multiple measures, they do not specifically propose any evaluation models [7]. A lot of literature has accumulated on evaluation models. Most of these models finalize the supplier selection decision making process on the basis of a set of supplier performance criteria [9]. Some important researches in the field are summarized below.

Farzad & Mohamad et al, (2008) they had used different selection methods concerning supplier selection are discussed and the advantages and disadvantages of selection methods, especially the analytic hierarchy process (AHP), are illustrated and compared. Santanu Das, & A.B. Chattopadhyay et al (2003) studied that the analytic hierarchy process (AHP), being a simple, but powerful decision-making tool, is being applied to solve different manufacturing problems. In this work, the AHP is applied to estimate the state of the cutting tool during the machining of a medium carbon steel work piece with coated carbide inserts. Three components of cutting forces are used to judge whether the tool is sharp, workable, or worn out. It is observed during the classification of the tool condition that the AHP assesses the state of the turning tool with reasonably good accuracy. Ali,Hadi & Awaluddin, (2011) they propose an integrated model that evaluates suppliers and allocates order to them. In the first step, they evaluate suppliers by qualitative criteria such as financial structure, services and loyalty with Fuzzy analytical hierarchy process (FAHP) and gain their weights.

Giuseppe et al, (2011) they focus on the use of AHP and its variants to solve different aspects of the problem. The results of the study allow individuating opportunities and open issues arising by the use of multi-criteria approaches. Sanjay, & Neeraj, (2009) they adopted researched methodology for the synthesis of priorities and the measurement of consistencies. A consistency ratio has also been calculated. Industries has been classifies into small scale, medium scale and large scale. After analysis of the results they found that for large scale industries, vendor reliability, product quality and vendor experience are the top three vendor selection problems that needs to be taken up on priority for effective vendor selection. Min Wu, (2007) there aiming for the supplier selection problem, they discusses a class of AHP (analytical hierarchy process) technique—simulation approach, which is valuable in that it examines the uncertainty in AHP and helps to reduce the uncertainty in AHP to some extent. Then the approach is illustrated by solving a simplified supplier selection problem in SCM.

Chon-Huat Goh et al. (1997) studied that investment decisions involving robots are capital intensive and are usually made by a committee of experts from different functional backgrounds within a company. In spite of this knowledge, most models in the literature for robot selection assume that there is only a single decision maker. In this paper, a robot selection model that incorporates the inputs from multiple decision makers is provided. This model is based on the analytic hierarchy process method, and both the subjective and objective criteria for robot selection are used. It does not assume that the decision makers have achieved a consensus; that is, they may not agree on evaluations of the robots with respect to each of the criteria. A numerical example is used to illustrate the model.

Petroni and Braglia (2000) discuss the principal component analysis (PCA) method which is a multi-objective approach to vendor selection that attempts to provide a useful decision support system for a purchasing manager faced with multiple vendors and trade-offs such as price, delivery, reliability, and product quality. The major limitation of this approach is it requires the knowledge of advanced statistical technique. Amanda et al, (2009) they propose an approach based on the analytic network process (ANP) with ratings for the final supplier selection. Ratings consist in assigning categories to previously defined criteria for alternatives selection. This approach reduces the number of judgments required for a decision and allows the analysis of cases with high number of alternatives. Dickson (1966), reports 23 different criteria for vendors' evaluation, of these criteria, he states that cost, quality, and delivery times are among the most important performance measures in the selection of vendors. Since that time, numerous papers have cited his work approaching the vendor selection problem mainly from three perspectives; conceptual, empirical, and mathematical. Tanmoy,Tamal & Parnab, (2011) They had adopted novel heuristic approach is adopted as an optimization technique to solve the above mentioned multi-criteria decision making (MCDM) problem. The simulation result is compared and shown to outperform the AHP result in terms of quality of the solution. Parthiban, Abdul & Swati, (2011) they showed that supplier selection procedure is a highly essential decision making process for companies. It is an endeavor to utilize ANP for ranking the potential suppliers and making the final selection. ANP - BOCR method is solved using super decision package.

Chaiu et al, (2011) they proposed an integrated network model from the aspect of product development so that four business functions, i.e., design, purchasing, manufacturing, and marketing, and their activities can be identified. Some dependent relations are processed by analytic network process (ANP) with pair-wise comparison, and suitable alternatives will be selected. In the final section, the model is employed by one leading electronic company in Taiwan. Fuh-Hwa Franklin Liu, Hui Lin Hai et al (2005) investigated that supplier selection has received extensive attention in supply chain management. Wei et al. (1997) in their paper discuss about the neural network for the supplier selection. Comparing to conventional models for, decision support system, neural networks save a lot of time and money for system development. The supplier-selecting system includes two functions: one is the function measuring and evaluating. Performance of purchasing (quality, quantity, timing, price, and costs) and storing the evaluation in a database to provide data sources to neural network. The other is the function using the neural network to select suppliers. This method incorporates qualitative and quantitative criteria. The neural network method saves money and time of system development. The weakness of this method is that it demands software and requires a qualified personnel expert on this subject.

III. PROBLEM DESCRIPTION

This multi criteria decision making problem is now a part of day to day affair of all the organizations. The attributes and the sub-attributes have to be most prevalent and important in the vendor selection process. Choosing the possible criteria for the vendor selection involves a decision making team which includes experts from the industry side (purchasing director, purchasing manager, sales manager, product manager, quality manager and production manager). The attributes and sub attributes involved in the vendor selection have been chosen by conducting a survey. A questionnaire consisting of these factors was designed for the survey. The respondents for the survey are selected randomly from different functional areas of the original equipment manufacturers company who are directly involved with the materials supplied by the vendors. Based on the survey conducted the major influencing attributes and sub-attributes involved in vendor selection is given in Table 1. The research objective is to select a set of vendors, evaluate and rank them according to predefined attributes. Figure 2 illustrates the proposed AHP model.

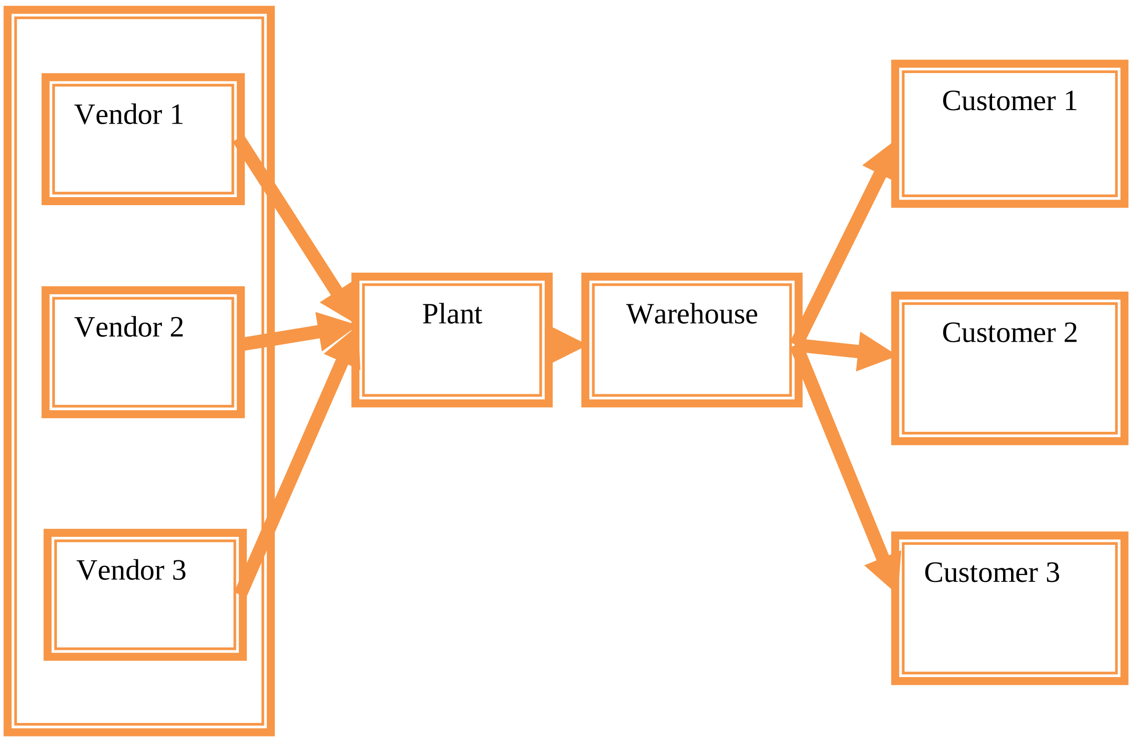

Figure 1 Best vendor selection model

The main objective of the paper is to rate vendors with respect to various criteria. In the present work analytical hierarchy process (AHP) has been used for evaluation & ranking of the vendors.

Table 1 Attributes and sub-attributes for the vendor selection

Attributes	**Sub-attributes**
Quality (Q)	% of rejection (Q-1) Defect's in process (Q-2) Customer complaint (Q-3)
Cost (C)	Product cost (C-1) Transportation cost (C-2) Ordering cost (C-3) Inventory cost (C-4)
Flexibility (F)	Urgent deliveries (F-1)
	Order size (F-2) Special request (F-3)
Reliability (R)	Delivery stability (R-1) Conformance of specification (R-2) Stability (R-3)

Figure 2 is comprised of 4 levels for selecting the best vendor. Level 1 represents the goal, i.e., selection of best vendor; level 2 represents the four attributes quality (Q), cost (C), flexibility (F), reliability (R); level 3 represents 13 sub-attributes; and level 4 represents the number of vendors.

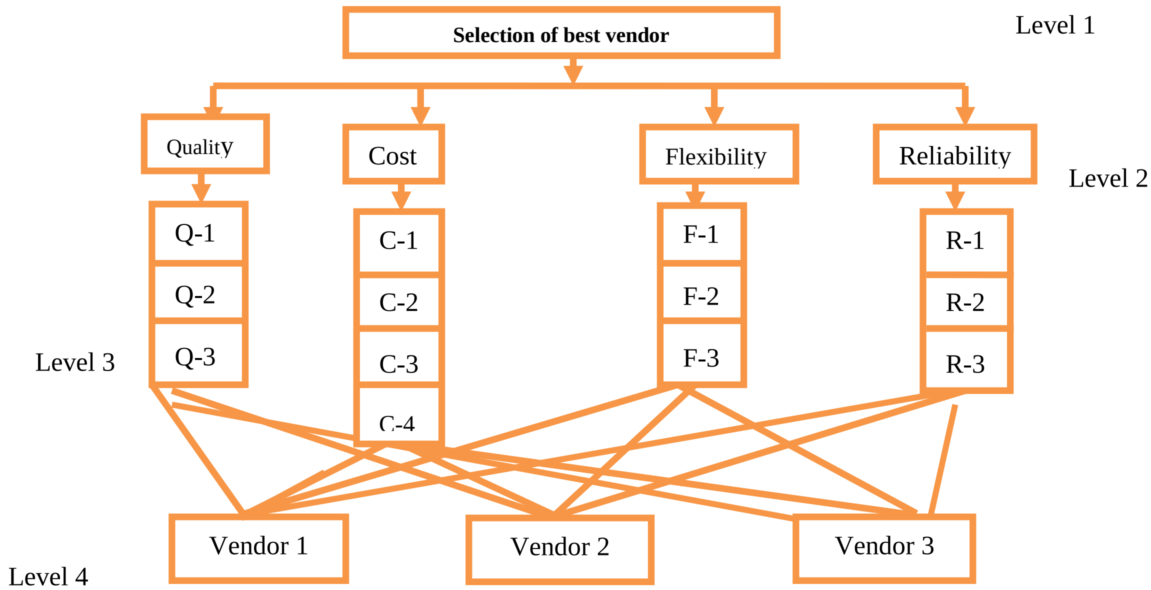

Figure 2 Proposed AHP model for an automobile company

Based on the ratings obtained through the questionnaire, matrices are formed and the priorities are synthesized using the methodology of AHP. Following are the steps used in this process:

- Synthesis of priorities for all the criteria and measurement of consistency ratio (CR).
- Prioritizing of small scale, medium scale and large scale industries as against all the criteria of vendor selection separately.
- Synthesis of overall priority matrix of small scale, medium scale and large scale industries

IV. AHP MODEL FOR AN AUTOMOBILE COMPANY

In this section a conceptual approach for structuring the selection of the best vendor using the AHP. A four level hierarchy decision process displayed in Figure 2 is described below:

Level I: Initially, the objective or the overall goal of the decision is presented at the top level of hierarchy. Specifically, the overall goal of this application is to ‘select the best or most suitable vendor for component supply to the manufacturing plant.

Level II: The second level represents the category of a vendor to supply a raw material for the manufacturing plant, which are identified to achieve the overall goal. The performance capabilities are derived from a number of sources. According to Jayant et. al. [1], the performance capabilities can be classified into five aspects: cost, quality, speed, flexibility, and dependability. However, in this study four issues have been considered and are used to constitute the second level to achieve the overall goal.

Levels III & IV: The third level of the hierarchy contains the sub-factors of each major factor. Four major factors and 13 sub-factors were identified from an extensive literature survey. The abbreviations for the factors and sub-factors are given in Table 1. The fourth level of the hierarchy represents the alternative vendors. The AHP model shown in Figure 2 may be regarded as a feasible way for visualizing any vendor selection decision problem systematically. The decision-maker can apply this framework to structure their particular problem in selecting the best vendor for their choices in different business environment.

V. STEPS OF THE ANALYTICAL HIERARCHY PROCESS

Proposed steps of supplier selection using AHP

[1] Define the overall objective.
[2] Define the structured hierarchy consisting of attributes (criteria for the supplier selection for a given product) and alternatives.
[3] Determination of the priority weights of the attributes using pair-wise comparison matrix and its consistency ratio.
[4] Determination of priority weights of alternatives with respect to attributes (various alternatives bids with respect to the individual criteria for selection) and consistency ratio for each pair-wise comparison matrix.

[5] Enumeration of overall priority weights for all alternatives and consistency ratio for entire hierarchy

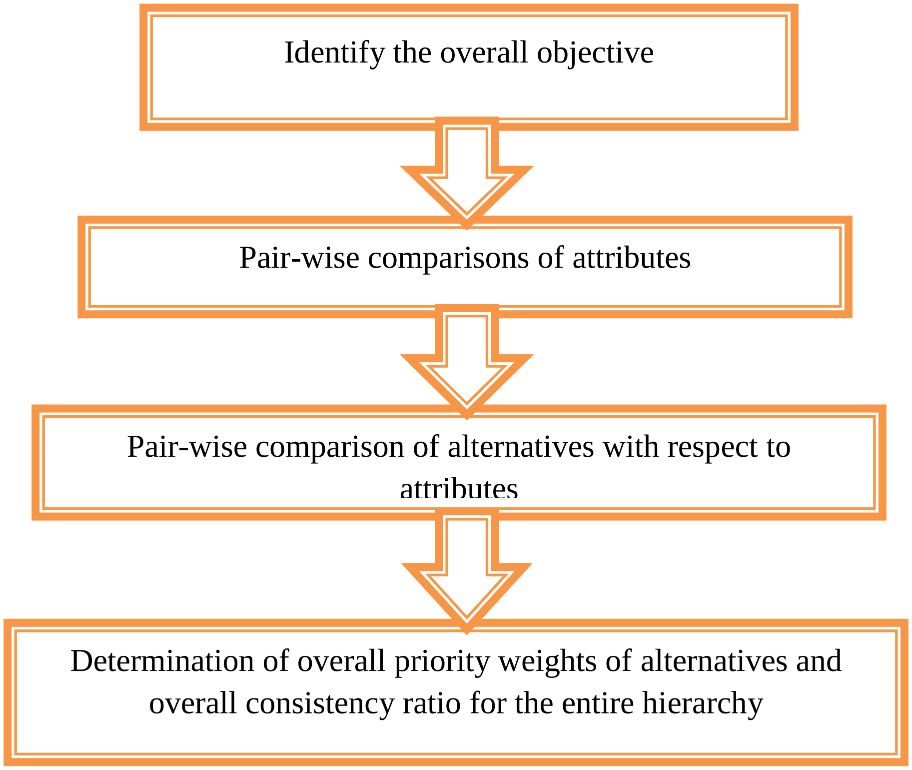

Figure 3 Steps of the Analytical Hierarchy Process

5.1 The decision matrix (Comparative judgments)

Once the hierarchy has been structured, the next step is to determine the priorities of elements at each level ('element' here means every member of the hierarchy). A set of comparison matrices of all elements in a level of the hierarchy with respect to an element of the immediately higher level are constructed so as to prioritize and convert individual comparative judgments into ratio scale measurements. The preferences are quantified by using a nine-point scale. The meaning of each scale measurement is explained in Table 2. The pair-wise comparisons are given in terms of how much more element A is important than element B. As the AHP approach is a subjective methodology, information and the priority weights of elements may be obtained from a decision maker of the company using direct questioning or a questionnaire method.

Table 2 Thomas Saaty's nine-point scale (Saaty, 1994)

Intensity of importance	Definition	Explanations
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong important	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgment	When compromise is needed
Reciprocals of above nonzero	If activity I has one of the above non zero numbers assigned to it when compared with activity j, then has the reciprocal value when compared with I,	A reasonable assumption

Following are the steps used in this process:

- Synthesis of priorities for all the criteria and measurement of consistency ratio (CR).
- Prioritizing of small scale, medium scale and large scale industries as against all the criteria of supplier selection separately.
- Synthesis of overall priority matrix of small scale, medium scale and large scale industries.

5.2 Synthesis of priorities and the measurement of consistency

The pair-wise comparisons of the criteria of supplier selection problem generate a matrix of relative rankings for each level of the hierarchy. The number of matrices depends on the number of elements at each level. The number of elements at each level decides the order of every matrix of the next higher level. After all matrices are developed, eigenvectors or the relative weights (the degree of relative importance amongst the elements) and the maximum eigen-value (λ max) for each matrix are calculated. The λ max value is an important validating parameter in AHP. It is used for calculating the consistency ratio CR of the estimated vector in order to validate whether the pair-wise comparison matrix provides a completely consistent evaluation. The consistency ratio is calculated as per the following steps:

Step 1 Calculate the eigen-vector or the relative weights and λ max for each matrix of order m

Step 2 Compute the consistency index for each matrix of order n by the formulae:-

$$CI = (\lambda_{max} - m)/(m-1)$$

Step 3 the consistency ratio is then calculated using the formulae:-

$$CR = CI/RCI$$

Where CI = Consistency index

CR = Consistency ratio

RCI = Random consistency index

M = Number of elements

5.3 Random consistency index (RCI)

Where random consistency index (RCI) varies depending upon the order of matrix. Table 3 shows the value of the Random Consistency Index (RCI) for matrices of order 1 to 10 obtained by approximating random indices using a sample size of 500.

Table 3 Random consistency index (RCI)

N	3	4	5	6	7	8	9	10	11	12	13	14	15
RCI	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.51	1.52	1.54	1.56	1.57	1.59

The acceptable CR range varies according to the size of matrix i.e. 0.05 for a 3 by 3 matrix, 0.08 for a 4 by 4 matrix and 0.1 for all larger matrices, m>= 5. If the value of CR is equal to, or less than that value, it implies that the evaluation within the matrix is acceptable or indicates a good level of consistency in the comparative judgments represented in that matrix. In contrast, if CR is more than the acceptable value, inconsistency of judgments within that matrix has occurred and the evaluation process should therefore be reviewed, reconsidered and improved. An acceptable consistency ratio helps to ensure decision-maker reliability in determining the priorities of a set of criteria.

VI. WORKING STEPS OF CALCULATIONS AND APPLICATIONS FOR AHP

Table 4 Criteria pair-wise comparison matrix (level 2)

Criteria	Quality	Cost	Flexibility	Reliability
Quality	1	7	5	9
Cost	1/7	1	1/3	3
Flexibility	1/5	3	1	5
Reliability	1/9	1/3	1/5	1
	1.4539	11.3333	6.5333	18

Table 5 Criteria pair-wise comparison matrix (level 2) normalized

Criteria	Quality	Cost	Flexibility	Reliability	Sum	Wi
Quality	0.6878	0.6176	0.7653	0.5	2.5707	0.6427
Cost	0.0982	0.0882	0.0510	0.1666	0.404	0.1010
Flexibility	0.1375	0.2647	0.1530	0.2777	0.8329	0.2082
Reliability	0.0764	0.0294	0.0306	0.555	0.1999	0.0479

Check of the consistency
Let A1= pair-wise comparison matrix
A2= weight age matrix

$$A1 = \begin{pmatrix} 1 & 7 & 5 & 9 \\ 1/7 & 1 & 1/3 & 3 \\ 1/5 & 3 & 1 & 5 \\ 1/9 & 1/3 & 1/5 & 1 \end{pmatrix} \qquad A2 = \begin{pmatrix} 0.6423 \\ 0.1010 \\ 0.2082 \\ 0.0479 \end{pmatrix}$$

Then A3 =A1*A2 A3 = $\begin{pmatrix} 0.6654 \\ 0.0905 \\ 0.2044 \\ 0.0430 \end{pmatrix}$ And A4= A3/A2 A4 = $\begin{pmatrix} 4.0695 \\ 4.2276 \\ 4.0308 \\ 4.3674 \end{pmatrix}$

λmax= Average of the elements of A4
λmax = 4.1738

Consistency Index (CI) = (λmax -M) / (M-1)
And Consistency Ratio (CR) = CI/RCI corresponding to M.

Where RCI= Random Consistency Index and
M= Number of elements
CI= (4.1738 - 4) / (4 - 1) = 0.0579
CR= 0.0579/0.9 = 0.06433

Here CR is less than 10% (0.1), so the judgment is consistent.

Table 6 Sub-criteria quality pair-wise comparison matrix (level 3)

Sub Criteria	% Of Rejection	Defects In Process	Customer Complaint
% Of Rejection	1	3	9
Defects In Process	1/3	1	6
Customer Complaint	1/9	1/6	1
	1.4444	4.1667	16

Table 7 Sub-Criteria quality pair-wise comparison matrix (level 3) normalized

Sub Criteria	% Of Rejection	Defects In Process	Customer Complaint	Sum	Wi
% Of Rejection	0.6923	0.7179	0.5625	1.9774	0.6586
Defects In Process	0.2307	0.2399	0.3750	0.8456	0.2816
Customer Complaint	0.0769	0.0399	0.0625	0.1793	0.0597

Table 8 Sub-criteria cost pair-wise comparison matrix (level 3).

Sub criteria	Product Cost	Transportation Cost	Ordering Cost	Inventory Cost
Product Cost	1	5	3	7
Transportation Cost	1/5	1	1/3	5
Ordering Cost	1/3	3	1	6
Inventory Cost	1/3	1/5	1/6	1
	1.6761	9.2	4.5	19

Table 9 Sub-criteria cost pair-wise comparison matrix (level 3) normalized

Sub criteria	Product Cost	Transportation Cost	Ordering Cost	Inventory cost	Sum	Wi
Product Cost	0.5966	0.5434	0.666	0.3684	2.175	0.5438
Transportation Cost	0.1193	0.1086	0.0740	0.2631	0.565	0.1412
Ordering Cost	0.1988	0.3260	0.2222	0.3157	1.0627	0.2657
Inventory Cost	0.0852	0.0217	0.0370	0.052	0.1965	0.0493

Table 10 Sub-criteria flexibility pair-wise comparison matrix (level 3)

Sub Criteria	Urgent Deliveries	Order Size	Special Requests
Urgent Deliveries	1	5	9
Order Size	1/5	1	3
Special Requests	1/9	1/3	1
	1.3111	6.3333	13

Table 11 Sub-Criteria flexibility pair-wise comparison matrix (level 3) normalized

Sub Criteria	Urgent Deliveries	Order Size	Special Requests	Sum	Wi
Urgent Deliveries	0.7627	0.7894	0.6923	2.2444	0.7482
Order Size	0.1525	0.1578	0.2307	0.541	0.1803
Special Requests	0.0847	0.0526	0.0769	0.2142	0.0714

Table 12 Sub criteria reliability pair-wise comparison matrix (level 3)

Sub Criteria	Delivery Reliability	Conformance Of Specification	Stability
Delivery Reliability	1	3	5
Conformance Of Specification	1/3	1	3
Stability	1/5	1/3	1
	1.5333	4.3333	9

Table 13 Sub Criteria reliability pair-wise comparison matrix (level 3) normalized

Sub Criteria	Delivery Reliability	Conformance Of Specification	Stability	Sum	Wi
Delivery Reliability	0.6521	0.6923	0.5555	1.8999	0.6333
Conformance Of Specification	0.2173	0.2307	0.3333	0.7813	0.2604
Stability	0.1304	0.0769	0.1111	0.3184	0.1061

Table 14 Comparison % of rejection w.r.t vendors

% Of Rejection	V1	V2	V3	Sum	Wi
V1	1	¼	6	7.25	0.5838
V2	1	1	1	3	0.2416
V3	1/6	1	1	2.1666	0.1744

Table 15 Comparison defects in process w.r.t vendors

Defects In Process	V1	V2	V3	SUM	WI
V1	1	5	6	12	0.6779
V2	1/5	1	1/3	1.5333	0.0866
V3	1/6	3	1	4.1666	0.2354

Table 16 Comparison customer complaint w.r.t vendors

Customer Complaint	V1	V2	V3	SUM	WI
V1	1	4	1/3	5.3333	0.3008
V2	¼	1	1/7	1.3928	0.0785
V3	3	7	1	11	0.6205

Table 17 Comparison product cost w.r.t vendors

Product Cost	V1	V2	V3	SUM	WI
V1	1	1/6	1	2.1666	0.1249
V2	6	1	6	13	0.7500
V3	1	1/6	1	2.1666	0.1249

Table 18 Comparison transportation cost w.r.t vendors

Transportation Cost	V1	V2	V3	Sum	Wi
V1	1	5	8	14	0.7121
V2	1/5	1	3	4.2	0.2136
V3	1/8	1/3	1	1.4583	0.0741

Table 19 Comparison ordering cost w.r.t vendors

Ordering Cost	V1	V1	V3	Sum	Wi
V1	1	3	9	13	0.7244
V2	1/3	1	2	3.3333	0.1857
V3	1/9	1/2	1	1.6111	0.0897

Table 20 Comparison inventory cost w.r.t vendors

Inventory Cost	V1	V2	V3	Sum	Wi
V1	1	2	6	9	0.6
V2	½	1	3	4.5	0.3
V3	1/6	1/3	1	1.5	0.1

Table 21 Comparison urgent deliveries w.r.t vendors

Urgent Deliveries	V1	V2	V3	Sum	Wi
V1	1	1/5	2	3.2	0.1793
V2	5	1	7	13	0.7285
V3	½	1/7	1	1.6428	0.0920

Table 22 Comparison order size w.r.t vendors

Order Size	V1	V2	V3	Sum	Wi
V1	1	2	5	8	0.5700
V2	½	1	3	4.5	0.3206
V3	1/5	1/3	1	1.5333	0.1092

Table 23 Comparison special requests w.r.t vendors

Special Requests	V1	V2	V3	Sum	Wi
V1	1	5	7	13	0.7285
V2	1/5	1	2	3.2	0.1793
V3	1/7	1/2	1	1.6428	0.0920

Table 24 Comparison delivery reliability w.r.t vendors

Delivery Reliability	V1	V2	V3	Sum	Wi
V1	1	1	3	5	0.4615
V2	1	1	2	4	0.3692
V3	1/3	1/2	1	1.8333	0.1692

Table 25 Comparison conformance of specification w.r.t vendors

Conformance Of Specification	V1	V2	V3	Sum	Wi
V1	1	5	7	13	0.6328
V2	1/5	1	1/5	1.4	0.0681
V3	1/7	5	1	6.1428	0.2990

Table 26 Comparison stability w.r.t vendors

Stability	V1	V2	V3	Sum	Wi
V1	1	5	7	13	0.6960
V2	1/5	1	1/3	1.5333	0.0820
V3	1/7	3	1	4.1428	0.2218

VII. RESULTS & DISCUSSION

After pair-wise comparisons were obtained and entered into data matrices, the relative weights of each element from level II and level III and the consistency ratio of each matrix were analyzed. Then the relative weights were combined together with respect to all successive hierarchical levels in order to obtain the global weights of all 13 sub-criteria. Table 27 summarizes the relative weights and the global priority weights of the company based on AHP. Relative weight for the attributes of the company have been obtained by making the pair wise comparisons using AHP and the relative weights for the sub-attributes have been obtained using the pair wise comparisons using AHP. Global weight for the sub-attributes of the company is found out by multiplying the relative weight for the attributes and the relative weight for the sub-attributes.

After finding the global weight of the company, local or relative weights of the three vendors are found out using the pair wise comparisons using AHP in Table 28. Global weight of the three vendors is found out multiplying the relative weight for the attributes, the relative weight for the sub-attributes and the local or relative weights of the three vendors and Table28. Based on the global weight of the vendors, ranking has been assigned to the vendor according to their overall priority value. After finding the global weight of the company, local or relative weights of the three vendors are found out using the pair wise comparisons using AHP in Table 28. Global weight of the three vendors is found out multiplying the relative weight for the attributes.

Table 27 Composite relative weight of the four critical attributes of the company

Issues	Relative Weight Using AHP	Factor	Relative Weight Using AHP	Global Weight
Quality	0.6427	Q1 Q2 Q3	0.6586 0.2816 0.0597	0.4232 0.1809 0.0383
Cost	0.1010	C1 C2 C3 C4	0.5438 0.1412 0.2657 0.0491	0.0549 0.0142 0.0268 0.0049
Flexibility	0.2082	F1 F2 F3	0.7482 0.1803 0.0714	0.1557 0.0375 0.0148
Reliability	0.0479	R1 R2 R3	0.6333 0.2604 0.1061	0.0303 0.0124 0.0050

In above table based on the comparison of vendor and the method applied it can be seen that vendor 1 is number 1 ranking and preferred. Since, it is having the highest weight of 0.5053 among three vendors. Vendor 2 is second choice with overall priority of 0.3114 and vendor 3 is the last choice with overall priority of 0.1801. The result shows that the model has the capability to be flexible and apply in different types of industries to choose their vendor. The final priority weight of each alternative at the last level of the hierarchy will lead to a recommended best option. It can be concluded that the model could facilitate decision making process in a turbulent business environment.

Table 28 Overall rating of three vendor indentify by company using AHP

Issues	Sub Criteria	Global Weight	Local Weight V1	Local Weight V2	Local Weight V3	Global Weight V1	Global Weight V2	Global Weight V3
QUALITY	Q1	0.4232	0.5838	0.2416	0.1744	0.2470	0.1022	0.0738
	Q2	0.1809	0.6779	0.0866	0.2354	0.1226	0.0156	0.0425
	Q3	0.0383	0.3008	0.0785	0.6205	0.0115	0.0030	0.0237
COST	C1	0.0549	0.1249	0.7500	0.1249	0.0068	0.0411	0.0068
	C2	0.0142	0.7121	0.2136	0.0741	0.0101	0.0030	0.0010
	C3	0.0268	0.7244	0.1857	0.0897	0.0194	0.0049	0.0024
	C4	0.0049	0.6	0.3	0.1	0.0029	0.0014	0.0004
FLEXIBILITY	F1	0.1557	0.1793	0.7285	0.0920	0.0279	0.1134	0.0143
	F2	0.0375	0.5700	0.3206	0.1092	0.0213	0.0120	0.0043
	F3	0.0148	0.7285	0.1793	0.0920	0.0107	0.0026	0.0013
RELIABILITY	R1	0.0303	0.4615	0.3692	0.1692	0.0139	0.0111	0.0051
	R2	0.0124	0.6328	0.0681	0.2990	0.0078	0.0008	0.0037
	R3	0.0050	0.6960	0.0820	0.2218	0.0034	0.0004	0.0011
						0.5053	0.3114	0.1801

VIII. CONCLUSIONS

This paper proposed an AHP approach for the selection of vendors in a supply chain. The major advantages of this research are that it can be used for both qualitative and quantitative criteria. Pair-wise comparison used in this work reduces the dependency of the model on human judgment. A systematic approach using AHP has been applied for vendor selection. The results show that the model has the capability to be flexible and apply in different types of industries to choose their vendor. The final priority weight of each alternative at the last level of the hierarchy will lead to a recommended best option. It can be concluded that the model could facilitate decision making. The approach could help in reducing time consuming efforts in the vendor selection process. Not only can the model make tradeoffs between both qualitative and quantitative factors, but it also enables decision-makers to deal with inconsistent judgments' systematically. The pair-wise comparison procedure is able to capture relative judgments' of two elements at one time in a trustworthy manner and ensure consistency of these values.

In the present work methodology of the AHP has been implemented to solve the problem of best supplier selection. The present work proposes an AHP approach for the selection of vendors in a supply chain. The major advantages of this research are that it can be used for both qualitative and quantitative criteria. Pair-wise comparison used in this work reduces the dependency of the model on human judgment. A systematic approach using AHP approach has been applied for vendor selection. In above table based on the comparison of vendor and the method applied it can be seen that vendor 1 preferred. Since to has the highest weight of (0.5053) among three vendors. Vendor 2 is at the second choice (0.3114) and vendor 3 is the last choice (0.1801). The result shows that the model has the capability to be flexible and apply in different types of industries to choose their vendor. The final priority weight of each alternative at the last level of the hierarchy will lead to a recommended best option. It can be concluded that the model could facilitate decision making.

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