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Vendor Evaluation and Rating Using Analytical Hierarchy Process

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Abstract -Vendor evaluation is a system for recording and ranking the performance of a supplier in terms of a variety of issues, which may include delivery performance and the quality of the items. A process of vendor rating is essential to effective purchasing. The company under study, purchases capital goods, raw materials, equipment's, spares, intermediary products, office items etc. for all its divisions and departments. They had no system to evaluate and rate its vendors based on their performance in the purchase department. A vendor evaluation and rating system is formulated, which incorporates the company's evaluation and rating criterions. The present study is limited to the evaluation of suppliers of valves, purchased through the equipment spares and supplier section of the purchase department.

Keywords: **Vendor Evaluation, Vendor Rating, AHP, ANP.**

I. INTRODUCTION

Vendor evaluation is a system for recording and ranking the performance of a supplier in terms of a variety of issues, which may include delivery performance and the quality of the items. A process of vendor rating is essential to effective purchasing. Vendor selection is crucial because of its strategic importance especially when it comes to Government Supplies where money & quantities involved are generally very large. Usually, the most important measure of a supplier's service is his record of past performance. Vendor rating is the result of a formal vendor evaluation system. Vendors or suppliers are given standing, status, or title according to their attainment of some level of performance, such as delivery, lead time, quality, price, or some combination of variables.The ratings shall be used to;

- Assess and monitor supplier performance with a view to rewarding suppliers who meet expectations with on-going and future supply relationships.
- Provide accurate feedback to suppliers to highlight their strengths as well as their weaknesses (through the eyes of the customer) which can be used as an effective continuous improvement tool.
- Provide benchmark data, which will allow suppliers to establish where they are placed in relation to the best performers in their industry and hence improve overall competitiveness in the market.
- Helping minimize subjectivity in judgment and make it possible to consider all relevant criteria in assessing suppliers.
- Providing feedback from all areas in one package and hence specific action could be taken to correct identified performance weaknesses.
- Establishing continuous review standards for vendors, thus ensuring continuous improvement of vendor performance.
- To select vendors for further development.

II. PROBLEM DEFINITION

Purchase department of the company purchases capital goods, raw materials, equipment's, spares, intermediary products, office items etc. for all its divisions and departments. The company had no system to evaluate and rate its vendors based on their performance in the purchase department.The objective of the present study is to develop a vendor evaluation and rating system that incorporates the company's evaluation and rating criterions. The study is limited to the evaluation of suppliers of valves, purchased through the Equipment spares and supplier section of the purchase department.

III.METHODOLOGY

The various steps involved in methodology are identifying methods to measure supplier performance, method selection, identifying the key supplier evaluation factors, data collection, data analysis and overall supplier evaluation and ranking. Supplier performance can be measured by the methods like Categorical Method, Cost ratio

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method, Linear averaging method, Analytic Hierarchical Process (AHP) and Artificial Neural Network (ANN). A method is selected from this and the key supplier factors are to be identified. The data for the overall supplier evaluation and rating are to be collected and analyzed. An overall supplier ranking system with their individual score is to be developed from the analysis of the data collected.

A. IDENTIFYING METHODS TO MEASURE SUPPLIER PERFORMANCE

The methods identified are categorical method, cost ratio method, linear averaging method, Analytic hierarchical process (AHP) and Artificial neural network (ANN). Categorical method involves classifying each vendor's performance in specific areas defined by a list of relevant performance variables. This consists of a procedure whereby the buyer keeps a record of all vendors to be monitored, along with their actual performance by product. A list of significant performance factors is developed for evaluation purposes, and the buyer assigned a "grade" in simple categorical terms, such as "good," "neutral," and "unsatisfactory," indicating the vendor's actual performance in each area. Cost ratio is a methodology and philosophy, which looks beyond the price of a purchase to include many other purchase-related costs. The method evaluates supplier performance by using the tools of standard cost analysis. Linear averaging or weighted pointed method seeks to combine the qualitative elements of the categorical plan with the systematic nature and quantifiable procedures of the cost-ratio plan. Any number of evaluation factors can be included, and their relative importance can be expressed in numerical terms (weights) so that a composite performance index can be calculated and supplier comparisons made. After performance factors have been selected and judgmentally weighted, a specific procedure is then developed to measure actual supplier performance on each individual factor. Analytical Hierarchical Process (AHP) is a decision-making method developed for prioritizing alternatives when multiple criteria must be considered and allows the decision maker to structure complex problems in the form of a hierarchy, or a set of integrated levels. Mathematical programming models often consider only the more quantitative criteria; this approach includes the Artificial Neural Network (ANN). The ANN model saves money and time. The weakness of this model is that it demands specialized software and requires qualified personnel who are expert on this subject.

B. METHOD SELECTION

A vendor selection is a multi-objective problem involving quantitative & qualitative criteria. The organization has a very exhaustive vendor pre-qualification process but the lacks a basic technique to evaluate them. Analytic Hierarchy Process can play a vital role to tackle this deficiency if adeptly implemented in the evaluation process. The Analytic Hierarchy Process (AHP) is a structured technique for helping people deal with complex decisions involving multiple objectives. Rather than prescribing a "correct" decision, the AHP helps people to determine one that suits their needs and wants. Based on mathematics and psychology, it was developed by Thomas L. Saaty in the 1980s and has been extensively studied and refined since then. The AHP provides a comprehensive and rational framework for structuring a problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. It is used throughout the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education. Analytic hierarchical process was selected for vendor evaluation and rating out of the various methods. There are various reasons associated with the selection of this method; a few are the following;

- It incorporates both qualitative and quantitative factors into decision making.
- AHP allows decision makers to rank suppliers based on the relative importance of criteria.
- The method is ideal for ranking alternatives when multiple criteria and sub-criteria are present in decision making.
- Strength of this method lies in its ability to structure a complex, multi attribute problem hierarchically.
- Both weight of criteria and rank of suppliers are determined by one method while using AHP.

AHP offers a methodology to rank alternative courses of action based on the decision maker's judgments concerning the importance of the criteria and the extent to which they are met by each alternative. For this reason AHP is ideally suited for the supplier selection, evaluation problems. Managerial judgments are used to drive the AHP approach. These judgments are expressed in terms of pair wise comparisons of items on a given level of the hierarchy with respect their impact on the next higher level. Pair wise comparisons express the relative importance of one item over the other in meeting the goal or a criterion. This ratio scale for processing human judgments has been applied to variety of decision making problems in other fields, and it has been validated in situations where standard measures exist. Because AHP utilizes ratio scale for human judgments, the alternative weights reflect the relative importance of the criteria in achieving the goal of the hierarchy. AHP allow some small inconsistency in judgment because human is not always consistent. In order to measure the inconsistency in the users judgment Prof.Satty has suggested the calculation of consistency ratio (CR). CR is calculated from CI value which inturn is

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calculated from the largest Eigen value of the matrix. The formulas for the calculation of CI and RI are shown below;

$CI = (\lambda max - n) / (n - 1)$ (3.2.1)

$CR = CI / RI$ (3.2.2

Where,

λmax = largest Eigen Value
CI = Consistency Index (shows degree of consistency of our judgments)
CR = Consistency Ratio
N = Size of matrix
RI = Random Consistency Index [1,2]

Table .1: Random Consistency index

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 the CR value obtained is less than 0.10, inconsistency in human judgment is considered acceptable; otherwise it indicates that the judgment is highly inconsistent. The AHP approach as applied to supplier selection problem consists of the following five steps [3].

1. Specify the set of criteria for evaluating the suppliers.
2. Obtain pair wise comparision of the relative importance of the criteria in achieving the goal and compute weights of the criteria based on this information.
3. Obtain measures that describe the extent to which each supplier achieves the criteria.
4. Using information in step 3, obtain the pair wise comparision of the relative importance of the suppliers with respect to the criteria and compute the corresponding weights.
5. Using the results of step 2 and 4 compute the priorities of each suppliers.

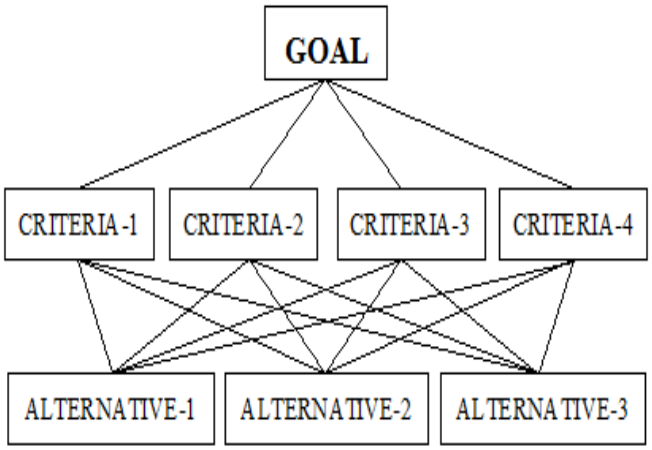

Fig.1: Hierarchichal structure

Hierarchical structure of the problem is shown in figure is given above. Level 0 is the goal of the analysis. Level 1 is multi criteria that consist of several factors. You can also add several other levels of sub criteria and sub-sub criteria. The last level is the alternatives. The lines between levels indicate relationship between factors, choices and goal. In level, 1 you will have one comparison matrix corresponds to pair-wise comparisons between 4 factors with respect to the goal. Thus, the comparison matrix of level 1 has size of 4 by 4. Because each choice is connected to each factor, and you have 3 choices and 4 factors, then in general you will have 4 comparison matrices at level 2. Each of these matrices has size 3 by 3.The scale of numbers that indicates how many times more important or dominant one element is over another element with respect to the criterion or property with respect to which they are compared is shown below . One compares a criteria indicated on the left with another indicated at the top and answers the question: How many times more, or how strongly more is that criteria than the one at the top? One then enters the number from the scale that is appropriate for the judgment: for example, enter 9 in the position meaning that this criterion is of extreme importance when compared with the other. It is automatic that 1/9 is what one needs to use in the transpose position. One always enters the whole number in its appropriate position and automatically enters its reciprocal in the transpose position.

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Table 2: Ratings

Rating	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2,3	Weak, moderate importance	Experience and judgement slightly favour one over the other
4,5	Moderate plus, strong importance	Experience and judgement strongly favours one over the other
6,7	Strong plus, very strong	An activity is very strongly favoured over the other
8,9	Very extreme importance	One activity is highly favoured over the other

C.IDENTIFYING THE KEY SUPPLIER EVALUATION FACTORS

The purchasing function directly affects the competitive ability of a firm. Purchasing managers need to periodically evaluate supplier performance in order to retain those suppliers who meet their requirements. The importance of incorporating multiple attributes into vendor evaluation is well established. The factors that could be considered while evaluating the supplier's performance [4] are quality, delivery, service, price, information system capability, overall personal capabilities, environmental regulation compliance, financial capabilities, etc. After discussions with the purchase officials of the ESS section certain supplier evaluation factors were selected and they are quality, delivery, service (rediness to help in emergencies, rediness to replace rejected materials, providing support documents in time, promptness in reply) and environmental regulation compliance. The Hierarchical structure of vendor rating (valves) is shown in figure 3.3.1.In the figure,1 indicates rediness to help in emergencies, 2 indicates rediness to replace rejected materials,3 indicates providing support documents in time and 4 indicates promptness in reply.

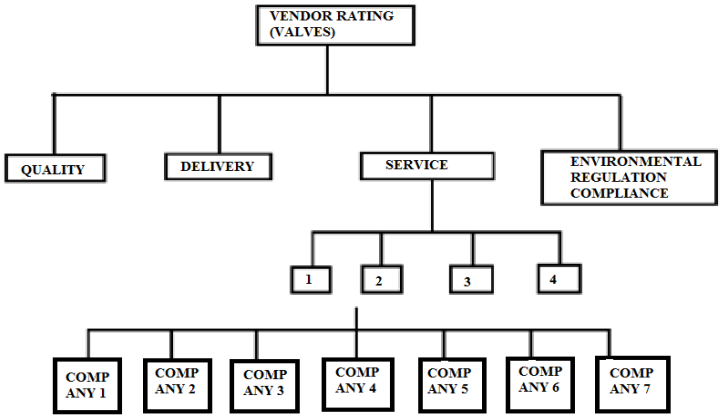

Fig 2. Hierarchical structure of vendor rating (valves)

D. DATA COLLECTION

Service related data was collected through a questionnaire to the ESS section official in charge of the purchase of valves. Answers to the questionnaire were used as data to assess the service provided by respective organizations. Environmental regulation compliance data was collected by direct enquiry to the companies and from their respective websites. The data collected is from the respective organizations. Quality and delivery related data are collected for a period of 1 year.

Table 3: Evaluation factors data
(Quality, Delivery, Environmental regulation compliance)

VENDOR	Quality Data		Delivery Data		Environmental Regulation Compliance Data
	No. of items rejected	No. of items purchased	No. of times delivery is not on time	No. of times items have been purchased	Certifications
Company 1	25	131	4	28	ISO 9001:2000, ISO 14001:2000
Company 2	21	89	4	23	ISO 9001:2008
Company 3	17	99	2	24	ISO 9001:2000
Company 4	12	76	4	12	ISO 9001:2000, ISO 14001:2000
Company 5	36	128	3	21	ISO 9001:2000

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Company 6	49	122	5	19	ISO 9001:2000
Company 7	23	110	4	24	ISO 9001:2000

The data that need to be collected for the various criterions for evaluation factors are listed in the below above.

E. DATA ANALYSIS

The Pair wise comparision of main criteria with respect to the Goal is shown in table given below.

Table 4 Pair wise comparision matrix of main criteria with respect to the Goal

	Quality Factor	Delivery Factor	Service Factor	Environmental Factor	Priority
Quality Factor	1	2	2	8	0.446
Delivery actor	½	1	1	7	0.2556
Service Factor	½	1	1	7	0.2556
Environmental Factor	1/8	1/7	1/7	1	0.0428

λmax = 4.0503CI = 0.0168 CR = 0.0186

The above matrix indicates how important each criterion is with respect to each other. The priorities of each factor are a measure of their importance. The matrix has an acceptable CR value indicating consistency in judgment.

1 QUALITY

The data collected is converted into parts per million by the following formula

PPM= (No of items rejected/No of items purchased) × 1000000

Here PPM means no of items rejected not meeting the specifications per one million items (Douglas C Montgomery, 2004).

Table 5.Data for Quality evaluation

VENDOR	No of items rejected	No of items purchased	PPM
Company 1	25	131	190840
Company 2	21	89	235955
Company 3	17	99	171717
Company 4	12	76	157895
Company 5	36	128	281250
Company 6	49	122	401639
Company 7	23	110	209091

Depending on data from the above table pair wise comparision between the various vendors with respect to quality is made. The vendor with least PPM gets the best rating in the preceding table.

Table 6 Pair wise comparision matrix of vendors with respect to Quality

	Company 1	Company 2	Company 3	Company 4	Company 5	Company 6	Company 7	Priority
Company 1	1	3	½	1/3	4	6	2	0.1594
Company 2	1/3	1	¼	1/5	2	4	1/2	0.0715
Company 3	2	4	1	½	5	7	3	0.2374
Company 4	3	5	2	1	6	8	4	0.3501
Company 5	¼	½	1/5	1/6	1	3	1/3	0.0488
Company 6	1/6	¼	1/7	1/8	1/3	1	1/5	0.0261
Company 7	½	2	1/3	¼	3	5	1	0.1067

λmax = 7.3397CI = 0.0566 CR = 0.0429 .The matrix has an acceptable CR value indicating consistency in judgement.

2 DELIVERY

The delivery data collected is shown in table given below.

Table 7: Delivery related data

VENDOR	No of times delivery is not on time	No of times items have been purchased	PPM
Company 1	4	28	142857.143
Company 2	4	23	173913.043
Company 3	2	24	83333.333
Company 4	4	13	307692.308

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Company 5	3	21	142857.143
Company 6	5	19	263157.895
Company 7	4	24	166666.667

The data collected is converted into parts per million by the following formula;

PPM= (No of times delivery is not on time/No of times items have been purchased) × 1000000

PPM means no of times delivery is not meeting the agreed delivery time per one million deliveries. 0-3 day's early delivery is considered on time and all other deliveries as not on time. Depending on data from the above table pair wise comparision between the various vendors with respect to delivery is made. The vendor with least PPM gets the best rating in the preceeding table.

Table 8: Pair wise comparision matrix of vendors with respect to Delivery

	Company 1	Company 2	Company 3	Company 4	Company 5	Company 6	Company 7	Priority
Company 1	1	2.5	1/3	7	1	6	2	0.1759
Company 2	1/2.5	1	1/5	6	1/2.5	5	1/2	0.0941
Company 3	3	5	1	2	3	7	4	0.372
Company 4	1/7	1/6	1/8	1	1/7	1/3	1/6.5	0.0234
Company 5	1	2.5	1/3	7	1	6	2	0.1759
Company 6	1/6	1/5	1/7	3	1/6	1	1/5	0.0371
Company 7	1/2	2	¼	6.5	1/2	5	1	0.1215

λmax = 7.5524CI = 0.0921 CR = 0.0697

The matrix has an acceptable CR value indicating consistency in judgement.

3 SERVICE

Service criterion is divided into four sub-criterions, and hence the importance of the sub-criterions with respect to each other is calculated and shown in the table below. The value of priorities indicates each sub-criterions importance, higher the priority value more important is the sub-criterion. In the current situation rediness to help in emergencies and rediness to replace rejected materials has higher importance than the other sub-criterions. The table given below shows pairwise comparision matrix of sub-criteria with respect to service

Table 9: Pairwise comparision matrix of sub-criterions of service

	Rediness to help in emergencies	Rediness to replace rejected materials	Providing support documents in time	Promptness in reply	Priority
Rediness to help in emergencies	1	1	3	3	0.375
Rediness to replace rejected materials	1	1	3	3	0.375
Providing support documents in time	1/3	1/3	1	1	0.125
Promptness in reply	1/3	1/3	1	1	0.125

λmax = 4.0000CI = 0.0000 CR = 0.0000

The matrix has an acceptable CR value indicating consistency in judgement.

Pair wise comparison matrix of various vendors with respect to their rediness to help in emergencies

The following matrix shows the various organizations willingness to help when there is an emergency. Higher the priority value better is the company's rediness to help in emergencies.

Table 10: Pair wise comparison matrix of vendors with respect to their rediness to help in emergencies

	Company 1	Company 2	Company 3	Company 4	Company 5	Company 6	Company 7	Priority
Company 1	1	1/2	1/5	5	4	6	2	0.1484
Company 2	2	1	¼	6	5	7	2	0.1954
Company 3	5	4	1	7	6	8	5	0.4163
Company 4	1/5	1/6	1/7	1	1/3	3	1/4	0.0404
Company 5	¼	1/5	1/6	3	1	4	1/3	0.0645
Company 6	1/6	1/7	1/8	1.3	1/4	1	1/5	0.0248
Company 7	½	1/2	1/5	4	3	5	1	0.1104

λmax = 7.8512CI = 0.1419 CR = 0.1075

The matrix has an acceptable CR value indicating consistency in judgement.

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2 Pair wise comparision matrixes of various vendors with respect to their rediness to replace rejected materials

The following matrix shows the various organizations willingness to replace rejected materials. Higher the priority value better is the company's rediness to replace rejected materials.

Table 11: Pair wise comparision matrix of various vendors with respect to their rediness to replace rejected materials

	Company 1	Company 2	Company 3	Company 4	Company 5	Company 6	Company 7	Priority
Company 1	1	1	1/5	4	3	4	3	0.1539
Company 2	1	1	1/5	4	3	4	3	0.1539
Company 3	5	5	1	8	6	8	6	0.4559
Company 4	1/4	¼	1/8	1	1/3	1	1/4	0.0349
Company 5	1/3	1/3	1/6	3	1	3	1	0.0775
Company 6	1/4	¼	1/8	1	1/3	1	1/4	0.0349
Company 7	1/3	1/3	1/6	4	1	4	1	0.089

λmax = 7.5896CI = 0.0983 CR = 0.0744

The matrix has an acceptable CR value indicating consistency in judgement.

3 Pair wise comparision matrix of various vendors with respect to providing support documents in time

The following matrix shows the various organizations performance with respect to providing support documents in time.

Table 12: Pair wise comparision matrix of various vendors with respect to providing support documents in time

	Company 1	Company 2	Company 3	Company 4	Company 5	Company 6	Company 7	Priority
Company 1	1	1	1	1	2	2	1	0.1667
Company 1	1	1	1	1	2	2	1	0.1667
Company 3	1	1	1	1	2	2	1	0.1667
Company 4	1	1	1	1	2	2	1	0.1667
Company 5	1/2	1/2	½	1/2	1	1	1/2	0.0833
Company 6	1/2	1/2	½	1/2	1	1	1/2	0.0833
Company 7	1	1	1	1	2	2	1	0.1667

λmax = 7.0000CI = 0.0000 CR = 0.0000

The matrix has an acceptable CR value indicating consistency in judgement.Higher the priority value,better is the company's rediness to replace rejected materials. Providing of support documents in time is considered because unless and untill all documents are provided the purchase process cannot be completed. Hence this criterion is given consideration while evaluating the supplier's performance.

4 Pair wise comparision matrix of various vendors with respect to promptness in reply

The following matrix shows the various organizations performance with respect to its promptness in reply. Higher the priority value better is the company's promptness.

Table 13 Pairwise comparision matrix of various vendors with respect to promptness in reply

	Company 1	Company 2	Company 3	Company 4	Company 5	Company 6	Company 7	Priority
Company 1	1	1	1	2	2	3	2	0.2057
Company 2	1	1	1	2	2	3	2	0.2057
Company 3	1	1	1	2	2	3	2	0.2057
Company 4	1/2	1/2	½	1	1	2	1	0.1073
Company 5	1/2	1/2	½	1	1	2	1	0.1073
Company 6	1/3	1/3	1/3	½	1/2	1	1/2	0.061
Company 7	1/2	1/2	½	1	1	2	1	0.1073

λmax = 7.0172CI = 0.0029 CR = 0.0022

The matrix has an acceptable CR value indicating consistency in judgement.

The final table combines the matrixes of all criterions and sub-criterions into one matrix. It is in this final matrix that all the weights are multiplied in order to get the overall supplier performance. The performance of suppliers (priorities) with respect to each criterion and sub-criterion of each vendor is multiplied with the individual weights

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of all the criterions and added together to obtain individual scores of respective vendors. Once the individual scores are calculated ranking of suppliers based on the respective score could also be carried out.

Table 14: Final Table

	QualityFactor 0.4460	Delivery Factor 0.2556	Service Factor 0.2556				Environmental Factor 0.0428	
Vendor Name			Rediness to help in emergency 0.375	Rediness to replace rejected materials 0.375	Providing support documents in time 0.125	Promptness in reply 0.125		**Individual Score**
Company 1	0.1594	0.1759	0.1484	0.1539	0.1667	0.2057	0.3913	**0.1737**
Company 2	0.0715	0.0941	0.1954	0.1539	0.1667	0.2057	0.0435	**0.1032**
Company 3	0.2374	0.372	0.4163	0.4559	0.1667	0.2057	0.0435	**0.2983**
Company 4	0.3501	0.0234	0.0404	0.0349	0.1667	0.1073	0.3913	**0.1948**
Company 5	0.0488	0.1759	0.0645	0.0775	0.0833	0.1073	0.0435	**0.0883**
Company 6	0.0261	0.0371	0.0248	0.0349	0.0833	0.061	0.0435	**0.0333**
Company 7	0.1067	0.1215	0.1104	0.089	0.1667	0.1073	0.0435	**0.1084**

F. OVERALL SUPPLIER RANKING

The Overall Supplier Ranking is shown in the table given below.

Table 15: Overall Supplier Ranking

Rank	Vendor Name	Individual Score	Idealised Score
1	Company 3	0.2983	1
2	Company 4	0.1948	0.653
3	Company 1	0.1737	0.5822
4	Company 7	0.1084	0.3632
5	Company 2	0.1032	0.3458
6	Company 5	0.0883	0.2959
7	Company 6	0.0333	0.1117

The above table shows the ranking of suppliers based on the various criterions and sub-criterions. An idealized score which shows how all the vendors perform with respect to the best vendor is also presented.

IV. CONCLUSION

Absence of a vendor evaluation and rating system in the organizations purchase department was taken as the study. A Vendor evaluation and rating system that incorporates the company's evaluation criterions was successfully developed using AHP technique. The ranking of suppliers based on the various criterions and sub-criterions was formed .An idealized score which shows how all the vendors perform with respect to the best vendor is also formulated.

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