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THE PERFORMANCE EVALUATION OF AN EMPLOYEE USING ANALYTICAL HIERARCHY PROCESS

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ABSTRACT

The Performance Evaluation of an Employee consists of analyzing and measuring the performance of different employees in order to rank and evaluate for improving the competitiveness or for the selection of an employee for a post. In the case of evaluation or selection of an employee many conflicting factors are to be taken into account in the analysis, and the problem can be tackled using multi-criteria models and methods. In this work a study of different factors are considered for the evaluation or selection of an employee. Here the use of Analytical Hierarchy Process (AHP) methodology is studied. Crucial aspects which arise when the methodology is actually applied for the evaluation of selection of an employee are identified and discussed.

Keywords: *Employee Evaluation and AHP*

1. Introduction

In any organization, the evaluation or selection of an employee is a very difficult task. The evaluation depends on many factors. One employee may excel in one area whereas the other may excel in another area. When it comes to the evaluation of a particular employee, it is done arbitrarily, basing on the weightage given in the area in which he excels. But in this competitive world, it has been a challenge for the employer to compare his employees at the time of assigning an important task, or at the time of promotion or a hike in the salary.

When the employer wants to take a decision impartially, basing on the abilities of the employee a suitable method of study is not available to compare different employees.

Therefore, organizations need to identify ways and means to take the decision in an impartial way. This not only improves the quality of the decision, the employee also will be happy that the decision is taken in an impartial way and the one with low performance will try to improve his performance to be successful, when he is considered for evaluation for the promotion or a pay hike next time. This problem can be compared with the problem of a supplier selection problem in the supply chain management. A key role is played by the supplier evaluation process (Sarkara and Mohapatrab, 2006; Saen, 2007). In particular, suppliers' selection has assumed a strategic role in determining large customer firms' competitiveness. This employee evaluation process can be compared with the suppliers' selection process.

The Employee evaluation consists of analyzing and measuring the performance of a set of parameters in order to rank and select them to improve the competitiveness of the entire organization. Many conflicting factors should be taken into account in the analysis, both qualitative and quantitative. Several approaches and methodologies like artificial intelligence, qualitative and descriptive models have been developed to cope with this problem. When there are number of factors, there is little empirical evidence of the practical usefulness of the tools in the evaluation of the employee. There is little empirical evidence of the practical usefulness of such tools in the selection process (de Boer and van der Wegen, 2003). These methodologies are often tested on some numerical examples, without emphasis on the development process and on the real appreciation by the user. The problem is intrinsically multi-objective.

A well known methodology Analytical Hierarchical Process (AHP) developed by Saaty (1980 and 1994) is a theory of measurement that depends on the values and judgments of individuals and groups. In particular the method is based on an evaluation model structured in a hierarchical way. Weights are assigned to each criteria or sub-criteria through pair-wise comparisons using a "semantic" scale to define their relative importance. Due to this sophisticated technique

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to derive weights avoiding the use of absolute numerical values in judgments, the AHP has been widely applied to solve several decision making problems like location or investment selection, and projects ranking etc.

In this paper it is focused on the application of the AHP and its numerous variants for the employee evaluation. The aim is to identify and evaluate different criteria and to discuss crucial aspects which arise when the methodology is actually applied in real cases.

Various factors are identified which are used for the employee evaluation. A brief description of AHP and its possible variants is provided. A specific focus on the use of the AHP and its variants for the employee evaluation is given. And some crucial aspects related to the use of multi criteria approaches and of AHP-based methods are discussed.

2. The Factors in the Employee Evaluation

The evaluation of an employee is a multi factorial problem. When the employees are to be evaluated in different areas of skills, each one's skills differ from one another. One may be very good and highly effective in one area of doing the tasks and the other may be good in other areas. So at the time of selection of personnel, it is difficult to judge and select a particular person for the job. The personnel should have a set of competencies to be a part of the system.

The study on the supplier selection can be compared to the selection of the personnel. It is studied in two different stages (de Boer et al., 2001). The first concerns the selection process (selection problem) of new suppliers for inclusion in a supplier list. Selecting the right supplier is a difficult task as suppliers are characterized by strengths and weaknesses which require careful evaluation. It is done through a ranking process (ranking problem) of a set of suppliers previously qualified. The second phase regards the monitoring and control of the suppliers' behaviour. This same methodology can be applied here to the personnel selection with the objective of optimizing a given utility function.

Traditionally, supplier evaluation was fundamentally based on financial measures; recently, more and more emphasis has been devoted to other aspects, bringing multiple criteria into the evaluation process. Dickson (1966) analyzed and showed that quality, delivery and performance history could be considered, in the selection of the supplier. Ha and Krishnan (2008) updated this set of attributes as shown in Table 1. These attributes when analyzed show the complexity of the problem as many conflicting factors are taken into account. Moreover, while some of these factors can be easily measured some others are qualitative concepts: the aggregation of these attributes in a final judgment can result in a tricky problem. Combining the qualitative and quantitative factors in the analysis of the problem is not an easy task. So, here the AHP is considered for analyzing such factors and select a personal with different criteria.

AHP has the ability to handle qualitative and quantitative attributes (by providing suitable quantification using a semantic scale (Wedley, 1990).

3. The Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) proposed by (Saaty 1986) simplifies the problem of decision making by forming problem into matrices. It is formed by forming a mathematical structure of consistent matrices and they are solved for the eigenvector's to generate true or approximate weights, Merkin (1979); Saaty (1980, 1994).

The AHP methodology compares criteria, or alternatives with respect to a criterion, in a natural, pair wise mode. The AHP uses a fundamental scale of absolute numbers that has been proven in practice and validated by physical and decision problem experiments. The fundamental scale has been shown to be a scale that captures individual preferences with respect to quantitative and qualitative attributes just as well or better than other scales (Saaty 1980, 1994). It converts individual preferences into ratio scale weights that can be combined into a linear additive weight for each alternative. The resultant can be used to compare and rank the alternatives and, hence, assist the decision maker in making a choice.

In this study, all the criteria are rated from 1 to 9 when compared with all other criteria. They are given in the Table 1 (Crowe et al., 1998; Saaty, 2000; Hafeez et al., 2002)

Following are the steps used in this process:

i. Synthesis of priorities for all the criteria and measurement of Consistency Ratio (CR).
ii. Prioritizing of different attributes of the personnel who is going to be selected.
iii. Synthesis of overall priority matrix.

3.1 Synthesis of priorities and the measurement of consistency

The pair-wise comparisons of the criteria of personnel 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.

Table 1: Scale of Preference between Two Elements

S.No	Preference weights/ level of importance	Definition	Explanation
1	1	Equally Preferred	Two activities contribute equally to the objective
2	3	Moderately Preferred	Experience and judgment slightly favour one activity over another
3	5	Strongly Prefer-red	Experience and judgment strongly or essentially favour one activity over another
4	7	Very Strongly Preferred	An activity is strongly favoured over another and its dominance demonstrated in practice
5	9	Extremely Preferred	The evidence favouring one activity over another is of the highest degree possible of affirmation
6	2,4,6,8	Inter-mediate Values	Used to represent compromise between the preferences listed above
7	Reciprocals	Reciprocals	For Inverse Comparison

The λ_{max} value is an important validating parameter in AHP. It is used for calculating the Consistency Ratio CR (Saaty, 2000) 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 eigenvector or the relative weights and λ_{max} for each matrix of order *n*.

Step 2: Consistency Index is calculated for each matrix of order *n* by the formula:

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

Step 3: Consistency ratio is then calculated using the formula:

$$CR = CI / RI \qquad - \ (2)$$

Where, RI is Random Consistency Index
CI is Consistency Index
CR is Consistency Ratio.

The Random Consistency Index (RI) varies with the order of matrix. Tables 2 shows the value of the Random Consistency Index (RI) for matrices of order 1 to 10 obtained by approximating random indices using a sample size of 500 (Saaty, 2000).

Table 2: Average Random Index (RI) based on Matrix Size (Saaty, 2000)

Size of Matrix (n)	Random Consistency Index (RI)
1	0
2	0
3	0.52
4	0.89
5	1.11
6	1.25
7	1.35
8	1.40
9	1.45
10	1.49

The Consistency Ratio values are calculated, and they must be checked whether they are within the limits or not. The acceptable CR range varies according to the size of matrix. It is 0.05 for a 3 by 3 matrix, 0.08 for a 4 by 4 matrix and 0.1 for all larger matrices, $n \geq 5$ (Saaty, 2000, Cheng and Li, 2001).

If the value of CR is equal to, or less than that value, it implies that the evaluation within the matrix is acceptable level of consistency in the comparative judgments represented in that matrix. Whereas the higher values of CR indicates inconsistency of judgments within that matrix. Then the evaluation process should be reviewed, reconsidered for improvement. An acceptable consistency ratio helps to ensure decision-maker reliability in determining the priorities of a set of criteria.

3.2 The problem of prioritizing the attributes

The pair wise comparison of all criteria for each person is studied. For each criterion, a priority matrix is taken and the procedure explained above is followed to get the result.

3.3 Synthesis of overall priority matrix

After the synthesis of priority matrices for the criteria of evaluation of the employee for every criterion, an overall priority matrix is synthesized. This priority matrix is obtained by multiplying the priority matrix obtained for each criterion for various types of industry with the priority matrix obtained by the comparison of criteria itself. The matrix thus synthesized will give the overall priority matrix.

3.4 The Evaluation / Selection Process using AHP

Evaluation or Selection of personnel is a typical Multi Criteria Decision Making (MCDM) problem involving multiple criteria that are both qualitative and quantitative (Sonmez, M., 2006). It involves many criteria. These criteria may vary depending on the type of organization for which the personnel selection is considered and it involves many judgmental factors (Sarkis, Alluri, 2002), (Jayaraman, Srivastava, Benton, 1999). Some criteria which are generally used in the selection of the personnel are considered here. They are Marketing Skills, Administrative Skills, Communication Skills and Supervisory Skills, Technical Skills and any other skills that are required for a particular organization can be included. Here the problem is how to select a particular person who can perform optimally on the desired criteria. AHP (Analytical Hierarchy Process) is one of the most extensively used MCDM methods. It can handle the multi criteria and helps the decision maker for the selection of personnel. The overall goal is depicted in the figure 1.

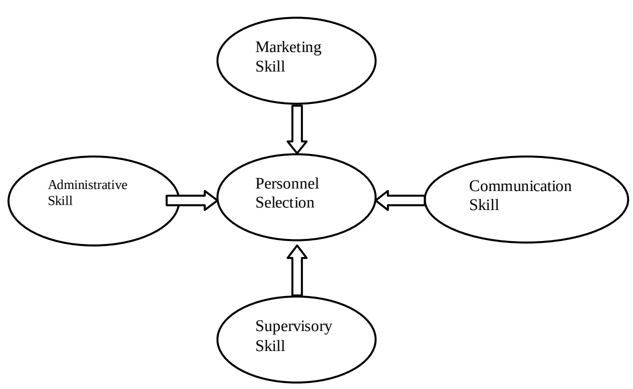

Fig. 1 Criteria for the Selection Process

3.5 Model development

A hierarchy model for the Selection or Evaluation of the personnel is designed as shown in the fig.2. A three level hierarchical decision making process is considered here.

Level 1:

The objective or the overall goal of the decision is selected at the top level of hierarchy. In this case it is the selection of the Personnel.

Level 2:

The Second level shows the main criteria affecting the selection of the personnel. Four skills are considered for the criteria. They are Marketing Skills, Administrative Skills, Communication Skills and Supervisory Skills.

Level 3:

It is the Lower level of Hierarchy. Here various alternatives are considered. The Personnel who are considered for selection or evaluation are considered here. P1, P2, P3… are the Personal considered.

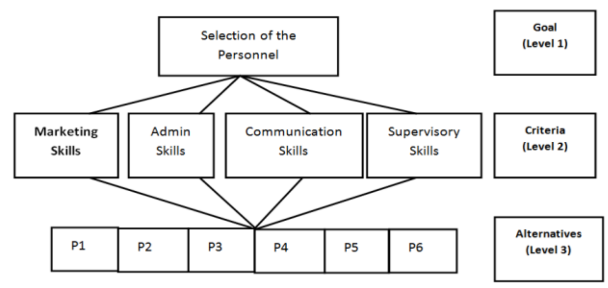

Fig. 2 A Hierarchy Model for the Selection of Personnel

3.6 Problem formulation – construction of pair wise comparison matrix

At each level of the hierarchy, a matrix will collect the pair wise comparisons. It is a known fact that it is easier to express one's opinion on only two alternatives than simultaneously on all the alternatives. It also allows checking the consistency between the different pair wise comparisons. A pair-wise comparison matrix (size n × n) is constructed for the lower levels with one matrix in the level immediately above. The order of the matrix at each level depends on the number of elements at the lower level that it links to. The number of matrices depends on the number of elements at each level. Here the number of judgments required is n × (n –1). These judgments are based on the decision maker's experience. Using this pair wise comparison, the matrix is filled. It is shown in the Table 3.

Table 3: Pair Wise Comparison for the Overall Goal

Overall Goal	Marketing Skill	Administrative Skill	Communication Skill	Supervisory Skill
Marketing Skill	1	3	2	4
Administrative Skill	1/3	1	2	3
Communication Skill	1/2	1/2	1	4
Supervisory Skill	1/4	1/3	1/4	1
Column Total	2.08	4.83	5.25	12.00

3.7 Methodology of solving the problem

The vectors of priorities are calculated by the average of normalized column. Then this Averaged Normalized Column is to divide the elements of each column by the sum of the column elements and then add the element in each resulting row and divide this sum by the number of elements in the row (n). This is a process of averaging over the normalized columns. The summary results for this calculation are shown in Table 4. In mathematical form, the vector of priorities can be calculated as

$$W_i = \frac{1}{n}\sum_{j=1}^{n}\frac{a_{ij}}{\sum_1^n a_{ij}}, \quad i, j = 1,2, \ldots n \qquad (1)$$

The calculation for the first priority vector is as follows

The first step is totaling all the elements in the column.

The second step is dividing the elements by the corresponding total of that column.

And the third step is totaling thus obtained elements in the table and finally the sum of the corresponding row is divided by the number of elements.

Table 4: Synthesized Matrix

Overall Goal	MS	AS	CS	SS	Total Row	Priority Vector	New Vector
MS	0.480	0.621	0.381	0.333	0.815	0.454	0.956
AS	0.160	0.207	0.381	0.250	0.998	0.249	0.074
CS	0.240	0.103	0.190	0.333	0.867	0.217	0.888
SS	0.120	0.069	0.048	0.083	0.320	0.080	0.331

Where, MS–Marketing Skill, AS–Administrative Skill, CS–Communication Skill & SS – Supervisory Skill.

3.8 Eigenvalue (λmax)

A New vector is obtained by multiplying the matrix of judgments with the priority vector. Then by dividing all these elements of the weighted sum matrices or the new vector by their respective priority vector elements results in the values:

1.956/0.454 = 4.31; 1.074/0.249 = 4.31;
0.888/0.217 = 4.10; 0.331/0.08 = 4.14;

Then the average of these values are calculated to obtain λ_{max} = (4.31 + 4.31 + 4.1 + 4.14) /4 = 4.21

Consistency Index (CI) = (λmax– n) / (n – 1) = Where n is the matrix size.

CI = (4.21 – 4) / (4 – 1) = 0.071

Consistency Ratio (CR) CR = CI/RI

Appropriate value of Random Index (RI=0.89 for a 4 x 4 matrix) from table 2 is considered.

CR = CI/RI = 0.071/0.89 = 0.08.

As the value of CR is less than 0.1, the values taken for the pair wise comparisons are acceptable.

The same calculations are done for all the levels in the Hierarchy Model when there are many number of levels. But here in this case it is a 3 level Model. So next the priority vectors are obtained for the alternatives. For convenience sake, the priority matrix for the alternatives are calculated and the final priority vectors are given here.

Table 5: The Consistency Test for Alternatives

	Criterion			
	MS	AS	CS	SS
	0.454	0.249	0.217	0.08
Alternatives				
P1	0.325	0.212	0.325	0.367
P2	0.162	0.188	0.362	0.229
P3	0.214	0.262	0.159	0.161
P4	0.136	0.428	0.235	0.293
P5	0.106	0.308	0.106	0.095
P6	0.058	0.057	0.046	0.040
Consistency Test				
λ_{max}	6.55	6.48	6.26	6.14
CI	0.111	0.096	0.052	0.028
RI	1.25			
CR	0.089	0.077	0.042	0.023

4. Developing Overall Priority Rank

After testing the consistency of the alternatives also, the final overall Priority Vector is calculated for all the criteria and alternatives.eg. 0.325 * 0.454 + 0.212 * 0.249 + 0.325 * 0.217 + 0.367 * 0.08.

Table 6: The Priority Vector

	Criteria				
	MS	AS	CS	SS	Overall Priority
	0.454	0.249	0.217	0.08	
	Alternatives				
P1	0.325	0.212	0.325	0.367	0.300
P2	0.162	0.188	0.362	0.229	0.217
P3	0.214	0.262	0.159	0.161	0.210
P4	0.136	0.428	0.235	0.293	0.243
P5	0.106	0.308	0.106	0.095	0.155
P6	0.058	0.057	0.046	0.040	0.054

Table 7: Selection based on Priority

Sl. No.	The Result	Priority
1	P1	0.300
2	P4	0.243
3	P2	0.217
4	P3	0.210
5	P5	0.155
6	P6	0.054

5. Results

From the Table 7, the candidate P1 with highest value 0.300 (30 %) is the best candidate to select with the given criterion of selection. The Second Candidate will be P4 with 0.243 (24.3%) and the next order of priority goes to the candidates P2, P3, P5 with 0.217 (21.7%), 0.21 (21%), 0.155 (15.5%) and the last candidate will be P6 with only 5.4% preference.

6. Conclusion

The AHP is a very convenient tool for solving Multi Criterion Decision Making situations. AHP is helpful in the evaluation or selection of an employee based on the criterion and sub criterion of a decision. This analysis reveals that P1 is the best candidate with the highest value (0.3 or 30%) among all the other candidates. And the candidate P6 is very much behind compared to all other candidates (with a value of 0.54 or 5.4%) and needs to improve his skills. This technique can be applied not only in the field of engineering but also in various walks of life in complex MCDM situations.

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