Application of Analytical Hierarchy Process (AHP) Model to Employee Selection, Promotion and Succession Planning

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ABSTRACT

One of the most important decisions facing HR departments is choosing the best candidate considering the large number of options available to them. Making selection decisions can be made easier with the use of decision support models. One of such models is the Analytical Hierarchy Process (AHP) developed by Thomas Saaty (1977). The AHP approach views the decision problem as a hierarchy of objectives, whose variables and decision alternatives are weighed to reach a decision. The AHP has been applied to a variety of business decisions and processes. It is more systematic and consistent than traditional ranking methods.

The purpose of this paper is to demonstrate how the Analytical Hierarchy Process (AHP) can be applied to achieve an optimal selection of employees. The paper presents the theory of AHP and explains step by step how to apply it to a typical recruitment and selection case. The software package used in the example is Auto Decision Maker (AutoDM) developed by the author.

It should be pointed out that the focus of this paper is on the theory and application of the AHP decision making model rather than the actual process of recruitment and selection.

INTRODUCTION

Employment recruitment is composed of several stages: verifying that a vacancy exists; drawing up a job specification; finding candidates; selecting them by interviewing and other means such as conducting a psychometric test; and making a job offer. One of the most difficult decisions facing HR Management is choosing the best candidate considering the sheer number of options available to them.

Selection assessment commonly utilises a variety of methods – for example, references, application forms, CVs, interviews, tests and assessment centres that may involve work simulation, sample exercises, group activities etc. After all these methods of data collection the question is: how to choose the right candidate from the most qualified persons to fill the vacant position?

Selection is the process of choosing individuals who have relevant qualifications to fill vacant positions. ‘Selection' is a strategic operation not a tactical one. It is crucial to ensure that the selection process is systematic and that the eventual selection decisions are reliable, valid, standardised and free from bias.

There are many ways to classify decisions. A common method is based on the selection of criteria. With this method we can identify two types of decisions: single criterion decisions, and multiple criteria decisions. Single criterion decisions are obviously based on one criterion and are usually easy decisions to make. For example, deciding to purchase a car based only on its price.

Multi criteria decisions are more difficult, and their difficulty increases in proportion to the number of criteria we use. In choosing a car, for example, we may find that in addition to the price, other factors such as reliability, comfort, spare-parts, performance etc also have to be taken into account.

Decision-making becomes even more complicated when the criteria differ in relative importance. Some people, for example, may consider the comfort of the car is most important, while others may rate performance as the most desirable quality and so on.

The process of identifying an alternative that involves appropriate tradeoffs and stakeholder input can be aided with decision support tools such as Multiple Criteria Decision Making (MCDM) facilitates identification of an alternative that best meets a set of criteria. The ability of MCDM to handle multiple criteria represented in different units makes it an appealing decision support framework for many applications. It has received widespread attention and its application to many areas is being explored.

The MCDM can be defined as a group of techniques with the following characteristics:

- A finite number of alternatives or options;
- A set of attributes by which the alternatives are judged; and
- A method of ranking the alternatives based on how well they satisfy the attributes.

The decision process phases are:

(1) Defining the objectives,
(2) Choosing the attributes,
(3) Specifying the alternatives,
(4) Transforming the attribute scales into commensurable units,
(5) Assigning weights to the attributes which reflect their relative value to the decision maker,
(6) Selecting and applying an algorithm for ranking the alternatives, and
(7) Choosing an alternative. In practice this process is highly iterative.

Objectives in an MCDM problem are often generated using a hierarchical approach. In this method, the most general, overriding objective is specified first. It is then progressively broken down into more specific objectives that can, in turn, be broken down into sub-objectives. At the fingertips of the hierarchy lies the attributes or criteria. In most cases, the stakeholders will apply weights to the objectives. Placing weights on attributes tends to be a more scientific/technical task that is undertaken by experts or the decision analyst.

Employment selection is a multi criteria decision making (MCDM) problem. A large variety of algorithms and techniques can be employed to achieve best results in employment selection, as there are different ways to weight the objectives, rank the alternatives and standardise the data.

CRITERIA FOR SELECTION

Decisions involving multiple criteria are the most difficult to make and yet they are often the most crucial. Identifying the criteria relevant to the decision being made and determining their relative importance usually requires both expert judgement and specialised techniques.

Selection processes should be based on ability to do the job, ability to make a contribution to the organisation's effectiveness and potential for development.

Consider the example of deciding which job applicants to hire. Here, identifying the relevant criteria is likely to be relatively straight-forward.

Selection should be based on job-related qualifications including, but not limited to: required or preferred education; experience; and knowledge, skills, and abilities as identified in the job description.

The hard bit, however, is determining the relative importance of the criteria so that when the applicants are assessed according to the criteria, they are ranked from best to worst, or at least the best applicant is identified.

Most criteria and sub-criteria's parameters may be determined from main areas of evaluating candidates such as:

- Education
- Experience

- General Traits
- Leader's Features
- Predispositions

Another example of general criteria for selecting a successor are:

- Availability
- Capability
- Competency
- Commitment

One of the challenges associated with selection criteria is that they don't remain constant, and that they depends on nature of the job or position.

Criteria should be judged against what the decision maker(s) feel are the most important qualities. Brainstorming may be a useful way for a group to agree appropriate criteria.

MULTIPLE CRITERIA DECISION MAKING

Real-world decision-making problems are usually too complex and ill-structured to be considered through the examination of a single criterion, attribute, or point of view that will lead to the optimum decision. In fact, such a unidimensional approach is merely an oversimplification of the actual nature of the problem at hand, and it can lead to unrealistic decisions. A more appealing approach would be the simultaneous consideration of all pertinent factors that are related to the problem. However, through this approach some very essential issues/questions emerge: how can several and often conflicting factors be aggregated into a single evaluation model?

Addressing such issues constitutes the focal point of interest in multiple-criteria decision making (MCDM). MCDM constitutes an advanced field of operations research that is devoted to the development and implementation of decision support tools and methodologies to confront complex decision problems involving multiple criteria, goals, or objectives of conflicting nature.

THE ANALYTICAL HIERARCHY PROCESS (AHP)

The Analytic Hierarchy Process (AHP) is a powerful and flexible decision making tool for complex, multi-criteria problems where both qualitative and quantitative aspects of a problem need to be incorporated.

The AHP helps decision makers structure the important components of a problem into a hierarchical structure similar to a family tree. Then, by reducing complex decisions to a series of simple comparisons and rankings, then synthesizing the results, the AHP not only helps arriving at the best decision, but also provides a clear rationale for the choice that has been made.

Designed to reflect the way people actually think, the AHP was developed by Thomas Saaty, more than 20 years ago and continues to be one of the most highly regarded and widely used decision-making theory.

The Analytic Hierarchy Process is a comprehensive methodology that provides groups and individuals with the ability to incorporate both qualitative and quantitative factors in the decision making process.

AHP is a general method for Structuring intricate or ill-defined problems and is built around three principles:

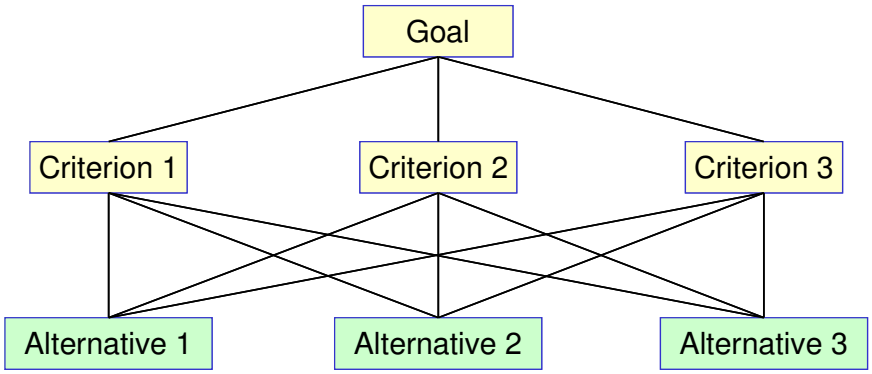
- The principle of constructing hierarchies.
- The principle of establishing priorities.
- The principle of logical consistency.

CONSTRUCTING HIERARCHIES

The AHP uses a hierarchical model comprised of a goal, criteria, perhaps several levels of sub criteria and alternatives for each problem or decision.

The simplest model of hierarchy consists of three levels:

- The main objective (goal),
- The criteria (attributes) and
- The options (alternatives)



Generally speaking, there are two types of attributes or criteria:

- Quantitative attributes such as prices, sizes, weights, time, number of defects...etc can be expressed in figures.
- Qualitative attributes such as quality of life, reputation, customer status, leadership ability, …etc, cannot be expressed directly in any unit.

ESTABLISHING PRIORITIES

The fundamental input to the AHP is the decision maker's answers to a series of questions of the general form, 'How important is criterion *A* relative to criterion *B*?' In other words AHP requires the decision maker to rate the importance of each attribute in pairs on a nine-point scale with 1 designating equal importance and 9 indicating absolutely more important.

The nine-point scale is based on experiments that tested how accurately people can assign numbers when comparing two objects, items, features or aspects. These comparisons are called absolute judgment (Miller). The table below shows this 9-point scale.

How important (or preferable) is *A* relative to *B*?	**Preference index**
Equally important	1
Moderately more important	3
Strongly more important	5
Very strongly more important	7
Absolutely more important	9
Intermediate values	2, 4, 6 and 8

The 9-point scale

If the judgement is that *B* is more important than *A*, then the reciprocal of the relevant index value is assigned. For example, if *B* is felt to be very strongly more important as a criterion for the decision than *A*, then the value $^1/_7$ would be assigned to *A* relative to *B*.

Pair Comparison

The pair comparison method has been found a simple and effective method to rank a set of items. Paired comparison gets decision makers to focus on only two decision elements at a time. This limited focus helps to maintain a cohesive thought pattern while simultaneously discussing all elements of the decision. This paired comparison focus also helps people understand each other and can bring consensus among divergent perspectives in a company.

Paired comparisons involve the comparison of each attribute against every other attribute in pairs. It forces the decision maker to thoroughly consider all the tradeoffs in a decision problem.

The number of comparisons is given by:

$$\boldsymbol{P} = \boldsymbol{n}(\boldsymbol{n}-1)$$

where $\boldsymbol{P}$ is the number of comparisons and $\boldsymbol{n}$ is the number of attributes/objectives.

A matrix instrument can be used to simplify the process of pair comparison as illustrated in the following figure:

Reference	A1	A2	A3	A4
A1	1			
A2		1		
A3			1	
A4				1

A four elements pair comparison matrix "judgment matrix".

The items to be ranked (A1, A2, …, An) are listed as column headings in any order from left to right in the matrix. The items are also listed as row headings in the same order from top to bottom in the matrix.

In the matrix, the comparisons are expressed by comparing the attribute in the left hand column with attribute in the row above.

The number of pairs in this matrix is 16 (4 x 4). Since comparing an element with itself doesn't mean any thing, the number of comparable pairs is 12 (= 16 – 4). The four shaded cells, with number "1" inside each of them, represent the comparison of each element with itself. Note also that the lower triangle of the matrix can easily be filled from the inverse of values in the upper triangle. In this case the number of comparisons is reduced to:

$$\boldsymbol{P} = \frac{\boldsymbol{n}(\boldsymbol{n}-1)}{2}$$

The cell “Reference” in the left-upper corner shows the reference which the comparison is made with respect to it. Any comparison, whether it is for attributes or alternatives, has to be made with respect to a certain reference attribute, goal or objective.

All pairs of items can then be judged in the permuted combinations, by sequentially comparing each column item to each row item.

Synthesis

Scoring of alternatives and criteria proceed interactively. Scores for each alternative are entered with respect to each sub criterion and a synthesised score is obtained by multiplying that score by the weight for that particular sub-criterion. The sum of the synthesised scores within each main criterion is determined and we proceed to the next level. This procedure uses a weighted average normalisation to combine the scores for the alternatives. The synthesised score for each alternative with respect to each main criterion are obtained by multiplying the lower level scores by the weight for a particular main criterion. These scores are summed to determine the overall score for each alternative with respect to the goal.

CONSISTENCY

Consistency of Judgment is the assurance that a set of values satisfies prescribed conditions.

The decision maker's estimates will not be perfectly consistent due to natural inconsistencies due to uncertainty inherent in human judgments. Hence, a mathematical procedure is required to estimate an underlying ratio scale based on an inconsistent judgment matrix.

In the AHP approach the maximum or principal eigenvalue of each matrix of pairwise comparisons is computed for checking the degree of inconsistency. If inconsistency is too high, it is necessary to review the judgments by means of new pairwise comparisons.

In order to measure the consistency of the evaluator's judgment through pairwise comparisons, the AHP model uses a **consistency index** (C.I.). The consistency index reflects the consistency of qualitative judgments of the importance of criteria and the impact of the degree (or strength) of importance on all comparisons.

AHP provides a table of different-order random matrices and their average consistencies. These random consistency numbers indicate on a random basis the numerical judgment, which can be used to compare with the C.I.

The ratio of C.I. to the random consistency number of the same size matrix is called the **consistency ratio** (C.R.). C.R. is a measure of inconsistency. Inconsistency less than .10 is considered to be appropriate. If the inconsistency is more than .10, the evaluator should reassess the adequacy of his pairwise comparisons and make revisions.

AutoDM uses the concept of consistency rather than inconsistency. Consistency more than 90% is considered to be appropriate. If it is less than 90%, the evaluator should reassess the adequacy of his pairwise comparisons and make revisions.

EXAMPLE:

Application of Analytic Hierarchy Process (AHP) Model to Employee Selection

The following is a simplified version of a real application of the AHP method.

Green Services Company looking to choose a manager from three short listed candidates:

- Ramsey Sayed
- Jamal Numan
- Sami Bakr

The company was looking to select the best candidate among these three. Therefore the overall goal was established as to select the "best candidate".

After some discussions and consultation the selection committee has established four major criteria for the selection process, as follows:

- Experience
- General Traits
- Education
- Leadership Features

Further, the General Traits criterion was broken down into three sub-criteria, they are:

- Morality
- Creativity
- Self-control

A description of the AHP procedure is given here in five steps. AHP Decision Making software (AutoDM) developed by the author is used in this example.

Step 1: Problem definition

The problem definition is summarised in the following table:

Criteria

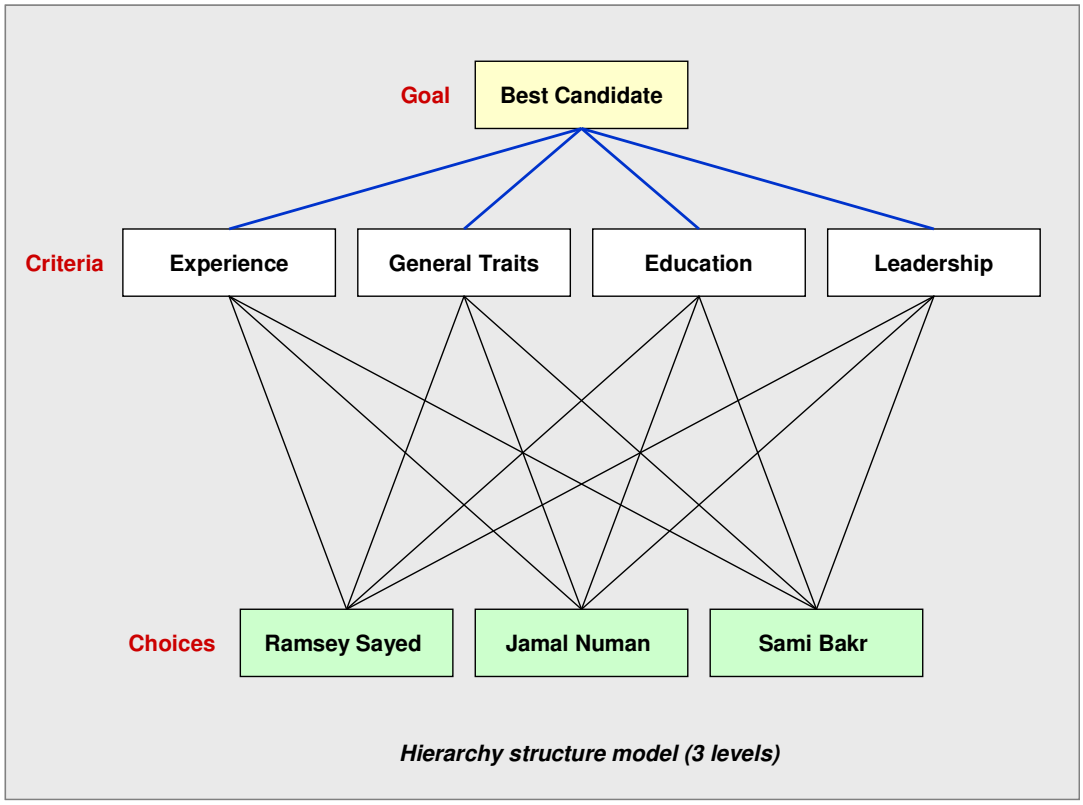
Overall goal	Criteria	Sub criteria
Select the best candidate	Experience	
	General Traits ➜	Morality
		Creativity
		Self-control
	Education	
	Leadership	

Alternatives (Choices)

Alternatives
Ramsey Sayed
Jamal Numan
Sami Bakr

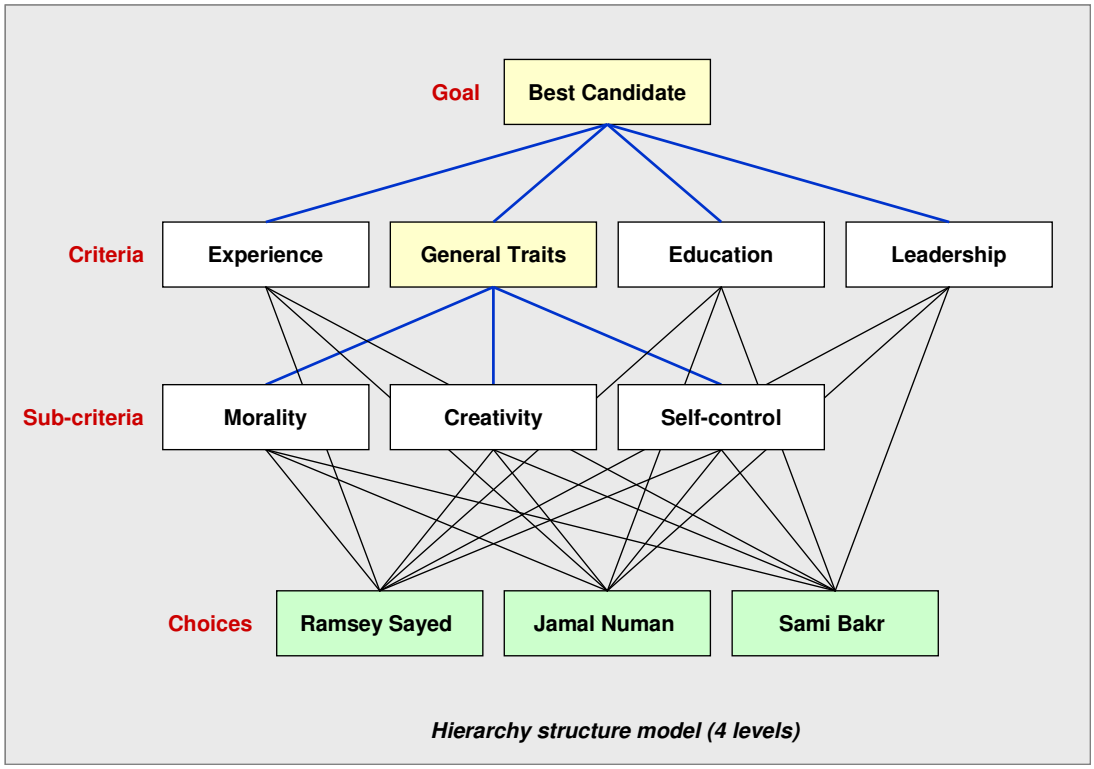
Step 2: Hierarchy construction

Construct the hierarchy for this problem. This would look like the following:



Hierarchy structure model (3 levels)

Since the second criterion "General Traits" has been broken down into three sub-criteria, the above hierarchy need to be expanded into four levels as follows:



Hierarchy structure model (4 levels)

Step 3: Rating relative importance for each criteria

Rating relative importance (or preference) for each criterion among those which have same parent node (the goal or the parent criteria) i.e., siblings. Rating is done using the scaled pair comparison method. That is, for all distinct pairs of sub-criteria under a criterion, a single rating from 1 to 9 is assigned corresponding to the AHP scale.

A square matrix is formed when every two criteria are compared. The matrix has the property the element $\mathbf{a_{ij} = 1/a_{ji}}$ (if item i is 2 times as important as item j, then item j is 1/2 as important as item i).

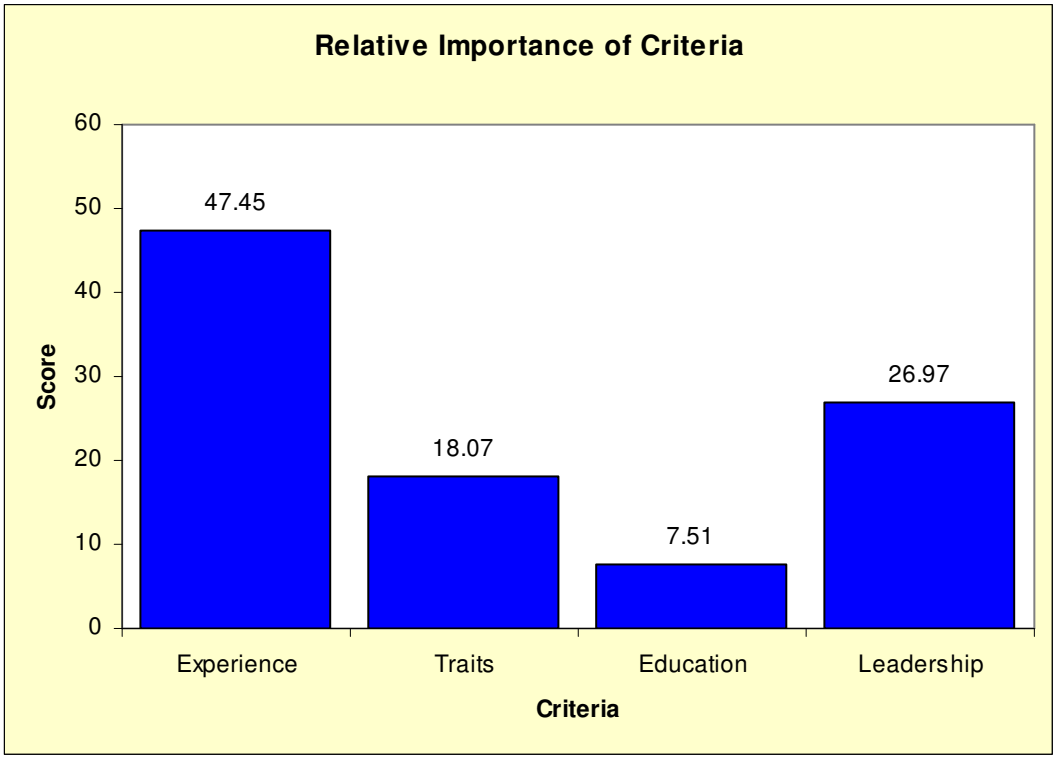
The hierarchy of this problem has two pair comparison judgment matrices for rating the relative importance for each criterion:

1. Relative importance for each major criterion with respect to the goal "Best Candidate".

Matrix

Best Candidate	Experience	Traits	Education	Leadership	Priorities	
Experience	1	5	5	1	47.45	
Traits	1/5	1	3	1	18.07	
Education	1/5	1/3	1	1/3	7.51	
Leadership	1	1	3	1	26.97	
					Consistency = 90.1%	

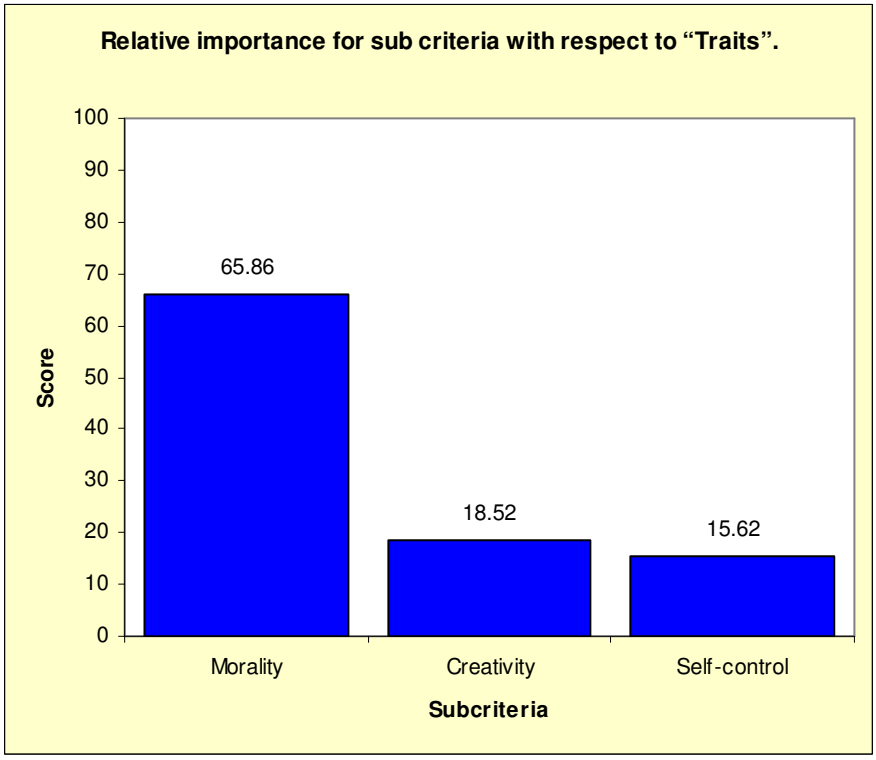
The relative importance of the criteria may be represented as a bar chart as follows:



2. Relative importance for each sub criterion with respect to “Traits”.

Traits	Morality	Creativity	Self-control	Priorities	
Morality	1	3	5	65.86	
Creativity	1/3	1	1	18.52	
Self-control	1/5	1	1	15.62	
				Consistency = 97.2%	

The relative importance of the above sub-criteria may be represented as a bar chart as follows:



The priority vectors resulting from each of the above matrices represent the relative importance of each element in the corresponding matrix.

The relative importance is given as a normalised eigenvector of the pairwise comparison matrix, guaranteeing that the sum of relative importance of siblings always equals one.

Experience	Traits	Education	Leadership
47.45	18.07	7.51	26.97

Morality	Creativity	Self-control
65.86	18.52	15.62

The relative importance for sub criteria (65.86, 18.52, 15.62) represents the **local** priorities. To obtain the importance of each sub criterion relative to the overall goal, the local priorities are multiplied by the priority of the parent criterion to obtain their **global** priorities with respect to the goal as shown below.

For Morality: 0.6586 x 0.1807 = 0.119

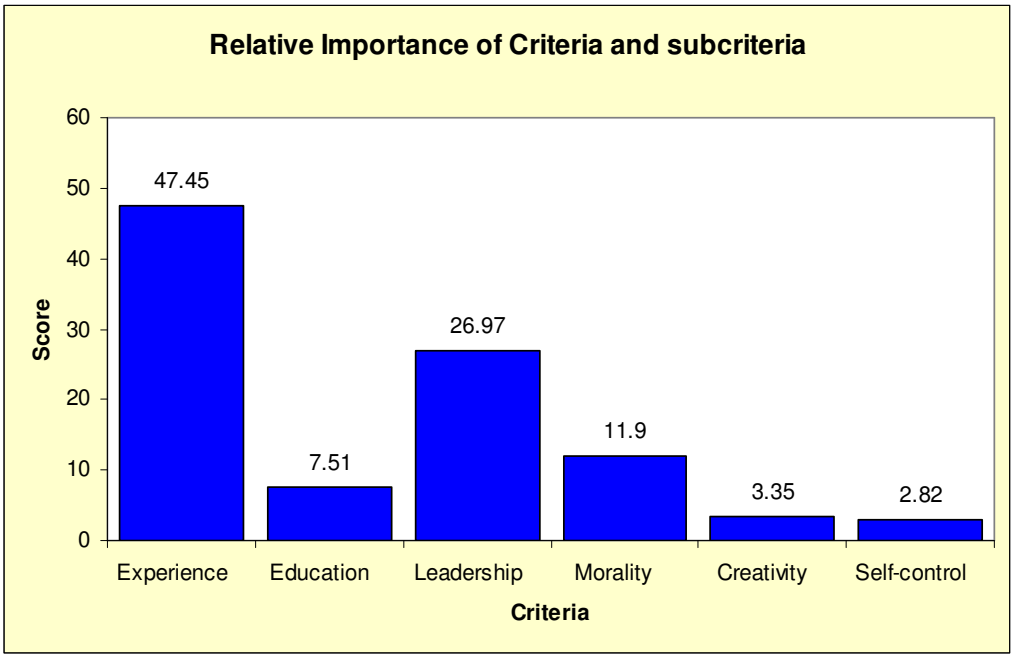
For Creativity: 0.1852 x 0. 1807 = 0.034

For Self-control: 0.1562 x 0. 1807 = 0.0282

		Traits			
Experience	Morality	Creativity	Self-control	**Education**	**Leadership**
47.45	11.9	3.35	2.82	**7.51**	**26.97**

(Notice that the total of these values = 0.1807, which is the relative importance of the parent criteria "Traits").

The relative importance of the criteria and sub-criteria may be represented as a bar chart as follows:



Step 4: Find relative importance for each alternative

Relative importance for each alternative is rated in the same way as for criteria— all 3 alternatives are judged against each of the 6 terminal criteria, therefore there are six pair comparison judgment matrices as shown below:

Experience	Ramsey	Jamal	Sami	Priorities
Ramsey	1	5	1	48.06
Jamal	1/5	1	1/3	11.4
Sami	1	3	1	40.54

Education	Ramsey	Jamal	Sami	Priorities
Ramsey	1	1/3	3	24.26
Jamal	3	1	7	66.94
Sami	1/3	1/7	1	8.79

Leadership	Ramsey	Jamal	Sami	Priorities
Ramsey	1	3	1/3	24.26
Jamal	1/3	1	0.14	8.79
Sami	3	7	1	66.94

Morality	Ramsey	Jamal	Sami	Priorities
Ramsey	1	1/3	1	18.52
Jamal	3	1	5	65.86
Sami	1	1/5	1	15.62

Creativity	Ramsey	Jamal	Sami	Priorities
Ramsey	1	5	3	63.7
Jamal	1/5	1	1/3	10.47
Sami	1/3	3	1	25.83

Self-control	Ramsey	Jamal	Sami	Priorities
Ramsey	1	3	9	67.16
Jamal	1/3	1	5	26.54
Sami	1/9	1/5	1	6.29

The priority vector resulting from each of the above matrices represents the relative importance of each of the 3 alternatives with respect to the corresponding criteria.

The relative importance is given as a normalized eigenvector of the pair-wise comparison matrix, guaranteeing that the sum of relative importance of siblings always equals one.

Now the absolute importance for each criterion and alternative has been computed.

Step 5: Compute absolute importance for all criteria and alternatives

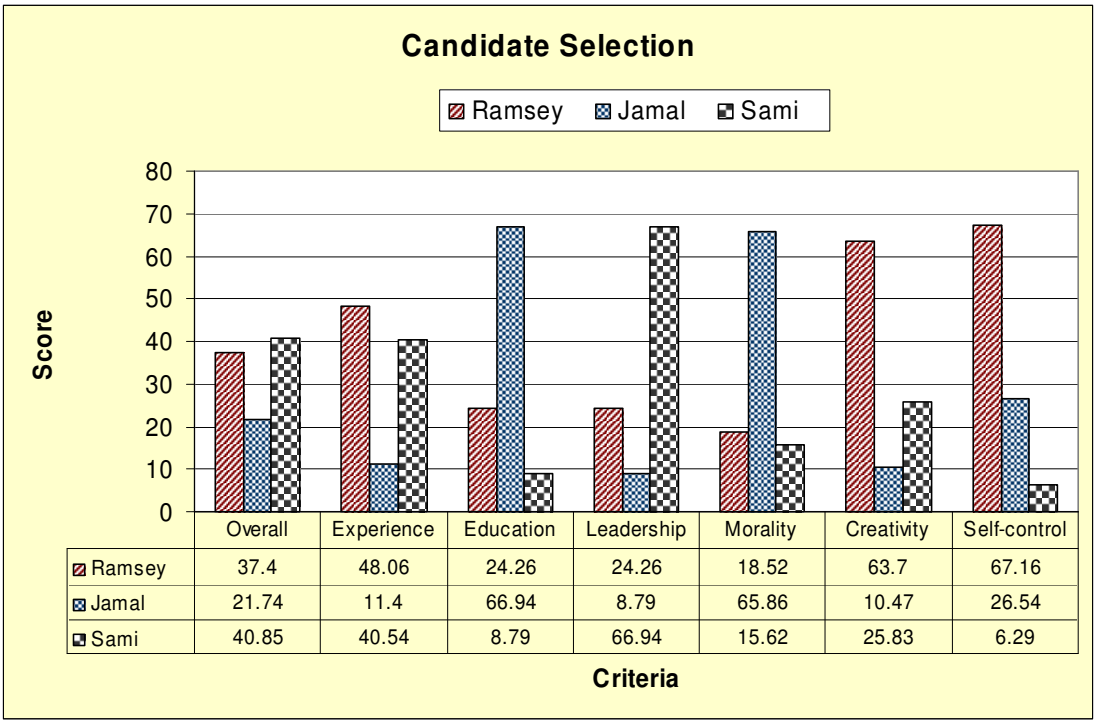
Now we multiply each alternative score by the priority of the corresponding criteria sum to obtain the overall priorities.

For each alternative, all of their m absolute importances are summed; this value equals the total number of preference points. Alternatives with greater amounts of points are preferable to alternatives with lesser amounts of points. This is shown in the following table:

		Ramsey	Jamal	Sami
Experience	**47.45**	48.06	11.4	40.54
Education	**7.51**	24.26	66.94	8.79
Leadership	**26.97**	24.26	8.79	66.94
Morality	**11.9**	18.52	65.86	15.62
Creativity	**3.35**	63.7	10.47	25.83
Self-control	**2.82**	67.16	26.54	6.29
Total (normalised)		**37.4**	**21.74**	**40.85**

Best Candidate Table

The final rankings of alternatives and criteria are shown below.



	Overall	Experience	Education	Leadership	Morality	Creativity	Self-control
Ramsey	37.4	48.06	24.26	24.26	18.52	63.7	67.16
Jamal	21.74	11.4	66.94	8.79	65.86	10.47	26.54
Sami	40.85	40.54	8.79	66.94	15.62	25.83	6.29

Conclusions

The purpose of this paper is to present a structured and systematic method, the Analytic Hierarchy Process (AHP), for the evaluation and selection of employees.

This method offers a rigorous model on which a complex decision problem can be dealt with more effectively.

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