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AHP and TOPSIS methods applied in the field of scientific research

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ABSTRACT

Scientific research is a major issue for universities because it ensures its innovation and productivity, but to ensure the proper functioning of universities, the decisions-makers need powerful tools to assist them in this process. Multi criteria decision making (MCDM) may present an appropriate asset for this area especially with the analytical hierarchy process (AHP) which presents a theory of measurement through pairwise comparisons and relies on the judgments of experts to derive priority scales.

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1. INTRODUCTION

The good governance [1] requires the modernization and rationalization of management information decision assist system in administrative and managerial aspects. The management and automation of scientific research in universities [2] represents a great challenge for universities especially for the decisions-makers which comes the need of find techniques and solutions suitable for their specific purposes. The decision making system [3] is a process based on best practices related to the university's strategy that deal with complex evaluation, prioritization, and selection situation. Because not all information is useful, and a lot of information cannot guarantee fthat we understand better the decisions-makers need to determine: the problem, the aim and objective from the decision, the criteria of the decision, and the consequences of this decision.

In this direction Analytic Hierarchy Process (AHP) represent one of the methods of Multi Criteria Decision Making (MCDM) that's usually used to solve some problem that heavily involves human participation and judgments.The paper has three parts. First section describes the different research methods. Full Research methodology and results are reported in the second section before concluding.

2. RESEARCH METHOD

2.1. Multiple Criteria Decision Making

Multiple criteria decision-making [4] (MCDM) are used in order to solve problems related to several criteria. Multiple criteria decision-making are regrouped into two sections:

Firstly, multi-attribute decision making [5] (MADM) this method is used to solve problems with discrete decision spaces and a predetermined or a limited number of alternative choices, is related to the judgment of the personal statement like the choice of (new managers, the choice of new provider…) Between the popular technique we find Analytic Hierarchy Process (AHP), ANP, TOPSIS, ELECTRE, MAUT, and PROMETHEE I & II.

Secondly multi-objective decision making (MODM) [6] this method is used when we have decision variable values that are determined in a continuous or integer domain with either an infinitive or a large number of alternative choices, the best of which should satisfy the decision-maker constraints and preference priorities. Between the popular techniques we find fuzzy analytic hierarchy process (FAHP).

2.2. Techniques in Multiple Criteria Decision Making

The main steps followed in multiple criteria decision-making:

1) Define the Problem by specifying the object that must be realistic and measurable.
2) Determine the requirement.
3) Establish the goals.
4) Identify the alternative.
5) Develop evaluation criteria.
6) Selecting decision making tool.
7) Apply the tool.
8) Find the result.

For the selection of the criteria that must be [7]:

1) Able to distinguish among alternatives.
2) Complete enough to cover all goals.
3) Non-redundant.
4) Few numbers.
5) Operational and meaningful.

2.3. Analytic Hierarchy Process Principles [8]

Discovering by Saaty AHP can be combined with another technique like Fuzzy logic, linear programming to provide a better result in their areas. The use of AHP is due to the steps imposed by the seven techniques [9]:

1) Define the Problem.
2) Determine the objectives and expected results.
3) Determine the main criteria involved.
4) Prioritize the problem in different levels, Let D is a n x n pair-wise comparison matrix.

$$D = \begin{bmatrix} a_{11} & a_{21} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

Diagonal elements are all equal to 1.

5) Compare each element in the corresponding level, by normalizing the matrix with geometric means, where:

$$w_i = \frac{\left[\sum_{j=1}^{n} a_{ij}\right]^{1/n}}{\sum_{i=1}^{n}\left[\sum_{j=1}^{n} a_{ij}\right]^{1/n}}$$

i,j=1,2,......n

Perform consistency check. If C denotes n dimensional column vector describing the sum of:

$$C = [C_i]_{n \times 1} = D W^T$$

where i=1,2,......n.

$$[w_1 w_2 \dots\dots w_n] = \begin{bmatrix} C_1 \\ C_2 \\ C_n \end{bmatrix} \quad DW^T = \begin{bmatrix} 1 & a_{12} \dots\dots & a_{1n} \\ a_{21} & 1 \dots\dots & a_{2n} \\ a_{n1} & a_{n2} \dots\dots & 1 \end{bmatrix}$$

6) Find the maximum eigenvalue, consistency ratio (CR), consistency index (CI).

$$\lambda_{max} = \frac{\sum_{i=1}^{n} cv_i}{n}$$ Where i=1,2,......n

$$CI = \frac{\lambda_{max-n}}{n-1}$$

$$CR = \frac{CI}{RI}$$ Where RI denotes average random index.

7) Repeat the operation until you reach the values in the desired range.

2.4. Technique for Order Preference by Similarity to Ideal Solution

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [10] has been used in a various comparisons of alternatives such: ranking leaders or entities item selection from among alternatives, supply chain operations, data mining, etc.

TOPSIS can be summarized is that the selected alternative should have shortest distance, in a geometrical sense, from the ideal solution and longest distance from the worst solution. It is one of the classical MCDM approach, based on aggregating function to find a solution which is nearest to positive ideal solution and farthest from negative ideal solution.

3. RESULTS AND ANALYSIS

In this paper, we choose to work with the dataset provided by laboratories which belongs to the Sultan Moulay Slimane University. also we choose to apply multi-attribute decision making method through the analytic hierarchy process (AHP) technique by choosing the adequate dimensions. In this order the decision makers want to know the laboratory with the highest score the last year, the decision will be based on four factors:

a. The number of new registered in the laboratory the previous year.
b. The number of publications in the laboratory the previous year.
c. The number of thesis supported in the laboratory the previous year.
d. The number of events organized by the laboratory the previous year.

Decision-makers consider the number of publications from members of each research laboratory as the most important factor in the decision, and give less importance to the new doctoral candidate in the first year.

1) The number of publications in the previous year.
2) The number of thesis supported in the previous year.
3) The number of events organized by the laboratory in the previous year.
4) The number of new registered in the laboratory in the previous year.

According to the data collected from the scientific research service, the study is limited to five research laboratories:

Variable	MPA	SL	ES	MET	RCC
Publications	10	16	11	12	8
Thesis	2	4	1	2	1
Publications	3	5	4	1	2
New-Registered	12	11	13	10	14

a. MPA: Mathématique Physique Appliquée.
b. SL: Sciences Langage.
c. ES: Environnement Santé.
d. MET: Modélisation des Ecoulements des Transferts.
e. RCC: Recherche Culture Communication.

3.1. AHP

Step1: we create a diagram based on the objectives of the decision criteria and alternative solutions:

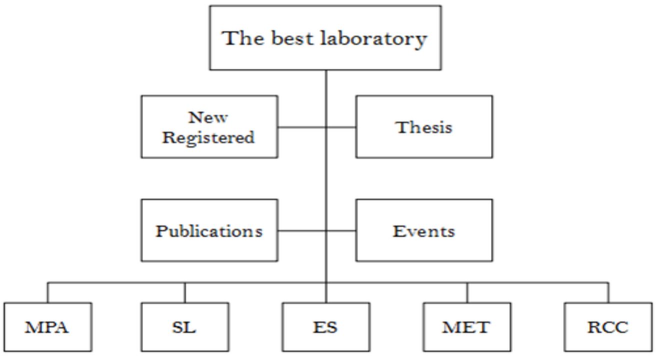


Figure 1. Diagram of the decision criteria and alternative solutions

Step2: A decision criterion matrix is made in order to compare them:

	Events	Publications	New-Registered	Thesis
Events	1	1/4	2	1/2
Publications	4	1	5	2
New-Registered	1/2	1/5	1	1/3
Thesis	2	1/2	3	1

The importance of each criterion with respect to another according to the following scale:
1 = Equal importance.
2 = Moderate importance.
3 = Strong importance.
4 = very strong importance.
5 = extreme importance.
Ratio = importance of the criterion on the line / importance of the criterion on the column.

A second matrix to express each ratio in relative percentage:

	Events	Publications	New-Registered	Thesis	average
Events	0.133	0.128	0.182	0.130	0.143
Publications	0.533	0.513	0.455	0.522	0.506
New-Registered	0.067	0.103	0.091	0.087	0.087
Thesis	0.267	0.256	0.0273	0.261	0.264

Step3: For each criterion of decision, a matrix is created which makes it possible to compare the different solutions:

Events

	MPA	SL	ES	MET	RCC
MPA	1	3	2	1/3	1/2
SL	1/3	1	1/2	1/5	1/4
ES	1/2	2	1	1/5	1/4
MET	3	5	5	1	2
RCC	2	4	4	1/2	1

Matrix with relative percentages:

	MPA	SL	ES	MET	RCC	average
MPA	0.146	0.2	0.16	0.149	0.125	0.156
SL	0.048	0.066	0.04	0.089	0.062	0.061
ES	0.073	0.133	0.08	0.089	0.062	0.087
MET	0.439	0.333	0.4	0.447	0.5	0.423
RCC	0.292	0.266	0.32	0.223	0.25	0.272

Publications

	MPA	SL	ES	MET	RCC
MPA	1	4	2	3	1/2
SL	1/4	1	1/3	1/2	1/5
ES	1/2	3	1	2	1/3
MET	1/3	2	1/2	1	1/4
RCC	2	5	3	4	1

Matrix with relative percentages:

	MPA	SL	ES	MET	RCC	average
MPA	0.245	0.266	0.292	0.285	0.219	0.261
SL	0.061	0.066	0.048	0.047	0.087	0.061
ES	0.122	0.2	0.146	0.190	0.141	0.160
MET	0.080	0.133	0.73	0.095	0.109	0.098
RCC	0.490	0.333	0.439	0.380	0.438	0.416

New-Registered

	MPA	SL	ES	MET	RCC
MPA	1	3	2	1/3	1/2
SL	1/3	1	1/2	1/5	1/4
ES	1/2	2	1	1/4	1/3
MET	3	5	4	1	2
RCC	2	4	3	1/2	1

Matrix with relative percentages:

	MPA	SL	ES	MET	RCC	average
MPA	0.146	0.2	0.190	0.144	0.122	0.160
SL	0.048	0.066	0.047	0.087	0.061	0.172
ES	0.073	0.133	0.095	0.109	0.080	0.098
MET	0.439	0.333	0.380	0.438	0.490	0.416
RCC	0.292	0.266	0.285	0.219	0.245	0.261

Thesis

	MPA	SL	ES	MET	RCC
MPA	1	1/2	2	1/3	3
SL	2	1	3	1/2	3
ES	1/2	1/3	1	1/4	2
MET	3	2	4	1	5
RCC	1/3	1/3	1/2	1/5	1

Matrix with relative percentages:

	MPA	SL	ES	MET	RCC	average
MPA	0.146	0.120	0.190	0.144	0.214	0.162
SL	0.292	0.240	0.285	0.219	0.214	0.250
ES	0.073	0.079	0.095	0.109	0.142	0.099
MET	0.439	0.480	0.380	0.438	0.357	0.418
RCC	0.048	0.079	0.047	0.087	0.071	0.066

Step4: We will create a solution matrix

	MPA	SL	ES	MET	RCC	average
MPA	0.245	0.266	0.292	0.285	0.219	0.261
SL	0.061	0.066	0.048	0.047	0.087	0.061
ES	0.122	0.2	0.146	0.190	0.144	0.160
MET	0.080	0.133	0.73	0.095	0.109	0.098
RCC	0.490	0.333	0.439	0.380	0.438	0.416

Step5: Multiply the solution matrix with the average of relative percentages matrix

	Events	Publications	New-Registered	Thesis
MPA	0.146	0.120	0.190	0.144
SL	0.292	0.240	0.285	0.219
ES	0.073	0.079	0.095	0.109
MET	0.439	0.480	0.380	0.438
RCC	0.048	0.079	0.047	0.087

Multiply the solution matrix with the average of relative percentages matrix

Laboratory	Score	coefficient distribution
MPA	0.211	21.1%
SL	0.120	12%
ES	0.128	12.8%
MET	0.256	25.6%
RCC	0.285	28.5 %

Based in the result found in the step 5, we conclude that the laboratory RCC is the laboratory that most closely matches the criterion imposed for choosing the ideal laboratory followed by MET, MPA, ES, et SL. The prime objective of this approach is to help managers to improve one or more service areas.

3.2. TOPSIS:

Step1: Choose a scale to measure the values of criterion:

The importance of each criterion with respect to another according to the following scale:

1 = not interesting at all.
2 = not interesting.
3 = very uninteresting.
4 = moderately interesting.
5 = interesting.
6 = very interesting.
7 = super interesting.
8 = perfectly interesting.

Step2: Matrix alternative X criteria.

	Events	Publications	New-Registered	Thesis
MPA	6	5	6	5
SL	8	8	5	8
ES	7	6	7	4
MET	4	7	4	5
RCC	5	4	8	4

Allocation of weighting W:
Publication: 0.4
Thesis: 0.3
Events: 0.2
New-Registered: 0.1

Step3: Standardized matrix by criterion (attribute)

We normalize all the scores of the matrix of the levels attributed to the criteria, for that we apply the following formula where x_{ij} criterion:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}}$$

	Events	Publications	New-Registered	Thesis
MPA	0.43	0.36	0.43	0.41
SL	0.58	0.58	0.58	0.66
ES	0.5	0.44	0.50	0.33
MET	0.29	0.50	0.29	0.413
RCC	0.36	0.29	0.36	0.33

Step4: Standardized and weighted matrix:

We simply multiply all the entries r_{ij} of the standardized matrix by the weighting associated with each criterion.

$$r_{ij} = w_j \times x_{ij}$$

	Events	Publications	New-Registered	Thesis
MPA	0.086	0.144	0.043	0.123
SL	0.116	0.232	0.036	0.198
ES	0.1	0.176	0.05	0.099
MET	0.058	0.2028	0.029	0.123
RCC	0.072	0.116	0.058	0.099

Step5: Calculates the ideal favorable solution A+:

For each criterion (attribute) we calculate the most favorable associated value A + according to the nature of the criterion (favorable or unfavorable).

$$A^{+} = \{max_i x_{ij}\ (i \in J^{+}) | \ min_i x_{ij}\ (i \in J^{-})\}$$

	Events	Publications	New-Registered	Thesis
MPA	0.116	0.232	**0.058**	0.198

Step6: Calculates the ideal unfavorable solution A-:

For each criterion (attribute) we calculate the least favorable associated value A- according to the nature of the criterion (favorable or unfavorable).

$$A^{-} = \{min_i x_{ij}\ (i \in J^{+}) | \ max_i x_{ij}\ (i \in J^{-})\}$$

	Events	Publications	New-Registered	Thesis
MPA	0.058	0.116	0.029	0.099

At first sight, if one relies solely on the Euclidean distance as a criterion for optimality, this is not enough, because it is the model ‘New-Registered ‘which is closest to A + and the model ‘Publications ‘which is the most away from A-. if a single model that meets both criteria would have at this stage and it will represent the best choice. Therefore, it is necessary to determine another metric experiment the two criteria at once called 'proximity factor' defines by the mathematical formula.

Step7: Calculates the deviation of the ideal unfavorable solution from each row of the matrix:

$$E^{+}_{i} = \sqrt{\sum_{j=1}^{m} (r_j^{+} - r_{ij})^{2}}$$

	MPA	SL	ES	MET
E+	0.120	0.022	0.182	0.1033

Step8: Calculates the deviation of the ideal unfavorable solution from each row of the matrix:

$$E^{-}_{i} = \sqrt{\sum_{j=1}^{m} (r_j^{-} - r_{ij})^{2}}$$

	MPA	SL	ES	MET
E-	0.0483	0.1633	0.0761	0.090

Step9: Calculates proximity coefficient of the ideal solution and storage in order of choice S*:

$$S^{*}_{i} = \frac{E^{-}_{i}}{E^{-}_{i} + E^{+}_{i}}$$

$$A^{-} = \{min_i x_{ij}\ (i \in J^{+}) | \ max_i x_{ij}\ (i \in J^{-})\}$$

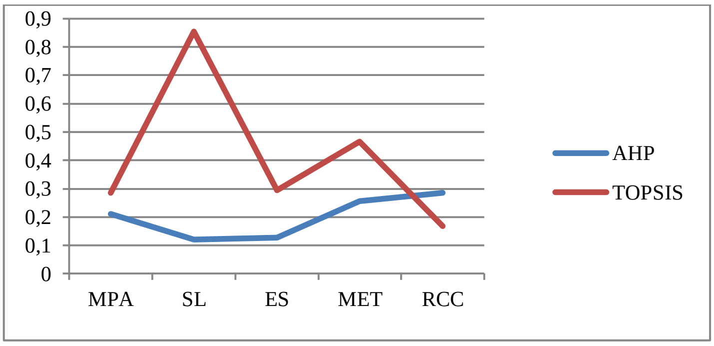
Laboratory	Score	coefficient distribution
MPA	0.2869	13.87%
SL	0.8536	41.25%
ES	0.2948	14.25%
MET	0.4655	22.5%
RCC	0.1686	8.13%

The proximity coefficient of each alternative, as the name suggests, measures the proximity ratio of the most unfavorable ideal solution A- to the most favorable ideal solution. In conclusion the ranking in descending order of the 5 research laboratory models on the basis of the scores and weights provided and the following:

The laboratory RCC is the laboratory that most closely matches the criterion imposed for choosing the ideal laboratory followed by MPA, ES, MET, et SL. The prime objective of this approach is to help managers to improve one or more service areas.

Table 1. Calculated point interval of methods

Methods	Minimum point	Maximum point	Mean point
AHP	0.120	0.2895	0.2
TOPSIS	0.1686	0.8536	0.41388



AHP is uniformly worse than TOPSIS [11]. Similarly, AHP and TOPSIS methods are applied to our case with same criteria. Ranking distribution of calculated points are shown in the last table.TOPSIS point interval is higher than others. Moreover as shown, distribution of calculated points with AHP are not distinguishable. TOPSIS is better than AHP because distributions of calculated points with TOPSIS are uniformly distinguishable rather than AHP. Therefore, TOPSIS method has best performance for evaluation.

4. CONCLUSION

This paper has addressed the problem of scientific research selection decision making. Decision makers can be able to select the best Laboratory among N number of alternative laboratory available based on following four criteria's: Events, Publications, New-Registered and Thesis. Each head of the laboratory needs to fill the values for above mentioned criteria's and based on that final data have been assigned to each criterion.

In this paper, we considered one sample numerical example and applied the both methods AHP and TOPSIS in order to calculate weight of each criterion also to select the best laboratory. The proposed technique will help decision makers to select the best laboratory. Numerical results obtained after applying each method gives a final ranking of laboratory and this definitely helps any decision makers to prioritize all available laboratory and choose the better one, which results in his or her bright future.

This work was a real opportunity to present a method of management system of scientific research, using the tool of analytic hierarchy process and TOPSIS. We conclude that TOPSIS minimizes efforts for the decisions-makers to solves many problems and apply governance policy in all respect related to scientific research.

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