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Fuzzy Analytical Hierarchy Process Method to Determine the Project Performance in the portfolio.

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Abstract –

When reaching a decision most preferable way is to go through the analytical way instead of taking decisions without considering all the factors. Analyzing the project performance in the portfolio requires a special ability, full knowledge and as well as years of experience working in the industry. However, many times measuring a verbal expression can be taken into account for better decision making and it can offer precise interpretation in Infront of an observer. therefore, while making the decisions, need of a proper analyze of every factor's impact is essential.

The diversity of the projects in the industry cannot be mapped as it has a too wide scope. Also, the human mind is vulnerable to errors while quantifying and analyzing various factors and variables and having sure decision-making and a trustworthy tool is essential. studies and Scholars suggest the Analytical Hierarchy Process (AHP) as the best method for deciding among the complex criteria structures at different levels. The fuzzy AHP is the nothing but an extension of the Classical AHP. The study used in this paper is Fuzzy Analytical Hierarchy process which is one of the most used methods by the decision makers in various sectors. Also, Fuzzy AHP is preferred while dealing with different decision-making issues. This paper utilizes the F-AHP to prioritizes the projects in the portfolio.

1.INTRODUCTION

There are always various confusions with decision making if there are various options available, and studies shows that while making a decision with pre-determined criteria is always difficult. Decision-making issues are can be faced while analyzing the project performance in the portfolio. The diversity of projects and their scope with configuration, Time, Demand and other so many factors serve as constraints when data is incomplete and there is a lack of individual knowledge about analyzing the performance of the project. To have a valid performance analysis of the projects every factor mentioned in the paper shall be considered to perform an error-free analysis. Previous papers and numerous studies have used the F-AHP method and proven that F-AHP can be used as a decision-making tool to take hard decisions in real life

Two researchers Ker-Wei Yu and Chien-Chang Chou [1] had proposed a hybrid fuzzy AHP method that helps to deal with the decisions based on uncertain and multiple criteria environments, in which F-AHP method techniques combines with the AHP with fuzzy set theory. [2] The method proposed by Ker-Wei Yu and Chien-Chang Chou [1] can totally concentrate on evolution criteria along with thinking logic by the human being. In the paper [3] results show different categories such as safety, health, environmental, aspects as well as physiochemical properties shows the best balance of performance in every aspect.

A few assumptions we can understand made in F-AHP are all the criteria and factors involved are independent of each other. However, in the real world, the relationship between criteria is complex to understand, and there are huge chances that they can be interdependent. To analyze the projects with no error we need relevant elements & methods [4].

The MCDM methods have various options while using the Fuzzy model. [5] The f-AHP model can be helpful for most decision-makers [6]. the fuzzy AHP method is used to control for analysis and is useful for various multicriteria decision-making problems [7] people think the cost of the projects does matter but other criteria like quality of the product as a comparison can make the quality products better than low-cost products. [8] F-AHP method can help decision makers more efficient, flexible, and realistic decisions based on various criteria and alternatives [9]. Therefore, we can use the F-AHP method to analyze the project performance in the portfolio.

1.1 Data of the Projects

Table 1: Data here referred for the study have taken from the portfolio of an industry which shall not be disclosed that can cause privacy issues. Authors have taken appropriate steps to preserve the confidentiality of study participants and the data collected from them.

Portfolio	Time-line	Cost	Est. Revenue	Resources Used
Project 1	15 Months	180 K Euros	24 K Euros	57 Persons
Project 2	12 months	150 K Euros	14 K Euros	48 Persons
Project 3	12 months	140 K Euros	21 K Euros	52 Persons
Project 4	14 months	160 K Euros	17 K Euros	40 persons

Table -1: Project Data used for the calculations (Values are Per Prototype)

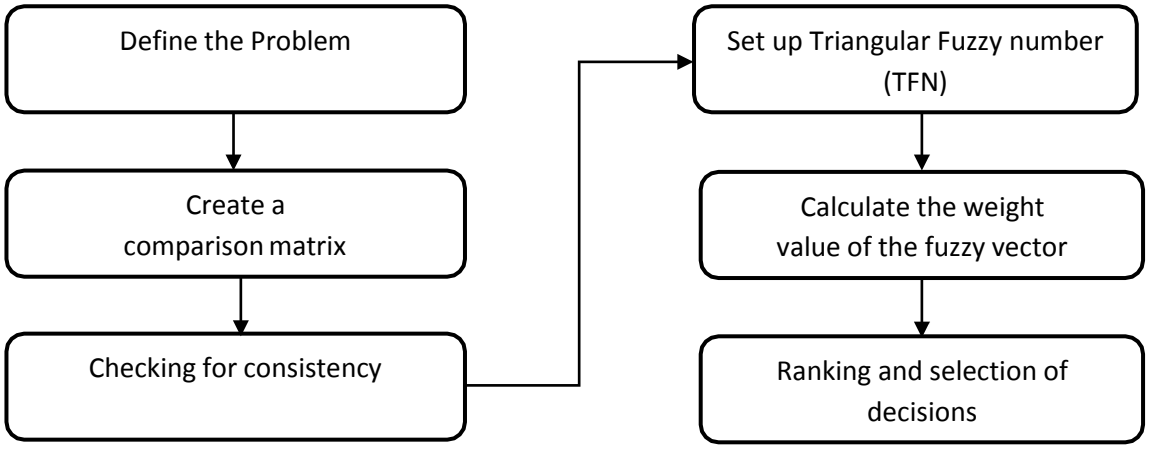

Figure 1: Block diagram has six steps of F-AHP phase

1.2 Privacy Policy

Data used in the research is to be kept confidential. In order to fully understand the implications of the study, it is necessary to keep the data confidential. This will help protect the participants and the research team. This data is gathered through surveys and interviews, and any information that could identify the participants is carefully guarded. The sources used in this paper were all anonymous, meaning the researcher will not be able to identify them. The author feels that this keeps the data more objective and unbiased.

Table -1: Please refer to dataset mentioned in table format.

1.3 Materials and Methods

Analytical Hierarchy process (AHP) is a method which breakdown the problem along with the solutions. Mainly it was developed to support the decision making, it does breakdown the problem, the solution of a problem and groups them to convert it into a hierarchical structure that gives us priority criteria. This method uses already determined measurements aligned with criteria to give output. The main input for the method is given by the stakeholders or experts of the subject therefore, there's also a factor of reclamation of a decision inconsistency limits along with data validity also get considered.[10]

In this method data validity with inconsistency, and limits are also get considered. [10] While performing the analysis the consideration of uncertainty and the margin of error also the doubt in giving the assessment definitely can cause affect results. we need to define the problem according to the criteria used to determine the project performance. Time, Cost, features, and demand are mainly used as determining criteria for determining project performance.

Step 1: In order to review the project performance in the portfolio according to the criteria used to determine is with following factors are Timeline, Cost, revenue & resources. Thus, due to privacy concern the data source cannot be disclosed.

Step 2: To Create comparison matrix we shall consider the data source available in table number 1. The matrix referred is simple and has strong position for consistency framework. The equation used for determining pairwise comparison is as follows.

Equation used to determine Pairwise comparison:

$$a_{ij} = \frac{\omega_i}{\omega_j}, \quad i,j = 1,2,3 \ldots . n \qquad \text{.... Eq-1}$$

Where,

n = Number of criteria compared.

wi= Weight of an I criterion.

Aij =is ratio of i criterion & j criterion.

After knowing the comparison of its criteria in Table 2, the next thing done is to normalize each column into the Advances in Fuzzy Systems.

CRITERIA	TIME	COST	REVENUE	RESOURCES
TIME	1	2	4	4
COST	1/2	1	2	4
REVENUE	1/4	1/2	1	2
RESOURCES	1/4	1/4	1/2	1

Table 2: Comparison of criteria, as the weighted value of each criterion.

TABLE 3: Ratio index.

n	1	2	3	4	5	6	7	8	9	10
RI	0,00	0,00	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

Matrix form by dividing each value in the column i and row j with the largest value in column i.

$$a_{ij} = \frac{a_{ij}}{\max a_{ij}}, \quad \forall i, j \qquad \text{.... Eq-2}$$

The Normalized matrix is as follows from **Table 2**

$$\begin{bmatrix} 0.50 & 0.53 & 0.53 & 0.36 \\ 0.25 & 0.27 & 0.27 & 0.36 \\ 0.13 & 0.13 & 0.13 & 0.18 \\ 0.13 & 0.07 & 0.07 & 0.09 \end{bmatrix} \qquad \text{.... Eq-3}$$

Step 3: The consistency index and random index generator comparison is as follows by Saaty [10] This value depends on the matrix order n.

Here is the equation used to calculate the value of consistency.

First, we must recognize the value of the eigenvector which is the weighted value of the criterion. To calculate the eigenvector, we use the following equation:

$$w_i = \frac{\widehat{a_i}}{n}, \quad \forall i \qquad \text{...Eq-4}$$

The largest eigenvalue is the number of times multiplying the number of columns with the main eigenvector (see Table 4). So, it can be obtained by the equation.

The largest eigenvalue is the number of times multiplying the columns with main eigen vector.

So, Equation used is as follows:

$$\lambda maks = \left(\sum GM_{11-n1} \times \overline{X1}\right) + \ldots + \left(\sum GM_{1n-ni} \times \overline{Xn}\right) \qquad \text{.... Eq-4}$$

Table 4: Eigenvector on criteria.

Eigenvectors	
TIME	0.5
COST	0.3
REVENUE	0.1
RESOURCES	0.1

Table 5: Weighted sum value calculated is as follows.

	TIME	COST	REVENUE	RESOURCES	Weighted Sum
TIME	0.5	0.6	0.7	0.3	2.0
COST	0.2	0.3	0.3	0.3	1.1
REVENUE	0.1	0.1	0.2	0.1	0.6
RESOURCES	0.1	0.1	0.1	0.1	0.3

The equation through which we can calculate the consistency index also with the help of "n" -Number of criterions.

$$\text{Consistency Index (C.I.)} = \frac{\lambda_{max} - n}{n-1} \quad \text{.... Eq- 5}$$

Weighted sum (A)	CRITERIA Weights (B)	A/B
2.0	0.5	4.1
1.1	0.3	4.0
0.6	0.1	4.0
0.3	0.1	3.9
Avg		4.0

So, we get, **λmax = 4.0** and calculating CI (Consistency Index)

CI = (4-4) / (4-1) = 0

Hence, the matrix is consistent and the weight values we are considering are correct.

W1 = 0.5

W2 = 0.3

W3 = 0.1

W4 = 0.1

Step 4: set up Triangular Fuzzy Number

There are three values in F-AHP scale and those are lowest value (lower, L), middle value (median, M), and highest value (upper, U). Please refer the table Number

Refer (Table Number

Step 5: In order to calculate Fuzzy synthesis value, need to transform AHP Comparison values to F-AHP scale value. This can be achieved by using following formula.

$$Si = \sum_{j=1}^{m} M_{gi}^{j} X \frac{1}{\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]} \quad \text{..... Eq -6}$$

□□ = fuzzy synthesis value

$\sum_{j=1}^{m} M_{gi}^{j}$ = summing the cell value in that column starting from column 1 in each row matrix

i = row

j = column.

Step 6: Defuzzification ordinate value.

Compare fuzzy synthesis values to get defuzzification ordinate value.

To Calculate: V' we can use following formula.

$$V(M2 \geq M1) = \begin{cases} 1, & ,if\ m2 \geq m1 \\ 0, & ,if\ l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)'} & ,etc \end{cases} \quad \text{.... Eq – 7}$$

To Calculate fuzzy vector weight (W'). we can use following formula to calculate fuzzy weight value.

$$d'^{(Ai)} = \min V(Si > Sk) \quad \text{.... Eq – 8}$$

Previously obtained ordinate values as below.

$$\Sigma W' = (vsk1, vsk2, \ldots, vskn) \quad \text{.... Eq – 9}$$

Using the following formula, we can normalize the weight vectors obtained.

$$W' = \left(d'(A1), d'(A2), \ldots, d'(An)\right) \mathrm{T} \quad \text{.... Eq – 9}$$

Table 6: Advances in Fuzzy Systems (Triangular Fuzzy Scale)

TFN scale.

TFN Scale	L	M	U
1	1	1	1
2	0,5	1	1,5
3	1	1,5	2
4	1,5	2	2,5
5	2	2,5	3
6	2,5	3	3,5
7	3	3,5	4
8	3,5	4	4,5
9	4	4,5	4,5
0,5	0,666667	1	2
0,333333	0,5	0,666667	1
0,25	0,4	0,5	0,666667
0,2	0,333333	0,4	0,5
0,166667	0,285714	0,333333	0,4
0,142857	0,25	0,285714	0,333333
0,125	0,222222	0,25	0,285714
0,111111	0,222222	0,222222	0,25

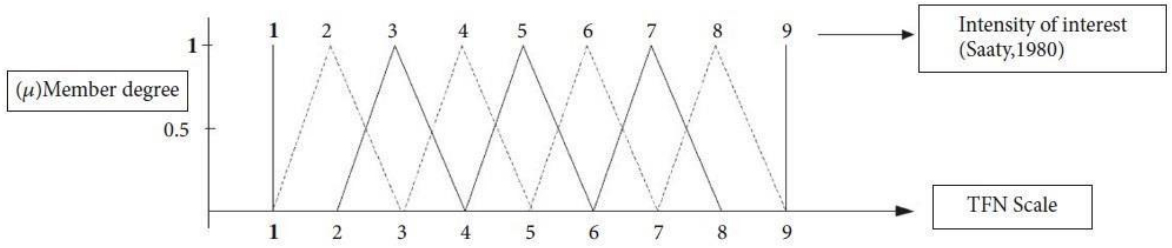

Figure 3: Graph of Fuzzy Triangle Set give above.

Table 7: TFN set of criteria; each value in the criteria comparison (see Table 6) is changed to TFN referring to the TFN scale.

CRITERION	TIME			COST			REVENUE			RESOURCES		
TIME	1	1	1	0.5	1	1.5	1.5	2	2.5	1.5	2	2.5
COST	0.66667	1	2	1	1	1	0.5	1	1.5	1.5	2	2.5
REVENUE	0.4	0.5	0.66667	0.66667	1	2	1	1	1	0.5	1	1.5
RESOURCES	0.4	0.5	0.66667	0.4	0.5	0.66667	0.66667	1	2	1	1	1

Table 8: Calculations for Synthesis values after calculations are as follows:

	L	M	U
s1	0.19	0.34	7.50
s2	0.15	0.29	7.00
s3	0.11	0.20	5.17
s4	0.10	0.17	4.33

The calculation of each criteria weight value is given below.

Table 9: Criteria Weight Value.

Criteria	Weight
TIME	0.4826
COST	0.2867
REVENUE	0.1434
RESOURCES	0.0873

Step 7: Ranking the projects in portfolio

Collecting Ordinate Values Previously obtained

$$\Sigma W' = (vsk1, vsk2, \ldots, vskn) \quad \text{.... Eq- 10}$$

Vector Weight Values Normalization

$$W' = \left(d'(A1), d'(A2), \ldots, d'(An)\right) \mathrm{T} \quad \text{.... Eq- 11}$$

1.4 Discussion

While performing the calculation the help from excel tools as well as using online AHP Portals can be taken for ease & accuracy of calculation. and support decision making.

Considering all the factors the results are as follows.

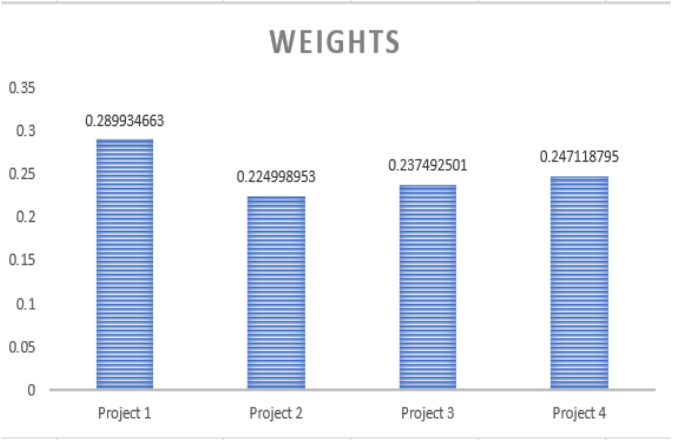

Figure 4: Ranking graph

The above figure shows that the Project number 1 has highest weight, and it is performing well in the portfolio.

Portfolio	Time-line	Cost	Est. revenue	resources used	Weights
Project 1	15 Months	180 K Euros	24 K Euros	57 Persons	0.289934663
Project 4	14 months	160 K Euros	17 K Euros	40 persons	0.247118795
Project 3	12 months	140 K Euros	21 K Euros	52 Persons	0.237492501
Project 2	12 months	150 K Euros	14 K Euros	48 Persons	0.224998953

1.5 Result

Here with the results, we can see their project performance in the portfolio is in the order of Project 1, Project 4, Project 3, and Project 2 with respective weights of 0.2899, 0.2471, 0.2374 & 0.2249.

With the data we can clearly state that in the portfolio the project 4 which is development of a prototype has performed well till now.

1.6 Conclusion

Conclusion of this study article is that F-AHP system can be implemented to analyses and find out accurately in the project management field.

It can also assist project Manager to take decisions with appropriate analysis of project performance in the portfolio using AHP & F-AHP.

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