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Multi Criteria Decision Making Approach with A Case Study in Prioritizing the Projects for A Company

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KEYWORDS

Multi Citeria Decision Making (MCDM), Analytical Hierarchical Process (AHP), decision-making.

ABSTRACT

The research activities in-group decision making have intensely increased over the last decade in all spheres of business and management. The application of Multi Criteria Decision Making (MCDM) approach occupies a vast area in the related literature. However, there is no systematic classification scheme for these researches. This paper presents a generic framework for group decision management using Multi Criteria Decision Making (MCDM) approach. The objective of this paper is to present, discuss, and apply the principles and techniques of the analytic hierarchy process (AHP) in the prioritization and selection of projects in a portfolio. AHP is one of the main mathematical models currently available to support the decision theory. This technique helps the decision makers to choose for right project amongst three projects keeping in mind the parameters like Finance, Return on Investment (ROI), Risk and Technical Knowledge...

1. INTRODUCTION

Making decisions is a vital element of our life. Every day, we make decisions of many types, from simple ones that don't require deep knowledge or hard thought to more difficult ones where mistakes may have serious implications and making the right option takes a lot of information and effort, and may even be impossible [1]. Complicated decision-making difficulties need a vast number of factors with varying degrees of relevance, and humans are nearly incapable of identifying the correct conclusion. MCDM approaches are frequently effective in such instances, assisting the decision-making process to the best answer for a given choice problem. However, care should be taken to select the best approach for the particular choice issue.

2. REVIEW OF LITERATURE

The application of Multi-Criteria Decision Making (MCDM) approaches has seen significant growth across various fields, notably in engineering, healthcare, construction, and business management. Among these techniques, the Analytic Hierarchy Process (AHP) is widely recognized for its capacity to support structured decision-making through hierarchical modeling and pairwise comparison of alternatives.

Rakhade et al. (2021) applied AHP and other MCDM methods to determine the optimal agricultural drone selection. Their work considered practical attributes such as payload capacity, cost, and flight endurance, which are comparable to the factors influencing project prioritization in business—especially technical viability and economic feasibility. Canco et al. (2021) emphasized the reliability of AHP for quality business decisions. Their research in a corporate setting demonstrated how qualitative business judgments could be translated into quantifiable scores to guide investment or strategic decisions.

Baek (2025) implemented a SWOT-AHP model to analyze consumer-centric strategies in national healthcare portals. This integration of strategic analysis tools with MCDM techniques showcased a method for making more informed and balanced decisions—a concept that can be effectively applied to project portfolio selection where both internal and external factors matter. Similarly, Chabok and Tešić (2024) used fuzzy MADM techniques for strategic planning in the construction industry, highlighting the effectiveness of fuzzy logic in handling ambiguity and human judgment, which are integral in selecting projects under uncertain business conditions.

Yu et al. (2021) conducted a longitudinal study of AHP research trends from 1982 to 2018. Their bibliometric analysis revealed AHP's adaptability and rising importance in academic and industrial decision-making. Debnath et al. (2025) proposed a hybrid MABAC-AHP method enhanced with Aczel–Alsina and Bonferroni mean operators. Their contribution advanced traditional MCDM models by enabling decision-making under complex and weighted criteria settings.

Chen et al. (2025) and Ma et al. (2025) introduced hesitant fuzzy and Fermatean fuzzy approaches into MADM frameworks. These allow for better expression of uncertainty and evaluator hesitation, particularly useful when projects involve uncertain ROI or varied stakeholder input. Dong et al. (2025) combined hybrid MADM with development projections for urban energy vehicles, emphasizing multidimensional assessment methods that consider both technical and strategic development criteria—analogous to company-level project evaluation.

Emam and Muha (2025) further extended MADM into artificial intelligence-driven systems for energy management, reinforcing the method's role in highly complex and data-driven environments. Meanwhile, Azimi and Chen (2025) presented a systematic review of MCDM methods, categorizing the evolution and comparative strengths of methods like AHP, TOPSIS, and VIKOR, providing a foundational base for selecting appropriate decision tools in research and practice.

These studies collectively underline the flexibility, reliability, and scalability of AHP and other MCDM models. They also highlight the growing need to hybridize classical techniques with fuzzy logic or statistical variance handling tools to accommodate real-world complexity and decision ambiguity. The insights from these references validate the use of AHP in the current study for prioritizing business projects, particularly where factors such as finance, return on investment, risk, and technical expertise play a central role.

Building upon the literature reviewed, it becomes evident that the effective application of Multi-Criteria Decision Making (MCDM) methods—particularly AHP and its fuzzy or hybrid extensions—requires a structured, stepwise approach. The studies examined, including those by Rakhade et al. (2021), Canco et al. (2021), and Baek (2025), emphasize not only the technical rigor of these methods but also the importance of clarity in problem definition, criteria identification, and goal alignment. These insights underscore the necessity of following a disciplined process to ensure the validity and impact of decision outcomes.

The works of Chabok and Tešić (2024) and Debnath et al. (2025) particularly highlight the role of well-defined steps in managing ambiguity and weighting stakeholder perspectives. Their frameworks demonstrate that the robustness of decision outcomes is directly proportional to the granularity with which each step is executed..

3. STEPS INVOLVED IN MULTI CRITERIA DECISION MAKING

Following steps should be taken care of while making decisions:

4. PROBLEM FORMULATION & GOAL SETTING

The process of precisely defining and identifying a problem that has to be resolved is known as problem formulation. It entails comprehending the context, defining the issue, establishing its parameters (scope), and identifying the relevant parties. After the problem has been formulated, goal setting entails establishing specific objectives to deal with the issue. Specific, Measurable, Achievable, Relevant, and Time-bound are the hallmarks of effective goals. This guarantees that the effort to solve problems is targeted, practical, and measurable.

5. IDENTIFYING CRITERIA AND ALTERNATIVES

One of the most important steps in making an excellent decision is determining the criteria and options. Standards like cost, sustainability, feasibility, and efficiency are used to assess possible solutions. These have to be pertinent, quantifiable, and in line with the objectives of the issue. Alternatives, or potential solutions, are produced once criteria are established. A wide variety of options helps prevent bias and guarantees a comprehensive examination of options. To choose the optimal option, each alternative will then be evaluated in light of the criteria. This phase increases the likelihood that problems will be resolved successfully by ensuring that judgments are supported by careful comparison and in line with established goals.

6. ASSESSING ALTERNATIVES

Assessing alternatives involves evaluating each potential solution against the established criteria to determine the most effective and feasible option. This step ensures that decisions are made based on objective analysis rather than assumptions or bias. Each alternative is scored or compared based on how well it meets the key criteria, such as cost, effectiveness, sustainability, and implementation ease. Tools like decision matrices or cost-benefit analysis may be used to support this process. By systematically assessing alternatives, decision-makers can identify the option that offers the best overall outcome and aligns most closely with the goals and priorities of the project.

7. AGGREGATING AND RANKING

Combining the assessments of each choice according to predetermined standards and then arranging them in order of least to most appropriate is known as aggregating and ranking. By evaluating each option's performance across all pertinent parameters, this stage assists in determining the optimal overall solution. To guarantee a fair comparison, techniques like multi-criteria decision analysis, weighted scoring, and ranking systems can be applied. Ranking offers a distinct hierarchy of options, whereas aggregation combines individual scores. Stakeholders can agree on the most efficient and important course of action with the aid of this organized approach, which promotes transparent, objective decision-making.

8. DECISION AND IMPLEMENTATION

The last stage of the decision-making process is decision and implementation, during which the option with the highest ranking is chosen and implemented. Stakeholder input, in-depth study, and alignment with established goals should all be considered before making the decision. Following the decision, a detailed implementation plan is created that details the necessary actions, materials, roles, and deadlines. To guarantee flawless execution, effective collaboration, communication, and monitoring are crucial. Ideas become reality through implementation, which frequently involves backup plans to handle unforeseen obstacles. A successful implementation puts the organization or project one step closer to reaching its goals and validates the decision-making process.

9. TECHNIQUES OF MCDM

Multi Criteria Decision Making (MCDM) techniques such as Analytical Hierarchical Process (AHP), Elimination and Choice Translating Reality (ELECTRE), Vlsekriterijumska Optimizacija I KOmpromisno Resenje (VIKOR) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) as shown in Figure 1.

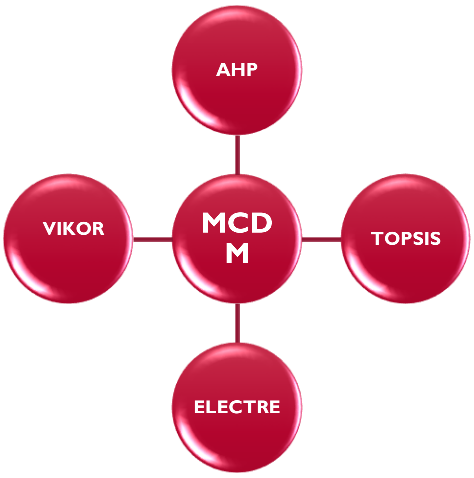

Figure1: Techniques of MCDM

Analytical Hierarchical Process (AHP) - The most common decision making technique organizes complicated issues into a hierarchy of standards and options. It helps prioritize options by pairwise comparison and consistency check. Its simplicity of use, ability to manage both qualitative and quantitative data, and decision-making rationale are among its benefits. Its dependence on subjective assessments, the possibility of inconsistent comparisons, and its inability to handle very large situations are drawbacks. It is a flexible multi-criteria decision tool with applications in business, engineering, healthcare, and government for tasks including resource allocation, supplier selection, and project prioritization.

Elimination and Choice Translating Reality (ELECTRE) – It is a multi-criteria decision-making technique that outranks less desirable options through pairwise comparisons. To deal with conflicting criteria, it assesses options using concordance (agreement) and discordance (disagreement) indices. Benefits include handling qualitative and quantitative data, producing reliable outcomes, and skillfully making complicated decisions with competing criteria. Its computational complexity, threshold-setting challenges, and occasionally less obvious outcomes are drawbacks. Applications include risk assessment, supplier evaluation, environmental management, and project selection, particularly in situations where making decisions requires balancing conflicting goals.

Vlsekriterijumska Optimizacija I KOmpromisno Resenje (VIKOR) – It is a multi-criteria decision-making technique that focuses on finding the compromise option that is closest to the ideal in order to rank and choose among alternatives. It uses a measure of both individual regret and group utility to balance competing requirements. Benefits include being relevant to both quantitative and qualitative data, offering alternatives for compromise, and skillfully managing competing criteria. Sensitivity to weight allocations and trouble interpreting findings when criteria strongly conflict are drawbacks. Applications include energy management, sustainable development, supplier selection, and engineering design, where decision-makers look for fair trade-offs between a numbers of conflicting variables.

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) – It rates options according to how much they deviate from the ideal best and ideal worst solutions. The solutions that are closest to the positive ideal and the ones that are farthest from the negative ideal is identified. Benefits include ease of use, a solid mathematical basis, and the capacity to manage both qualitative and quantitative standards. Its assumptions that criteria are increasing or decreasing monotonically, as well as its sensitivity to the scale of criterion and weight determination, are drawbacks. Applications include healthcare, environmental management, project prioritization, and supplier selection, assisting decision-makers in identifying the best alternative in relation to ideal standards.

Project Ranking through AHP

“The Analytic Hierarchy Process (AHP) was developed by Thomas L. Saaty in early 1970s”. It is a powerful tool based on 9-point scales and is used to assign weights to criteria’s chosen for decision making. The AHP method can be applied by the following procedure.

1. Analyze the problem and structure it into a set of alternatives and criteria’s. Let A = {1,2,3…….,M}be the set of alternatives .
2. Let P = {1,2,3……….,N} be the set of parameters for evaluation. AHP initially breaks down a problem into at least three level hierarchies consisting of:

- Top level is the goal of the problem,
- Middle level is the set of alternative decisions, and
- Bottom level is the decision parameter

Study the criteria’s and their relationship with one another in detail to design pair-wise comparisons between them. This pair-wise comparison is made with the help of Saaty’s scale as shown in Table 1.

Relation	**Intensity of importance**
Equally Important	1
Moderately more important	3
Strongly more important	5
Very strongly more important	7
Extremely more important	9
Intermediate values	2,4,6,8

Table1: Saaty scale of nine levels

E.g., if criteria C1 is three times more important than criteria C2, then design N*N matrix (here N=2) for pair-wise comparison is shown in Table 2.

Criteria	**C1**	**C2**
C1	1	3
C2	1/3	1

Table 2: Pair-wise comparison of two criteria's

In general, an evaluation matrix D of $N * N$ elements can be generated from pair- wise comparisons on 'N' criteria can be composed where N is the number of parameters.

Criteria used in the prioritization of projects

1. **Finance:** A set of criteria designed to understand the economic value of a project. These are directly related to cost, productivity, and profit indicators. It is non –beneficial as less the finance involved, more are the profits.
2. **ROI:** It is the percentage of return on the project. This allows you to compare the economic benefits of projects with different investments and returns. It is a beneficial as more the returns, more the profits.
3. **Risk:** It determines the level of risk tolerance that an organization accepts to carry out a project. Another possible perspective on this criterion is the organizational risk of not executing a project. It is non –beneficial as less the risk involved, more are the profits.
4. **Technical Knowledge:** The more technical knowledge that is readily available, the easier it is to run a particular project, and as a result, the less resources the project consumes. It is a beneficial criteria as more the knowledge, more the profits.

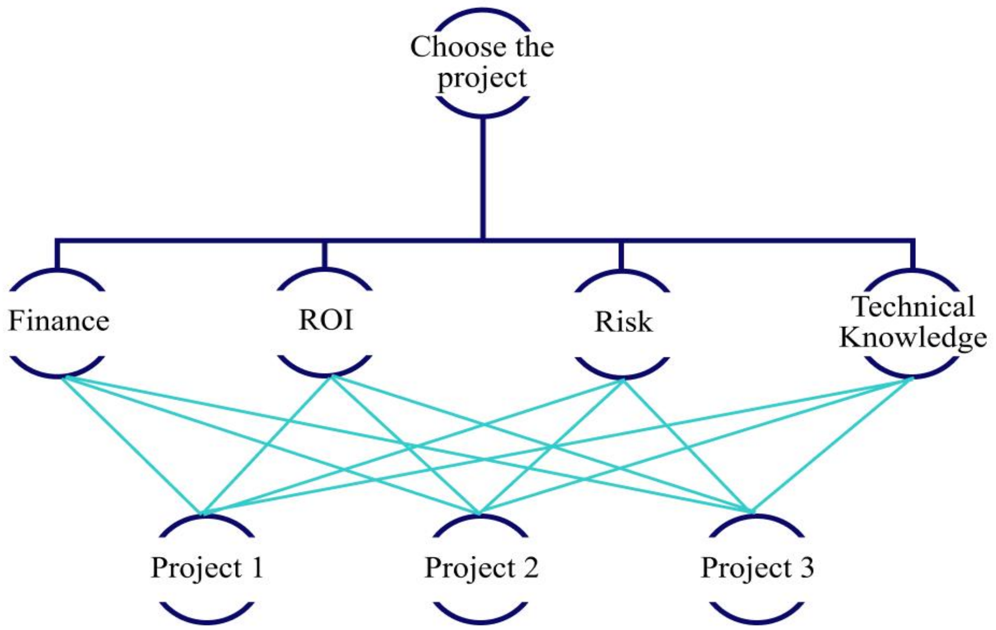

Figure 2: Developing a model

Step1: Prepare Pairwise Comparison Matrix

Parameters	Finance	ROI	Risk	Technical Knowledge
Finance	**1.00**	**0.14**	**0.20**	0.33
ROI	**3.00**	**1.00**	**2.00**	3.00
Risk	**5.00**	**0.50**	**1.00**	3.00
Technical Knowledge	**3.00**	**0.33**	**0.33**	1.00
Sum	**12.00**	**1.98**	**3.53**	**7.33**

Step 2 : Normalized Pair wise Matrix (Each value divided by sum of that column)

Parameters	Finance	ROI	Risk	Technical Knowledge
Finance	0.0833	0.0723	0.0566	0.0455
ROI	0.2500	0.5060	0.5660	0.4091
Risk	0.4167	0.2530	0.2830	0.4091
Technical Knowledge	0.2500	0.1687	0.0943	0.1364

Step 3 : Calculate weights (Sum of each row divided by 4)

Parameters	Finance	ROI	Risk	Technical Knowledge	weights
Finance	0.0625	0.0723	0.0566	0.0455	**0.05921**
ROI	0.4375	0.5060	0.5660	0.4091	**0.47966**
Risk	0.3125	0.2530	0.2830	0.4091	**0.31441**
Technical Knowledge	0.1875	0.1687	0.0943	0.1364	**0.14672**

Step 4 : Calculate priority & Rank for each alternative

	Non Beneficial	Beneficial	Non Beneficial	Beneficial
Alternatives	**Finance**	**ROI**	**Risk**	**Technical Knowledge**
Project 1	15,000	4000	5.6	5

Project 2	11,000	3000	6	3
Project 3	16,000	2500	5.2	8

Alternatives	Finance	ROI	Risk	Technical Knowledge	Priority	Ranking of Projects
Project 1	0.7333	1.0000	0.9286	0.6250	**0.9067328**	**I**
Project 2	1.0000	0.7500	0.8667	0.3750	**0.7464638**	**III**
Project 3	0.6875	0.6250	1.0000	1.0000	**0.8016226**	**II**
Weights	**0.059212**	**0.479663**	**0.314405**	**0.146719**		

With this, it can be comprehended that the organization will get maximum benefit for opting Project 1.

10. CONCLUSION

AHP has been attracting the practice of many researchers, especially because of the mathematical functions of the approach and the reality that facts access is reasonably easy to be produced. Its simplicity is characterized with the aid of using the pair-smart evaluation of the options in step with unique criteria.

Its utility to pick initiatives for the portfolio lets in the selection makers to have a selected and mathematical selection help device. This device now no longer handiest helps and qualifies the decisions, however additionally permits the selection makers to justify their choices, in addition to simulate feasible outcomes.

The use of AHP additionally presumes the usage of a software program utility tailor-made specially to acting the mathematical calculations. In this paper, the goal has been to expose the primary calculations executed at some point of the analysis, permitting mission managers to have an ok know-how of the technique, in addition to the complexity worried to creating the calculations with the aid of using hand (in case software program packages can`t be used).

Another essential thing is the best of the reviews made with the aid of using the selection makers. For a selection to be the maximum ok feasible, it ought to be regular and coherent with organizational outcomes. We noticed that the coherence of the outcomes may be calculated with the aid of using the inconsistency index. However, the inconsistency index lets in handiest the assessment of the consistency and regularity of the evaluations from the selection makers, and now no longer whether or not those evaluations are the maximum ok for a selected organizational context.

Finally, it's far essential to emphasize that selection making presumes a broader and greater complicated know-how of the context than using any unique technique. It predicates that a selection approximately a portfolio is a fruit of negotiation, human aspects, and strategic analysis, wherein techniques like AHP choose and manual the execution of the work, however they can't and ought to now no longer be used as commonplace criteria

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