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Prioritizing Research and Development Projects using a MCDM Technique

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Abstract: Research and development (R&D) projects are projects that are focused on creating new knowledge, products, processes, or services, or on improving existing ones. Prioritizing research and development projects refers to the process of evaluating and ranking a set of R&D projects based on their relative importance or value to the organization. A model was established by gathering the criteria to be used in Fuzzy Technique for Preference by Similarity to the Ideal Solution (F-TOPSIS) and Fuzzy Analytic Hierarchy Process (F-AHP) in prioritizing R&D projects. By combining these methods, it is possible to consider a wide range of factors and to handle uncertain or imprecise data when prioritizing R&D projects. The analysis was done using an example to prioritize research and development projects in an organization and comparing results.

Keywords: Research and Development, Projects, Prioritizing, Decision making, Fuzzy logic

I. INTRODUCTION

R&D initiatives are the lifeblood of innovation-driven organizations, whether they are in the technology sector, pharmaceuticals, military, manufacturing, or any other industry. These initiatives are the driving force behind product development, process optimization, and staying ahead of the competition.

Managing R&D projects is different from conventional project management, primarily because the outcomes are less certain and therefore so are time scales and plans. Organizations often face resource constraints, be it financial limitations, time pressures, or personnel shortages. This necessitates a rigorous evaluation and selection process to ensure that the most promising projects receive the necessary support and attention. Herein lies the critical role of project prioritization. MCDM methods offer a systematic approach to decision-making that accounts for the complexities inherent in R&D project evaluation. Unlike traditional decision-making processes that rely on single-criterion analysis or subjective judgments, MCDM takes a multi-dimensional approach.

MCDM emerges as a powerful tool to navigate this decision landscape. MCDM provides a structured framework for evaluating and prioritizing R&D projects based on multiple, often conflicting, criteria. In this research, we delve and explore into the intricacies of MCDM and merging it with Fuzzy logic in the context of R&D project prioritization. We aim to uncover how organizations can leverage FUZZY-MCDM methods to make informed decisions that align with their strategic goals and resource constraints.

II. STATEMENT OF THE PROBLEM

Most R&D projects are single-chance projects, for example, financial and human resources are pooled together for a period of time to focus on a particular task, such as developing a new product, and then those resources are dismantled and reallocated to new projects, so managing such projects requires a special type of organization to manage the resources of the research project in an effective manner and to maintain a clear picture of the progress of the project.

Prioritizing at the strategic and operational level is what usually makes the difference between success and failure. But many organizations don't do it well. Prioritizing increases success rates for strategic projects, increases alignment and focus of senior management teams around strategic goals, removes uncertainty in operations teams during decision-making, and most importantly, builds an execution-focused mindset and culture. Traditional decision-making approaches often fall short in providing organizations with the necessary tools to navigate this intricate decision landscape, leading to suboptimal resource allocation, missed opportunities, and potential project failures.

The core problem addressed in this research is the lack of a systematic and objective framework for prioritizing R&D projects that accounts for the multiple dimensions of evaluation, such as financial viability, strategic alignment, technical feasibility, and so. Companies that begin by prioritizing can benefit from significant cost reductions of about 15% by discontinuing less vital activities and incorporating repetitive activities (According to Harvard Business Review). The problem statement therefore revolves around the need to develop and implement a comprehensive decision-making framework that leverages Multiple Criteria Decision-Making (MCDM). This research will help R&D organizations in determining the importance and priority of the projects and tasks that they will carry out.

III. RESEARCH OBJECTIVES

The importance of this research is to provide a useful technique for prioritization R&D projects so that organization can focus their resources on successfully delivering those value-added projects, align the projects with organization strategies, balance the volume of projects with the organization capabilities to deliver those projects and support the managers in uncertainty decisions.
Multi-criteria decision-making techniques will be used and combined with fuzzy logic, such as Fuzzy-TOPSIS and F-AHP.

Fuzzy Technique for Order Preference by Similarities to Ideal Solution (F-TOPSIS) is one of the best methods to get ideal solution among the similar options. Also, it can be used to automate the process and overcome ambiguity and uncertainty in the selection process. Fuzzy Analytic Hierarchy Process (F-AHP) is a method of Analytic Hierarchy Process developed with fuzzy logic theory. The Fuzzy AHP method sets the AHP scale into the fuzzy triangle scale to be accessed priority.

IV. LITERATURE REVIEW

This section presents the previous studies related to research and development projects, and several tools could be used for Multi criteria Decision Making analysis such as: TOPSIS and AHP and using fuzzy logic in MCDM tools.

A. ***R&D Projects prioritization criteria***

Research and development (R&D) refer to the work that organizations do to develop new products, processes, or technologies. It typically involves a systematic and creative approach to discovering new ideas, testing hypotheses, and developing prototypes or proof-of-concepts. R&D can be applied to a wide range of fields, including science, engineering, healthcare, and business. It is an important aspect of innovation and helps organizations stay competitive in their respective industries. R&D can be costly, as it often involves significant investment in time, resources, and personnel, but it is considered essential for driving progress and growth [1].
Research and development (R&D) projects are projects that are focused on creating new knowledge, products, processes, or services, or on improving existing ones. R&D projects are typically undertaken by organizations to advance their capabilities, competitiveness, and [2].

Overall, R&D is an important aspect of any organization's growth and success. It helps organizations stay competitive, drive progress, and solve problems, which ultimately leads to increased efficiency and innovation [3]. Research and development (R&D) can have a significant impact on an organization's strategic direction. R&D is an important aspect of innovation, and the results of R&D projects can help an organization shape its strategic goals and objectives. For example, if an organization's R&D efforts lead to the development of a new product or process, this can inform the organization's strategic plan and lead to the creation of new business opportunities [4]. R&D can help an organization stay competitive and adapt to changing market conditions. For example, if an organization's R&D efforts lead to the development of a new technology that is in high demand, this can be a key component of the organization's strategic plan [5].

*B. **Fuzzy Multi-criteria descision making***

Fuzzy logic is a mathematical framework developed by Lotfi A. Zadeh in the 1960s that allows for the handling of uncertainty and subjectivity in decision-making by representing and manipulating vague or imprecise information. It is based on the idea that in many real-world situations, data and information may be imprecise, incomplete, or uncertain, and traditional binary logic (i.e., true/false or 1/0) may not be sufficient to represent and process this information [6].

In fuzzy logic, data and information are represented using fuzzy sets, which are sets of values that are assigned a degree of membership ranging from 0 (not a member) to 1 (fully a member). For example, a fuzzy set representing the concept of "temperature" might include values such as "cold" (degree of membership 0.2), "warm" (degree of membership 0.6), and "hot" (degree of membership 0.9). This allows for the representation of uncertainty and subjectivity in the data, as the degree of membership for a given value reflects the level of uncertainty or subjectivity associated with it [6].

In MCDM, "fuzzy" refers to the use of fuzzy set theory to deal uncertain or imprecise information about the criteria weights and the decision matrix. In a fuzzy MCDM model, the criteria weights and the decision matrix are expressed as fuzzy numbers, which are numbers that have a degree of uncertainty or imprecision [7].

V. RESSEARCH METHODOLOGY

*C. **R&D Projects prioritization criteria***

First Prioritizing research and development (R&D) projects involve a variety of criteria that can be used in fuzzy TOPSIS (FTOPSIS) to prioritize research and development (R&D) projects. In the pursuit of comprehensive insights into the prioritization of Research and Development (R&D) projects, a structured interview process was undertaken with five executives representing key facets of organizational management. Executives were selected based on their roles in decision-making processes in R&D organization, encompassing a spectrum of functions such as finance, strategy, technology, and operations. Their diverse expertise contributed to a comprehensive understanding of the multifaceted criteria influencing project prioritization. This methodological approach was employed to systematically collect criteria essential for effective project prioritization.

The gathered data from these interviews will be used in Fuzzy-MCDM methodology. The most prominent criteria that were derived from these interviews are the following:

- **Strategic alignment:** as a criterion for prioritizing R&D projects, refers to the extent to which a proposed project is in harmony with an organization's long-term goals, objectives, and overall strategic direction. In other words, it assesses how well a project aligns with the company's mission, vision, and strategic plans. When using strategic alignment as a criterion, organizations aim to ensure that the projects they invest in contribute directly to the fulfillment of their larger business strategies. Every organization has a strategic roadmap that outlines its goals, competitive positioning, and ways to achieve sustainable growth. This strategy might include aspects like expanding market share, entering new markets, introducing innovative products, improving operational efficiency, or enhancing customer experience. When assessing strategic alignment, organizations evaluate whether a proposed R&D project supports or enhances the realization of their strategic goals. For instance, if a company's strategic goal is to become a market leader in sustainable technologies, a project focused on developing innovative eco-friendly products would be strategically aligned. Projects that are strategically aligned have the potential to generate long-term benefits and contribute to the organization's sustained success. This aligns with the goal of maintaining stability and minimizing unnecessary risks. Strategic alignment ensures that an organization's projects are not pursued in isolation but rather as part of a cohesive strategy.

- **Importance to customer:** as a criterion for prioritizing R&D projects refers to evaluating how much a proposed project addresses the needs, preferences, and pain points of the organization's customers. This criterion focuses on ensuring that R&D efforts lead to the development of products, services, or solutions that resonate with customers and add value to their lives. Prioritizing projects that are important to customers reflects a customer-centric approach. It acknowledges that a business's success is closely tied to how well it meets the demands and expectations of its customers. Projects that align with customer needs are more likely to be relevant to the market and have a higher chance of success. A project that solves a pressing customer problem or fulfills an unmet need is more likely to generate interest and demand. Prioritizing projects that address customer importance can help a business stand out from its competitors. Unique features or solutions that directly cater to customer needs can provide a competitive advantage. Projects addressing customer needs can drive innovation by pushing the boundaries of what's possible to provide enhanced value. This can lead to breakthroughs and new market opportunities. Considering importance to customer as a prioritization criterion ensures that R&D efforts are directed toward creating products and solutions that resonate with customers, meet their needs, and contribute to the company's success in the marketplace.

- **Likelihood of success:** as a criterion for prioritizing R&D projects refers to the assessment of the probability that a proposed project will achieve its intended goals and objectives successfully. The project's technical, financial, and resource-related feasibility is evaluated. Projects that align with the organization's capabilities, expertise, and available resources are more likely to be successful. Projects are assessed based on the availability of necessary resources, including skilled personnel, funding, technology, and equipmentProjects that address current or emerging market demands have a higher likelihood of gaining traction. The maturity of the required technology plays a role in project success. Projects relying on established technologies are generally less risky than those involving unproven or cutting-edge technologies. The complexity of a project influences its likelihood of success. Projects with clear and manageable scopes are easier to execute successfully. Projects that have strong support from key stakeholders, including management, investors, and customers, are more likely to overcome challenges and achieve success. Reviewing the organization's track record in similar projects or industries can provide insights into its ability to execute and achieve successful outcomes. Considering the likelihood of success as a prioritization criterion helps organizations make informed decisions about allocating resources to projects that have a higher chance of achieving the desired results.
- **Project status:** as a criterion for prioritizing R&D projects refers to the current stage of development, progress, and status of ongoing projects within an organization. This criterion involves assessing the maturity, completion, and potential impact of projects that are already in progress when making decisions about prioritizing new R&D initiatives. Evaluating the progress of

ongoing projects helps in understanding how close they are to completion and whether they are on track to achieve their objectives. Monitoring the status of ongoing projects aids in managing the budget effectively. Understanding the status of ongoing projects enables organizations to assess the potential impact of their completion on the overall business goals. Completed projects might open up new opportunities or necessitate follow-up projects. If a high-priority project is encountering difficulties, the organization might need to adjust priorities to address the challenges and prevent further delays. Considering "project status" as a prioritization criterion helps organizations make informed decisions about the allocation of resources, timelines, and overall project portfolio management. It allows them to balance existing commitments with new opportunities and ensure that resources are utilized optimally to achieve both short-term and long-term goals.

- **Potential impact:** as a criterion for prioritizing R&D projects refers to the value and importance that a proposed project can bring to the organization. Projects that are significant align closely with the organization's strategic objectives, contributing directly to its mission, vision, and long-term goals. Significant projects address market needs, trends, and customer preferences. They have the potential to capture a substantial market share and generate demand. Projects that introduce solutions, technologies, or approaches can have a transformative impact on the organization and the industry. Innovation-driven projects are often considered significant. Projects that create a unique competitive advantage by offering features, capabilities, or solutions not currently available in the market are typically deemed significant. Projects with the potential to generate substantial revenue or open new revenue streams are considered significant from a business standpoint. Potential impact as a prioritization criterion helps organizations focus their R&D efforts on initiatives that have the potential to bring substantial value, innovation, and growth. It ensures that the organization's resources are channeled into projects that align with its long-term vision and contribute to its success in the market.

- **Technology utilized:** as a criterion for prioritizing R&D projects refers to the assessment of the technologies, tools, methodologies, and resources required to execute a proposed project. This criterion involves evaluating whether the organization has the necessary technical capabilities and expertise to successfully develop and implement the project. Projects that align with the organization's existing technical capabilities are more likely to be prioritized. If the required technology is already within the organization's expertise, it reduces the risk associated with implementation. Organizations need to have access to the required resources, equipment, and infrastructure to implement the technology involved in the project. The proposed technology should be compatible with the existing technological ecosystem within the organization to ensure smooth integration and implementation. The familiarity of the organization with the technology can influence the time it takes to bring the project to market. Familiar technologies are often associated with faster development cycles. The scalability of the technology is important, especially if the project aims to grow or expand in the future. Understanding how the proposed technology compares to what competitors are using can help in assessing the project's potential impact. Technology utilized as a prioritization criterion helps organizations evaluate whether they have the necessary technical capabilities, resources, and expertise to execute a proposed project.

- **Project feasibility:** as a criterion for prioritizing R&D projects refers to the assessment of whether a proposed project is realistically achievable within the organization's resources, capabilities, and constraints. This criterion involves evaluating various aspects of the project's feasibility to determine whether it can be successfully executed and whether the potential benefits outweigh the associated costs and risks. Organizations need to have the necessary human resources, funding, equipment, and facilities to execute the project effectively, evaluating whether the project can be completed within the allocated budget and whether the potential returns justify the investment.

Evaluating whether there is sufficient market demand for the project's outcomes. Feasible projects should have the potential to generate interest and meet customer needs. Ensuring that the project can be executed while complying with relevant laws, regulations, and industry standards. Project feasibility as a prioritization criterion ensures that R&D projects have a higher chance of delivering positive outcomes while minimizing risks and resource wastage.

*D. **Fuzzy TOPSIS and fuzzy AHP steps***

- Define the decision problem: Identify the criteria and alternatives for the decision problem and define the decision matrix that represents the evaluation of the alternatives based on the criteria.
- Assign criteria weights: Use fuzzy AHP to assign weights to the criteria based on their relative importance.
- Calculate the distance of each alternative from the ideal solution and the worst solution: Use fuzzy TOPSIS to calculate the distance of each alternative from the ideal solution and the worst solution for each criterion.
- Calculate the overall importance of each alternative: Use fuzzy AHP to calculate the overall importance of each alternative based on the criteria weights and the rankings obtained from fuzzy TOPSIS.
- Select the best alternative or a range of acceptable alternatives: Use defuzzification techniques to convert the fuzzy importance values into crisp (non-fuzzy) values and use these values to select the best alternative or a range of acceptable alternatives.

VI. RESULTS AND DISCUSSION

This chapter presents the data analysis and result discussion. All the data and inputs were done through interviews with senior executives and experts in research and development. FUZZY AHP and FUZZY TOPSIS tools will be used with the following criteria: Strategic alignment, Importance to customer, Likelihood of success, Project status, Potential impact, Technology utilized, and Project feasibility.

*E. **Fuzzy Analytic Hierarchy Process (F-AHP)***

Fuzzy analytic hierarchy process which will be used to calculate the weights of criteria. The most important step in AHP is creating the pairwise comparison matrix which will be created with the help of scale of relative importance.

The values in the scale of relative importance are numeric values, in fuzzy these numeric values are converted to fuzzy number, there are various terms used in fuzzy system.

- **Step.1 Fuzzification**

Fuzzification is converting linguistic terms into membership function. There are many kinds of membership functions we can used, but we will use triangular membership function.

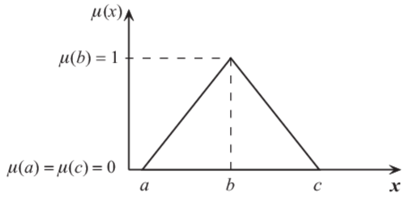

Figure 1: The membership function of a triangular fuzzy number

The fuzzy value is generally represented using three numbers together are known as fuzzy number, which is associated with the membership function. These three numbers are the lower, middle, and upper ends of the triangle on the X axis.

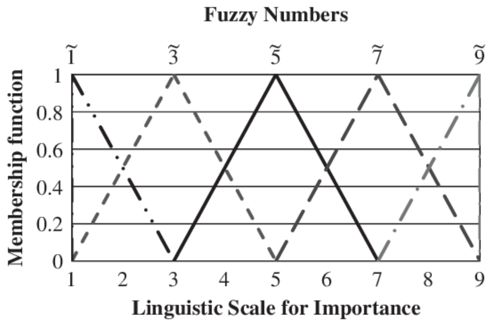

Figure 2: Fuzzy cyclic triangular membership function

Table 1: Converting linguistic terms into membership function

Importance	Scale	Fuzzification Scale
Equal	1	(1,1,1)
Moderate	3	(2,3,4)
Strong	5	(4,5,6)
Very Strong	7	(6,7,8)
Absolute Strong	9	(9,9,9)
Intermediate Values	2	(1,2,3)
	4	(3,4,5)
	6	(5,6,7)
	8	(7,8,9)

- **Step.2 Calculate the fuzzified pair-wise comparison matrix:**

Determine the relative importance of each criterion by comparing it to the other criteria using pairwise comparisons get a fuzzified pairwise comparison matrix, but the reciprocal value will be calculated using the following equation:

$$\tilde{A}^{-1} = (l, m, u)^{-1} = \left(\frac{1}{l}, \frac{1}{m}, \frac{1}{u}\right)$$

- **Step.3 Calculate the fuzzy geometric mean value** $\tilde{r}_i$

The following equation is used to multiply two fuzzy numbers. So, the lower point is multiplied with the lower point, the middle point with the middle point and the upper point with the upper point.

$\tilde{A}_1 \otimes \tilde{A}_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1 * l_2, m_1 * m_2, u_1 * u_2)$

- **Step.4 Calculate the fuzzy weights $\widetilde{w}_i$**

The fuzzy weights for each criterion will be calculated using the following formula.

$$\widetilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \ldots \oplus \tilde{r}_n)^{-1}$$

Adding all the fuzzy geometric mean values, the lower values are added together, middle values are added together, and upper values are added together to get the summation of two fuzzy number, then the reciprocal of sum by using the previous equation, then multiplied each fuzzy geometric mean value with the reciprocal of the geometric mean summation, the result will be a fuzzy number.

- **Step.5 Calculate the normalized weights.**

By take the average of fuzzy weight, and the weights are normalized by dividing each weight with the total (1.06)

Table 2: Normalized weight

		Weights (W)	**Normalized**
Criteria	C1	0.36	0.34
	C2	0.17	0.16
	C3	0.07	0.06
	C4	0.06	0.05
	C5	0.29	0.27
	C6	0.05	0.05
	C7	0.06	0.06
	Sum	1.06	1.00

*F. **Fuzzy Technique for Preference by Similarity to the Ideal Solution (F-TOPSIS)***

Fuzzy-TOPSIS used in scenario for performance value in decision Matrix, and it is not numeric value but instead they are linguistic terms which are given by the decision maker, without any numeric value, it's tough to calculate the rank or proceed with the calculation. Instead of directly assigning the linguistic term to the weights, decision maker can use fuzzy AHP to obtain the fuzzy number for weights of each criterion as was done previously.

- **Step.1 Fuzzification**

The five-point scale was fuzzified taken triangular membership function and each linguistic term was given a fuzzy number.

Table 3: Converting linguistic terms into membership function

Term	**Scale**	**Fuzzy Scale**
Very Low	1	(1,1,3)
Low	3	(1,3,5)
Average	5	(3,5,7)
High	7	(5,7,9)
Very High	9	(7,9,9)

- **Step.2 Create decision matrix.**

The five-point scale was in this study there are 7 alternatives which are ranked according to the 7 criteria which was rated by 3 Stakeholder based on five-point scale. The following table describes the characteristics of criterion as well as weight assigned with each criterion.

- **Step.3 Combination decision matrix.**

Combination of all three stakeholders' decision matrix on a single decision matrix using the following formula:

$$\tilde{\boldsymbol{x}}_{ij} = (\boldsymbol{a}_{ij}, \boldsymbol{b}_{ij}, \boldsymbol{c}_{ij})$$

- **Step.4 Normalized fuzzy decision matrix.**

The normalized fuzzy decision matrix is calculated using the following formula.

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right)$$

$$c_j^* = \max\{c_{ij}\}$$

- **Step.5 Weighted normalized fuzzy decision matrix.**

The weighted normalized fuzzy decision matrix is calculated using the following formula.

$$\tilde{v}_{ij} = \tilde{r}_{ij} \, x \, \tilde{w}_j$$

Multiplying the weightage with each component to get weighted normalized fuzzy decision matrix, using multiplying formula.

$$\tilde{A}_1 \otimes \tilde{A}_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1 * l_2, m_1 * m_2, u_1 * u_2)$$

- **Step.6 Calculate fuzzy ideal solution.**

Computing the fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS) using the following formulas.

$$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \ldots, \tilde{v}_n^*) \text{ where } \tilde{v}_j^* = \max\{v_{ij3}\}$$

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \ldots, \tilde{v}_n^-) \text{ where } \tilde{v}_j^- = \min\{v_{ij1}\}$$

In the formula, $\{v_{ij3}\}$ that is the C component of the fuzzy number is looked upon for $\{v_{ij3}\}$ that is FPIS, while $\{v_{ij3}\}$ that is the A component of the fuzzy number is looked upon $\{v_{ij3}\}$ that is FNIS.

- **Step.7 Compute the distance.**

compute the distance of each alternative from FPIS and FNIS, the following formula used to calculate the distance between two fuzzy numbers:

$$d(\tilde{x}, \tilde{y}) = \sqrt{\frac{1}{3}[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2]}$$

Then finding the summation of the values using the following formulas.

$$\tilde{d}_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij}, v_j^*) \qquad \tilde{d}_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, v_j^-)$$

- **Step.8 Compute closeness coefficient.**

Finding closeness coefficient to rank the alternative, highest value will be ranked first alternative, and the lowest value will be the last ranked alternative.

$$CC_i = \frac{\tilde{d}_i^-}{\tilde{d}_i^- + \tilde{d}_i^*}$$

Table 4: Rank the alternatives

Projects	CC	Prioritization
P1	0.655585	2
P2	0.6791165	1
P3	0.4319117	6
P4	0.5706529	4
P5	0.5200701	5
P6	0.6526496	3
P7	0.4005568	7

VII. CONCLUSION AND FUTURE WORK

Prioritizing R&D projects is a critical challenge for organizations aiming to allocate limited resources effectively and drive innovation. Successful R&D project prioritization lies in its alignment with an organization's strategic objectives and long-term vision. Without this alignment, organizations risk investing in projects that may not contribute meaningfully to their growth and competitiveness. Therefore, the starting point for any effective R&D project prioritization process is a clear understanding of the strategic goals and the role R&D plays in achieving them, this alignment ensures that R&D investments contribute directly to the growth and competitiveness of the organization.

To achieve this alignment, many organizations turn to structured decision-making frameworks, and one of the most excellent methodologies in this regard is the Analytic Hierarchy Process (AHP). AHP allows decision-makers to systematically evaluate and prioritize R&D projects by breaking down the decision criteria into a hierarchical structure. This method enhances transparency and consistency in the decision-making process. Moreover, AHP's flexibility in accommodating both qualitative and quantitative factors make it suited for R&D project prioritization. It empowers decision-makers to make informed choices by assigning relative importance to various criteria.

Additionally, the utilization of AHP, when combined with the fuzzy logic (Fuzzy-AHP), helps address the inherent uncertainty and subjectivity that often surrounds R&D project selection. Fuzzy-AHP allows for the incorporation of vague or imprecise information, which is common when evaluating R&D projects in the early stages. It enables decision-makers to express their preferences and judgments in linguistic terms, making the process easy and more realistic.

Another valuable technique used in this research is the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). TOPSIS offers a different perspective on project prioritization by identifying the projects that are closest to the ideal solution while considering multiple criteria simultaneously. Combining TOPSIS with fuzzy logic (Fuzzy-TOPSIS) adds the ability to manage ambiguity in criteria assessments, making it suitable for R&D project prioritization, this approach provides a clear ranking of projects.

Furthermore, the combination of Fuzzy-AHP and Fuzzy-TOPSIS can provide a comprehensive approach to R&D project prioritization. Fuzzy-AHP assists in structuring the criteria and determining their relative importance, while Fuzzy-TOPSIS focuses on ranking and selecting the most promising projects. This integrated approach combines the strengths of both methodologies to offer a holistic decision support system for organizations.

Moving forward, organizations should consider adopting a flexible prioritization framework tailored to their specific needs and objectives, the following recommendations are provided for organizations looking to improve their R&D project prioritization processes:

- Begin by ensuring a clear alignment between R&D projects and the organization's strategic objectives. Establish a well-defined innovation strategy that outlines the types of projects that will contribute to long-term growth and competitiveness.
- Consider incorporating fuzzy logic extensions, such as Fuzzy-AHP and Fuzzy-TOPSIS, into the decision-making process. These extensions allow for the representation of uncertainty and subjectivity in project assessments.
- Engage senior experts and stakeholders in the project prioritization process. Their insights and knowledge are invaluable for defining criteria, determining weights, and assessing project performance.
- Prioritization is an ongoing process. Continuously review and update the criteria, weights, and project evaluations to adapt to changing circumstances and evolving organizational goals and use the prioritization results to optimize resource allocation for R&D projects.
- Ensure transparent communication of the prioritization process and results to all stakeholders. This fosters trust, understanding, and alignment with organizational goals.
- Collect and analyze relevant data to support decision-making and establish key performance indicators (KPIs) to monitor the progress of selected projects.

In conclusion, the effective prioritization of R&D projects is a pivotal factor in an organization's ability to innovate and stay competitive. By implementing these recommendations of multi criteria decision-making frameworks coupled with fuzzy logic extensions like Fuzzy-AHP and Fuzzy-TOPSIS, organizations can substantially enhance their capacity to select and execute projects that are closely aligned with their strategic objectives. This approach not only drives sustainable growth and innovation but also ensures that resources are allocated for maximum impact.

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Ethical statement: The author declares that he followed the ethical responsibilities.

REFERENCES

[1] Moris, F. (2018). Definitions of research and development: An annotated compilation of officialsources. Alexandria, VA: National Science Foundation.

[2] Kenton, W. (2023, July 19). Research and Development (R&D) Definition, Types, and Importance. Investopedia.

[3] Sarpong, D., Boakye, D., Ofosu, G., & Botchie, D. (2023). The three pointers of research and development (R&D) for growth-boosting sustainable innovation system. Technovation, 122, 102581.

[4] Padgett, R. C., & Moura-Leite, R. C. (2012). The impact of R&D intensity on corporate reputation: Interaction effect of innovation with high social benefit. Intangible Capital, 8(2).

[5] Brennan, T., Ernst, P., Katz, J., & Roth, E. (2020, November 3). Building an R&D strategy for modern times. McKinsey & Company.

[6] Balaman, S. Y. (2018). Decision-Making for Biomass-Based Production Chains: The basic concepts and Methodologies.

[7] Krohling, R. A., & De Souza, T. T. M. (2012). Combining prospect theory and fuzzy numbers to multi-criteria decision making. Expert Systems With Applications, 39(13), 11487–11493.

