Research Article/Industrial Engineering http://doi.org/10.15446/ing.investig.114973

Integrating the Analytic Hierarchy Process, the Preference Ranking Method, and Stakeholder Analysis: A Methodological Guide for Strategic Decision-Making in Organizations

Integración del proceso analítico jerárquico, el método de preferencia para la toma de decisiones y el análisis de grupos de interés: una guía metodológica para la toma de decisiones estratégicas en organizaciones

Sebastian Bolaños-Cano [1], John A. Coy-Mejía [2], and Diego L. Peña-Orozco [3]

ABSTRACT

Contemporary organizational management entails a growing complexity in strategic decision-making processes, underscoring the need to have effective tools that support organizational sustainability in making complex decisions that consider multiple criteria. Said tools must follow a multidimensional approach that ensures a comprehensive evaluation of strategic options, considering criterion weighting, alternatives evaluation, and stakeholder influence. This work seeks to propose an integrated methodological guide for strategic decision-making in organizations, which combines the analytical hierarchy process (AHP), the Promethee II method, and stakeholder analysis, complemented by a PESTEL feasibility analysis to validate execution possibilities. The methodology described herein leverages the mathematical rigor of the AHP to determine the relative importance of the criteria, and it employs Promethee II for a detailed alternatives analysis. In addition, stakeholder analysis facilitates the alignment of strategic decisions with the expectations of all the relevant groups of interest, resulting in a robust and adaptable tool that facilitates a more informed and strategically aligned decision-making. The results obtained demonstrate that integrating these techniques significantly improves the clarity and objectivity of the decision-making process. It is concluded that our structured method can be adapted to a diversity of organizational contexts, which suggests its broad potential for application in strategic management processes, even in small and medium enterprises.

Keywords: multicriteria decision-making, analytical hierarchy process, preference ranking method (Promethee), stakeholder analysis, alternatives evaluation

RESUMEN

La gestión organizacional contemporánea plantea una creciente complejidad en los procesos de decisión estratégica, lo que resalta la necesidad de contar con herramientas efectivas que apoyen la sostenibilidad de la organización en la toma de decisiones complejas que consideran múltiples criterios. Dichas herramientas deben tener un enfoque multidimensional que asegure una evaluación integral de opciones estratégicas, considerando la ponderación de criterios, la evaluación de alternativas y la influencia de los stakeholders. Este trabajo busca proponer una guía metodológica integrada para la toma de decisiones estratégicas en organizaciones, donde se combinan el proceso analítico jerárquico (AHP), el método Promethee II y el análisis de stakeholders, complementados por un análisis de viabilidad PESTEL para validar las posibilidades de ejecución. La metodología aquí descrita aprovecha el rigor matemático del AHP para determinar la importancia relativa de los criterios y emplea Promethee II para el análisis detallado de alternativas. Adicionalmente, el análisis de stakeholders facilita la alineación de las decisiones estratégicas con las expectativas de todos los grupos de interés relevantes, lo que produce una herramienta robusta y adaptable que facilita decisiones más informadas y estratégicamente alineadas. Los resultados obtenidos demuestran que la integración de estas técnicas mejora significativamente la claridad y la objetividad del proceso de toma de decisiones. Se concluye que el método estructurado puede adaptarse a diversos contextos organizacionales, sugiriendo su amplio potencial de aplicación en procesos de gestión estratégica incluso para pequeñas y medianas empresas.

Palabras clave: toma de decisiones multicriterio, proceso analítico jerárquico, método de preferencia para la toma de decisiones (Promethee), análisis de stakeholders, evaluación de alternativas

Received: June 11th, 2024
Accepted: June 06th, 2025

[1] Industrial engineer, Universidad del Valle, Colombia. Affiliation: Young researcher, Universidad del Valle, Colombia. Email: sebastian.bolanos.cano@correounivalle.edu.co

[2] Industrial engineer, Universidad del Valle, Colombia. Affiliation: Young researcher, Universidad del Valle, Colombia. Email: john.coy@correounivalle.edu.co

[3] Industrial engineer, Universidad del Valle, Colombia. PhD in Engineering with an emphasis on Industrial Engineering, Universidad del Valle, Colombia. Affiliation: Associate professor at the Department of Engineering of Corporación Universitaria Minuto de Dios (UNIMINUTO), Colombia. Email: dpenaorozco@uniminuto.edu.co

Introduction

The definition of strategies in modern organizations faces increasing complexity, mainly due to the diversity of criteria to be considered in responding to the expectations of interested parties. In this context, the analytical hierarchy process (AHP) and the Promethee II method stand out as fundamental techniques within the realm of multi-criteria decision methods (MCDM), providing a methodological structure to address these complex decisions. These methods have been applied in several contexts, from supplier selection to infrastructure planning, confirming their usefulness in the comprehensive and strategic evaluation of options [1], [2].

For instance, a study conducted in the energy sector used AHP and Promethee II to select the optimal locations for offshore wind power stations while integrating multiple technical and environmental criteria. This approach provided a robust and well-informed solution for site selection, highlighting the versatility of these methods in environmentally sensitive contexts [3].

Another relevant case was the use of AHP and Promethee II in the construction industry, where quarry designs were evaluated and selected, weighing criteria such as flood risk and environmental impacts. This approach led to the selection of micro-tunnel systems, offering an effective and sustainable solution for stormwater management in urban areas [4].

As stated by Freeman, the relevance of stakeholder analysis is indisputable in strategic management, since it provides a framework for understanding the influences and priorities of each group interested in organizational decisions [5]. This approach is crucial for ensuring that decisions are not only effective but also inclusive and accepted by all the parties involved. A systematic review of MCDMs over 44 years revealed the significant evolution of these tools, showcasing their adaptation and application in several sectors to address emerging challenges [6]. Furthermore, recent studies demonstrate how MCDMs can improve the efficiency of industrial processes, highlighting their positive impact on organizational management and process optimization [7].

Notably, research on the AHP-Promethee combination has yielded consistent and reliable results, underscoring the effectiveness of integrating different MCDMs to improve objectivity and consistency. For instance, a study that applied several MCDMs for outdoor thermal stress mitigation showed that combining AHP with other methods can significantly optimize results, facilitating the selection of effective and sustainable strategies [8].

Furthermore, the introduction of new MCDMs that combine intuitive techniques and more detailed analyses, such as intuitive fuzzy sets and the feature object method, has driven continued innovation in the field, offering new opportunities to improve the adaptability and effectiveness of organizational decisions [9].

This article proposes a methodological guide that integrates stakeholder analysis, AHP, and Promethee II, providing a structured and replicable tool. The tool's workflow is presented in Fig. 1. Our methodology not only captures the complexity inherent in modern decisions; it also constitutes a balanced and comprehensive approach.

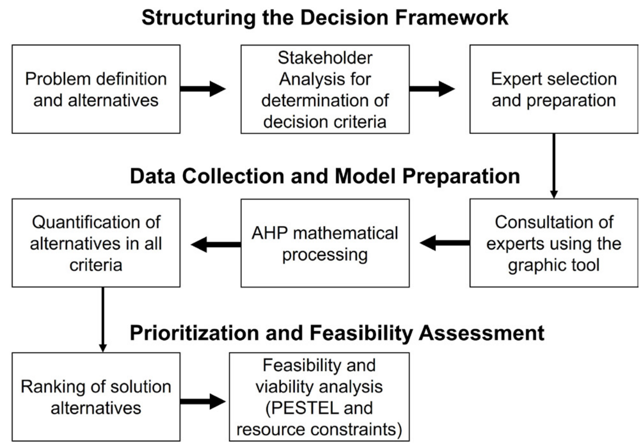


Figure 1. Methodological workflow of the tool
Source: Authors

Literature review

Analytical hierarchy process

The AHP was developed by Thomas L. Saaty in the 1980s. According to Saaty, this is a decision-making technique that decomposes a complex problem into a more manageable hierarchy of subproblems (Fig. 2). This methodology allows decision-makers to focus their attention on one criterion at time and then combine their judgments into a coherent overall structure [1].

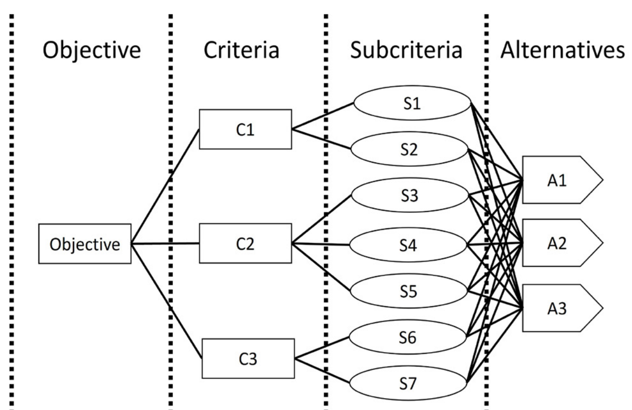


Figure 2. Example of an AHP
Source: Authors

Basic principles

AHP is based on three fundamental principles: decomposition, pairwise comparison, and synthesis of priorities.

- **Decomposition.** The first step is to decompose the problem into a decision hierarchy, which includes the general objective, the criteria used to fulfill said objective, and the alternatives to be evaluated.
- **Pairwise comparison.** In the second step, pairwise comparisons between criteria and alternatives are made. Decision-makers assign numerical values to represent the relative importance of each criterion or alternative compared to the others [10]. This is done using a scale of 1 to 9, where 1 indicates equal importance and 9 indicates extreme importance of one element over another (Table I).
- **Synthesis of priorities.** The third step involves the synthesis of the pairwise comparison into a set of global priorities. This process uses the eigenvector method to calculate weights for each criterion and alternative, thereby ranking the available options.

Table I. Saaty scale for pairwise comparison

VALUE	DEFINITION	COMMENTS
1	Equal importance	Both criteria contribute equally to the objective
2	Intermediate values	
3	Moderate importance	Experience suggests a slight preference for criterion A over criterion B
4	Intermediate values	
5	Great importance	Evidence shows a notable preference for criterion A over criterion B
6	Intermediate values	
7	Paramount importance	Criterion A is significantly more important than criterion B
8	Intermediate values	
9	Extreme importance	The superiority of criterion A over criterion B is absolutely evident

Source: Authors

Applications and advantages

AHP has been applied in a wide variety of contexts, including supplier selection, strategic planning, and project evaluation. Its main advantages include the ability to structure complex problems in a hierarchical manner and its systematic approach to weighting criteria and alternatives. Additionally, AHP allows decision-makers to incorporate both qualitative and quantitative data into the process, making it particularly useful in situations where multiple factors and perspectives must be considered [1].

Recent extensions and innovations

Recent advancements in the AHP have significantly improved its adaptability to complex and uncertain decision-making environments. One such development is the introduction of parsimonious AHP models, which aim to reduce the cognitive load on decision-makers while preserving analytical robustness. [11] proposed a dynamic and perspective-based AHP model that streamlines traditional structures to better suit industrial contexts, emphasizing efficiency and clarity in prioritization. Expanding on this, [12] developed the parsimonious spherical fuzzy AHP (*i.e.*, P-SF-AHP), which incorporates spherical fuzzy logic to better capture expert hesitancy and reduce assessment ambiguity. This method not only enhances the interpretability of preferences under uncertainty but also simplifies data collection through fewer pairwise comparisons.

Similarly, [13] applied the spherical fuzzy AHP framework to transportation planning problems, particularly for determining park-and-ride facility locations. Their approach demonstrates the method's efficacy in synthesizing opinions from heterogeneous expert groups while handling conflicting priorities under uncertainty. These innovative adaptations of AHP strengthen its relevance in modern decision-making by addressing two fundamental limitations of the classical model, *i.e.*, excessive comparison requirements and a limited treatment of uncertainty. Despite these developments, the classical version of AHP is still preferred for its mathematical soundness and ease of use, particularly when integrated with other MCDMs such as Promethee II.

Promethee II

The Promethee method was developed by Jean-Pierre Brans and Bertrand Mareschal in 1982. It is a MCDM used to rank and order a set of alternatives evaluated based on multiple criteria. Unlike other methods, Promethee allows for direct preference analysis and does not require criterion compensation [2].

Fundamental principles

Promethee is based on the pairwise comparison of alternatives in relation to each criterion, using preference functions that quantify the advantage of one alternative over another. Several preference functions (Fig. 3) can be applied depending on the nature of the criterion and the preferences of the decision-maker [14].

- The **usual function (I)** is applied when the differences between the alternatives are not significant.
- The **u-shape function (II)** is used when a small difference is indifferent, but a larger one is significant.
- The **v-shape function (III)** is like the u-shape function, but with a linear slope.
- The **level function (IV)** is used for qualitative criteria.
- The **v-shape function with indifference (V)** combines the features of the v-shape and usual functions.
- The **Gaussian function (VI)** is used when small differences are more important than large ones [15].

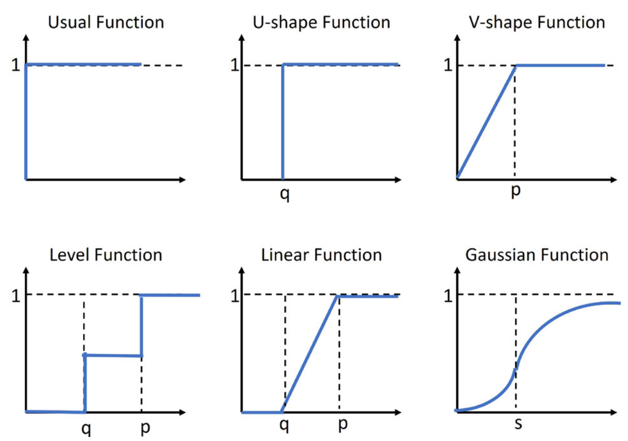


Figure 3. Representative graph of the Promethee II functions
Source: Authors

Promethee procedure

The Promethee procedure involves several key steps:

i. Alternatives and relevant criteria are identified and defined.
ii. Each alternative is evaluated based on the defined criteria.
iii. Appropriate preference functions are applied to quantify the advantage of one alternative over another.
iv. Aggregate preference indices are calculated, and preference values are added for each pair of alternatives.
v. Alternatives are classified based on the aggregate preference indices [16].

Applications and benefits

Promethee has been widely used in various fields, including supplier selection, urban planning, and project evaluation. One of its key advantages lies in the ability to handle complex problems with multiple conflicting criteria, in addition to its flexibility in the selection of preference functions, which makes it suitable for a wide range of decision problems [17].

Stakeholder analysis

Stakeholder analysis is a fundamental technique in strategic and project management. It focuses on identifying and evaluating all the groups and individuals that affect or are affected by the decisions and activities of an organization. This technique is crucial for understanding the influences, interests, and power of different stakeholders, which in turn facilitates the effective planning and management of organizational initiatives [18].

Fundamentals

The concept of *stakeholder* was popularized by R. Edward Freeman in his 1984 book titled *Strategic Management: A Stakeholder Approach*. Freeman defined stakeholders as "any group or individual who can affect or be affected by the achievement of an organization's objectives" [3, p. 46], an approach that has revolutionized strategic management. Below are the steps involved in this method.

i. **Stakeholder identification.** All groups and individuals who may have an interest in the project or decision are identified. This includes both internal (employees, managers) and external (customers, suppliers, regulators) stakeholders.
ii. **Stakeholder classification.** The stakeholders are classified based on their power, legitimacy, and urgency, which helps to prioritize their management. A commonly used tool for this classification is the power/interest matrix [3], which is shown in Fig. 4.
iii. **Assessment of interests and influences.** The interests and influence of each stakeholder are evaluated, which implies understanding their positions and the potential impact of their actions on the project.
iv. **Development of stakeholder management strategies.** Specific strategies are developed to manage all positions and minimize conflicts with key stakeholders, highlighting active participation throughout the decision-making process.

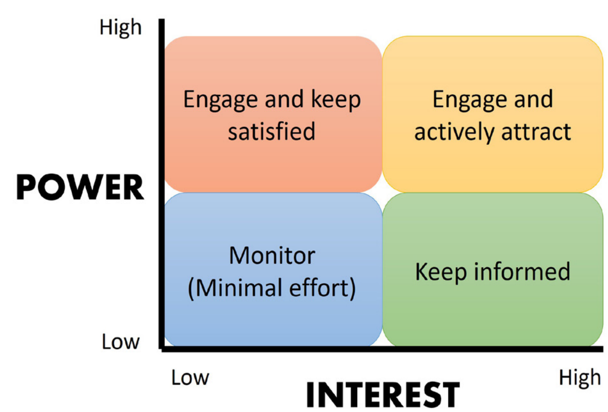


Figure 4. Power/interest stakeholder matrix
Source: Authors

Importance

Stakeholder analysis is vital for the success of any project or strategic decision. Among its advantages, the following can be highlighted:

i. It improves decision-making. It provides a clear understanding of the power dynamics and interests at play, facilitating more informed and balanced decision making.
ii. It facilitates acceptance and support. By involving stakeholders in the decision-making process, the likelihood of acceptance and support for final decisions is increased.
iii. It minimizes conflicts. It allows identifying and addressing potentially conflicting interests before they become significant problems.
iv. It promotes transparency and accountability towards all stakeholder groups [20].

Recent developments in MCDMs and justification for the selected approach

In recent years, various MCDMs have emerged to address the increasing complexity of decision environments. Among these, the Grey PSI and Grey MARCOS models offer robust solutions for ranking alternatives under uncertainty and limited data availability, proving useful in sectors like finance and insurance, where precise measurements are challenging and the criteria are numerous [21].

Additionally, hybrid approaches combining fuzzy logic and traditional decision models have been developed for highly technical applications. For instance, [22] introduced a decision framework integrating the fuzzy AHP (*i.e.*, FAHP) with Lanchester combat simulation models to optimize defense planning under uncertainty. These advanced models provide greater flexibility in modeling ambiguity and can yield highly precise results in structured environments with access to specialized software and expert evaluators.

Despite the merits of these modern approaches, their applicability in small and medium-sized enterprises (SMEs) is often limited due to constraints related to technical infrastructure and expertise. Therefore, models that are both analytically sound and accessible become essential.

The combination of AHP and Promethee II offers an ideal balance between methodological rigor and practical usability. AHP is widely recognized for its structured pairwise comparison framework and its ability to capture expert judgment consistently, while Promethee II is known for its transparent preference modeling and ease of ranking alternatives. Together, they form a hybrid approach that is highly adaptable to real-world decision-making, especially in organizational contexts with limited resources.

This hybrid AHP-Promethee II model has been validated across diverse sectors. For example, [23] applied it to evaluate the resilience of sewer networks in Seoul while considering urban flood and ground collapse risks. Similarly, [24] utilized it to determine suitable areas for artificial groundwater recharge in Iran. Moreover, [25] employed this framework to assess the severity of factors influencing road accidents in Gujarat, India. Their study incorporated expert judgments to weigh injury types and ranked 82 minor factors, ultimately identifying speeding, the male gender, and clear weather conditions as the most severe contributors to road accidents. These applications demonstrate the model's versatility and robustness in handling complex, multi-criteria decisions.

In the context of SMEs characterized by constraints related to technical capacity and decision times, the AHP-Promethee II approach provides a decision support system that is not only technically grounded but also intuitive and adaptable. By integrating stakeholder analysis, this framework enhances the participation and alignment of internal and external actors. This is particularly valuable in SMEs, where decision processes are often less formalized.

Methodology

The proposed methodology combines a variety of techniques and tools to provide a comprehensive solution for strategic decisions in organizations. This section details each of the necessary steps in its implementation.

Identification of the problem and alternative solutions

The process starts with a clear identification of the problem to be addressed. This involves carrying out a thorough analysis of the current situation and identifying possible alternative solutions based on the proposed objectives. For this pre-methodological stage, the use of the Logical Framework is recommended, along with its problem and objective trees, which are the basis for identifying alternative solutions.

List of criteria through stakeholder analysis

The next stage is the identification and weighting of the relevant criteria for the decision process, which employs stakeholder analysis.

Stakeholder identification

All relevant stakeholders who have an interest in the decision under study must be identified. This may include employees, customers, suppliers, shareholders, and any other group or individual who may be affected by the decision. They should be knowledgeable about the basic activities and functioning of the organization.

Stakeholder analysis

The power/interest matrix is used to analyze each stakeholder's influence and interest. In other words, the stakeholders are listed and classified based on power and interest criteria regarding the situation or problem. Accordingly, each of them is placed in a quadrant of the matrix (Fig. 4). In the next step, we recommend focusing the efforts on the stakeholders in the high-power/high-interest and high-power/low-interest quadrants. This is due to their ability to influence the project outcomes and their strategic importance. According to this technique, stakeholders with both high power and high interest should be managed closely due to their ability to support or derail the project, and those with high power but low interest should be kept satisfied through minimal but adequate updates, given that their participation and commitment are key to project success. Meeting their basic needs and keeping them informed at a high level helps to prevent them from becoming blockers [5].

List of criteria

Based on the stakeholder analysis, an information collection tool is defined, be it interviews, group meetings, or surveys. From the discussions carried out and the tools applied, the key elements that stakeholders consider critical for decision-making are extracted and consolidated into a list. This list should be reviewed with all interested parties to ensure that all important aspects are appropriately covered and prioritized.

Expert selection and preparation

It is important to distinguish between stakeholders and experts within this methodology: stakeholders participate mainly in identifying and prioritizing decision criteria, while experts are selected to provide technical judgments and evaluate alternatives.

Expert selection is crucial for ensuring the validity and reliability of the evaluation process. Criteria must be selected while considering the economic activities of closely related companies. Specific experience in areas related to the alternatives and contextual knowledge of the company are essential criteria for this evaluation. Nevertheless, it is more important to know the company's field of operation than having exhaustive knowledge of organizational operations.

On the other hand, detailed problem briefings and decision processes, along with visual support tools (Fig. 5), are recommended to ensure adequate understanding and effective engagement.

Consulting experts using the graphical tool

The graphical tool presented in this work is a fundamental innovation of this methodology, as it facilitates the experts' pairwise comparison of criteria in a visual and interactive way, with the aim of improving their understanding.

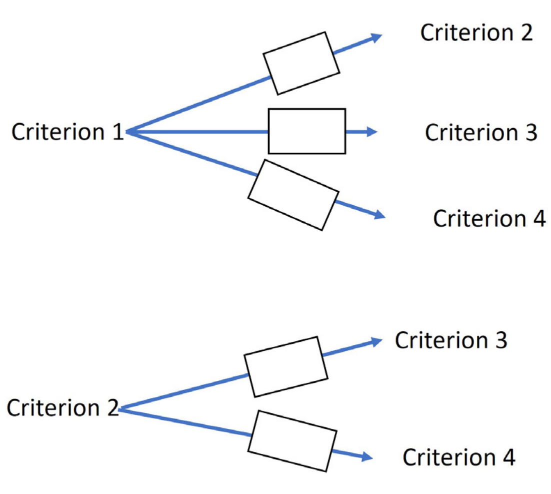


Figure 5. Graphical pairwise comparison tool
Source: Authors

This tool shows the possible relationships between the previously listed criteria. Its operation, which is fully subjective and related to the expert's preferences, involves deciding on one of two criteria. As an example, if criterion X is preferred over criterion Y, a color is selected to write, in the corresponding white box, a number that represents the level of preference. This number indicates how much one criterion is preferred over the other, according the Saaty scale. Fig. 6 shows an example of ratings given by an expert, where green represents a preference for the left-side criterion, while red represents the opposite. In addition, a translation/explanation statement is provided to facilitate the interpretation of the tool.

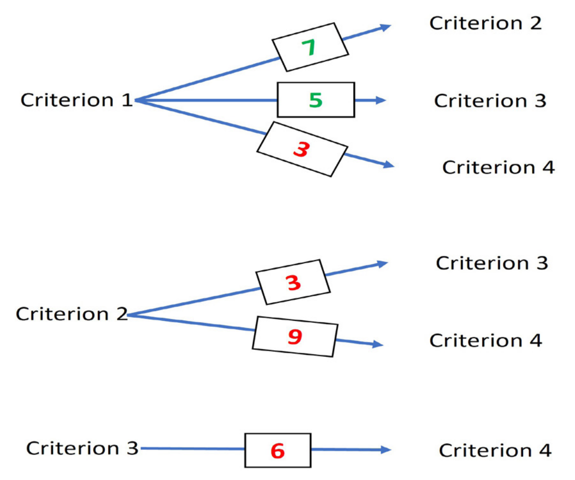


Figure 6. Example of the graphical tool's application
Source: Authors

The verbal rating scale presented in Fig. 6 is as follows:

- Criterion 1 is preferred over criterion 2 with very great importance
- Criterion 1 is preferred over criterion 3 with great importance
- Criterion 4 is preferred over criterion 1 with moderate importance
- Criterion 3 is preferred over criterion 2 with moderate importance
- Criterion 4 is preferred over criterion 2 with extreme importance
- Criterion 4 is preferred over criterion 3 with great to very great importance

We recommend presenting the tool face to face to the expert, establishing the colors used to represent preference. Furthermore, we recommend explaining all instructions and the rating scale used (Fig. 7).

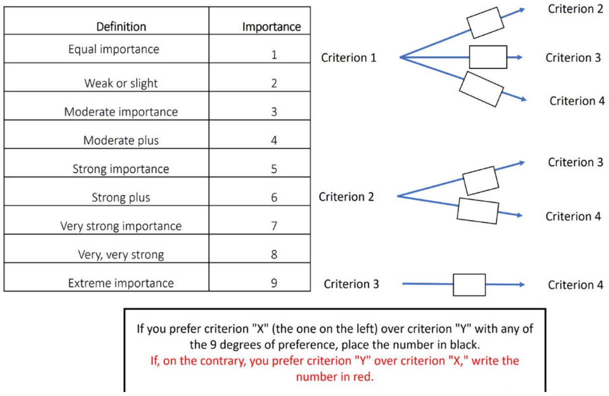


Figure 7. Graphical tool with recommended elements
Source: Authors

Mathematical processing of the information obtained

The experts' evaluations are transferred to different AHP matrices while considering the colors and locations of the numbers, as well as their corresponding inverses within the pairwise comparison matrix. This is done to verify the consistency of the evaluations and ensure data reliability. It should be noted that, in the first instance, it is possible to obtain inconsistencies greater than 10%, which is the recommended limit, given the experts' learning curve regarding the method and the use of the tool.

Next, the comparison matrices are unified by means of the geometric mean, which aids in preserving the reciprocity and multiplicativity of the pairwise comparison matrices [26]. Then, based on this unified matrix, the priority vector is calculated in order to determine the weight of each criterion within the decision-making process.

Quantifying the alternatives

To implement Promethee II, it is necessary to obtain accurate data on how each alternative meets the established criteria by consulting key experts or secondary sources. A thorough investigation is necessary; the more precise the data, the better the results obtained.

The preference functions used in Promethee II must also be configured with input from the most relevant stakeholders (quadrant 4), although the final calibration and evaluation are performed by the selected experts. Those classified in quadrant 4 (high power/high interest) are recommended, as they constitute the most influential people in the project and allow for the highest probability of success.

Implementation of Promethee II

Promethee II is applied using the criterion weights obtained via AHP and the data from the previous step, with the purpose of calculating the net flow of each alternative and generate a ranking.

Feasibility analysis of the selected alternatives

In this subsection, we propose a complementary technique for evaluating the feasibility of the alternatives in the ranking. This tool focuses on determining whether the alternatives obtained can be executed by the company, analyzing each one according to the PESTEL factors (political, economic, social, technological, environmental, and legal). These factors are defined below.

- The political factor involves an assessment of the political stability conditions, government regulations, and fiscal policies that could influence the implementation of an alternative.
- The economic factor considers the current economic situation, as well as access to funding and associated costs.
- The social factor analyzes an alternative's social impact and acceptance by staff, clients, and all parties involved.
- The technological factor evaluates the existing technological infrastructure and the capacities necessary for implementing an alternative.
- The environmental factor considers the sustainable impact of an alternative.
- The legal factor refers to regulatory and legal considerations that could impact the implementation of an alternative, including compliance requirements, licensing, or potential legal constraints.

For each of these factors, an evaluation scale from 1 to 5 is used. This allows precisely qualifying each factor according to its impact on the feasibility of an alternative. The proposed scale is presented below.

1. – very unfavorable: extremely adverse conditions that make implementation impossible
2. – unfavorable: unfavorable conditions that significantly hinder implementation
3. – neutral: conditions that do not significantly facilitate or hinder implementation
4. – favorable: several favorable conditions that facilitate implementation
5. – very favorable: optimal and highly favorable conditions for implementation

To evaluate each alternative in the ranking, we recommend consulting key people with knowledge of both the company and the factors associated with the evaluation. Moreover, it is necessary for them to understand the implication of the solution alternatives. A key element of this technique is the definition of a minimum score threshold for determining whether an alternative is viable. This threshold can be adjusted by the company according to the specific context and priorities. We recommend using a total score of 18 as the initial threshold, which is equivalent to an average of 3 in each factor. This value ensures sufficient conditions regarding all aspects. Alternatives with total scores equal to or greater than the minimum threshold can be classified as viable. Their application can be assessed in descending order according to the ranking obtained through Promethee II, *i.e.*, if the first alternative in the ranking does not meet the threshold, the next one is evaluated, and so on. This ensures that the company chooses the most viable and feasible alternative for a given context.

Results

As a case study, we analyzed an SME located in an intermediate city in Valle del Cauca (Colombia), with about 35 000 inhabitants. Founded in 2019, this company specializes in manufacturing iron strappings for the construction industry. Difficulties have been identified regarding the company's ability to supply the demand, especially in periods with high order volumes. This could harm the company in terms of its economy and reputation, among other aspects. It could be said that SMEs in this sector have similar structures and generally face operational limitations that confront them with the need for strategic decisions aimed at ensuring their sustainability.

Problem identification and alternative solutions

Once the central problem had been identified (the company's inability to efficiently satisfy the demand at times with high order volumes), it was broken down into key components. This structured analysis (Fig. 8) provides a thorough understanding of the underlying causes and resulting effects.

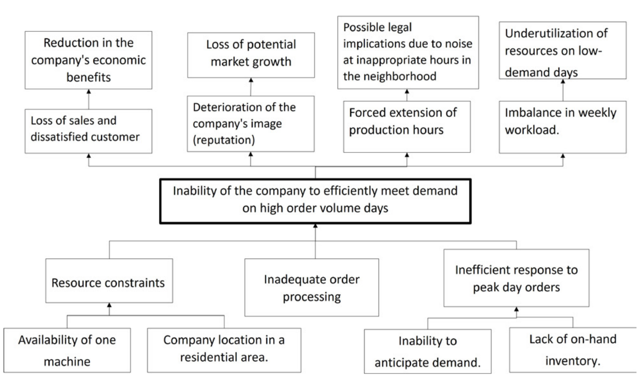


Figure 8. Problem tree for the case study
Source: Authors

The proposed objective tree (Fig. 9) represents a problem of strategic analysis. This tool divides it into branches and proposes concrete measures to address the identified causes.

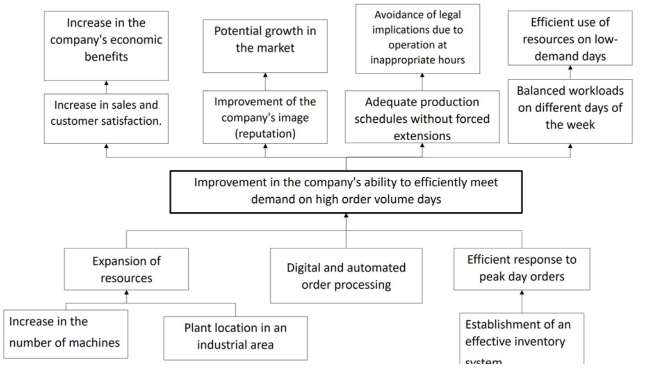


Figure 9. Objective tree for the case study
Source: Authors

List of criteria

As previously mentioned, stakeholder analysis focuses on evaluating the power and interest of each group in relation to the project. Below is a brief description of the stakeholders identified in this case study, followed by their classification, in order to appropriately establish the evaluation criteria.

- *Business owner:* responsible for strategic direction and key decision-making. He has a comprehensive vision of the business and seeks to optimize operations and maximize profitability. This stakeholder has high power and high interest.
- *Neighborhood:* local community affected by noise pollution and other externalities of the company's operation. This stakeholder has low decision-making power but high interest.
- *Client:* buyers of the company's products, interested in quality, delivery times, and competitive prices. They have no power over decision-making but a high interest.
- *Suppliers:* they supply the raw materials necessary for production and are interested in maintaining a stable and continuous commercial relationship. They have low power and interest.

The stakeholder classified in quadrant four (high/high) corresponds to the owner of the SME. The crucial criteria for alternatives assessment were provided by him through interviews:

- Initial investment cost
- Monthly operating costs
- Lead time reduction.
- Success probability
- Time horizon
- Operating efficiency

Expert selection and preparation

During the analysis, highly relevant experts were identified in relation to the proposed alternatives. For the SME under study, the following were selected:

- *Business owner:* an expert with in-depth knowledge of internal operations, history, and the local market. He is familiar with the company's clients and challenges. Additionally, he has information about available financial resources and limitations.
- *The municipal government's infrastructure secretariat:* an expert with in-depth knowledge of the regulations, restrictions, and opportunities associated with the location and work schedules of companies in different areas of the municipality.
- *Operator:* an expert with in-depth knowledge of the company's internal day-to-day operations.
- *Client:* a regular customer of the company with experience in the construction industry, especially regarding the use of strapping in construction projects. He has a working knowledge of product quality and customer needs.
- *Industrial engineer:* an expert with in-depth knowledge of inventory management strategies, their design, the costs involved, financial analysis, and resource optimization.

Consulting experts using the graphical tool

Individual sessions were organized with each expert to familiarize them with the graphic tool. Figs. 10-13 show the results obtained for two of the five experts consulted.

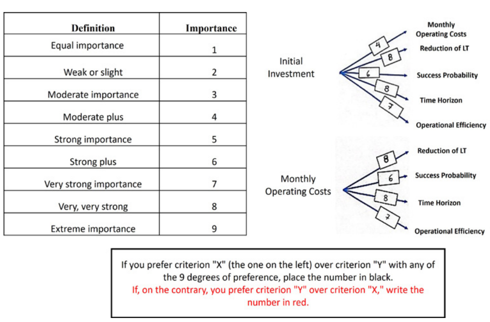


Figure 10. Assessment provided by the business owner after using the graphical tool
Source: Authors

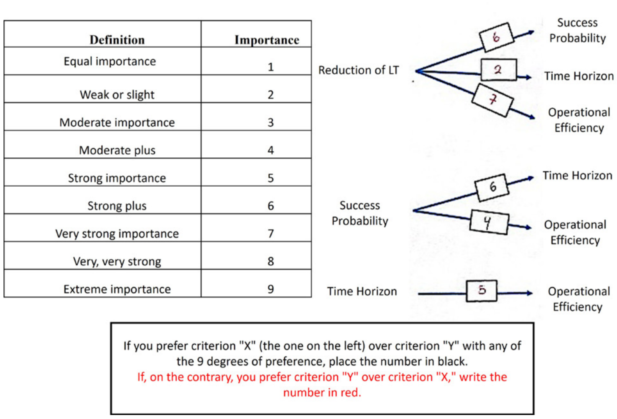


Figure 11. Assessment provided by the business owner after using the graphical tool (2)
Source: Authors

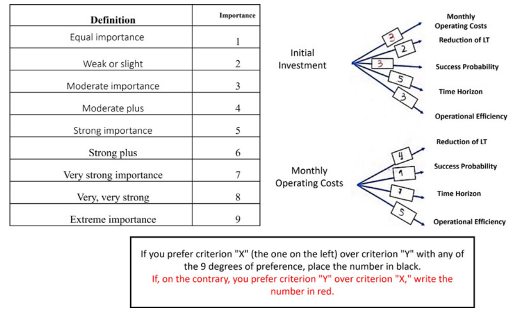


Figure 12. Assessment provided by the industrial engineer after using the graphical tool
Source: Authors

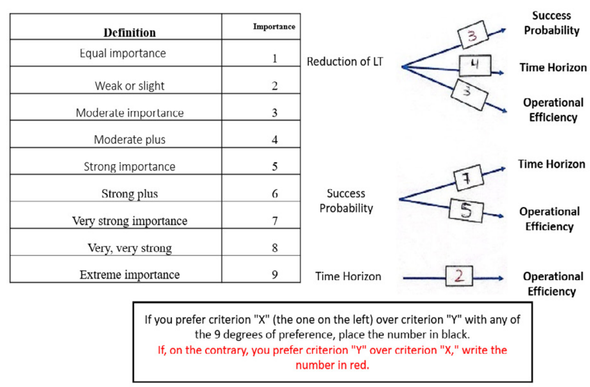


Figure 13. Assessment provided by the industrial engineer after using the graphical tool (2)
Source: Authors

Mathematical processing of the information obtained

The AHP was used to ensure weight consistency by calculating the consistency coefficient. In cases of significant discrepancies, experts were asked to review and adjust their judgments. The data obtained from all consultation sessions were unified into a matrix to calculate the final weights of the criteria (Table II and III), as well as the corresponding consistency coefficient.

Table II. Priority vector of the criteria

Criterion	VP
Initial investment	0.468710716
Monthly operating costs	0.266098027
Lead time reduction	0.033671037
Probability of success	0.097793158
Time horizon	0.045923271
Operational efficiency	0.087803792

Source: Authors

Table III. Consistency indicators of the matrix

λ	CI	CR
7.382413838	0.276482768	0.307203075

Source: Authors

Quantifying the alternatives

This process involved collecting detailed data on how each option satisfied the established criteria, with elements such as quotes from different suppliers, cost projections for each solution alternative, the risk/viability of each alternative as evaluated by internal and external experts, and projections based on the implementation times of similar projects. On the other hand, preference functions were defined through workshops with the business owner, who provided valuable information on strategic and operational priorities. These functions helped to establish specific thresholds of acceptance and intolerance, in order to reflect decision-maker behavior.

The results of this process are presented alongside the preference functions obtained (Tables IV and V).

Table IV. Table of alternatives and description

ALTERNATIVES	DESCRIPTION
A	Construction of a second machine
B	Relocation of the plant to an industrial zone
C	Systematization of order processing
D	Anticipated demand planning
E	Design of an inventory management system

Source: Authors

Table V. Quantification of alternatives and preference functions

	C1	C2	C3	C4	C5	C6
	Initial investment	Monthly operating costs	Lead time reduction	Probability of success	Time horizon	Operational efficiency
Preference	min	min	max	max	min	max
Type	II	III	I	I	I	I
Parameter	q=3 500 000	p=1 200 000	-	-	-	-
A	$ 45 000 000.00	$ 3 400 000.00	40%	60%	6	15%
B	$ 6 000 000.00	$ 4 000 000.00	30%	60%	1	20%
C	$ 1 500 000.00	$ 1 900 000.00	10%	90%	2	25%
D	$ 2 000 000.00	$ 1 900 000.00	20%	80%	7	10%
E	$ 1 200 000.00	$ 1 900 000.00	40%	80%	3	18%

Source: Authors

Implementation of the Promethee II method

The mathematical processing using Promethee II included the calculation of the positive ($\Phi+$) and negative (Φ-) net flows for each alternative. These flows measure the relative preference of one alternative over another. In this work, they were used to generate an alternative ranking, providing a clear view of the most and least preferable options (Table VI).

It is worth noting that items D and E were conceptually integrated during the evaluation stage, giving rise to a new alternative: a hybrid production system. Therefore, the final analysis includes only four consolidated alternatives.

Table VI. Ranking obtained through Promethee II

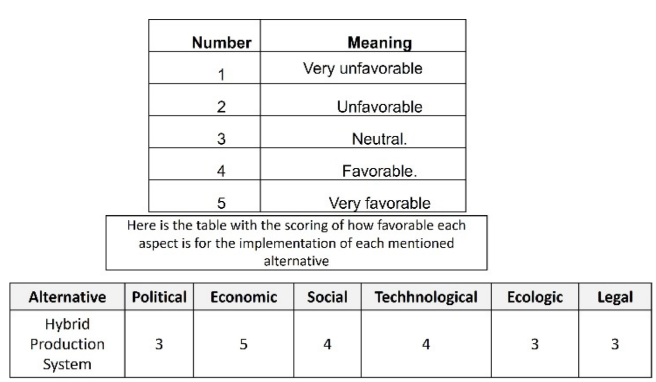
ALTERNATIVES	FLOW +	FLOW -	NET FLOW	RANK
Construction of a second machine	0.109653246	0.587196	-0.47754304	4
Relocation of the plant to an industrial zone	0.19500413	0.484092	-0.28908787	3
Systematization of order processing	0.514170256	0.163434	0.350735776	2
Hybrid production system	0.555626639	0.139732	0.415895135	1

Source: Authors

As evidenced in Table VI, the alternative/strategy recommended by the method is the implementation of a hybrid production system.

Feasibility analysis of the selected alternative

In this case, the criteria provided by the owner of the studied SME were used, given his knowledge of the subject. Then, a rating matrix was designed based on the scale defined in the methodology, obtaining the results shown in Fig. 14.



Number	Meaning
1	Very unfavorable
2	Unfavorable
3	Neutral.
4	Favorable.
5	Very favorable

Here is the table with the scoring of how favorable each aspect is for the implementation of each mentioned alternative

Alternative	Political	Economic	Social	Techhnological	Ecologic	Legal
Hybrid Production System	3	5	4	4	3	3

Figure 14. PESTEL feasibility analysis
Source: Authors

The hybrid production system obtained a total score of 22, with the economic factor reporting the highest score (5). This result exceeds the recommended viability threshold (18), confirming the feasibility of the selected alternative.

Discussions

The tool developed in this study, which combines AHP, Promethee II, and stakeholder analysis, is highly relevant in the context of strategic decision-making in SMEs, as it provides a structured and systematic framework for evaluating and selecting the best alternative among multiple options while considering a variety of criteria and the active participation of key stakeholders [27].

AHP allows comparing the obtained criteria against the results of the stakeholder analysis by means of pairwise comparison matrices, which facilitates capturing the preferences of the experts involved. Furthermore, Promethee II complements AHP by calculating net preference flows between alternatives, enabling the generation of rankings based on the evaluated criteria [28]. This helps to identify globally preferable alternatives, whose relevance in terms of execution is finally evaluated using the PESTEL technique.

The results obtained by applying the proposed methodology reflect the coherence and solidity of the decisions made. This hybrid method allows for a detailed evaluation of alternatives, facilitating the identification of the best available option. This work confirmed the consistency provided by the pairwise comparison matrix, ensuring the reliability of the results obtained. Nevertheless, for the other stages in this tool, we recommend the highest possible precision in the data entered.

Our proposal can be effectively applied to a wide range of organizations in terms of both size and sector. It can benefit small and medium-sized organizations in strategic decision-making aimed at maximizing resource use and optimizing operational performance. On the other hand, large and multinational organizations can leverage this methodology to manage the complexity inherent in large-scale decisions involving multiple stakeholders and a wide range of criteria [29]. Considering that SMEs contribute significantly to the progress of developing countries and to poverty alleviation [30], this tool can be used in any sector. In Latin America, 99.5% of companies are MSMEs [31]. In Colombia in particular, they account for 99%, generating approximately 79% of jobs and contributing 40% of the gross domestic product (GDP). All these SMEs have similar organizational profiles. Sectors such as manufacturing, construction, technology, and services can employ this tool to evaluate specific projects, product launches, or market expansions, to name but a few possible applications.

While the integration of AHP and Promethee II enhances the robustness of the decision-making process, it is essential to acknowledge the inherent limitations of both methods. AHP relies heavily on expert judgments, which may introduce subjectivity and inconsistencies, especially when the number of criteria and alternatives increases considerably [32]. Moreover, this method assumes the independence of the criteria, a condition that may not hold in complex organizational environments [33]. On the other hand, though effective for ranking alternatives, Promethee II requires the definition of preference functions and threshold parameters, which can be challenging and highly subjective. Additionally, its sensitivity to changes in weights and its inability to account for criteria interdependence may compromise the reliability of the results in dynamic contexts [34]. Recognizing these limitations allows for a more critical and adaptive application of the proposed framework in strategic organizational decisions.

Nevertheless, the clear structure and the graphical preference modeling offered by the tool enable SMEs to implement more intuitive and structured decision-making processes. Furthermore, it provides a suitable balance between methodological simplicity, expert knowledge availability, and the technological constraints typical of such organizations, ultimately reducing subjectivity and strengthening the reliability of the decisions made.

Conclusions

This research developed an integrated tool for strategic decision-making in organizations and validated it through a case study involving an SME dedicated to iron strapping production for the construction industry. A structured and systematic methodological framework was established which allows evaluating and selecting the best alternative among multiple options. The results show the efficiency of combining multicriteria tools as well as their wide range of applications. Some studies have proposed different variations of this method, which confirms its relevance [35]. The implications for the field are significant, since the proposed methodology is applicable to many organizations and sectors, particularly in SMEs in developing countries, but without excluding large multinationals. The inclusion of stakeholder analysis ensures that decisions are not only effective, but also inclusive and accepted by all parties involved.

Improved transparency in decision-making stands out among the tool's benefits. In addition, our proposal enhances the reproducibility of strategic decisions, which allows verifying its results in different organizational contexts. The combination of AHP and Promethee II allows adapting the tool to various types of strategic decisions, improving the flexibility and adaptability of the process. However, some limitations must be considered: the effectiveness of our proposal and the quality of its results rely heavily on the accuracy of the data entered, and verifying the consistency of AHP assessments can be challenging, especially when working with multiple experts with different levels of understanding and experience in the methodology.

Future research could explore additional methods to improve the capture of stakeholder preferences and expectations, as well as techniques for managing conflicts of opinion more efficiently. Furthermore, introducing new MCDMs such as feature object methods could improve the tool's adaptability and effectiveness in more complex contexts [36]. We also recommend investigating the tool's applicability in non-traditional sectors (*e.g.*, the public sector) in order to evaluate its effectiveness in different operational and regulatory environments.

CRediT author statement

Sebastian Bolaños-Cano: conceptualization, formal analysis, investigation, methodology, validation, visualization, writing (original draft, review, and editing).
John A. Coy-Mejía: conceptualization, formal analysis, investigation, methodology, visualization, writing (original draft).
Diego L. Peña-Orozco: investigation, methodology, supervision, validation, visualization, writing (original draft, review, and editing).

References

[1] T. L. Saaty, *The analytic hierarchy process: Planning, priority setting, resource allocation*. New York, NY, USA: McGraw-Hill, 1980. https://archive.org/details/analytichierarch0000saat

[2] J. P. Brans and B. Mareschal, "The PROMETHEE VI procedure: How to differentiate hard from soft multicriteria problems," *J. Decision Syst.*, vol. 4, no. 3, pp. 213-223, 1995. https://doi.org/10.1080/12460125.1995.10511652

[3] S. García-Orozco *et al.*, "Using multi-criteria decision making in Quality Function Deployment for selecting optimal locations for offshore wind farms," *Energies*, vol. 16, no. 18, art. 6533, 2023. https://www.mdpi.com/1996-1073/16/18/6533

[4] A. M. Alhumaid, A. H. Aleisa, B. T. Al-Marshad, A. U. A. Al-Ruwaih, S. Al-Harbi, and A. A. Al-Ghamdi, "Design evaluation for urban drainage systems," *Water*, vol. 10, no. 5, art. 581, 2018. https://www.mdpi.com/2073-4441/10/5/581

[5] R. E. Freeman, *Strategic management: A stakeholder approach*. Boston, MA, USA: Pitman, 1984. https://www.cambridge.org/core/books/strategic-management/E3CC2E2CE01497062D7603B7A8B9337F

[6] M. P. Basílio, V. Pereira, H. G. Costa, M. Santos, and A. Ghosh, "A systematic review of the applications of multi-criteria decision aid methods (1977–2022)," *Electronics*, vol. 11, no. 11, art. 1720, 2022. https://www.mdpi.com/2079-9292/11/11/1720

[7] H.-Q. Nguyen, V.-T. Nguyen, D.-P. Phan, Q.-H. Tran, and N.-P. Vu, "Multi-criteria decision making in the PMEDM process by using MARCOS, TOPSIS, and MAIRCA methods," *App. Sci.*, vol. 12, no. 8, art. 3720, 2022. https://www.mdpi.com/2076-3417/12/8/3720

[8] A. M. Qureshi and A. Rachid, "Comparative analysis of multi-criteria decision-making techniques for outdoor heat stress mitigation," *App. Sci.*, vol. 12, no. 23, art. 12308, 2022. https://www.mdpi.com/2076-3417/12/23/12308

[9] S. Faizi, W. Sałabun, T. Rashid, S. Zafar, and J. Wątróbski, "Intuitionistic fuzzy sets in multi-criteria group decision making problems using the characteristic objects method," *Symmetry*, vol. 12, no. 9, art. 1382, 2020. https://www.mdpi.com/2073-8994/12/9/1382

[10] V. Yepes, "Tag: Saaty," Blog de Víctor Yepes. [Online]. Available: https://victoryepes.blogs.upv.es/tag/saaty

[11] G. Fattoruso, S. Scognamiglio, and A. Violi, "A new dynamic and perspective parsimonious AHP model for improving industrial frameworks," *Mathematics*, vol. 10, no. 17, art. 3138, 2022. https://doi.org/10.3390/math10173138

[12] S. Moslem, "A novel parsimonious spherical fuzzy analytic hierarchy process," *Eng. App. Art. Intell.*, vol. 128, art. 107447, 2024. https://doi.org/10.1016/j.engappai.2023.107447

[13] J. Ortega, S. Moslem, and D. Esztergár-Kiss, "An integrated approach of the AHP and spherical fuzzy sets for analyzing a park-and-ride facility location problem," *IEEE Access*, vol. 11, pp. 55316–55324, 2023. https://doi.org/10.1109/ACCESS.2023.3281865

[14] H. Taherdoost and M. Madanchian, "Using PROMETHEE method for multi-criteria decision making: Applications and procedures," *Iris J. Econ. Busi. Manage.*, vol. 1, no. 1, art. 000502, 2023. https://irispublishers.com/ijebm/pdf/IJEBM.MS.ID.000502.pdf

[15] N. Hernández and M. Vélez, "Sensitivity analysis of PROMETHEE II for the evaluation of environmental websites," *App. Sci.*, vol. 11, no. 19, art. 9215, 2021. https://doi.org/10.3390/app11199215

[16] M. Behzadian, A. Kazemzadh, D. Albadvi, and M. Aghdasi, "PROMETHEE: A comprehensive literature review on methodologies and applications," *Eur. J. Oper. Res.*, vol. 200, pp. 198–215, 2010. https://www.sciencedirect.com/science/article/pii/S0377221709010092

[17] J.-P. Brans and B. Mareschal, "PROMETHEE methods," in *Multiple criteria decision analysis: State of the art surveys*, J. Figueira, S. Greco, and M. Ehrgott, Eds. London, UK: Springer, 2005, pp. 163-186. [Online]. Available: https://link.springer.com/chapter/10.1007/978-1-4939-3094-4_5

[18] Mind Tools, "Stakeholder analysis: Winning support for your projects," MindTools.com. https://www.mindtools.com/pages/article/newPPM_07.htm

[19] "Matriz de interesados poder-interés," ResearchGate. [Online]. Available: https://www.researchgate.net/figure/Figura-2-Matriz-de-interesados-poder-interes_fig1_320993049

[20] ProjectManager, "Stakeholder management strategies." [Online]. Available: https://www.projectmanager.com/blog/stakeholder-management

[21] O. Y. Akbulut, "Analysis of the corporate financial performance based on Grey PSI and Grey MARCOS model in Turkish insurance sector," *Knowl. Decis. Syst. App.*, vol. 1, pp. 57–69, 2025. https://doi.org/10.59543/kadsa.v1i.13623

[22] H. A. Dağıstanlı, "Weapon system selection for capability-based defense planning using lanchester models integrated with fuzzy MCDM in computer assisted military experiment," *Knowl. Decis. Syst. Appl.*, vol. 1, pp. 11–23, 2025.

[23] C. Zhang, S. Kwon, J. Oh, and K. Park, "An integrated AHP-PROMETHEE II ranking method to evaluate the resilience of sewer networks considering urban flood and ground collapse risks," *Water Sci. Technol.*, vol. 87, no. 6, pp. 1438–1453, 2023. https://doi.org/10.2166/wst.2023.067

[24] H. Nasiri, A. D. Boloorani, and H. A. F. Sabokbar, "Determining the most suitable areas for artificial groundwater recharge via an integrated PROMETHEE II-AHP approach," *Environ. Monit. Assess.*, vol. 185, pp. 707–718, 2013. https://doi.org/10.1007/s10661-012-2586-0

[25] P. Trivedi, J. Shah, S. Moslem, and F. Pilla, "An application of the hybrid AHP-PROMETHEE approach to evaluate the severity of the factors influencing road accidents," *Heliyon*, vol. 9, art. e21187, 2023. https://doi.org/10.1016/j.heliyon.2023.e21187

[26] E. Forman and K. Peniwati, "Aggregating individual judgments and priorities with the analytic hierarchy process," *Eur. J. Oper. Res.*, vol. 108, no. 1, pp. 165-169, Jan. 1998. https://doi.org/10.1016/S0377-2217(97)00244-0

[27] J.-J. Wang, M.-M. Wang, F. Liu, and H. Chen, "Multistakeholder strategic third-party logistics provider selection," *Trans. J.*, vol. 54, no. 3, pp. 312-338, 2015. https://doi.org/10.5325/transportationj.54.3.0312

[28] M. A. M. Isa, N. S. Saharudin, N. B. Anuar, and N. F. Mahad, "The application of AHP-PROMETHEE II for supplier selection," *J. Phys. Conf. Ser.*, vol. 1988, no. 1, art. 012062, 2021. https://doi.org/10.1088/1742-6596/1988/1/012062

[29] A. Mardani, A. Jusoh, K. MD Nor, Z. Khalifah, N. Zakwan, and A. Valipour, "Multiple criteria decision-making techniques and their applications – A review of the literature from 2000 to 2014," *Econ. Res.-Ekon. Istraz.*, vol. 28, no. 1, pp. 516–571, 2015. https://www.tandfonline.com/doi/full/10.1080/1331677X.2015.1075139

[30] F. Manzoor, L. Wei, and N. Sahito, "The role of SMEs in rural development: Access of SMEs to finance as a mediator," *PLOS ONE*, vol. 16, no. 3, art. e0247598, 2021. https://doi.org/10.1371/journal.pone.0247598

[31] M. Dini and G. Stumpo, Coord., *Mipymes en América Latina: un frágil desempeño y nuevos desafíos para las políticas de fomento*. Santiago, Chile: CEPAL, 2018. https://www.cepal.org/es/publicaciones/44148-mipymes-america-latina-un-fragil-desempeno-nuevos-desafios-politicas-fomento

[32] T. L. Saaty, "Decision making with the analytic hierarchy process," *Int. J. Serv. Sci.*, vol. 1, no. 1, pp. 83–98, 2008. http://dx.doi.org/10.1504/IJSSCI.2008.017590

[33] V. Belton and T. J. Gear, "On a short-coming of Saaty's method of analytic hierarchies," *Omega*, vol. 11, no. 3, pp. 228–230, 1983. https://doi.org/10.1016/0305-0483(83)90047-6

[34] J. P. Brans and P. Vincke, "A preference ranking organization method: The PROMETHEE method for MCDM," *Manage. Sci.*, vol. 31, no. 6, pp. 647–656, 1985. https://doi.org/10.1287/mnsc.31.6.647

[35] H. B. Slama, R. Gaha, M. Tlija, S. Chatti, and A. Benamara, "Proposal of a combined AHP-PROMETHEE decision support tool for selecting sustainable machining process based on toolpath strategy and manufacturing parameters," *Sustainability*, vol. 15, no. 24, art. 16861, 2023. https://www.mdpi.com/2071-1050/15/24/16861

[36] M. Marttunen, J. Lienert, and V. Belton, "Structuring problems for Multi-Criteria Decision Analysis in practice," *Eur. J. Oper. Res.*, vol. 263, no. 1, pp. 1–17, 2017. https://doi.org/10.1016/j.ejor.2017.04.041