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SESSION
Advances and applications in outranking methods

Twenty years of use of ELECTRE multicriteria methods for agri-environmental decision-support issues

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Abstract

Multi-criteria decision support is proving very useful and effective in dealing with the complex processes involved in agri-environmental risk analysis, particularly in terms of the relationship between certain intensive farming practices and the quality of ecosystems (soil, biodiversity, surface water).
Over the years, these approaches have been presented to the MCDA working group and has benefited from contributions of colleagues, starting with Bernard ROY.

Initially, the ELECTRE III and then ELECTRE Tri-C methods, coupled with a GIS, were used to assess the risk of erosion of agricultural plots in small catchments in dairy farming areas in Normandy, France (MCDA69, Brussels, 2009; MCDA70, Moncton, 2009; MCDA71, Torino, 2010). These methods, always coupled with GIS, assessed the contribution of agricultural plots in small catchment areas to the risk of transferring pesticides and excess nitrogen to surface water (MCDA73, Corte, 2011) in south-west France. On the scale of a large region, the risk of pesticide transfer was evaluated using spatial modelling based on satellite images. To refine this assessment, very precise approaches were implemented using the ELECTRE TRI-C method with GIS (MCDA74, Yverdon, 2011). In 2012, the year in which the political project on agroecology was launched in France, we attempted an evaluation method in the context of public policies via a sorting procedure (MCDA80, Quebec, 2014). We then evaluated good environmental practices for reducing the transfer of pesticides in catchment areas (MCDA83, Barcelona, 2016).

At the same time as assessing the risks of contaminant transfers of agricultural origin for surface water quality, we have worked at farm level in order to assess their agri-environmental and socio-economic performance, since this is the level at which decisions are taken (MCDA88, Lisbon, 2018) and assessed scenarios of changes in practices that we have constructed (MCDA94, Elounda, 2022; MCDA 96, Jaén, 2023), by coupling the ELECTRE III and Tri-nC models. A research project on agroforestry in nouvelle-Aquitaine, France, led us to evaluate the performance of production systems according to agri-environmental criteria (MCDA98, Catania, 2024) and supplemented with socio-economic criteria (MCDA99, Venice, 2025) implemented with the ELECTRE Tri-nC method.

These multi-criteria decision-support methods are proving very useful both on the scale of small areas and on farms, where decisions are taken directly.

Keywords

Multiple Criteria Decision Aiding, ELECTRE methods, Agri-environment, Contamination risks, Best agricultural practices, Watersheds, Agricultural farms, Performances, EWG MCDA.

Rank reversal in the PROMETHEE methods: what do we know ?

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Abstract

PROMETHEE belongs to the family of so-called outranking multicriteria methods. They have been initiated and developed by Prof. Jean-Pierre Brans since the 80s. For the last forty years, several researchers have contributed to its methodological developments and applications to real problems. These cover finance, health care, environmental management, logistics and transportation, education, sports, etc. The successful application of PROMETHEE is certainly due to its simplicity and the existence of user-friendly software such as PROMCALC, Decision Lab 2000, Visual PROMETHEE and D-SIGHT. PROMETHEE has initially been developed for (partial or complete) ranking problems. Later, additional tools have been proposed like, for instance, GAIA for the descriptive problem setting, PROMETHEE V for portfolio selection problems or extensions to sorting and clustering contexts.

Since the late 90s, authors have pointed out that PROMETHEE methods “suffered” from the so-called dependence to third alternatives; the relative position of two alternatives in the ranking may depend or not on the presence of a third alternative. This could lead to manipulation threads. Later, works have been focused on the study of rank reversal occurrences. More precisely, authors have investigated under which condition(s) it could occur. The aim of this talk is to summarize these contributions and highlight directions for future research.

Keywords

PROMETHEE, Ranking, Rank reversal

Economics, outranking ELECTRE and computing:

From memory to an algorithm for optimising index calculations

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Abstract

In 1974, Bernard ROY published an innovative scientific article in the Revue d'Economie Politique, on the subject of multiple criteria and preference modelling with the contribution of outranking relations. The purpose of this paper is firstly to remember this contribution, which was recognised in economics at a time when monetary evaluations had the monopoly. The aim is also to continue the economic reading, by linking the unicriteria indexes of the ELECTRE methods to the advantages and preferences, in order to build a high-performance calculation algorithm.

Keywords

Bernard ROY, Political Economy, Outranking ELECTRE, Index, OPL Algorithm.

Advancing Sustainable Tourism Recommendations using ELECTRE-H

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Abstract

As tourism evolves, destinations must reconcile the cherished memories of visitors with the imperative to safeguard local resources and community well-being. While conventional point-of-interest (POI) recommendation systems typically optimize for individual tourist preferences, they often overlook the complex interplay of social, economic, and environmental impacts. In line with the centennial theme "From memories to the future," this contribution presents a forward-looking framework that utilizes Multi-Criteria Decision Analysis to advance sustainable and balanced tourism recommendations.

Our approach centers on the ELECTRE-H method, which enables structuring the decision problem into a hierarchy of criteria reflecting the multifaceted objectives of sustainable tourism. The technique incorporates both quantitative and qualitative criteria—including cultural value, environmental sensitivity, and economic contribution—within a multi-level hierarchical framework. The key advantage of ELECTRE-H lies in its parametric flexibility including weights assigned to criteria, indifference and preference thresholds, veto mechanisms, and the construction of outranking relations, that are carefully adjusted to reflect stakeholder values and the specific context of each destination.

This method facilitates the comprehensive aggregation and comparison of POIs across multiple dimensions, effectively considering conflicting objectives. The resulting outranking relations identify POIs that balance visitor satisfaction with long-term sustainability—encompassing local asset preservation, minimized environmental impact, and equitable distribution of tourism benefits-. Moreover, by explicitly modeling trade-offs and stakeholder preferences at each hierarchical level, the method supports transparent decision-making and allows destination managers and policymakers to move beyond single-objective optimization, adopting a holistic and future-oriented approach to tourism management.

This contribution demonstrates the potential of advanced MCDA methodologies—specifically, the hierarchical and outranking capabilities of ELECTRE-H—to bridge the gap between past experiences and future aspirations, ensuring that tourism development remains both memorable and sustainable for future generations.

Keywords

Multiple Criteria Decision Aiding, ELECTRE-H, Recommendation, Sustainability

Acknowledgments

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Exploring Agroforestry Performance through MCDA: Insights from a Participatory Assessment in Southwestern France

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Abstract

"We do not inherit the Earth from our ancestors, we borrow it from our children."
— attributed to Antoine de Saint-Exupéry

In a context of ecological degradation, climate instability, and soil exhaustion, supporting agroecological transitions requires not only agronomic innovation but also decision-support tools capable of handling complex, multi-dimensional systems. This work presents the use of Multiple Criteria Decision Aiding (MCDA)—specifically ELECTRE Tri-C and ELECTRE III—to evaluate the performance of agroforestry systems (AFS) in southwestern France.

Conducted within the AC²TION project, the study involves 29 farmers and 33 AFS plots. A participatory process led to the co-construction and weighting of seven socio-agro-environmental criteria: functional biodiversity, resilience of agronomic practices, landscape amenities, additional workload, care of trees and shrubs, health of ligneous plants, and access to knowledge and guidance.

As the AFS are still young, their measurable impact on soil and climate remains limited. We therefore developed a separate "Soil Potential" (PSOL) criterion—based on biophysical soil characteristics—as an explanatory variable used post hoc to interpret performance differences revealed by the MCDA. Climate factors were treated similarly.

Our results show that MCDA can structure stakeholder knowledge and diverse indicators into actionable insights, even in systems marked by uncertainty and limited historical data. This approach supports better-informed public policy and helps identify potential levers or barriers to the agroecological transition.

In line with the theme *"From Memories to the Future"*, this work explores how integrating ecological memory—soil characteristics and long-term system functions—with current stakeholder knowledge can inform the development of agroforestry, a promising but still marginal practice in the region.

Keywords:
Agroforestry, Socio-agro-environmental assessment, Sustainable agriculture, Multiple Criteria Decision Aiding, Decision support, Participatory evaluation

Is It Better to Be Overconfident or Financially Literate? A PROMETHEE-Based Ranking of Investor Profiles

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Abstract

This study compares three distinct investor profiles identified using results from the FINRA financial literacy test: Overconfident (high self-assessed but low objective knowledge), Conscious Ignorance (low knowledge with awareness of limitations), and Financially Literate (high objective and self-assessed knowledge). For each profile, we construct an economic and behavioral characterization based on investment patterns, portfolio diversification, savings habits, and attitudes towards algorithmic advisory tools. By applying the PROMETHEE multicriteria decision analysis method, we generate a ranking of the profiles, which allows us to address a central question: Is it better to be overconfident or financially literate when making investment decisions?

Our analysis also incorporates behavioral dimensions such as the status quo effect and prospect theory within PT- PROMETHEE, especially in the case of financially illiterate individuals who may avoid action due to loss aversion or decision inertia. These insights offer a nuanced view of how different types of financial (in)competence affect market participation and strategy.

Keywords

Financial literacy, Behavioral finance, Status quo effect, Prospect theory, PROMETHEE

Random Preference Model

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Abstract

We introduce the Random Preference Model (RPM), a non-parametric and flexible discrete choice model. RPM is a rank-based stochastic choice model where choice options have multi-attribute representations. It takes preference orderings as the main primitive and models choices directly based on a distribution over partial or complete preference orderings over a finite set of alternatives. This enables it to capture context-dependent behaviors while maintaining adherence to the regularity axiom. In its output, it provides a full distribution over the entire preference parameter space, accounting for inferential uncertainty due to limited data. Each ranking is associated with a subspace of utility functions and assigned a probability mass based on the expected log-likelihood of those functions in explaining the observed choices. We propose a two-stage estimation method that separates the estimation of ranking-level probabilities from the inference of preference parameters variation for a given ranking, employing Monte Carlo integration with subspace-based sampling. To address the factorial complexity of the ranking space, we introduce scalable approximation strategies: restricting the support of RPM to a randomly sampled or orthogonal basis subset of rankings and using partial permutations (top-k lists). We demonstrate that RPM can effectively recover underlying preferences, even in the presence of data inconsistencies. The experimental evaluation based on real data confirms RPM variants consistently outperform multinomial logit (MNL) in both in-sample fit and holdout predictions across different training sizes, with support-restricted and basis-based variants achieving the best results under data scarcity. Overall, our findings demonstrate RPM's flexibility, robustness, and practical relevance for both predictive and explanatory modeling.

Keywords

choice models, nonparametric modeling, rankings, context-dependent preference, random utility

Sensitivity analysis in the spatial multi-criteria decision support process

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Abstract

The main objective of this work is to study and analyze the sensitivity of subjective parameters used in parametric multi-criteria spatial decision support methods and their effect on the robustness of the obtained results. This work is part of research related to spatial decision-making processes. The adopted methodology combines Geographic Information Systems, Spatial Multi-Criteria Decision Support methods, and sensitivity analysis algorithms. Eight criteria (vicinity of urban conglomerations, nature of the soil, kind of civil engineering structures, number of civil engineering structures, expropriation, volume (difference between cuts and fills), maximum slope, and route length) were used in this study. The criteria's weights were evaluated using the AHP (Analytic Hierarchical Process) method with the help of experts in the domain. Discrimination thresholds (indifference, preference, and veto thresholds) were defined. Decision-makers' performance was aggregated using the ELECTRE III multi-criteria decision-making method. The adopted methodology was applied to select the best route for a road connecting two urban conglomerations among several route proposals, considering technical, physical, and socioeconomic aspects. A sensitivity analysis was carried out to verify the stability and robustness of the chosen solution, which could lead to a new preference model after decision-makers' acceptance.

Keywords

MCDM, GIS, Sensitivity analysis, Discrimination thresholds.

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SESSION
Advances in preference-based methods and aggregation techniques

Collective preference elicitation for the SRMP preference model using preference paths

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Abstract

The *Ranking based on Multiple reference Profiles* (RMP) model[1] is an outranking method using reference profiles to model preferences. For each profile, an outranking relation on alternatives is defined by comparing the importance of criteria where the alternative is at least as good as the profile. A ranking is derived by considering the outranking relations in a lexicographic order σ. A simpler version, named SRMP, defines importance with additive weights on the criteria. The parameters of this model can be determined by solving a Mixed-Integer Linear Program (MILP)[2] to best fit pairwise comparisons on the alternatives given by the decision-maker (DM). In a group decision setting, with several DMs, the aim is to reach a collective decision. Numerous group decision processes exist in the literature[3][4], but none have yet used the SRMP model. In order to find a SRMP model to represent the preferences of the group, in the cooperative case[3], we propose an iterative process.

The process takes place in two stages. Stage 1 determines a single collective model M_c with the objective to minimize the greatest number of comparisons a DM needs to change to match it, using a modified version of the MILP[2]. Stage 2 computes for each DM a *preference path*, that will lead them to M_c. These *preference paths* are sequences of pairwise comparisons, starting with the DM's preferences and ending with the preferences corresponding to M_c. Each DM advances along its own path and, if one of them refuse a change of preference, the group returns to stage 1 with the additional information of the refusal of a preference change. To compute these *preference* paths, firstly, a sequence of SRMP models, starting with M_c and ending with a model fitting the pairwise comparisons of a DM, is found by using a *Greedy Best-First Search* algorithm[5]. The neighborhood used in this algorithm is the smallest modification for each parameter that results in a change of at least one pairwise comparison. Then, the sequence of pairwise comparisons for each model is considered as *preference path*, without the comparisons that change preferences in the opposite direction to what the DM has already accepted. Numerical experiments show the validity of the process as well as the utility of the *preference paths*.

Keywords

reference profiles, group decision making, preference elicitation

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Interactive Multi-objective Optimization Guided by Decision Rules Representing User Preferences

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Abstract

An interactive multi-objective optimization framework based on preference learning is proposed to effectively guide the search of the best compromise solution toward the decision maker's preferred region of the Pareto front. As usual in the interactive procedure, calculation phase alternates with decision phase. Within the calculation phase, the framework employs one of two multi-objective weight models to generate a sample of Pareto-optimal solutions presented to the user in the decision phase. The first model is inspired by the algorithm proposed by Choo-Atkins, while the second one is based on projection of the ideal point towards the Pareto front using the Achievement Scalarizing Function (ASF). These models are characterized by different distribution of uniformity and diversity of the Pareto-optimal solutions in the sample. In the decision phase, the user classifies the presented solutions into promising ("good") and others ("bad"). On the basis of this preference information, "if..., then..." decision rules are induced using the Dominance-based Rough Set Approach (DRSA). All these rules, or a subset selected by the user, are then transformed into constraints of the multi-objective optimization problem, favoring "good" and avoiding "bad" solutions in the next calculation phase. In this way, in successive iterations, the rules are guiding convergence toward regions better aligned with decision maker preferences. The computational experiment aims at checking which model is more appropriate for the calculation phase, and if the interpretability and explanatory advantages of decision rules contribute to convergence of the procedure. We believe that these findings underscore the value of interactive optimization, preference learning and rule interpretation in multi-objective decision support, further enriching the methodology of explanatory interactive preference-driven multi-objective optimization.

Keywords

Interactive Multi-objective Optimization, Preference learning, Decision rules

Belief Structure in a New TOPSIS-Based Approach for Rank Aggregation

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Abstract

This paper introduces a novel method, RA-TOPSIS (Rank Aggregation TOPSIS), based on the B-TOPSIS (Belief Structure TOPSIS) approach, for solving the rank aggregation problems, which involve combining individual rankings from multiple decision-makers into a single, collective ranking. The method integrates a belief structure model to quantify the decision-makers evaluations and employs a utility-based similarity measure to assess the proximity of alternatives to ideal solutions. In this approach, decision-makers are assigned weights that reflect their expertise or influence, enabling a weighted aggregation of preferences. The utility function is designed to account for the varying significance of positions in the evaluated rankings, ensuring that the importance of each ranked position is adequately reflected in the final consensus. RA-TOPSIS addresses rank aggregation challenges by balancing the influence of decision-makers based on their expertise, ensuring that the utility of each ranked position is properly incorporated into the final consensus ranking. It also offers the advantages of computational simplicity and intuitive interpretation, making it straightforward to explain and apply in practice. These qualities position the method as a viable alternative to more advanced and computationally complex optimization rank aggregation models. The proposed methodology is validated through numerical examples, demonstrating its potential to deliver more accurate and reliable solutions compared to traditional aggregation methods. The results highlight the effectiveness of RA-TOPSIS in addressing complex rank aggregation problems across diverse decision-making contexts.

Keywords

ordinal preferences, rank aggregation, belief structure, TOPSIS, sensitivity analysis

Heuristic Rating Estimation Method for incomplete pairwise comparisons

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Abstract

The Heuristic Rating Estimation Method supports decision-makers by utilizing existing ranking data and expert evaluations. In this method, the ranking scores for a subset of alternatives are known beforehand, while the scores for the remaining alternatives must be determined. These scores can be computed using either an additive or multiplicative approach, both of which traditionally require complete sets of pairwise comparisons. This paper demonstrates how these methods can be adapted to function without requiring experts to compare all alternatives, one against the others. By reducing the burden on experts, the enhanced methods lower the overall cost of the decision-making process and streamline the data collection phase.

Keywords

Incomplete pairwise comparisons method, reference alternatives, AHP

Multistage Bipolar Method

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Abstract

Multistage Bipolar Method (MBM) first presented in [3] allows for multicriteria decision support in multistage decision-making processes. This is an extension of the bipolar analysis proposed in [1] and [2]. We can classify and rank all multistage alternatives and choose the best of them as well**.** In MBM we do not compare multistage alternatives directly with each other, but with the use of sets indicated by the decision maker called stage reference objects. They are divided into two groups. The first one („good" reference objects) defines the situations desired by the decision maker. The second group ("bad" reference objects) includes objects that specify undesirable situations that the decision maker would like to avoid. The reference objects, as well as the decision alternatives, are characterized numerically by the values of the criteria considered by the decision maker.

MBM consist of 5 following steps:
Step 1. Stage alternatives are compared with reference objects. Well known procedures, as ELECTRE, AHP and PROMETHEE (or other) can be employed.

Step 2. Position of each stage alternative with respect to the bipolar stage reference system is established.

Step 3. Relationships in the set of multistage alternatives are established.

Step 4. Multistage alternatives are assigned to predefined classes.

Step 5. The final solution is pointed from the multistage alternatives belonging to the "best" class.
The original version of the method [3] is based on ELECTRE methodology. In the later versions AHP and PROMETHEE procedures are involved. Theoretical considerations are illustrated by the application to determine a sustainable regional development plan.

Keywords

Multistage decision process, Multistage Bipolar Method, sustainable regional planning

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Modelling Group Preferences from Numeric Ratings and Textual Opinions: A Consensus based Framework

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Abstract

This study introduces a novel group preference modelling framework designed to address decision-making scenarios where decision-makers express opinions through a mix of numeric ratings and textual descriptions. To address the challenge of handling heterogeneous preference formats, we propose a novel unification mechanism called STandR-BUI (Sentiment from Text and Ratings – Basic Uncertain Information). In this framework, each preference is represented as a tuple (x,c), where $x \in [0,1]$ indicates the expressed opinion and $c \in [0,1]$ reflects the decision-maker's confidence in that opinion. This unified representation captures both the quantitative and qualitative aspects of preferences, along with their inherent uncertainty. Based on this representation, we design an automatic consensus mechanism tailored to the STandR-BUI structure, enabling the aggregation of diverse and uncertain preferences into a collective group opinion. The framework supports flexible and interpretable consensus formation, particularly suited to contexts where preferences are expressed in both structured and unstructured formats, such as in online platforms or participatory settings. An illustrative example is provided to demonstrate the effectiveness and practicality of the proposed approach.

Keywords

Group Decision Making, Preference Modelling, Basic Uncertain Information, Sentiment

Aggregating Linguistic Ratings into a Continuous Scale Through Sentiment Analysis

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Abstract

Large-scale decision-aiding models based on social platforms usually suggest an ordered set of alternatives, considering the opinions of a large group of users. In general, alternatives are assessed using ratings based on a linguistic scale. Refining rating scales through continuous perceptual maps enables a more nuanced understanding of subjective opinions. A continuous perceptual map combines linguistic perceptual mapping and sentiment analysis to systematically represent users' linguistic opinions. Linguistic perceptual mapping allows us to differentiate between different users' rating profiles, while sentiment analysis allows us to refine each rating value by using the extraction and quantification of opinions from textual data. In this study, we construct a continuous perceptual map by considering a set of sub-intervals of the unit interval, allowing for a more precise representation of user preferences. Furthermore, we propose a methodological framework for generating and applying continuous perceptual maps in real-world scenarios. We apply our approach to user reviews from the Amazon Books platform, demonstrating its effectiveness in capturing subtle variations in sentiment and enhancing traditional rating systems. Our findings suggest that continuous perceptual mapping can improve the interpretability and precision of rating scales, offering valuable insights for both researchers and industry practitioners.

Keywords

Information Aggregation, Sentiment Analysis, Rating scale, Linguistic Perceptual Maps

The New Frontier: Hierarchical Behavioral Portfolio Management under the Virtue of Complexity

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Abstract

This study introduces a novel decision-making framework for portfolio optimization that integrates hierarchical behavioral goals and constraints with machine learning-based return prediction within an enhanced structure of Modern Portfolio Theory (MPT). Attributable to Harry Markowitz, MPT assumes rational utility-maximizing behavior and relies on mean-variance optimization. It is well known that the MPT suffers from empirical limitations such as estimation sensitivity, non-stationarity of returns, and the exclusion of cognitive and sustainability-related preferences. Behavioral Portfolio Theory (BPT), as formalized by Shefrin and Statman (2000), addresses many of these gaps by modeling investors under the assumption of layered portfolio goals according to psychological needs of the investor. Still, recognized extensions of BPT generally do not integrate predictive modeling of asset returns derived from high-dimensional or nonlinear features (for further discussion, see Santos et al., 2021; Dash and Kajiji, 2014).

Building on the complexity perspective advocated by Kelly, Malamud, and Zhou (2023), this study utilizes machine learning techniques to generate complex nonlinear return forecasts using limited but information-rich features. These forecasts are refined through regularization techniques (e.g., ridge regression, as shown by Kajiji, 2000 and Buncic, 2025) and used as inputs to a multi-objective, multi-layered behavioral portfolio optimization model. To this end, we propose and solve the AI-MBPM (Artificial Intelligence Multi-Objective Behavioral Portfolio Model), which incorporates (i) shrinkage-adjusted asset covariances, (ii) complexity-enhanced expected returns from neural networks, and (iii) behavioral goal prioritization via lexicographic multi-objective programming. In this framework, the goal set is specified as $\Gamma_k = \{x | Ax + h^- - h^+ = b;\ x \geq 0\}$ and solved sequentially through a hierarchy of linear programs (LP): $LP_1 \equiv Min\{Z_1 x | x \in \Gamma_1\}$, with each subsequent LP_k solved under constraints that preserve previously attained optima: $MLP_k = Min\{Z_k x | x \in \Gamma_k, \text{where} A_k x = A_{k-1} x^*\}$.

Initial simulation results indicate that portfolios generated by the AI-MBPM are characterized by superior risk-adjusted performance compared to portfolios that lie on the traditional efficient frontier. Furthermore, incorporating behavioral constraints yields efficient goal-aligned portfolios, albeit with trade-offs—e.g., high-priority loss-aversion constraints reduce Sharpe ratios, and sustainability constraints shift portfolio dominance from green to brown assets. Our research highlights the empirical value of embracing complexity in both prediction and investor behavior, advancing a new frontier in portfolio management.

Keywords: Hierarchical multiple objective behavioral portfolio optimization; asset return complexity; multi-target neural network prediction.

People, Places, Preferences: A Structured Approach to Conference Logistics

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Abstract

Organising a large academic conference involves balancing a wide array of competing objectives, ranging from logistical efficiency to participant satisfaction. We identify four broad categories of objectives: minimising inconvenience for attendees (e.g., reducing cross-building transitions), aligning with participant preferences, optimising resource utilisation (e.g., maximising room capacity and minimising overheads), and meeting organiser requirements (e.g., reducing workload and limiting in-session movement). The importance of these objectives may vary depending on context, including differences in cultural expectations as well as technical and logistical constraints. We therefore propose the incorporation of user preferences into this multi-objective setting. By collecting preference data from participants and stakeholders—through surveys, historical behaviour, or interactive planning tools—we aim to quantify the relative importance of different objectives. These preferences can then be integrated into the MCDM framework to support more context-sensitive and participatory decision-making. We discuss methods for eliciting and modelling such preferences, the challenges of aggregating diverse stakeholder inputs, and the implications for automated or semi-automated scheduling systems. Our goal is to explore how a preference-aware, multi-objective approach can lead to more adaptive, transparent, and satisfactory conference planning outcomes.

Keywords

Preference elicitation, managing large conferences, multi-objective optimisation.

Combining Artificial Intelligence and Multi Criteria Decision Analysis to improve spatial decision making

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Abstract

Multi-Criteria Decision-Making (MCDM) methods are essential for spatial decisions, particularly in evaluating geographic alternatives with multiple and often conflicting criteria. In spatial planning, these methods allow experts to structure complex problems such as site selection, resource allocation, and environmental assessment. By providing a systematic comparison framework, MCDM techniques facilitate informed decision-making across spatial dimensions. However, one of the major challenges in MCDM is the subjective and difficult process of selecting decision criteria and determining their relative importance. These criteria must be both relevant to the problem and accepted by stakeholders. The decision-making process becomes more constrained when criteria are interdependent, evolving, or derived from large unstructured datasets such as reports or expert feedback. To address these challenges, Artificial Intelligence (AI) can support and enhance MCDM. AI helps automate the selection of relevant criteria from large datasets such as textual reports, geospatial data, and expert inputs and intelligently ranks them based on their importance. This integration not only reduces human bias but also strengthens the decision-making process by ensuring consistency and adaptability to complex spatial problems. The main objective of this work is to exploit AI capabilities to assist decision-makers in identifying and evaluating criteria for a given spatial decision. Using pre-trained AI models, large textual datasets related to the defined spatial decision-making problem will be analyzed. A set of criteria will be determined, the relationships between these criteria will be identified, and a prioritization based on their relative importance will be proposed. This approach will enrich the MCDM process by integrating a broader perspective. The next step is to focus on the interaction between AI and human experts to enable decision-makers to validate and complement AI suggestions to ensure synergy between artificial intelligence and human expertise in the spatial decision-support process.

Keywords

MCDM, AI, Spatial Decisions Making, AI models.

Decision Support for Intelligent Autonomous Robots

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Abstract

This article is a follow-up to our earlier studies on modelling preferences in multicriteria sequential decision processes for autonomous multi-robot teams. The robots are assumed to perform various tasks jointly, such as exploring unknown terrain, inspecting industrial installations, or picking fruit. The case study presented here is motivated by current research on multi-robot space exploration mission planning beyond the Mars orbit, where the long communication delays with the nearest human operator make remote control impractical or inefficient. Such missions will require robots to possess unprecedented levels of decision-making autonomy. On the other hand, studying multicriteria decision-making in autonomous systems as a distinct field within Multi-Criteria Decision Analysis (MCDA) is justified by the coordinator's potential knowledge of each robot's decision algorithms—a feature that simplifies preference modelling—and by the anticipated complexity of exploration tasks involving large teams of heterogeneous cooperating robots.

We examine robot decision-making methodology in the context of solving the combined multicriteria Multi-Robot Task Allocation (MRTA) and Multi-Robot Path Planning (MRPP) problems, both of which are key challenges in autonomous mobile robotics. The first (MRTA) involves the autonomous assignment of tasks to each robot, which can be efficiently managed by a human or robotic coordinator. MRTA is followed by determining optimal paths (MRPP) to ensure effective deployment of the robot team. This article presents new ideas for multi-level robot decision-making and learning autonomy applied to solving MRTA-MRPP problems, as well as a novel approach to anticipatory coordination of robot teams combined with Model-Based Reinforcement Learning (MBRL). The MRTA coordination problem is formulated as the upper level in a bi-level multicriteria optimization problem, with one or more coordination criteria representing the team's overall objectives. Task allocation involves assigning exploration sites to robots. At the lower level, robots individually solve the MRPP problem by planning paths while considering criteria such as accrued risks, travel time, and energy consumption. Each robot autonomously resolves trade-offs between these criteria.

The multicriteria extension of MRTA-MRPP is particularly relevant for highly autonomous robots operating in unknown or uncertain environments, where efficiency competes with safety and risk. The robots are assumed rational, meaning their decision-making autonomy should always yield a non-dominated solution. We introduce a new method for transforming probabilistic risk superposition along path segments into an additive form, enabling the effective use of classical multicriteria shortest-path algorithms of Martins and A* for MRPP. Robotic MCDM procedures will leverage preference models based on each robot's assessment of scientific yields during the mission, shared within the team via transfer, imitation, and federated learning schemes. A numerical example illustrates practical techniques for planning traversal or avoidance of obstacles while navigating the rugged terrain of an icy moon to reach exploration sites. In conclusion, we argue that multicriteria decision-making models and identifying the best compromise will be essential for ensuring mission resilience in unknown environments and maximizing expected scientific returns while minimizing costs.

Keywords

Autonomous Decision Systems, Anticipatory Robots, Multiple Criteria Coordination, Decision Support

Hierarchical Dominance-based Rough Set Approach for Evaluating Omnichannel Retailing Strategies

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Abstract

We consider Dominance-based Rough Set Approach (DRSA) incorporating criteria hierarchy. The method enables the partial disaggregation of a base set of criteria into multiple levels, ranging from specific to general. The classification for a given node in the hierarchy is derived based on the outcomes attained or observed only for its child nodes. This approach is advantageous from both structuring and data processing perspectives. We applied the method to a dataset of 74 Serbian retailers' multichannel marketing integration, comprising 17 criteria organized into four hierarchical groups. We compared it against the classical DRSA with a flat criteria structure, using two rule induction algorithms, DOMLEM and DOMApriori, alongside two classification schemes — standard and score-based. The hierarchical DRSA demonstrated competitive accuracy in cross-validation, with the combination of DOMLEM and standard classification yielding the best performance. The results suggest that the inconsistency in top-level criteria values may impact classification quality. However, further improvements in data preprocessing could enhance the method's accuracy, making hierarchical DRSA a promising tool for addressing decision problems with complex criteria structures.

Keywords

Dominance-based Rough Set Approach, Decision rules, Multichannel retailing

Digital Requirements Prioritization in the Automotive Industry using a WOWA operator

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Abstract

This study presents a novel framework for prioritizing digital requirements in the automotive industry, with a specific focus on SEAT S.A.'s Digital Business department. Addressing the challenge of managing multiple digital projects under economic and workforce constraints, the proposed approach adopts a data-driven methodology based on the Weighted Ordered Weighted Average (WOWA) operator. The WOWA operator extends the capabilities of the Ordered Weighted Averaging (OWA) and Weighted Averaging (WA) operators, allowing flexible aggregation of criteria by incorporating both subjective importance weights and positional importance By aggregating diverse input criteria into a single ordinal score, the framework enables objective prioritization of digital initiatives according to their potential business impact. Its effectiveness is demonstrated through a real-world case study at SEAT S.A., where the framework provides a structured and transparent basis for decision-making. The proposed framework addresses an ordinal classification problem using a two-step process: aggregation of input values followed by discretization into predefined classes. Monte Carlo simulation results confirm the robustness of the model, showing strong agreement between predicted and actual prioritizations.

Keywords

WOWA operator, supervised discretization, requirements prioritization

Prioritization Uncertainty Arising from Judgments Based on Consistent Pairwise Comparisons

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Abstract

When the (in)consistency in Pairwise Comparisons (PCs) is considered as a subfield within the broader domain of Multi-Attribute Decision Making (MADM), it has significant implications across various research areas. These include diverse modeling scenarios such as reducing inconsistency in PCs, establishing appropriate consistency thresholds for inconsistent Pairwise Comparison Matrices (PCMs), completing incomplete PCMs, aggregating individual PCMs within Group Decision Making (GDM) contexts, and exploring the relationship between PCM (in)consistency and the credibility of Priority Vectors (PVs) derived using different Priority Derivation Methods (PDMs). The central focus in the latter domain concerns the uncertainty stemming from the inexactness of prioritization based on the derived PVs. Despite its importance, this issue has been addressed by only a limited number of studies, particularly in relation to the reliability of PCMs in credibly determining a decision maker's (DM's) priorities in a way that reduces prioritization uncertainty and mitigates potential — and often probable — ranking fluctuations. This challenge represents the core concern of the present study, as no existing research has been identified that approaches the problem from the standpoint of consistent PCMs. Accordingly, a clear research gap has been identified, which this paper aims to address. The findings of this study have important implications for the quality of prioritization using the PC methodology, particularly concerning the interpretation and reliability assessment of prioritization results. Firstly, the study offers a revised perspective on the rank reversal phenomenon, casting new light on a body of literature that has developed over several decades. Secondly, the results contribute to ongoing discussions regarding the inherent fuzziness in the outcomes of the Analytic Hierarchy Process (AHP). Finally, the study presents a novel opportunity to evaluate prioritization results obtained from consistent PCs through the lens of statistical hypothesis testing — specifically, by assessing the probability that accepted rankings (presumed correct due to a low likelihood of change) may in fact be incorrect and should be rejected, and conversely, that rejected rankings (presumed incorrect due to a high likelihood of change) may be correct and thus warrant acceptance. The principal finding of this research is that consistent PCMs produce PVs whose elements should not be regarded as definitively established, but rather as approximations within confidence intervals defined by a given level of probability. Since heuristic-related issues can only be explored through computer simulations — as they are not analytically tractable — the problem addressed in this study has been investigated using Monte Carlo simulations implemented with Wolfram Mathematica software. These research outcomes are expected to be of substantial value and relevance to both decision makers and scholars engaged in examining prioritization problems employing the PCs methodology.

Keywords

Multiple Criteria Decision Aiding, Multi-Attribute Decision Making, Pairwise Comparisons, AHP

Relevance of BLP model for the medical markets:

issues for Hahn, Hausman, Lustig specification test application

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This paper continues a research project on physicians' choice models, started in 2017 at MIT. Prof Huttin and Professor Hausman published a first experimental study to compare simulated data with an original dataset, extracted from the US National Ambulatory Care Survey, on Type II diabetes (Huttin and Hausman, 2021; Hahn, Hausman and Lustig, 2020).

The statistical analysis was run with a Mixed Logit model, with parameters for estimation of the demand model from previous disease econometric models, running logistic or cumulative logistic regressions on the parameters. The mixed logit form required to reshape the dataset to run a choice model on qualitative dependent variables, instead of these series of logistic regression on numbers to describe patterns of utilization of medical services.

The generation of alternatives for such choice models resulted from complex interactions between medical investigators and the economist team, it is described in another paper (Huttin, 2024). The approach is to select choice sets of three alternatives and check on each choice sets whether removing one of the three alternatives modify or not the estimators. Different sequences are used and tests to verify correlations of parameters according to number of random draws are also tested. This original study is a first milestone on choice modeling on critical drug areas or procedures. The mixed logit model has been the first one used for demand estimation on a medical market. The new specification econometric test from Hahn, Hausman and Lustig (2020) follows the generalized test proposed by Hausman and McFadden, to improve the nested logit model. This type of model is well specified only inside the branches of the tree, or in latent class models. At this stage of the research, only Hahn Hausman and Lustig proposed to compute a specification test at an individual level, which then does not require any more to use classification in latent classes and ensures the specification of the mixed logit model at individual level.

This paper aims to also discuss the specification issues of a second type of model, called the BLP model. Berry's approach is ideal for differentiated markets, such as pharmaceuticals, where oligopolies or duopolies are common. Empirical studies, often related to merger cases in markets like AIDS, already exist where misspecification tests can be empirically implemented. The medical markets have many cases of oligopolies, where competition authorities often use demand estimation to check in merger cases, ex ante and ex post cross elasticities of market segments impacted by the merger. Additional choice sets are then identified in major chronic conditions, or in procedures for genomic medicine (such as NGS) to compute misspecification tests at the individual level, as proposed by Hahn et ales (2020) and already tested with a Mixed Logit model in Huttin and Hausman (2021).

Keywords: Mixed Logit, BLP models, pharmaceuticals, misspecification tests, medical markets

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SESSION
Evaluating energy solutions with MCDA methods

A multi-step multicriteria approach to evaluate geothermal energy tunnels in urban contexts

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Abstract

Cities need profound change to meet energy transition goals and pursue sustainable urban development. The prevailing energy systems are based on the use of finite resources and produce considerable environmental degradation. Consequently, there is an imperative to diversify energy sources, to mitigate climate change and enhance urban resilience. In this context, the reuse and transformation of elements already present in the city and little exploited, such as underground tunnels, can be the starting point for creating new energy systems based on renewable energy sources, such as geothermal (Barla et al. 2025). The development of this technology requires a two-fold analysis: firstly, a spatial analysis to assess the most suitable areas, taking into account multidimensional and spatial criteria; and secondly, a physical-technical tunnel analysis to identify priority tunnels. Specifically, a spatial multi-criteria analysis (S-MCA) (Malczewski, 1999) is employed to assess the suitability of territories, according to seven dimensions (social, urban, economic, energy, environmental, cultural, and morphological), resulting in a suitability map for territory intervention. After that, a multicriteria analysis (MCA) (Greco et al. 2016) is, then, used to evaluate existing tunnels with respect to geometric-structural and property characteristics, usability, accessibility, and management. The results of the two analyses are aggregated through a system of weighing the different factors and dimensions to obtain a final overall categorization to identify priorities for intervention. The work is part of the European call Driving Urban Transitions (DUT) and, specifically, the REgENEraTE project, coordinated by the Polytechnic University of Turin, and focused on the study and development of innovative solutions for the redevelopment of tunnels (operational or abandoned) and existing underground spaces in urban areas for thermal energy production and storage (REgENEraTE, 2025). The methodological proposal is applied, in the first instance, to the case study of Turin (Italy), which is characterized by a significant presence of underground tunnels, particularly air raid shelters. However, the proposed methodology will be replicated in other contexts, not only to assess the feasibility of reusing individual tunnels, but also to analyze the spatial suitability of the areas where these structures are located.

Keywords

Multiple Criteria Decision Aiding, Sustainable development, Energy policy, Territorial suitability, Ranking

Incorporating imprecise inputs and robustness concerns: the development of Group Robust FlowSort method

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Abstract

Classical sorting approach in Multi-Criteria Decision-Aiding (MCDA), for example, FlowSort, assume a single decision maker (DM) who can elicit an exact, complete, and stable set of preference parameters. In many real-world problems, these assumptions are unrealistic: decision contexts evolve, stakeholder interests diverge, and the weights attached to evaluation criteria are imprecise. To close this gap, we introduce Group Robust FlowSort (GRF) that accommodates uncertainty in weight parameters and integrates input from multiple DMs, ensuring robust classification results that accurately reflect the collective preferences. GRF further offers group compromise recommendations through indicators that promote consensus even when input from the stakeholders is incomplete or imprecise.

Keywords

Multiple Criteria Decision Aiding, Group decision making, Multi-criteria Sorting

A multicriteria Group Decision Making framework for the evaluation of the sustainability and resilience of the long-term Swiss energy pathways

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Abstract

The transformation of the European energy system is essential for achieving net-zero greenhouse gas emissions by 2050 and meeting long-term energy policy objectives. This study specifically examines the Swiss energy transition, evaluating the sustainability and resilience of the future national energy system in the face of potential disruptive events. The research employs a comprehensive methodological framework consisting of three key components: (i) an analysis of possible long-term energy pathways influenced by certain prevalent shocks, (ii) an integrated assessment of different energy system configurations, and (iii) a multicriteria evaluation that incorporates stakeholder input. Central to this evaluation is the development of a detailed database of sustainability and resilience indicators, created and quantified using data from various energy and economic models, Life Cycle Assessments, and targeted surveys addressing sociopolitical, regulatory, and legislative factors. A selection of these indicators is chosen and fed into an MCDA model, based on stakeholder feedback, to evaluate the national long-term energy pathways. The MCDA preference model, based on the PROMETHEE II method, is assessed with input from a broad group of stakeholders and experts. Additionally, stakeholder preferences regarding the importance of different criteria are gathered through voting mechanisms rooted in social choice theory. The impact of potential shock scenarios is assessed within stakeholder groups using the Deck of Cards method. The evaluation framework not only ensures the feasibility and appropriateness of the evaluation process but also facilitates a collaborative and inclusive assessment of the Swiss energy transition.

Keywords

Multicriteria Decision Aid, Group Decision Making, Energy system resilience, Sustainability

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SESSION
Tools and approaches for sustainable decision making

Shaping Safe and Sustainable Healthcare with an MCDA Twist – The Initial Steps

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Abstract

The healthcare sector has recently become a target for several initiatives and projects that aim at maintaining (or enhancing) safety along the life cycle, while at the same time reducing its environmental and social impacts. Several tools and software are used nowadays in the healthcare sector to assess safety and sustainability implications of one or more of its life cycle stages. These go from 'light' Risk Assessment (RA), Environmental Life Cycle Assessment (E-LCA), Social Life Cycle Assessment (S-LCA), to 'heavier' and more quantitative RA, E-LCA, S-LCA, among others. Even if this use and proliferation of tools is valuable, we argue that a consistent mapping of these tools according to the Multiple Criteria Decision Analysis (MCDA) framework is firstly needed. This is necessary to shape a framework that will enable creating design guidelines for medical devices and packaging materials that guarantee safety, (environmental & social) sustainability, as well as circularity. In order to provide a suite of services that can cater different users to apply Safe and Sustainable by Design (SSbD) concepts, we are shaping an easily accessible template to map the key stakeholders, activities, tools and criteria that are used to aid SSbD-tailored decision-making. This enables the identification of which SSbD tools can be used at which stage, what expertise they require, what data need to be available, and how they can support decision-making within and across life cycle stages. We will describe this template as part of the initial steps of the ongoing ENKORE project, https://enkoreecohealthcare.eu/, which is a European project developing innovative eco-design solutions for single-use medical devices and sustainable packaging. Once these templates will be completed for the target use cases, we will be in a position to understand where data gaps are, what SSbD tools can be integrated at which life cycle stage, and which decision support capabilities we want the ENKORE platform to have.

Keywords

Sustainable healthcare, Multiple Criteria Decision Analysis, Sustainability assessment, Safety assessment

Blending Cost-Benefit and multicriteria analyses: implementing Positive Energy Districts through Digital Twin in Riga.

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Abstract

The transition towards Positive Energy Districts (PEDs) presents a complex multi-dimensional challenge, requiring tools that integrate real-time monitoring, energy optimization, and strategic decision-making. This paper explores the use of Digital Twin (DT) technology as a decision-support system, combining Cost-Benefit Analysis (CBA) and Multi-Criteria Decision Analysis (MCDA) to assess PED alternative implementation paths. Inspired by the integration of CBA and MCDA in environmental decision-making, this research adapts a hybrid evaluation framework aiming at strengthening and complementing the two methodologies to better assess alternative energy efficiency and renewable energy integration scenarios in urban districts. Using the ExPEDite project as a case study, this work leverages the experience gained while developing the DT of one of the Riga's districts. The DT is enriched with real-time energy consumption data, building stock performance, and user behavior. The proposed methodological approach applies CBA to assess the project's feasibility through economic analysis and monetary values, while MCDA evaluates non-monetary benefits such as resilience enhancement, and citizen engagement. To integrate these assessments, we adapt an aggregated decision-support model, enabling the ranking of energy interventions based on their overall impact. This study contributes to advancing PED design by integrating into urban planning the economic analysis of scenario simulations formulated in DT dynamic platform, allowing stakeholders to weigh trade-offs between financial, environmental, and social criteria in a structured manner.

Keywords

Positive Energy District, Digital Twin, Cost-Benefit, CBA, MCDA

MCDA for sustainability assessment - Conceptualization and implementation of the HELDA software

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Abstract

The sustainable transformation of energy systems is becoming increasingly important as various types of conflict arise, ranging from climate change to the management of critical resources and geopolitical issues. In such a dynamic context, it is crucial to accelerate decision-making processes while maintaining scientific soundness, transparency and inclusivity. Multi-criteria decision analysis (MCDA) and sustainability assessment (SA) concepts are widely used for this purpose. There is extensive literature on MCDA for SA in different contexts, as well as several software tools for implementing MCDA methods. However, SA practitioners still find it challenging to implement MCDA methods due to the significant resources required, including time, money and people. To facilitate and accelerate these decision-making processes, suitable MCDA software must be implemented. This research demonstrates how the functionality of an existing software tool (MCDA ToolKIT) was extended to support SA. Based on a recent review, this extension was conducted systematically, considering eight domains: applicability and accessibility; problem typology; problem structure; preference model; stakeholder involvement; output variability analysis; transparency; utility. High effort was required for the conceptualization and implementation of a module for stakeholder involvement. Further extended functionalities involved low to moderate effort and consisted of e.g. adding aggregation and weighting methods, improving the user interface, the user manual and help menu, and visualization of results. The extension process resulted in the creation of HELDA (Helmholtz MCDA Tool), a freely available MCDA software offering e.g. several aggregation and weighting methods, an online survey plugin for the interactive integration of stakeholders, the ability to conduct uncertainty analysis, and to visualize results. In this contribution, the features of HELDA are demonstrated in a case study on SA of energy technologies.

Keywords

MCDA, decision support tool, stakeholder integration, sustainability assessment

Trade-off Analysis for Sustainable Retrofitting of the Public Residential Stock Using a Fuzzy MCDA

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Abstract

Achieving energy transition goals and tackling climate change require retrofitting the current building stock, especially the aging and energy-inefficient public residential sector. Finding the best retrofit options, however, necessitates a comprehensive strategy that strikes a balance between several, frequently conflicting goals. In order to assess retrofit scenarios for public residential buildings, this study suggests a multi-criteria decision analysis (MCDA) framework that integrates four distinct criteria: economic efficiency, energy performance, environmental impact, and social considerations. Life cycle cost (LCC) and financial metrics like net present value (NPV), internal rate of return (IRR), and payback period (PB) are used to evaluate the economic dimension. The non-renewable primary energy demand (EPgl,nren), which is expressed in kWh/m²/year, is used to measure energy efficiency sustainability. Reductions in greenhouse gas (GHG) emissions, material reuse potential, and enhancements in living conditions and thermal comfort are additional criteria. A fuzzy MCDA approach is used to address the inherent uncertainties and imprecisions in the decision-making process. Subjective evaluations and linguistic factors can be incorporated using fuzzy logic, which makes it easier for stakeholders to communicate their priorities and preferences. The proposed framework integrates these diverse criteria through a hierarchical structure, facilitating trade-offs and sensitivity analyses. A representative case study from the Italian public residential building stock is used to illustrate the applicability and potential of this extensive and adaptable tool for finding retrofit solutions that best balance multiple objectives.

Keywords

Building retrofit; Fuzzy logic; Public Residential Building stock; Energy Efficiency; Economic Feasibility

Modelling and analysing uncertainties from stakeholder preferences in MCDA sustainability assessment of energy technologies

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Abstract

Transformations of energy systems towards sustainability require socio-technical processes, i.e. not only the development of novel technologies and system configurations, but also the active integration of different actorsof society. Multi-Criteria Decision Analysis (MCDA) has been extensively used to support decision-making processes, enabling effective communication between research and development teams, decision-makers, and societal stakeholders. The integration of stakeholders' preferences into decision models gives rise to a range of uncertainties that are frequently underestimated in comparison to the uncertainty arising from performance values. However, as larger and more diverse groups of stakeholders are involved in the decision problem, it is necessary to establish a systematic way to assess the uncertainties on the elicited preferences and their relevance to the decision problem. This contribution presents a software-aided methodology based on MCDA to facilitate the integration of stakeholders in MCDA for sustainability assessment and to assess related uncertainties. The methodology has two main contributions. Firstly, a two-stage preference elicitation process involving online surveys and consensus-reaching processes with real-time feedback in workshop settings. Secondly, the modelling of stakeholders' preferences using stochastic theory in order to quantify uncertainties and analyse intra-group dynamics. The methodology is demonstrated in real-life use cases of MCDA sustainability assessment of energy storage alternatives.

Keywords

decision support system, multiple criteria decision-making, energy transition, stakeholder integration, preferential uncertainty model, uncertainty analysis

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SESSION
Refining decision model – – criteria, robustness, and stakeholder perspectives

Application of DELPHI and MCDA UTASoP method for the assessment of evaluation models of the educational systems

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Abstract

Every organized society bases its existence on its educational system, trying through it to maintain, reproduce and improve its well-being. It is common sense that the educational systems are dynamic and sensitive to changes, requiring ongoing processes where a) evaluation of current state; b) analysis and identification of changes; c) implementation of changes and d) monitoring are taking place in a repeating circular manner. Today, the evaluation of an educational system is a transnational challenge and constitutes a major factor in the process of ensuring the quality of education. This research work proposes a methodological framework for the evaluation of national educational systems, based on the application of Multicriteria Decision Aid Analysis (MCDA) approach, combining with the DELPHI method. DELPHI method is utilized in order to ensure the involvement of experts in the field of education and the Disaggregation -Aggregation MCDA method UTASoP for the handling of the multiple factors related to the educational systems. The proposed methodological framework was applied for the composition of an additive value multicriteria model based on a reference set of six national educational systems which can further be exploited for the evaluation of national educational systems.

Keywords

Educational Systems Evaluation, Multicriteria Decision Aid, Group Decision Making

A SMAA-based heuristic for reducing redundant criteria in Multi-Criteria Decision-Making with minimal ranking impact

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Abstract

Multi-criteria decision-making often involves a large number of criteria, making the decision process complex and computationally demanding. However, even when the number of criteria is not excessive, eliminating one or more of them without compromising decision quality can be advantageous, especially considering the costs associated with data collection. This study proposes a methodology to reduce the number of criteria in multi-criteria analysis without significantly impacting the final ranking of alternatives. The approach employs the Stochastic Multi-criteria Acceptability Analysis (SMAA) method and introduces a heuristic based on the iterative removal of criteria. The first criterion to be eliminated is chosen randomly, while subsequent ones are removed based on the normalized Kullback-Leibler (KL) divergence between rankings before and after removal. This process continues until the elimination of additional criteria results in a significant change in the final ranking. The computational complexity of the approach grows quadratically with the number of criteria. Finally, the proposed methodology is compared to Principal Component Analysis (PCA), a widely used method for dimensionality reduction. While PCA transforms the criteria into principal components, potentially reducing the interpretability of results, the SMAA-based approach with KL divergence maintains decision-making transparency by eliminating only the criteria that have a minimal impact on the final ranking of alternatives.

Keywords

Multiple Criteria Decision Aiding, SMAA, Redundant criteria, Kullback-Leibler divergence

Deck of Cards method for Hierarchical, Robust and Stochastic Ordinal Regression

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Abstract

We consider the recently introduced application of the Deck of Cards Method (DCM) to ordinal regression proposing two extensions related to two main research trends in Multiple Criteria Decision Aiding, namely scaling and ordinal regression generalizations. On the one hand, procedures, different from DCM (e.g. AHP, BWM, MACBETH) to collect and elaborate Decision Maker's (DM's) preference information are considered to define an overall evaluation of reference alternatives. On the other hand, Robust Ordinal Regression and Stochastic Multicriteria Acceptability Analysis are used to offer the DM more detailed and realistic decision-support outcomes. More precisely, we consider preference imprecision and indetermination through a set of admissible comprehensive evaluations of alternatives provided by the whole set of value functions compatible with DM's preference information rather than relying on a single, definitive evaluation based on one value function. In addition, we also consider alternatives evaluated on a set of criteria hierarchically structured. The methodology we propose allows the DM to provide precise or imprecise information at different levels of the hierarchy of criteria. Like scaling procedures, the compatible value function we consider can be of a different nature, such as weighted sum, linear or general monotone value function, or Choquet integral. Consequently, the approach we propose is versatile and well-equipped to be adapted to DM's characteristics and requirements. The applicability of the proposed methodology is shown by a didactic example based on a large ongoing research project in which Italian regions are evaluated on criteria representing Circular Economy, Innovation-Driven Development and Smart Specialization Strategies.

Keywords

Multiple Criteria Analysis, Deck of Cards-Based Ordinal Regression, Scaling procedures, Robust recommendations, Multiple Criteria Hierarchy Process.

Measuring Satisfaction Among Public Authorities' Supervisors Regarding the Legislative Framework for Public Project Execution: a MUSA application

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Abstract

Public authorities increasingly rely on construction projects as a means of delivering value to citizens. The success of these projects is influenced by the legislative framework under which they must be implemented. This framework regulates essential elements of project management, including execution procedures, licensing, quality assurance provisions, and financial protocols. Public sector supervisors are responsible for effectively applying and enforcing these legislative provisions during the implementation phase. Therefore, their role is crucial for ensuring the project's success.

This study is conducted in two phases. In the first phase, the critical success factors identified in the literature are compared with the Greek legislative provisions to identify gaps. In the second phase, the Multicriteria Satisfaction Analysis (MUSA) method is applied to examine the level of satisfaction among public sector supervisors with the current legislative provisions governing public project management. MUSA is an ordinal regression-based preference disaggregation method used to assess satisfaction levels based on multiple criteria, providing simultaneous action maps to help decision-makers identify areas that need improvement. The analysis provides insight into supervisors' perceptions of the effectiveness of current legislative provisions in achieving project success. Low satisfaction levels indicate areas of the legal framework that may require reform or adjustment to enhance project performance and success.

Keywords

Project Success, Public Construction Project, Stakeholder Satisfaction, MUSA method