



Department of Business Administration  
& Department of Public Health Policy  
University of West Attica



THE ASSOCIATION OF  
EUROPEAN OPERATIONAL  
RESEARCH SOCIETIES



MCDA  
MULTIPLE CRITERIA  
DECISION AIDING

## 97<sup>th</sup> meeting of the Euro Working Group on Multiple Criteria Decision Aiding (EWG-MCDA 97)

April 4 – 6, 2024, Athens, Greece

Decision Aiding in Healthcare and  
Sustainable Development

<https://ewgmca97.uniwa.gr/>



## Book of Abstracts



THE ASSOCIATION OF  
EUROPEAN OPERATIONAL  
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MCDA  
MULTIPLE CRITERIA  
DECISION AIDING



MSc in Business Administration (MBA)  
Business Administration Department,  
University of West Attica



MSc in Management of Educational  
Organisations  
Business Administration Department,  
University of West Attica



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## TABLE OF CONTENTS

1. Welcome .....	3
2. Organisation.....	4
3. Conference Programme Overview .....	5
4. Detailed Programme .....	12
Session 1: Memorial session in honour of Dr. Evangelos Grigoroudis .....	12
Spatial multi-store benchmarking analysis based on customer preferences .....	13
Session 2: MCDA in healthcare (Round Table).....	14
MCDA: implementation experience and potential in decision-making in health care.....	15
MCDA in Health Technology Assessment-HTA process: current status.....	17
Session 3: MCDA and Sustainable Development .....	18
Multicriteria social impact assessment of AI-based learning platforms .....	19
A multicriteria framework to assess social benefits in the reuse of public buildings.....	21
Using MCDA to better close the policy cycle.....	22
A multicriteria framework for evaluating the sustainability performance of local governments: Application to French municipalities .....	23
Navigating ESG complexity: An in-depth analysis of sustainability criteria, frameworks, and impact assessment .....	24
Generated criteria use in a Decision Support System in Decisions regarding Circular Economy .....	25
Strategic Benchmarking for Sustainable Energy Efficiency Investments: Methodology and Evaluation Framework.....	26
Combination of SCOR model with multi-criteria approaches for supply chain performance evaluation in the Agri-food sector .....	27
Applications Extended Hellwig’s Method in Evaluating Sustainable Development in the Education Area.....	28
Session 4: Applications I.....	29
Analyzing Influential Factors in Cause-Related Marketing .....	30
Triggering investments on energy storage solutions through an MCDA-based decision-making tool.....	31
Evaluation of agrosylvicultural systems in southwestern France, using ELECTRE TRI-nC and ELECTRE III methods for decision support.....	33
AI and Cost sensitivity simulators for Healthcare Disease economic modeling and training in Machine Learning .....	34
Freight Logistics Hub Allocation using Analytical Hierarchy Process.....	35
Development of an Intelligent Multi-Criteria Recommendation System for New Product Design/Improvement during its Life Cycle .....	36
Sufficiency conditions in an optimization problem with interval-valued objective function.....	37

A Multi-Criteria Decision Aid approach for the evaluation of seismic retrofitting alternatives in existing buildings .....	38
Session 5: Theory and Methodology I .....	39
From Cognitive Maps to Value Trees .....	40
A Holistic Approach for Determining the Most Critical Criteria in MCDA .....	41
On the theoretical bridging of MCDA & Wald theory .....	42
Equality Group Decision Making Processes .....	43
Modifying Hellwig’s Method for Multi-Criteria Decision-Making with Mahalanobis Distance for Addressing Asymmetrical Relationships.....	44
Random Preference Model .....	45
Session 6: Theory and Methodology II.....	46
A Bibliometric Exploration of Multiple Criteria Decision Aid (MCDA) and Clustering - Towards a Conceptual Taxonomy .....	47
Deep aggregation of incomplete rankings in Multiple Criteria Group Decision Making.....	48
Optimizing Wildfire Response: A Mathematical Programming Framework for Fire Suppression .....	49
Multicriteria Modeling of Emotional Decisions in Art Market with PROMETHEE .....	50
Selection of a representative sorting model in a preference disaggregation setting: A review of existing procedures, new proposals, and experimental comparisons .....	51
Representation of preferences for multicriteria decision aiding in seven-valued logic .....	52
A multicriteria Group Decision Making framework for the evaluation of the sustainability and resilience of the long-term Swiss energy pathways .....	53
Session 7: Applications II .....	54
Enhancing Sustainability in Mediterranean Cropping Systems via Group Decision Analysis.....	55
An outranking decision-making framework for customer satisfaction benchmarking analysis in GIS environment.....	56
An application of MCDA procedure to the location of radioactive waste deposit according to Legislative Decree.....	57
Management of extremely satisfied or unsatisfied service recipients with the multi-criteria MUSA method: The case of postgraduate program graduates .....	58
Information Systems Strategy initiative in SMEs: Evaluating success using SEM Neural Network Analysis .....	59
Evaluation of critical success factors for public construction projects: Towards a Multi-Criteria Decision Aid framework .....	60

## 1. Welcome



**Athanasios Spyridakos**

*General Chair of the Conference organising committee*

*University of West Attica*

[tspyr@uniwa.gr](mailto:tspyr@uniwa.gr)

### Chair of the EWG-MCDA 97 Organisation Committee

Dear Colleagues and Dear Friends,

On behalf of the Organizing Committee, I am glad and proud to welcome you to the University of West Attica, host of the 97th meeting of the Euro Working Group on Multiple Criteria Decision Aiding. We would like to warmly welcome participants from countries around Europe.

I would like to thank the coordinators of the EWG-MCDA for entrusting us with organising the group's 97th meeting. Organising such a great conference is a great honour for the Departments of Business Administration and Public Health Policy.

The University of West Attica (UNIWA) was founded in March 2018 by merging the former Piraeus University of Applied Sciences and the Technological Educational Institute of Athens. The National School of Public Health joined the newly established university in 2019, making it the third-largest university in the country in terms of student numbers. UNIWA includes twenty-seven departments organised into six Schools, covering a wide range of disciplines,

The topic of the 97th meeting of EWG-MCDA is “Decision Aiding in Healthcare and Sustainable Development,” which have always been areas of interest for operational researchers. In recent years, issues of social well-being, particularly in the areas of health and social welfare, have emerged even more, given the economic status, the conflicts worldwide, and the international health conditions. In this context, Multicriteria Decision Aid plays an even more critical role in decision-making by offering essential tools for managing conflicting criteria.

In closing, I would like to thank the University of West Attica, the Conference Chairs, the Organizing and Scientific Committees, and all those who worked on and contributed to this conference's success.

Above all, I would like to thank all of you who, with your participation, contribute to the advancement and dissemination of MCDA.

Let's enjoy the Conference.

**Athanasios Spyridakos**

*General Chair of the Conference organising committee*

## 2. Organisation

### Local Organisation

Athanasios Spyridakos	University of West Attica	Greece
Elpida Pavi	University of West Attica	Greece
Nikos Tsotsolas	University of West Attica	Greece
Costas Athanasakis	University of West Attica	Greece
Isaak Vryzidis	University of West Attica	Greece
Chara Karakosta	University of West Attica	Greece

### Program Committee

Roman Slowinski	Poznan University of Technology	Poland
Salvatore Greco	University of Catania	Italy
José Rui Figueira	Universidade de Lisboa	Portugal
Miłosz Kadzinski	Poznan University of Technology	Poland
Athanasios Spyridakos	University of West Attica	Greece
Nikos Tsotsolas	University of West Attica	Greece
Isaak Vryzidis	University of West Attica	Greece

### Scientific Committee

Alexis Tsoukias	Université Paris Dauphine	France
Athanasios Spyridakos	University of West Attica	Greece
Constantin Zopounidis	Technical University of Crete	Greece
Eleftherios Siskos	Technical University of Crete	Greece
Elpida Pavi	University of West Attica	Greece
Evangelos Triantaphyllou	Louisiana State University	USA
Isaak Vryzidis	University of West Attica	Greece
José Rui Figueira	Universidade de Lisboa	Portugal
Michael Doumpos	Technical University of Crete	Greece
Miłosz Kadzinski	Poznan University of Technology	Poland
Nikos Matsatsinis	Technical University of Crete	Greece
Nikos Tsotsolas	University of West Attica	Greece
Panos Xidonas	ESSCA School of Management	France
Roman Slowinski	Poznan University of Technology	Poland
Salvatore Greco	University of Catania	Italy
Vangelis Grigoroudis	Technical University of Crete	Greece
Vincent Mousseau	Centrale Supélec	France
Yiannis Siskos	University of Piraeus	Greece

### 3. Conference Programme Overview

CONFERENCE PROGRAM – WEEK OVERVIEW

April 4-6, 2024

	Thursday, April 4, 2024	Friday, April 5, 2024	Saturday, April 6, 2024
9:00		Session 4: Applications I	Closing session: Conference Wrap-Up and Important Take - Aways
9:30			
10:00			
10:30			
11:00			
11:30	Registration open	Honorary Ceremony organized by UNIWA	Guided tour in Acropolis & Plaka Neighborhood
12:00		Coffee break	
12:30	Opening session / welcome address	Session 5: Theory and Methodology I	
12:45			
13:00	Session 1: Memorial session in honour of Evangelos Grigoroudis	Lunch	
13:30			
14:00	Session 2: MCDA in healthcare (Round Table)	Regular Session: Life of the Group	
14:30			
15:00			
15:30	Coffee break	Session 6: Theory and Methodology II	
16:00			
16:30	Session 3: MCDA and Sustainable Development	Coffee break	
17:00			
17:30		Session 7: Applications II	
18:00	Gala Dinner		
18:30			
20:00			
20:30			

CONFERENCE PROGRAM – DAY OVERVIEW

Thursday, April 4, 2024

University of West Attica Conference Center, Athens Campus

196 Alexandras Avenue Postal Code 11521, Athens

20 min of Presentation + 10 min of Q/A

11:30 – 12:45 Registration/Coffee

12:45 – 13:00 **Opening session – welcome address**

Session 1 **Memorial session in honour of Dr. Evangelos Grigoroudis** *Chair: Yannis Siskos*

13:00 – 13:30 *A Memorial Tribute to Professor Vangelis Grigoroudis: Biographical sketch, Review of Scientific Contributions, and impact in EWG-MCDA community*  
**Yannis Siskos, Nikolaos Matsatstinis**

13:30 – 14:00 *Spatial multi-store benchmarking analysis based on customer preferences*  
**Anastasia Saridou, Athanasios Vavatsikos, Vangelis Grigoroudis**

Session 2 **MCDA in healthcare (Round Table)** *Chair: Elpida Pavi, Kostas Athanasakis*  
14:00 – 16:00

*Title: "MCDA: implementation experience and potential in decision-making in healthcare"*

*Panel Coordinator: **Professor Elpida Pavi**, Dean of the School of Public Health, University of West Attica*

*Panel presentations & Speakers:*

*MCDA in health: review and implementation framework*

**Kostas Athanasakis** (Assistant Professor, Laboratory for Health Technology Assessment, University of West Attica)

*Criteria and "value framework" in the evaluation of complex health technologies*

**Ioannis Agorastos** (Research Associate, Laboratory for Health Technology Assessment, University of West Attica)

*MCDA in Health Technology Assessment-HTA process: current status*

**Yorgos Goletsis** (Associate Professor, University of Ioannina, Dept. of Economics, Laboratory of Business Economics and Decisions), **Garoufalia Naka**

*MCDA as input in health policy decision-making: the international framework*

**Aris Angelis** (Secretary-General for Strategic Planning at Greek Ministry of Health)

16:00 – 16:30 Coffee break

Session 3      **MCDA and Sustainable Development**      *Chair: Athanasios Spyridakos*

16:30 – 17:00 *Multicriteria social impact assessment of AI-based learning platforms*

**Andrzej M.J. Skulimowski**

17:00 – 17:30 *A multicriteria framework to assess social benefits in the reuse of public buildings*

**Alessandra Oppio, Marta Bottero, Danny Casprini, Giulio Cavana, Federico Dell'Anna**

17:30 – 18:00 *Using MCDA to better close the policy cycle*

**Marion LE LOUARN**

### **Papers submitted to discussion**

*A multicriteria framework for evaluating the sustainability performance of local governments: Application to French municipalities*

**Michael Doumpos, Alexis Guyot, Emiliios Galariotis, Constantin Zopounidis**

*Navigating ESG complexity: An in-depth analysis of sustainability criteria, frameworks, and impact assessment*

**Marianna Eskantar, Constantin Zopounidis, Michalis Doumpos, Emiliios Galariotis**

*Generated criteria use in a Decision Support System in Decisions regarding Circular Economy*

**Lykourgos Lalis, Nikos Tsotsolas**

*Strategic Benchmarking for Sustainable Energy Efficiency Investments: Methodology and Evaluation Framework*

**Charikleia Karakosta, Jason Papathanasiou**

*Combination of SCOR model with multi-criteria approaches for supply chain performance evaluation in the Agri-food sector*

**George Sidiropoulos, Vasileios Zeimpekis, Nikos Tsotsolas**

*Applications Extended Hellwig's Method in Evaluating Sustainable Development in the Education Area*

**Ewa Roszkowska, Marzena Filipowicz-Chomko**

20:30 – 23:30 **Banquet**

Restaurant "To Kapodistriako" in "Kostis Palamas" building

Akadimias 48 & Sina str, Athens, 10562



CONFERENCE PROGRAM – DAY OVERVIEW

Friday, April 5, 2024

University of West Attica Conference Center, Athens Campus

196 Alexandras Avenue Postal Code 11521, Athens

20 min of Presentation + 10 min of Q/A

Session 4	<b>Applications I</b>	<i>Chair: Isaak Vryzidis</i>
09:00 – 09:30	<i>Analyzing Influential Factors in Cause-Related Marketing</i> <b>Konstantina Zacharaki, Jennifer Nguyen, Mònica Casabayó , Núria Agell</b>	
09:30 – 10:00	<i>Triggering investments on energy storage solutions through an MCDA-based decision-making tool</i> <b>Apostolos Arsenopoulos, Georgios P. Trachanas, Theodoros Tsalidis, Filippos Serepas, Ourania Markaki, Dimitris Askounis</b>	
10:00 – 10:30	<i>Evaluation of agrosylvicultural systems in southwestern France, using ELECTRE TRI-nC and ELECTRE III methods for decision support</i> <b>Odile Phelpin, Francis Macary</b>	
10:30 – 11:00	<i>AI and Cost sensitivity simulators for Healthcare. Disease economic modeling and training in Machine Learning</i> <b>Christine C Huttin</b>	
<b>Papers submitted to discussion</b>		
<i>Freight Logistics Hub Allocation using Analytical Hierarchy Process</i> <b>Theodore Tsekeris, Georgia Skintzi</b>		
<i>Development of an Intelligent Multi-Criteria Recommendation System for New Product Design/Improvement during its Life Cycle</i> <b>Nikolaos Matsatsinis, Fotinti Kalafataki</b>		
<i>Sufficiency conditions in an optimization problem with interval-valued objective function</i> <b>Najeeb Abdulaleem</b>		
<i>A Multi-Criteria Decision Aid approach for the evaluation of seismic retrofitting alternatives in existing buildings</i> <b>Alexandra Katsiada, Isaak Vryzidis, Constantinos Repapis</b>		
11:00 - 12:00 Ceremony organized by University of West Attica (Honorary Ceremony)		
12:00 – 12:30 Coffee break		

Session 5	<b>Theory and Methodology I</b>	<i>Chair: Constantin Zopounidis</i>
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12:30 – 13:00 *From Cognitive Maps to Value Trees*  
**Alexis Tsoukiàs, Berkay H. Tosunlu**

13:00 – 13:30 *A Holistic Approach for Determining the Most Critical Criteria in MCDA*  
**Evangelos Triantaphyllou and Juri Yanase**

13:30 – 14:00 *On the theoretical bridging of MCDA & Wald theory*  
**Dimitris Thomakos, Panos Xidonas**

### Papers submitted to discussion

*Equality Group Decision-Making Processes*

**Maria Barbati, Sajid Siraj**

*Modifying Hellwig's Method for Multi-Criteria Decision-Making with Mahalanobis Distance for Addressing Asymmetrical Relationships*

**Ewa Roszkowska**

*Random Preference Model*

**Moha Ghaderi, Miłosz Kadziński**

14:00 -15:00 Lunch

15:00 – 15:30	<b>Regular Session: Life of the Group</b>	<i>Chair: Roman Słowiński</i>
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Session 6	<b>Theory and Methodology II</b>	<i>Chair: José Rui Figueira</i>
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15:30 – 16:00 *A Bibliometric Exploration of Multiple Criteria Decision Aid (MCDA) and Clustering - Towards a Conceptual Taxonomy*  
**Pavlos Delias**

16:00 – 16:30 *Deep aggregation of incomplete rankings in Multiple Criteria Group Decision Making*  
**Grzegorz Miebs, Adam Mielniczuk, Miłosz Kadziński**

### Papers submitted to discussion

*Optimizing Wildfire Response: A Mathematical Programming Framework for Fire Suppression*  
**José Rui Figueira, Bibiana Granda-Chico, Begoña Vitoriano**

*Multicriteria Modeling of Emotional Decisions in Art Market with PROMETHEE*  
**Elżbieta Kubińska, Paweł Witkowski**

*Selection of a representative sorting model in a preference disaggregation setting: A review of existing procedures, new proposals, and experimental comparisons*

**Miłosz Kadziński, Michał Wójcik, Krzysztof Ciomek**

*Representation of preferences for multicriteria decision aiding in seven-valued logic*

**Salvatore Greco, Roman Słowiński**

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

**Eleftherios Siskos, He Huang, Peter Burgherr**

16:30 – 17:00 Coffee break

Session 7

**Applications II**

*Chair: Nikos Tsotsolas*

17:00 – 17:30 *Enhancing Sustainability in Mediterranean Cropping Systems via Group Decision Analysis*

**Eleni Androulidaki, Stelios Rozakis**

17:30 – 18:00 *An outranking decision-making framework for customer satisfaction benchmarking analysis in GIS environment*

**Anastasia S. Saridou, Athanasios P. Vavatsikos**

18:00 – 18:30 *An application of MCDA procedure to the location of radioactive waste deposit according to Legislative Decree*

**Vincenzo Piscopo, Antonino Scarelli**

### **Papers submitted to discussion**

*Management of extremely satisfied or unsatisfied service recipients with the multi-criteria MUSA method: The case of postgraduate program graduates*

**Athanasios Spyridakos, Yiannis Psaromiligkos**

*Information Systems Strategy initiative in SMEs: Evaluating success using SEM Neural Network Analysis*

**Maria Kamariotou, Fotis Kitsios**

*Evaluation of critical success factors for public construction projects: Towards a Multi-Criteria Decision Aid framework*

**Zisis Papastamatis, Isaak Vryzidis**

CONFERENCE PROGRAM – DAY OVERVIEW

**Saturday, April 6, 2024**

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<b>09:00 – 10:00</b>	<b>Closing session: Conference Wrap-Up and Important Take - Aways</b>	<i>Chair: Isaak Vryzidis</i>
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**10:00 – 13:00** **Guided tour in Acropolis & Plaka Neighborhood**

A walking guided tour of the picturesque parts of the old town of Athens (Plaka, Monastiraki, and Anafiotika) and the Acropolis of Athens (Parthenon, Erechtheion, Nike Temple, Dionysus Theater).

The tour lasts 3 hours and costs 30 euros for adults 25 years old and over (to be paid on Thursday at the conference). There is a discount for citizens of EU countries and non-EU countries under 25 years old. Please ask us on Thursday at the conference.

The cost includes the local licensed guide and the entrance fee to the Acropolis archaeological site.

Gathering point: Station “Acropolis” of Athens Metro Line 2 (Red Line) – Exit to “Makrigianni” street at 09:45.

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## 4. Detailed Programme

### Session 1: Memorial session in honour of Dr. Evangelos Grigoroudis

## Spatial multi-store benchmarking analysis based on customer preferences

Anastasia S. Saridou  
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Athanasios P. Vavatsikos  
Democritus University of Thrace (Greece)

Evangelos Grigoroudis†  
Technical University of Crete (Greece)

### Abstract

Several methods have been proposed in literature to measure customer satisfaction (CS). The MULTicriteria Satisfaction Analysis (MUSA) method is a regression-based approach capable of managing customer preferences and provide satisfaction outcomes. The MUSA+ method is an extension of the typical MUSA that allows benchmarking analysis among different stores to assist managerial decisions. Initially average satisfaction and demanding indices are produced indicating the level of CS and demandingness. The method provides action and comparative performance diagrams based on the indices generated. Geographic Information Systems (GIS) are computerized tools capable of handling and visualizing spatial information. Leveraging a business's database and geo technologies the method's results can be spatially interpreted. The proposed spatial MUSA+ model extends the method to its spatial context and generates geolocated maps estimating CS in relation to a stores' service areas. Service areas denote the influence zones of the stores formed using GIS technologies based on the minimum network distance between each store and each city block. The resulting maps highlight the service areas based on the method's comparative performance diagrams in addition to action diagrams findings, allowing managers to conduct a benchmarking analysis considering the given stores. To conclude with a model is developed in an opensource GIS software that takes as inputs shapefiles consisting of customer answers of a questionnaire formed by the business and demographic data expressed in city blocks to perform the spatial MUSA+ analysis.

**Keywords:** MUSA+, benchmarking analysis, consumer satisfaction, GIS, store performance

## Session 2: MCDA in healthcare (Round Table)

## MCDA: implementation experience and potential in decision-making in health care

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Elpida Pavi  
Dean of the School of Public Health, University of West Attica  
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### Abstract

During the last decades, the discourse surrounding health policy and planning has been increasingly focusing on the “key economic problem in health” i.e. the disparities (or “asymmetries”) between the available (scarce) resources to the health system and the diverse and increasing healthcare needs of the population. This discussion is not only timely but also profoundly pertinent, spurred by the pressing financial challenges confronting health systems. These challenges stem from a multitude of factors including technological advancements, demographic shifts towards an aging population, epidemiological transitions, and escalating consumer expectations.

Within this situation, policymakers find themselves tasked with the difficult dilemma of allocating scarce public resources across various disease areas, demographic groups, and interventions. Despite the complexity inherent in such types of decisions, replete with competing priorities and multifaceted considerations, decision-makers often rely on heuristics or intuition rather than evidence-based methodologies that ensure thoroughness, legitimacy, and transparency – and, what is most important, methodologies that can take into account both the positive as well as the normative aspects of decision making in healthcare resource allocation.

A growing body of literature has emerged, exploring tools to inform resource allocation and priority setting in healthcare, such as burden of disease estimations and economic evaluations. Yet, these tools often focus on singular dimensions of the decision-making process, neglecting vital determinants of societal well-being concerning health, including non-individualistic perspectives and caregiving externalities. Consequently, the above-mentioned approaches offer limited guidance on integrating the relative importance of societal values into decision-making processes.

In light of these challenges, multiple criteria decision analysis (MCDA) emerges as a structured, coherent, comprehensive, and transparent alternative. MCDA, in part, addresses the shortcomings of previous methodologies and enhances the quality of decision-making. Consequently, it has garnered increasing attention as a viable tool for decision-making in healthcare, particularly in prioritizing health interventions, conducting benefit-risk assessments, facilitating regulatory approvals for medicines, and conducting health technology assessments.

This table will focus on the status-quo and future perspectives of MCDA as a decision-making process for resource allocation in health. The discussion will start with presenting the current status around methodological approaches and guidance documents for the



implementation of MCDA, both in the research as well as the institutional settings. Following this, the potential applications of MCDA in an emerging part of resource allocation in health, i.e. access to complex technologies, will be discussed, with a focus on the criteria and "value frameworks" currently used in the evaluation process of advanced technologies. Focusing on the regulatory path of health technologies, the third presentation will discuss the evolution and use of MCDA in formal Health Technology Assessment (HTA) processes, as recorded by available data and published evidence internationally. Finally, and extending the above, the session will close with a discussion on how MCDA can serve as an input in the process of health policy decision-making, extending above and beyond health technologies and incorporating modern aspects of resource allocation in health.

## MCDA in Health Technology Assessment-HTA process: current status

Yorgos Goletsis

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Garoufalia Naka

### Abstract

Healthcare financing faces complex challenges related to priority setting. Conflicts arise among various stakeholders, including patients, scientific specialists, healthcare providers, manufacturers, and insurers. Allocating limited resources and funding to new medical technologies requires evaluating their multifaceted value beyond traditional economic assessments that focus solely on costs and single health outcomes (such as QALYs or DALYs).

Multicriteria Decision Analysis (MCDA) offers a way to enhance the standard assessment process. By considering multiple criteria and incorporating stakeholder preferences, including those of society, MCDA can provide a more comprehensive evaluation.

In our research, we review relevant literature and analyze 226 papers to identify theoretical foundations and trends. Despite progress, challenges remain for widespread adoption of MCDA in Health Technology Assessment. The main conceptual challenges are related to criteria, transparency, and robustness. Methodological challenges include the modelling process itself, the data quality and comparability, the health technology measures applied, the application of different value frameworks, while organisational challenges include the representation and participation of the stakeholders and the additional burden MCDA methods impose compare to the currently applied cost-effectiveness approaches.

Addressing conceptual, methodological, and organizational hurdles can facilitate the integration of multicriteria concepts and methods into healthcare technology evaluations and decision-making processes.

**Keywords:** Multicriteria analysis, MCDA, health technology assessment

## Session 3: MCDA and Sustainable Development

## Multicriteria social impact assessment of AI-based learning platforms

Andrzej M.J. Skulimowski<sup>1,2</sup>

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<sup>2</sup>International Centre for Decision Sciences and Forecasting, Progress & Business Foundation, 30-048 Kraków, Poland,  
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### Abstract

This paper studies the social impact assessment of AI-enabled non-profit web-based learning platforms (AILPs). The proposed approach sorts out the problem of estimating open-access platform financial characteristics which is necessary to use the common social return on investment (SROI) indicator. Namely, we assume that the adequate social impact can be achieved with an efficient user community building. Then, we define a family of user-community-oriented performance criteria based on user logs and stakeholders' interaction that make possible direct impact measurement for representative samples, followed by a trustworthy overall impact estimation. The difficulties with acquiring parameters of innovation diffusion in Norton-Bass model could be avoided as well. Finally, the social impact goals is described with:

- $J_1$  - The demographics of active users community measured at a certain cut-off moment or considered as a function of time. This composite indicator takes measures the intensity of using the platform as a weighted average of actual use time of each group members.
- $J_2$  - The user capability and engagement in effectively using AI tools provided on the platform, such as intelligent recommenders, autonomous web crawlers, chat bots etc., averaged across the entire user community. This indicator counts the number and time of user logs to advanced platform tools
- $J_3$  - User satisfaction with the information retrieved that shows in a readiness to promote the knowledge platform to additional users. This is a subjective indicator calculated from user interaction records ("promotion" buttons and links) and feedback forms from the users and their academic supervisors.
- $J_4$  - The assessment of the platform services and content quality by stakeholders (a Likert scale).

The attainment of the above goals is optimized by solving the discrete multicriteria optimization problem

$$[(J_1, \dots, J_N): V \rightarrow \mathbb{R}^N] \rightarrow \min, \quad (1)$$

where  $V$  is the set of feasible action plans, which may be performed by the AILP management. Best action ensembles boost the community of users and foster its quality in terms of user competence growth during interaction with an AILP. Action selection is performed with the reference set method.

A real-life information system which served as a motivation for this research is the exploitation of an e-science platform implemented within a Horizon 2020 project [2]. The use of indicators  $J_1$ - $J_4$  has been approved by the AILP stakeholders [1] according to the digital sustainability strategy of this AILP.

### References:

[1] Skulimowski, A.M.J. (2021). User Community Development in Social Networks to Support AI-Enabled Knowledge Provision, 42<sup>nd</sup> International Conference on Information Systems, Austin, TX, pp. 1-17, [https://aisel.aisnet.org/icis2021/is\\_sustain/is\\_sustain/9/](https://aisel.aisnet.org/icis2021/is_sustain/is_sustain/9/)

[2] Skulimowski, A.M.J., Köhler, T. (2023). A future-oriented approach to the selection of artificial intelligence technologies for knowledge platforms. J. Assoc. Inform. Sci. Tech. 74(8), 905-922, <https://doi.org/10.1002/asi.24763>

**Keywords:** Multicriteria social impact assessment, AI-based learning platforms, user community building

## A multicriteria framework to assess social benefits in the reuse of public buildings

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### Abstract

Decision-making processes in the use of public resources face different levels of complexity determined, among others, by the involvement of multiple stakeholders both in cases of more or less evident participatory processes, with the need to guarantee the legitimacy of the decisions made according to a social purpose. The application of participatory, value-driven and formalized methods to such processes could have the ability to support negotiation and reduce ambiguity in resource allocation. Among such public decision-making processes, the use of public properties could represent an exemplary case, further complicated by the limited resources available to the public authority to adequately manage such assets in a way oriented towards social welfare. One of the possible strategies to alleviate this risk is to delegate the use of publicly owned buildings to private initiatives, with the consequent risk of reducing the social benefits deriving from the use of such assets. This contribution aims to present an experimental project conducted together with an Italian municipality, to co-create an evaluation protocol to be used in the process of reuse and potential alienation of municipal properties. The objective of the protocol is to build a rewarding mechanism to determine monetary discounts against the generation of societal outcomes. In fact, the protocol provides a mean to conduct ex-ante impact evaluation of alternative solutions, analysing the effects that they can generate at the neighbourhood or city level. Based on the Multi-Attribute Value Theory (MAVT), the structure of the evaluation protocol was defined according to the municipality's long-term strategy, expressed through three main criteria specified by a series of indicators co-created together with a pool of stakeholders belonging to different categories of interests, from public authorities to economic actors, to the third sector and voluntary associations. The multi-stakeholder value system was modelled through the use of value functions derived from standard benchmarks and validated by the same broad spectrum of interests, or co-constructed during roundtables and workshops.

**Keywords:** Public interest, Policy Analytics, MAVT, Value Functions, Social impact, Participation

## Using MCDA to better close the policy cycle

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### Abstract

The Commission's Better Regulation agenda requires that policy proposals be grounded in the results of a *comprehensive evaluation of the previous policy cycle* (against relevance, effectiveness, efficiency, coherence and EU added value dimensions); and in a *transparent, accountable and rational impact assessment* (sound intervention logic, analysis of problem drivers/impact chains, respecting subsidiarity and proportionality principles, specifying *SMART* objectives and a range of relevant options considering the multiple/interlinked policy challenges of our digital world and foresight perspectives) based on stakeholders' consultations and assessing the options in terms of both economic, social and environmental impacts (as well as key issues such as Fundamental Rights) and ranking the options based on these expected impacts (net of the baseline) under the key dimensions of effectiveness, efficiency and coherence (to facilitate subsequent EU political deliberations/decision-making procedures).

The Commission's progress in this agenda is reflected in the latest, 2021 edition of the BR guidelines and toolbox (which stresses assessing costs and benefits, competitiveness, impacts on UN Sustainable Development Goals and using foresight). In this framework, Multi-Criteria Analysis (MCA) is increasingly used in impact assessments (though with further uptake potential) to help assess, compare and rank options transparently/with sensitivity analyses - including with JRC's support, which produced and trialled the SOCRATES MCA tool, under the leadership of Professor Giuseppe Munda (see his papers).

Nevertheless, I believe a further challenge needs to be addressed: how to use Multiple Criteria Analysis to better close the policy cycle better by helping to turn any MCA framework used to assess, compare and rank options (within an impact assessment), into a practical MCA framework to evaluate ex-post the "preferred" option retained by the EC and eventually adopted/modified by other EU institutions and subsequently implemented and impacting stakeholders.

After highlighting how the dimensions assessed in an ex-post evaluation relate to those addressed in an ex-ante impact assessment, I will outline a possible solution to this methodological challenge: considering the ex-post evaluation as a classification problem in which the MCA helps to assign synthetic performance levels to the 5 ex-post evaluation dimensions, based on the quantitative or qualitative assessment of their components - largely drawn from those assessed in the last impact assessment (possibly transformed).

**Keywords:** Policy cycle closure, impact assessment, evaluation, better regulation, EWG-MCDA, abstract submission

**Legal notice:** the above abstract is the responsibility of the author who drafted it and in no way represents the opinion of the European Commission or its services.

## A multicriteria framework for evaluating the sustainability performance of local governments: Application to French municipalities

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### Abstract

Sustainable development has become a central issue for policy decisions by governments and international organizations. The core framework of the UN's 2030 Agenda for Sustainable Development defines 17 Sustainable Development Goals (SDGs), which set the basis for operationalizing specific metrics to evaluate and monitor the actions and policies that countries take to balance social, economic, and environmental sustainability. Towards achieving the goals of the UN Agenda, the role of local governments is crucial. In this context, the objective of this study is to describe the development and implementation of a multicriteria framework for assessing the performance of local governments from the perspective of the UN's SDGs. The proposed framework is based on a comprehensive set of indicators that are aggregated through an outranking multicriteria decision aiding (MCDA) approach. The MCDA approach relies on a simulation process to consider the uncertainty and vagueness in the importance of the indicators across the various SDGs. Results are presented for a large sample of French municipalities, based on the most recent available data.

**Keywords:** Sustainable development goals, Local governments, Benchmarking, Outranking relations



## Navigating ESG complexity: An in-depth analysis of sustainability criteria, frameworks, and impact assessment

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### Abstract

Environmental, social, and governance (ESG) criteria serve to gauge a company's sustainability and societal impact. The evaluation of a firm's performance on these ESG criteria involves a thorough examination of its practices and policies across various domains, encompassing environmental responsibility, labor standards, human rights, corporate governance, and community engagement. Despite the considerable body of research in this domain, the absence of a universally accepted ESG framework and the lack of consensus on the practical utilization of diverse ESG indicators remain noteworthy challenges. With this backdrop, our study has two primary objectives. Firstly, we present a comprehensive framework that encompasses an extensive range of ESG criteria and associated indicators. Additionally, we gauge the relevance of these indicators by examining their correlation with ESG scores obtained from a prominent rating agency. To accomplish this, we employ a non-parametric regression analysis approach rooted in the multicriteria decision-making preference disaggregation paradigm. We present empirical findings based on an international dataset spanning the years 2006 to 2020.

**Keywords:** ESG performance, Environmental transition, Corporate responsibility, Multicriteria decision aid, Preference disaggregation

## Generated criteria use in a Decision Support System in Decisions regarding Circular Economy

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### Abstract

Through evolution of time, resources and materials, are being held primarily of major importance in their use as a contributing factor in the manufacturing process. Nowadays, it is widely known that materials are not infinite and their constantly increasing demand requires solutions with already used resources, which can be applied in this modern industrial world. For that reason, the generation of a “closed-loop” model should be applied so that the life circle of a product can be extended. The definition of this model demands marginal approach in the new standards of circular economy.

The model of circular economy may be described as a concept, in which material and resources are being used in way that they prolong the life circle of a product. It is based on principles such as the reduction of wastes, the circulation of materials and products, the regeneration of the nature. Its main focus is the is to use and maintain products and services as long as possible.

This research study, which is still on the ongoing phase, pinpoints a total of 198 researched criteria that are related to the model of circular economy with the aim of creating a managing tool for managers and engineers in the process of decision making. The criteria depict a variety of different decisions in areas such as the waste management, the eco-efficiency indicators, recycling etc. These criteria will be used as an input for a Decision Support System (DSS) that will be designed and developed.

The incorporation of the upper mentioned criteria in the DSS should be hierarchized in accordance to the CE pillars and their content. Regarding content these criteria should evoke their significance through the use of a Multi-criteria Decision Analysis (MCDA) model. Consequently, such a model will contribute to people associated in developing resources management efficiency and ultimately guide to a prosperous environment in the future throughout the decrease in the use of virgin material, which can lead to valuable results for society and companies.

**Keywords:** Circular Economy, Multi-criteria Decision Analysis (MCDA), Decision Support Systems (DSS), Criteria Generation

## Strategic Benchmarking for Sustainable Energy Efficiency Investments: Methodology and Evaluation Framework

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### Abstract

Decision making in the field of capital investments in energy efficiency is a complex process, made even more complicated when considering the complexities of energy efficiency projects per se. A benchmarking procedure could allow financing institutions and investors to set up their relevant investment strategy and handle demanding investments. In this context, the aim of this paper is to analyse the main steps, materials, and methodology to formulate an energy efficiency sustainable investments benchmarking. The study presents a benchmarking and evaluation methodology for assessing and categorising energy efficiency project ideas as potential investments to be undertaken by financing bodies. In particular, the methodology comprises three key steps aimed at establishing an effective assessment framework. The first step involves a literature review of best practices and methodologies, a stakeholder consultation process, and the identification of crucial energy efficiency project characteristics. The second step focuses on determining evaluation parameters, including Key Performance Indicators (KPIs), multi-criteria decision support methods, and EU Taxonomy technical criteria thresholds. Emphasizing compliance and environmental performance goals, this step seeks to prevent green-washing and enhance investor awareness. The final step delves into the assessment and evaluation of selected projects, guided by stakeholder engagement and consultation. Overall, the proposed benchmarking methodology emerges as a robust and adaptive approach for evaluating the diverse landscape of sustainable energy efficiency projects.

**Keywords:** Clean Energy Transition, Sustainable Development, Energy Policy and Planning, Decision Analysis, Key Performance Indicators

## Combination of SCOR model with multi-criteria approaches for supply chain performance evaluation in the Agri-food sector

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### Abstract

The purpose of this research is to present the current state of the research in supply chain performance evaluation in the agri-food sector and to determine important factors for an integrated agri-food supply chain performance measurement system. The evaluation and management of supply chain is a Multi-Criteria Decision-Making (MCDM) issue, in which the expert and decision-maker is faced with both qualitative and quantitative factors. In this research, an MCDM model is proposed by using a hybrid of Supply Chain Operations Reference metrics (SCOR metrics), the UTA (UTilités Additives) method and Weights Assessment through Prioritizations (WAP) approach for supply chain performance evaluation in the agri-food sector. Using a systematic literature review (SLR) on SCOR method and its metrics, SCOR's Level 1 KPIs that are defined in the first level will compose a new model that is applied to determine the weight of each factor with MCDM methods by estimating a total score for a selected company, and presented as a useful tool in final stage for comparing the selected company with its competitors in the same sector. As a result, the new decision-making model is found to be an ideal approach in this research. The contribution of this work is to help experts, decision makers and various stakeholders involved in the supply chain management of agri-food sector to understand the importance of an integrated supply chain for better evaluation and management. This research also introduces a useful tool for supply chain performance evaluation in other industries.

**Keywords:** Agri-food Sector, Supply Chain Operations Reference Model (SCOR Model), Supply Chain Performance Measurement (SCPM), UTA (UTilités Additives), Weights Assessment through Prioritizations (WAP).

## Applications Extended Hellwig's Method in Evaluating Sustainable Development in the Education Area

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### Abstract

The primary goal of the study is to introduce an enhanced version of Hellwig's method, referred to as H-EM, which incorporates entropy-based weights and Mahalanobis distance. Entropy is used to assign weights to criteria based on their information content, and Mahalanobis distance is employed to consider interdependencies among criteria. The aim is to enhance the accuracy and robustness of multi-criteria decision-making (MCDM) processes, especially when criteria are not independent. Next, the H-EM method was applied to assess the achievement of Sustainable Development Goal 4 (SDG4) of the 2030 Agenda by European Union countries in the field of education in 2021. In the study, we utilized data provided by Eurostat for the year 2021 concerning the Sustainable Development indicators related to education (SDG 4) for EU member states. The SDG 4 set consisting of five indicators comprises the main aspects designed to track progress across various educational levels and domains.

Furthermore, a performance comparison was conducted between the extended Hellwig's method and other versions of Hellwig's approaches. The findings suggest that the correlation between criteria, specifically the choice of distance measure (Euclidean or Mahalanobis) and the system of weights (equal or entropy-based), significantly influences the ranking of EU countries in education while using different versions of Hellwig's method.

The results revealed a high Pearson correlation (0.964) between Hellwig's measure with entropy weights and both Euclidean distance and Mahalanobis distance. Conversely, the lowest Pearson correlation (0.726) was observed between Hellwig's measure with entropy weights and Euclidean distance and Hellwig's measure with equal weights and Mahalanobis distance. We can observe significant disparities in the realization of SDG 4 of the 2030 Agenda by EU countries in the field of education in 2021. We have found that, according to the different variants of Hellwig's measure, the countries characterized by the high position were Sweden, Netherlands, and Slovenia. Meanwhile, those with the low position were Bulgaria, Romania, and Slovakia.

In summary, the study introduces an improved decision-making method, H-EM, and demonstrates its application in assessing the realization of a specific Sustainable Development Goal within the European Union. The performance comparison highlights the impact of the choice of distance measure and weight assignment system on the outcomes of Hellwig's method in evaluating the education domain.

Acknowledgment: The contribution was supported by the grant WZ/WI-IIT/2/22 from Bialystok University of Technology and was founded by the Ministry of Education and Science.

**Keywords:** Multi-criteria decision-making, Hellwig's method, entropy-based weights, Mahalanobis distance, Euclidean distance, Sustainable development, education

## Session 4: Applications I

## Analyzing Influential Factors in Cause-Related Marketing

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### Abstract

In this study, we propose a methodology, using hesitant fuzzy linguistic term set (HFLTS) to rank the influencing factors involved in a cause-related marketing campaign. Cause-related marketing is a technique used very frequently by companies. The idea is to use a social cause with the goal to raise both awareness for the cause and profitability for the company. Our research focuses on using a multi-criteria decision analysis approach. We identify and rank which variables are related to change of opinion, either negative or positive. As an application to our methodology, we have picked an advertisement from the company 'J&B' that was published in December 2022 in Spain. This influential advertisement is using the cause of transgender identity. Spain is one of the countries with the biggest LGBTQ population. Recent data show that the amount of discrimination and attacks against this population has increased considerably during the last years. We ran a two-session experiment. In the first session we measured participants' attitudes and beliefs towards transgender people implicitly and explicitly. In the second session, participants were asked to come to the laboratory, where they were shown the ad campaign. We measured their eye-gaze by using a camera-based eyetracker. Then we asked them to answer a few questions and we repeated the measurements on their attitudes and beliefs towards transgender people. This case shows the applicability of the proposed approach in a real-economic context with a focus on social wellbeing. This type of work is pivotal to gain a better understanding of the underpinnings of social injustice from the perspective of the company and of the public.

**Keywords:** hesitant fuzzy linguistic terms, multi-criteria aggregation, feature ranking

## Triggering investments on energy storage solutions through an MCDA-based decision-making tool

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### Abstract

The ever-increasing rise in the share of variable renewable energy generation within the energy mix and the consequent shift towards decentralized energy systems underscore the importance of providing flexibility to the electricity grid. This flexibility can be achieved through the widespread adoption of demand response programmes and adaptable power generation, with the main emphasis lying in deploying Energy Storage (ES) technologies. According to the IEA, limiting global warming to under 2°C requires a significant increase in globally installed ES capacity, from 140GW in 2014 to 450GW by 2050. As of this, it becomes clear that ramping up investment in large-scale storage deployment is also crucial for meeting climate targets. Therefore, an urgent need to advance the development and roll-out of innovative storage concepts, promote new technologies, and propose Hybrid Energy Storage System (HESS) emerge, which, in market terms, are translated into advancing the investments on innovative energy storage concepts. These efforts will facilitate the integration of renewables, improve power system management, and optimize grid operations.

In this respect, this paper aims to provide potential energy storage investors with an Investment Planning Tool, that enables the comparison among different options of standalone and hybrid energy storage technologies (alternatives of the problem) against a group of cross-sectoral criteria covering various dimensions of economic, technological, social, and environmental nature (restrictions of the problem). The tool gathers under a common conceptual umbrella a couple of advanced Multi-Criteria Decision Analysis (MCDA) methods and several methodological extensions of them, structured in a way that enables solving complex decision-making problems in the presence of imprecise input



data, facilitating the in-depth elicitation of the users' knowledge and perspective. The end-users are able to insert their preferential profile, both in terms of their market engagement to the energy storage field (e.g., market role, revenue streams, applications, etc.) and methodologically (e.g., incomplete weights, interval data, etc.), and the tool prioritizes the implicated energy storage systems in an optimal and robust way. The system has been built on a foundation of cross-platform technologies, like Python and .NET Core, easily deployable on any sort of system through the use of containerization.

The tool brings significant added value providing solutions to decision-making problems that are closer to reality (augmented reification), while also allowing the users to express their preferences with enhanced freedom, in a way that extends beyond strictly defining numerical values to determining relative order and/or using linguistic terms.

**Keywords:** Energy storage; Investments; Decision-making; Multi-criteria Decision Analysis; Tool

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## Evaluation of agrosylvicultural systems in southwestern France, using ELECTRE TRI-nC and ELECTRE III methods for decision support

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### Abstract

The French research institute for agriculture, food and environment: INRAE, aims to develop agroecological projects to decrease intensive pressure of agriculture on environment, and to lead towards the sustainability of agricultural systems, and the wellbeing of the population, with quality of food. One of the projects, TETRAE AC<sup>2</sup>TION, near Bordeaux, in which we are contributing, must evaluate the performances of agrosylvicultural systems at parcel level. At the start of the project, the objectives were to (i) identify agroforestry systems in the study area, (ii) propose a panel of criteria for modelling these performances, and (iii) test the adaptability of ELECTRE methods to the study theme.

Ten qualitative and quantitative socio-economic and environmental criteria were selected, basis of the literature and discussions with professionals. A large amount of information was collected during twenty-seven interviews with agroforestry farmers. These data and discussions enabled us to validate the relevance of the criteria formulated and to refine them. As the data were incomplete in 2023, only six criteria were used for this initial modelling, to test the methodology. The ELECTRE Tri-nC model was then used to assign agroforestry systems into four performance categories, and ELECTRE III to rank them within each category. The results of this two double modelling the relevance of the method and criteria used. The process also highlighted the improvements to be made. The continuation of this work will enable us to complete the modelling in 2024.

This study will be useful to provide stakeholders in the field, with decision-making support for their management system change, especially those in intensive processes. This is also very interesting locally to reconcile the urban population with agricultural practices.

**Keywords:** Agroforestry; Analysis for decision support; ELECTRE methods; EWG-MCDA Multiple Criteria; Field crops; TETRAE AC<sup>2</sup>TION

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## AI and Cost sensitivity simulators for Healthcare Disease economic modeling and training in Machine Learning

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### Abstract

The fast development of AI especially in medicine and health care will transform services provided to policy aiding making processes. The decision tools proposed by Prof Huttin with her academic enterprise EndepUSresearch only used verbal language in conversation of care in the original studies (Huttin, 2017). It may benefit of AI advances especially to generate economically the proposed metrics (e.g., from transcripts of conversation of care between providers and patients) and other types of unstructured data on cost of care, as proxy measures for value judgments of providers and patients.

Information processing on cost of care information is usually performed by medical billing companies or internal resource departments of Healthcare organizations. The development of machine learning tools and AI application in healthcare also affect the economic information processed for billing and other type of explicit and implicit financial information. Prof Huttin and Hausman' physicians 'choice model presented at Elounda EWG-MCDA meeting, is also useful since it has set up a framework for interfaces between economists and computer scientists for training economic demand models with key parameters identified in previous series of disease econometric models. This communication uses the C-K design theory in policy aiding analytics, to represent economic information for choice models in medical markets. The Concept space © is represented by economic concepts such as patient demand for cheaper treatment or patient affordability (using economic narratives during conversation of care) or demand for health. The Knowledge space (K) may include prices of products and services, discretionary discount practices, insurance categories and cost sharing profiles. AI tools help to generate contents including data elements from structured and unstructured data on costs of care. An evolving design is needed for the IT platforms and health portals, to assemble in a timely way, according to clinical pathways and disease stages, sets of measures appropriate to the Concepts of patient demand for affordable care or demand for health. The combination of DCEs or reversed conjoint models and machine learning algorithms help to address limitations of the original cost sensitivity simulators proposed in Prof Huttin on the following parameters:

- Cost of care information (types of additional information useful for critical decision points)
- Timing for generation of cost information in policy aiding processes-
- Attention management of providers and patients

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Kohane AI and HealthCare

**Keywords:** Services for Health Policy Analytics, AI, Cost Sharing Research

## Freight Logistics Hub Allocation using Analytical Hierarchy Process

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### Abstract

The selection of freight transport/logistics hub location can be regarded as a multi-objective decision-making process. This paper reviews the related scholarly literature and reports key factors that influence the allocation of freight logistics centres. Given that the suggested process is implemented for the optimal distribution of logistics centres at the regional level in Greece, these factors are represented by the following variables at the NUTS-2 level of spatial analysis: the road network density, job concentration, the Gross Domestic Product (GDP) per capita, the sectoral composition of the economy, as expressed by the shares of the primary and secondary sectors, and an accessibility index, based on the market (potential) access of each region. The data on these variables are largely originating from the Hellenic Statistical Authority (ELSTAT) and the National Transport Model of the Greek Ministry of Infrastructure and Transportation. These data are readily available and can be easily retrieved from a recently created and publicly accessible national research infrastructure called EN.I.R.I.S.S.T., which supports such types of transport planning applications. The proposed methodology for the allocation of freight logistics hubs across the country regions relies on the Analytical Hierarchy Process (AHP). Compared to other methodological approaches in the existing scholarly literature, which typically employ simple quantitative or qualitative decision support models of site selection, the AHP allows the incorporation of several policy criteria and their weighting on the decision-making process. Such a process is regarded as much more suitable for the incorporation of alternative preferences of decision makers in realistic situations and can properly facilitate a participatory process with possible involvement of different stakeholders. The outcomes of the proposed methodology are found to support a plausible distribution of freight logistics centres across the country, reconciling different objectives and matching several demand and supply considerations. In particular, the findings primarily support the location of logistics centres in the largest and most densely populated regions of the country. However, different scenarios involving alternative criteria and policy considerations, such as the promotion of combined transport at sea gateways, can lead to modified outcomes. This approach may also allow us to carry out a sensitivity analysis of different policy criteria and their prioritisation on the selection and ranking of freight logistics hubs. Last, the AHP can be combined with other suitable methods, through incorporating the results of alternative models, such as cost-benefit analysis, for the calculation of financial, environmental and other indexes and for the sustainable designation of freight logistics hubs.

**Keywords:** Freight transport, logistics, hub location, multi-criteria analysis, analytical hierarchy process

## Development of an Intelligent Multi-Criteria Recommendation System for New Product Design/Improvement during its Life Cycle

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### Abstract

This work presents the development of an intelligent recommendation system to support marketing decisions. The Recommendation system supports the decision makers, suggesting them a series of alternative scenarios that they can follow to achieve the desired market shares. The system offers knowledge derived from consumer segmentation and behavior analysis, estimates market shares and simulates product life cycles (PLCs). In addition, the system suggests improvements to product characteristics according to the results of criteria analysis and market simulations, with the aim of supporting them during their life cycle. The proposed system extends the capabilities of the MARKEK system, facilitating the development of new products and simulating product life cycles.

The system supports decision-making by integrating methodology and methods such as MARKEK, Musa, Musa-Kano, k-means algorithm, and the combination of Utastar with the logic of the Bass model. This combination of methods results in the development of a new methodology for simulating product life cycles (PLCs). Additionally, the results obtained from the Musa and Musa-Kano methods offer valuable information about the necessary improvements in their characteristics as well as their priorities, which are necessary for the redesign of the products/services during the various phases of their life cycle.

Decision-makers (DMs) have access to the results including PLCs, market shares, customer satisfaction and preferences. These results empower DMs to make informed decisions regarding the company's products and services, thereby enhancing their market presence. Furthermore, DMs can utilize scenarios to analyze potential changes in market shares and PLCs, aiding in the evaluation of product modifications.

Utilizing criteria analyses, such as the MARKEK methodology, and product satisfaction and preferences analyses, such as the Musa and Musa - Kano method, DMs can explore scenarios for improving market shares and extending the life cycle of the product under consideration.

In this work, the proposed intelligent recommendation system emerges as a robust solution, enabling the understanding of consumer behavior. By providing marketing strategies based on consumer needs and market trends, the businesses can success the optimal consumer satisfaction and increase their overall profitability. Additionally, this work not only presents a theoretical framework but also introduces the practical implementation of these methodologies, presenting their potential to revolutionize decision-making processes in the marketing domain.

**Keywords:** Multi-Criteria Decision Analysis, Intelligent Recommendation Systems, Product Life Cycle, Customer Satisfaction Analysis

## Sufficiency conditions in an optimization problem with interval-valued objective function

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### Abstract

In optimization theory, conventional approaches often model operations research problems as deterministic optimization with real-number coefficients, but many real-world scenarios involve uncertainty due to measurement errors or unforeseen factors. Interval-valued optimization offers an alternative by representing coefficients as closed intervals, accommodating uncertainty more effectively, which is particularly pertinent in Multi-Criteria Decision Analysis (MCDA). While the specification of closed intervals may still be subjective, it simplifies handling uncertain data bounds compared to Gaussian distributions in stochastic optimization, as it doesn't necessitate probabilistic or possibility distributions.

In this paper, a new class of multiobjective programming with multiple objective functions and with both inequality and equality constraints is considered. The functions constituting it are not necessarily differentiable, but they are E-differentiable. Several sufficient optimality conditions for both LU and LS order relations are derived for such interval-valued vector optimization problems under (generalized) E-B-invexity hypotheses. Suitable examples are provided to illustrate the aforementioned results.

**Keywords:** Interval-valued functions, Optimality conditions, LU and LS E-B-invex functions

## A Multi-Criteria Decision Aid approach for the evaluation of seismic retrofitting alternatives in existing buildings

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### Abstract

Estimating the seismic vulnerability of the existing building stock, determining the buildings that need to improve their seismic resilience, and selecting the structural scheme for retrofitting are essential for preventing future fatalities. Various alternatives for building retrofitting exist, and each outweighs a set of parameters compared to the others. The complexity of these decision-making problems is increased if we consider the need for more sustainable solutions in the construction industry. In recent years, various methodologies have been developed for this problem, some of which are based on multi-criteria decision analysis. This study aims to develop a decision-aiding approach for evaluating seismic retrofitting alternatives in existing buildings while considering technical, static, and environmental criteria.

**Keywords:** Seismic vulnerability, seismic resilience, sustainability, decision aid

## Session 5: Theory and Methodology I



## From Cognitive Maps to Value Trees

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### Abstract

Cognitive Maps and Value Trees are two well-known problem structuring methods widely used for decision aiding purposes. However, Cognitive Maps remain essentially descriptive (understanding a problem), while Value Trees focus too early on the value function formalization inducing information losses and potentially misleading choices.

In the paper we present a new procedure enabling to construct a value tree out of a cognitive map. We show that the suggested procedure satisfies both the requirement of enriching the decision support picture and of meeting the formal constraints imposed by the two methods (from a free, irreflexive binary relation carrying “influence semantics” to an acyclic, tree structure with “ends-means” semantics).

The procedure has been designed as part of a more general project aiming at supporting Conflict Transformation and Management processes, with specific emphasis on the policy design aspect of the decision aiding activity. A brief example, considering the Kurdish-Turkish conflict is presented and discussed.

**Keywords:** Cognitive Maps, Value Trees, Policy Desing, Conflict Transformation and Management.

## A Holistic Approach for Determining the Most Critical Criteria in MCDA

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### Abstract

Given a multiple criteria decision aiding (MCDA) problem, determining the most critical criteria depends on a number of aspects. The first aspect is the minimum amount of change (as a percentage) the weight of a criterion needs to have in order to cause a change on the ranking of the alternatives. The second aspect is the impact the change in the ranking has on the solution of the MCDA problem. Another aspect is how likely is for the decision maker to accept a weight to change by a given amount. It is assumed that the higher the level of change is, the less likely it is for the decision maker to implement it and vice versa. It is also assumed that the decision maker is considering an increase or a decrease weight change to a given level, equally likely. Another important aspect is the kind of MCDA problem under consideration as described by the four problematics first stated by Professor Roy. Current sensitivity analysis approaches depend on the particular MCDA method used and are of limited scope. Traditional sensitivity analysis approaches can even be grossly misleading. As criteria weights are the result of a subjective evaluation process, knowing which weights are more critical in a given MCDA problem is of paramount importance. Such knowledge can provide a valuable feedback mechanism that considers all aspects of the problem holistically. The proposed feedback mechanism has the potential to significantly improve the quality of the decision analysis. The proposed approach is independent of the MCDA method used and provides an exciting means to elevate current MCDA practice to the next level. Thus, any application area where MCDA is used has the potential to directly benefit in ways never envisioned before.

**Keywords:** Multiple criteria decision analysis (MCDA), multi-criteria decision making (MCDM), sensitivity analysis, most critical criteria, ranking of alternatives, normal distribution.

## On the theoretical bridging of MCDA & Wald theory

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### Abstract

We propose that there is a foundational correspondence between the optimal decision theory of Wald and several forms of MCDA. This is something that has not been pointed out in the literature and has two major theoretical and practical implications. First, it provides for a probabilistic foundation of MCDA decision functions and, therefore, provides for inference tools. Second, it establishes that under conditions the MCDA decisions might be optimal in the sense of Wald. We explain how this correspondence is formed, discuss the potential benefits for modeling, the extensions for inference rules and further research that can be done on this topic. We illustrate the above using standard examples from MCDA applications.

**Keywords:** Bayes solutions; complete class theorem; decision theory; inference; MCDA; Wald.

## Equality Group Decision Making Processes

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### Abstract

Groups of decision-makers often face critical choices among various alternatives. These decisions typically involve evaluating how each option is expected to perform across multiple criteria/objectives. In this context, fairness concerns arise regarding the equality among decision-makers and the moderator. The intensity of these concerns, measured through negotiation during decision-making and behavior analysis, is often quantified within a specific value range. We explore Equity, Diversity, and Inclusion (EDI) metrics in multicriteria group decision-making processes to promote fairness. Our aim is to integrate EDI principles into group decision-making processes and explore how the use of innovative metrics can enhance fairness in the decision-making process.

**Keywords:** Multicriteria Group Decision Making, Equality diversity and inclusion metrics, Fairness measures

## Modifying Hellwig's Method for Multi-Criteria Decision-Making with Mahalanobis Distance for Addressing Asymmetrical Relationships

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### Abstract

The Taxonomic Measure of Development (TMD), introduced by Hellwig in 1968, allows for determining the ranking of objects (such as countries) described in the multidimensional space by calculating distances between the pattern of development (an ideal built on the most preferred values) and the objects. This measure has been applied to assess differences and similarities among various countries regarding qualified staff, corresponding to the economic development level. Hellwig's method is particularly popular in Polish literature, especially in the field of economic research. It has also gained recognition among international researchers as a multi-criteria decision-making (MCDM) method based on a reference point. This method has been applied in various practical contexts, including sustainable development, quality of life, quality of human capital in EU countries, and socio-economic regional development, among others.

For each aspect of the analyzed phenomenon, a set of diagnostic variables (criteria) is selected based on substantive and statistical reasons, and relevant statistical data are gathered. Typically, this approach calculates distances using Euclidean distance, assuming implicitly that the considered indicators are independent. However, in real-world situations, the assumption of criteria independence is rarely met.

The research aims to propose an extension of Hellwig's method by incorporating the Mahalanobis distance. Substituting the Euclidean distance with the Mahalanobis distance has proven to be effective in handling correlations among criteria, especially in the context of asymmetrical relationships between them. It is worth noting that the Mahalanobis distance finds utility in several MCDM approaches, including TOPSIS (Technique for Ordering Preferences by Similarity to Ideal Solution) or TODIM (an acronym in Portuguese for Interactive and Multicriteria Decision Making) method.

We investigated the impact of the Euclidean and Mahalanobis distance measures on the Hellwig procedure, analyzing examples based on five illustrative data with 10 alternatives and 4 criteria. It can be observed that the rankings obtained using the Euclidean distance-based Hellwig method and Mahalanobis distance-based Hellwig method are different when there is a certain dependence within the data. Hellwig's method, neglecting the interaction between criteria, usually results in an overestimation of the values for high-scoring alternatives. Conversely, the low-scoring alternatives are underestimated when compared with their values in the Mahalanobis distance-based Hellwig's method. These results are consistent with other findings in the literature concerning TOPSIS. The proposed Mahalanobis-based Hellwig method enables a more accurate reflection of the true data structure, mitigating potential errors. It enables the evaluation of objects by considering interactions between criteria, providing a more comprehensive perspective on complex socio-economic phenomena.

**Acknowledgment:** The contribution was supported by the grant WZ/WI-IIT/2/22 from Bialystok University of Technology and was founded by the Ministry of Education and Science.

**Keywords:** MCDM, Hellwig's method, Euclidean distance, Mahalanobis distance, dependence among criteria, measurement of sustainable development

## Random Preference Model

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### Abstract

Modeling preferences from observed choices is a pivotal theme in mainstream economics, decision theory, operations research, marketing, and psychology, with expansive applications in welfare analysis, policymaking, healthcare, product design, pricing, and transportation. The standard approach in modeling preferences is to attach utility scores to choice options that are consistent with the order defined by the preferences. The utility scores are merely artifact or mediums to represent preferences, whereas preferences are the underlying construct generating choices. We develop a framework faithful exactly to this view. Building on the theoretical ground of the random preference literature, we model preferences directly by a probability distribution over the set of strict linear orderings of alternatives instead of an underlying utility. We develop an estimation process, discuss computational hurdles and model's scalability, and provide an approximation algorithm as a compromise between solution accuracy and computation time.

**Keywords:** Random Utility, Preference Disaggregation, Stochastic Choice

## Session 6: Theory and Methodology II

## A Bibliometric Exploration of Multiple Criteria Decision Aid (MCDA) and Clustering - Towards a Conceptual Taxonomy

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### Abstract

This work is about the intersection of Multiple Criteria Decision Aid (MCDA) and clustering techniques, aiming to reveal the untapped potential and novel perspectives arising from their integration. Beginning with a foundational overview of the motivations driving MCDA and the diverse motivations behind clustering, we emphasize that their integration can yield substantial benefits, challenging the conventional separation of these domains.

Following a bibliometric study of the field, this work categorizes existing approaches into three distinctive classes. The first category involves sequential applications—either clustering followed by MCDA or vice versa. It examines instances where clustering precedes MCDA for improving consistency, reducing alternatives, and identifying cluster heads. Conversely, it explores cases where MCDA precedes clustering, such as clustering clients based on their criteria weights. The second category introduces “ordered clustering”, leveraging criteria dependency to refine clustering structures. The work details how preferences and indifference metrics guide the construction of specific clustering procedures. The third category explores how MCDA can enhance the mechanics of clustering algorithms. Threads in this category focus on constructing similarity metrics, incorporating domain knowledge, and addressing robustness concerns.

The work final proposes a taxonomy along three axes: Units of Analysis, Instrumentalization, and Objective. The key takeaways emphasize the collaborative potential of MCDA envisioning a landscape where the integration of MCDA and clustering not only enhances existing methodologies but also spawns innovative paradigms, fostering a symbiotic relationship that extends beyond conventional boundaries.

**Keywords:** MCDA, Clustering, Bibliometric study, Taxonomy



## Deep aggregation of incomplete rankings in Multiple Criteria Group Decision Making

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### Abstract

In real-world decision-making problems often more than one Decision Maker is responsible for the process while most methods are suitable for a problem with just one decision maker. We aim to, instead of creating new methods supporting group decision-making, create a generic framework within which any method producing a ranking can be used in a group context. It is achieved via incomplete ranking aggregation. A suitable MCDA algorithm is used separately for each decision-maker. Then obtained rankings are aggregated into a compromise one. Since this problem has high complexity it is impossible to find an optimal solution in a reasonable time. In our approach, different heuristics and neural networks are used to introduce a tradeoff between computation time and the quality of the result.

**Keywords:** Group Decision Making, Deep Learning, Optimization, Rankings

## Optimizing Wildfire Response: A Mathematical Programming Framework for Fire Suppression

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### Abstract

Wildfires are natural recurring events that can be highly destructive if not addressed properly. In this context, Operations Research can play a crucial role in offering swift and robust solutions when quick and precise decisions are imperative. This paper specifically focuses on the response stage of wildfires, particularly addressing fire suppression operations. While the primary objective of a fire suppression strategy is to extinguish the fire, ensuring safety is paramount in dealing with such situations. The dynamic interaction between the fire and the wildfire suppression strategy enables a more comprehensive understanding of fire behaviour, facilitating the establishment of safety constraints for firefighters and preventing them from getting involved in perilous situations. This paper introduces a model designed to create a fire suppression strategy, simulating the behaviour of the fire and its modifications. Additionally, it determines the optimal fire suppression strategy in detail, identifying specific locations to control and specifying the timing of those controls while considering safety constraints and minimizing three objectives, the value of the parcels, the value of the costs, and the total time of the operations. A computational study is conducted to identify the most suitable solver for providing precise solutions.

**Keywords:** Wildfire management, Fire suppression, Multi-Objective Optimisation, Mixed Integer Linear Programming

## Multicriteria Modeling of Emotional Decisions in Art Market with PROMETHEE

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### Abstract

The presentation discussed the construction of an art preference model for various segments, including collectors, art dealers, and artists. The model incorporated criteria such as price, commission, and the opportunity for exhibition in Contemporary Art Museums or acceptance for new technologies. Additionally, factors related to influence and the pursuit of charitable goals were considered within impact investment. By considering such a multitude of different criteria within PROMETHEE model, risks and uncertainties of economic development and social impacts are considered.

**Keywords:** Art market, impact investment, alternative investment, PROMETHEE,

## Selection of a representative sorting model in a preference disaggregation setting: A review of existing procedures, new proposals, and experimental comparisons

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### Abstract

We consider preference disaggregation in the context of multiple criteria sorting. The value function parameters and thresholds separating the classes are inferred from the Decision Maker's (DM's) assignment examples. Given the multiplicity of sorting models compatible with indirect preferences, selecting a single, representative one can be conducted differently. We review several procedures for this purpose, aiming to identify the most discriminant, average, central, parsimonious, or robust models. Also, we present three novel procedures that implement the robust assignment rule in practice. They exploit stochastic acceptabilities and maximize the support given to the resulting assignments by all feasible sorting models. The performance of fourteen procedures is verified on problem instances with different complexities. The results of an experimental study indicate the most efficient procedures in terms of classification accuracy, reproducing the DM's model, and delivering the most robust assignments. These include approaches identifying differently interpreted centers of the feasible polyhedron and robust methods introduced in this paper. Moreover, we discuss how the performance of all procedures is affected by different numbers of classes, criteria, characteristic points, and reference assignments.

**Keywords:** Multiple criteria decision aiding, Preference disaggregation, Sorting, Representative model, Robustness analysis

## Representation of preferences for multicriteria decision aiding in seven-valued logic

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### Abstract

In recent discussions on reasoning about data using the rough set concept, a class of many-valued logics has emerged to differentiate between vagueness resulting from imprecision and ambiguity arising from coarseness. These logics, including the renowned Belnap four-valued logic, stem from a comprehensive seven-valued logic framework. This study explores the application of the seven-valued logic and its derivatives in multicriteria decision aiding (MCDA). Specifically, we demonstrate how our approach effectively addresses common challenges in MCDA, such as uncertainty, imprecision, ill-determination, and related robustness concerns.

**Keywords:** Multicriteria decision aiding, Preference modeling, Many-valued logics, Uncertainty of information

## 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 a mandate to reach the net-zero greenhouse gas emission targets by 2050 and achieve the long-term energy policy goals. This study focuses on the Swiss energy transition and assesses the sustainability and resilience of the national energy system to possible disruptive events. The overarching methodological framework combines three pillars, namely: (i) an analysis of the potential long-term pathways, exposed to certain prevalent shocks, (ii) an integrated assessment of the energy system configurations, and (iii) a multicriteria and stakeholder-based evaluation. The evaluation framework focuses on developing a comprehensive database of sustainability and resilience indicators, which feeds a Multicriteria Decision Aid (MCDA) modelling system. The indicator database is established and quantified based on the outputs of different energy models, Life Cycle Assessments (LCA), and dedicated surveys for sociopolitical, regulatory, and legislative aspects. A subset of these indicators is selected for inclusion in the MCDA model, based on the feedback from the stakeholders. The MCDA preference model is subsequently assessed with the subjective preferences, which are interactively elicited by the group of stakeholders. A Group Decision Making (GDM) preference elicitation framework facilitates the consensus-building among the diverse viewpoints of the stakeholders, verifies the feasibility and suitability of the process, and supports the consensual evaluation of the long-term energy pathways.

**Keywords:** Multicriteria Decision Aid, Group Decision Making, Energy system resilience, Sustainability

## Session 7: Applications II

## Enhancing Sustainability in Mediterranean Cropping Systems via Group Decision Analysis

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### Abstract

In the context of the project RESCHEDULE<sup>1</sup>, prominent research teams in soil, agronomy, and social sciences attempt to enhance soil health and microbiota in selected cropping systems under conditions of climate change in the Mediterranean. Desk and field research is pursued in Greece, Italy, and Tunisia supported by national experts and specialized groups in Germany and Portugal. The sustainability evaluation of alternative cultivation practices for selected crops is coordinated by the Bioeconomy and Biosystems Economics Lab of the School of Chemical and Environmental Engineering, Technical University of Crete. Firstly, we collected data from different farms in the case study areas in order to estimate trade-offs between costs versus tangible and intangible benefits. The objective is to rank the alternative practices at the farm level based on the opinions of stakeholders in terms of sustainability. Then incentives to incite the farmers to replace the current with more efficient alternatives are to be determined and specified. The former decision process implies a group decision-making procedure. Such exercises have been theoretically investigated in various fields by the literature focusing on Group decision-making and more specifically Group Multicriteria Analysis. In this paper, we review group decision analysis related to crop and/or farm management in different settings and proceed with a critical overview of suggested algorithms. We compare different approaches to aggregate individual preferences depending on the degree of consensus among decision-makers via an illustrative example regarding cropping practices toward sustainability. Finally, assumptions that group decision-making methods require are considered to select the most efficient and sound algorithm for our problem.

**Keywords:** Soil health, Climate change, Sustainability, Cultivation practices, Consensus, Group decision-making

<sup>1</sup>RESilient to Climate CHange Extremes MeDiterranean AgricUltural Systems: LEveraging the Power of Soil Health and Associated Microbiota



## An outranking decision-making framework for customer satisfaction benchmarking analysis in GIS environment

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### Abstract

Benchmarking store performance has been the subject of extensive academic discussion. In addition, customer satisfaction (CS) analysis plays an important role in assessing the overall performance of a store. Extending satisfaction analysis to the level of store performance evaluation a multi-criteria problem is formed. Since there are multiple customers and they express their preferences based on multiple criteria, the problem can be treated as a group decision problem. The proposed framework develops a hybrid decision making framework integrating two multicriteria methods and Geographical Information Systems (GIS) to perform spatial store performance analysis. Preference Ranking Organization METHod for Enrichment Evaluations (GDSS PROMETHEE) and CRiteria Importance Through Intercriteria Correlation (CRITIC) methods are combined in GIS environment to generate CS maps. The created model uses a simple questionnaire to perform the analysis. Service areas are created to represent the area of influence of all of the company's stores included in the analysis, and customers are assigned to the appropriate area to which they belong. The analysis goes even further by examining the company's competitors' performance. The resulting maps highlight the service areas based on the GDSS PROMETHEE flows results. Positive, negative, and net flows provide a wide range of results for interpretation. Managers are able to identify where the company's stores outrank or are outranked from their competitors. Thus, CRITIC provides insights regarding the criteria importance. In summary, managers can perform a benchmarking analysis of their stores and also navigate through the performance of their competitors. Such an analysis identifies the company's strengths and weaknesses, while providing opportunities for development and improvement.

**Keywords:** GDSS PROMETHEE, CRITIC, benchmarking analysis, consumer satisfaction, GIS

## An application of MCDA procedure to the location of radioactive waste deposit according to Legislative Decree

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### Abstract

The procedure followed by Sogin (company appointed by the Ministry of Economy and Finance for the location of the deposit of radioactive waste in Italy) regarding the suitability of the possible sites, has followed analytical procedures that do not find any confirmation in the scientific field of MCDA. The decisional process drawn up is clearly in contradiction with the provisions of art. 27 of Legislative Decree no. 31/2010, by which the technical and socio-environmental characteristics of the areas and the potential direct benefits to involved stakeholders, could be simultaneously quantified. Moreover, the structure of a decisional tree is missing and there is a remarkable mixture among factors and criteria, summarized in the irrational and schematic dichotomy of favorable and unfavorable, with a remarkable absence of weighting of them. This paper, considering the ministerial directives of the Legislative Decree, aims to highlight how the decision could be pointed out according to the procedures of the MCDA, with the quantification of the criteria in their physical, environmental, and social-economic values, in particular, as regarding the seismic aspect through the introduction of specific veto thresholds, spreading the areas in more or less high eligibility bands. Especially the stakeholders, who in the Sogin proposal were completely ignored, are also taken into account the specific economic and sustainable conditions of the area completely disregarded by Sogin. Considering a set of areas, as already considered eligible by Sogin, an application of MCDA procedure aims to enlighten how to point out a rational and coherent decisional process, also by an analysis of the robustness of the results as required by the directives imposed by the Legislative Decree.

**Keywords:** legal provisions, stakeholders, decision tree, thresholds, robustness.

## Management of extremely satisfied or unsatisfied service recipients with the multi-criteria MUSA method: The case of postgraduate program graduates

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### Abstract

The MUSA method concludes to the estimation of satisfaction barometers based on a consistent family of criteria through a polling process in which the degree of overall and partial satisfaction with each criterion is requested. In addition to the components of the Satisfaction barometer (criteria weights, Satisfaction Functions and Demand Functions) the method provides two more methodological tools, the action and the improvement maps. In this research work is examined the way of utilizing the previous mentioned tools, in order to confront cases where the sample appears very satisfied or the opposite, very low satisfied. Additional features are proposed enriching the action and improvement maps so as to ensure the effective analysis of the abovementioned cases and the supporting of the conclusions extraction. It is applied in two real world case studies related to assessment of satisfaction berometers in services a) very satisfied and b) very little satisfied, in order to illustrate the proposed features.

**Keywords:** MCDA, MUSA

## Information Systems Strategy initiative in SMEs: Evaluating success using SEM Neural Network Analysis

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### Abstract

In order to thrive in today's market, small and medium enterprises (SMEs) must always look for new ways to improve and maintain performance. Given the lack of formal processes and strategic planning, the application of strategy-as-practice is fruitless. Thus, in this study, we investigate how strategic processes and practices affect Information Systems (IS) success. Data was obtained from 294 information technology (IT) managers from Greek SMEs. Data was analyzed using the Structural Equation Model (SEM) Neural Network Analysis. Managers in SMEs prioritize strategy execution. IS executives also avoid spending time on the first two stages. Therefore, implementing an IS strategizing approach leads to IT strategies that are inefficient and don't help businesses achieve their goals. IT managers can only spend so much on IS development. This diverts their attention away from more pressing matters, such as determining the specific ways in which IS will boost business success. They were just concerned with speeding up the process and cutting costs as much as possible. Therefore, the most commonly encountered issues include the inability of IT projects to meet business needs, misalignment with existing systems, inflexibility of systems, and inadequate planning

This paper's theoretical contribution is its explanation of IS strategy for executive use. It's crucial that everybody knows their roles and responsibilities and that nobody overlooks anything. IS managers may benefit from learning the processes because it will help them not only focus on the organization's goals but also appreciate the value of strategy as practice. This has led to more success in IS strategizing and fewer issues with IT initiatives. Otherwise, achieving both would be challenging, and the strategy as practice can always be better.

The paper's practical contribution is that it can serve as a roadmap for enhancing the quality of decision-making in SMEs. Better options and decisions can keep the plan going and produce the same or even better results; thus, it's important for the company to recognize its IT goals so it can establish its future IT and organizational goals. IT executives can get insight into the difficulties inherent in implementing IS projects and the bearing of IS strategy by fostering interaction between business and IT management in strategic IS planning. Executives in Greek SMEs that follow the strategy-as-practice framework to the letter will have access to more up-to-date information regarding the external environment analysis of their businesses, allowing them to make better strategic and tactical decisions. As a result, there will be less environmental unpredictability and less dynamic risk.

**Keywords:** Information Systems Strategy, Success, Digital transformation, SMEs, SEM Neural Network Analysis

## Evaluation of critical success factors for public construction projects: Towards a Multi-Criteria Decision Aid framework

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### Abstract

Achieving success in public construction projects is difficult due to the complex regulations which define essential aspects, such as execution procedures, certification standards, permissions, fairness provisions, transparency requirements, etc. The relevant legislation defines the frame into which the projects are strictly implemented. Therefore, the critical success factors of a public construction project are defined in the legislative provisions, which must be evaluated periodically to ensure the project's success. This paper reviews the legislative changes and examines projects implemented under these different legislative frameworks in order to determine the implications of the changes from one legislation to another. Finally, the importance and usefulness of a decision-aid approach for evaluating the performance of the critical success factors defined by the legislation are discussed. Poor performance in one success factor will indicate the provisions which need to be changed.

**Keywords:** Project Success, Public Construction Project, Management of Legislative Framework changes, Decision Aid