FOUNDATIONS OF MULTI-CRITERIA DECISION ANALYSIS: A REVISITATION

LUIZ FLÁVIO AUTRAN MONTEIRO GOMES[1] - ALEXANDRE BEVILACQUA LEONETI[2]
[1] Universidade Federal do ABC- Rio de Janeiro, Brasil
[2] Universidade de São Paulo -São Paulo, Brasil
lfautranmg@gmail.com - ableoneti@usp.br

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ABSTRACT
The present paper details the foundations of Multi-Criteria Decision Analysis (MCDA) and describes their elementary structure. The paper also discusses the evolution of MCDA methods over the past 30 years and the integration of Artificial Intelligence in handling massive data and collaborative decision-making. By exploring the application of a multi-criteria approach to complex decision processes, highlighting its advantages such as facilitating dialogue among decision-making agents, accommodating subjectivities and uncertainties, and visualizing satisficing solutions as compromises between conflicting viewpoints, the paper aims to contribute to the consolidation of the approach for its practical use by engineers, mathematicians, statisticians, computer scientists, economists, and other experts in Operational Research.

KEYWORDS: MCDA - DECISION ANALYSIS - MULTI-CRITERIA DECISION THEORY

1 INTRODUCTION
In both professional and private life, individuals often face complex decision-making processes involving multiple, often conflicting criteria. These problems are typically unstructured, with ill-defined criteria and alternatives, and involve multiple stakeholders with differing viewpoints. Historically, humans have used abstractions, heuristics, and deductive reasoning to approach these problems, drawing on both scientific knowledge and intuition. The scientific study of decision-making, known as decision theory, emerged to support this process. Recent advancements in computational intelligence and the psychology of choice have led to the establishment of organizations and research programs dedicated to the study of complex decisions, bringing together experts from various fields (Petropoulos et al., 2023).

In general, complex decision-making processes have at least some of the following features: (i) the problem evaluation criteria are at least two, and they usually conflict with each other; (ii) both criteria and solution alternatives are not clearly defined and the consequences of choosing a particular alternative concerning to at least one criterion are not clearly understood; (iii) the criteria and the alternatives can be interconnected in such a way that a criterion seems to partially reflect another criterion, whereas the effectiveness of choosing another alternative depends on whether another has been or not also chosen when the alternatives are not mutually exclusive; (iv) the solution to the problem depends on a set of people, each one with its own point of view, many times in conflict with those of the others; (v) the problem restrictions are not quite well defined, and there may even be some doubt regarding what is a criterion and what is a constraint; (vi) while some criteria are quantifiable, others are so only by means of value judgements made with basis on a scale; (vii) the scale for a particular criterion can be cardinal, verbal, or ordinal, depending on the available data and the criteria nature itself. Other complications may arise from a real decision-making problem, but those previous seven aspects characterize the complexity of such problem. Problems of that nature are considered either unstructured or poorly structured.

In response to the need for scientific support, probabilistic decision-making methods have emerged, and they have been applied in various practical situations. In particular, until the first half of 20th century mathematical expectation was used for aiding similar decision-making processes. However, under certain conditions, it was noticed that limitations and the consequent risk associated with such treatment were unacceptable (Allais, 1953). In that scenario, the evolution of Multi-Criteria Decision Analysis (MCDA) methods has been a significant milestone in addressing those complex decision problems. While initial attempts to solve such problems through weighing alternatives and criteria were prevalent in academic settings, it wasn't until the late 1960s that scientifically formalized and application-oriented MCDA methods gained solidity. The 1970s saw the development of discrete decision methods tailored for multi-criteria environments, incorporating features such as decision process analysis, problem dimension comprehension, and explicit preference structures. This period also marked a transition from classical techniques like goal programming to more sophisticated multi-criteria approaches, addressing the limitations of earlier methods and paving the way for more robust decision support systems. Now, in the light of recent developments there is an increasing number of organizations and research programs devoted to the study and analysis of complex decisions through the MCDA approach.

This paper aims to contribute to the diffusion of the approach for its practical use by engineers, mathematicians, statisticians, computer scientists, economists, and other experts in Operational Research. I In that sense, in Section 2, the paper will delve into the foundations of MCDA. This section will cover several key aspects, starting with the origins of MCDA, tracing its development and the pioneering works that laid its groundwork. The stages of multi-criteria decision-making will then be explored, providing a structured overview of the process. The section will also address how to structure multi-criteria decision problems, highlighting the importance of clearly defining criteria and alternatives. Additionally, the subjective dimension of the MCDA approach will be discussed, emphasizing the role of personal judgments and preferences in decision-making. The concept of a satisficing solution, which seeks a satisfactory rather than an optimal outcome, will be examined. Finally, the pros and cons of the multi-criteria approach will be weighed, offering a balanced perspective on its application. In

Section 3, the conclusions drawn from the discussions in the previous sections will be presented, summarizing the key insights and implications for practical use by professionals in various fields.

2 FOUNDATIONS OF MULTI-CRITERIA DECISION ANALYSIS

2.1 The origins of Multi-Criteria Decision Analysis

Although attempts to solve decision making problems in the presence of multiple criteria (by means of weighing both alternatives and criteria) have been used, especially in academic environments, the MCDA methods – in a scientifically formalized way and oriented to actual applications – basically emerged in the end of the 1960s, first in Paris (Roy, 1968), and during the next decade in the United States of America (Keeney and Raiffa, 1976; Saaty, 1980). Those pioneering works notedly reflected unsatisfaction with the projects assessment methodologies available until then, which either were guided just by consequences expressed in monetary units – as the cost/benefit analyses – or presented themselves as impotent to deal, simultaneously, with multiple categories of consequences – monetary and non-monetary –, as the classic cost-effectiveness analyses.

Already in 1970s, the first methods focused on the discrete problems of decision in the multi-criteria or multi-objective environment have emerged, i.e., methods which use a differentiated approach for this class of problem and that start acting as support to the decision, not only aiming the multidimensional representation of the problems, but, as well, incorporating a series of features quite defined as to their methodology, such as, for example: decision process analysis to which this methodology is applied, always with the purpose of identifying critical information and applicable domains; better comprehension of the problem dimensions; the possibility of existing different valid formulations for the problem; the acceptance that, in complex problems, not always the situations obligatorily must fit within a perfect formalism and that, in particular, structures which represent just partially the comparability between the alternatives can be relevant to the process of support to decision; the usage of explicit representations of a structure of preferences, instead of numerical representations artificially defined, many times may be more appropriated to a problem of decision-making.

Chateau (1975) presented one of the first applications that compared goal programming techniques—a variant of linear programming—with the emerging multi-criteria method approach. In this context of transition, Charnes and Cooper (1977) provided an overview of the most classic and emerging modeling techniques based on goal programming and their relationship with multiple objective optimization techniques. However, Chankong et al. (1985) described this transition scenario, emphasizing the difficulties of more classical techniques. The authors specifically cited the case of goal programming, which requires, in addition to the objective vector and the respective weight vector, the choice of a deviation measure. They presented the concepts of compromise solution and the compromise set as treatments for this problem.

2.2 Stages of Multi-Criteria Decision Making

There is a consensus, on the part of Decision Theory scholars, that the way to the good decision usually encompass the three stages model of Hebert Simon (1960), including: (i) describing the context for making a decision, known as the intelligence phase; (ii) inventing or developing possible alternatives for making a decision, referred to as the design phase; and (iii) choosing between possible alternatives, termed the selection phase. The model can be extended as necessary, for instance, Clemen and Reilly (2014) recommended that, in addition to describing the context of the decision problem, it is also necessary to determine the objectives of the decision maker in the first stage, while Drucker and Maciariello (2008) pointed out the need to perform a classification of the problem to identify its structure and validate if a decision is necessary in the latter stages.

Therefore, as an illustration of the intelligence phase it could be considered to: (i) make sure you are trying to solve the right problem; (ii) think enough on the problem, trying to keep a minimum distance of possible emotional entanglements, and avoiding the so called psychological traps; (iii) seek all the relevant information; (iv) clearly identify which effectively matters, i.e., the hard core of the decision; (v) explicitly consider the commitments of moral and ethical nature; (vi) generate the widest possible set of viable alternatives; (vii) list the purposes of the decision making, both quantitative (such as finding the total annual lowest possible cost or minimizing the total annual cost) and qualitative – finding the best solution from an aesthetical point of view, for example, or maximizing aesthetics (note that the purposes are always formulated using the infinitive tense of verbs); (viii) for each one of the listed purposes, explain the decision criteria – thus, a purpose such as maximizing the social importance of the project can be broken down into criteria of meeting the most urgent needs of the population; the criteria are always formulated as nouns; (ix) explain the consequences of each alternative regarding each decision criterion, along with an estimate of probability for each one of the consequences that are expect to become real – the simplest way of doing it is by means of the construction of a table in which the lines will be associated to the alternatives, and the criteria will correspond to the columns (the information contained in the crossing of each line with each column will result from calculations, value judgements, or consultations to experts).

In turn, on the design phase, it could be considered that although this technical analysis, any aspect of the problem on which one might not have paid attention during those nine previous stages can emerge, thus generating, for example, new alternatives or new criteria. Additionally, in the design phase it could be considered to: (x) use one of the many analytical methods available in the Decision Theory literature – designated as MCDA methods – so as to select, order, classify or describe in details the alternatives on which the decision will be made; (xi) criticize the results obtained in the above tenth stage, trying to place yourself both in the position of who will make the decision and who will live the direct and indirect consequences of it – and, eventually, as a result of such criticism, there will be necessary to redo that tenth stage; (xii) produce quite objective recommendations to who will make the decision, here including a proposal of the decision itself and the best way to implement it, guaranteeing the transparent documentation of all the stages, with a view to organizational learning. The perception of the feasibility of implementation of each one of the candidate alternatives must, in fact, permeate the entire process above described, and may even, in many cases, constitute one of the decision criteria.

2.3 Structuring Multi-Criteria Decision Problems

In multi-criteria decision models, various alternatives are analyzed based on criteria representing different aspects of the same problem, with conflict being an inherent part of its nature. Thus, multi-criteria decision-making is characterized as a situation where a decision-maker must prioritize or select one or more alternatives from a finite set of possible solutions, depending on their compliance with the selected criteria, which are typically conflicting. The modeling of multi-criteria problems can be conceptualized with the aid of a matrix that includes the available alternatives and criteria, and additionally, a vector of weights for the selected criteria. The matrix, known as a decision matrix, is generally standardized (transforming its various scales into a uniform scale ranging from zero to one) and then weighted by multiplying it by a vector of weights. This vector of weights defines the decision-maker's preferences in fulfilling the criteria considered most significant.

For structuring the multi-criteria decision problem, the first and part of the second stage from Simon (1960), constitute the set of activities which usually is denoted by problem structuring. The third stage constitutes the decision analysis, while it is considered the synthesis of the decision problem. Throughout this decision process, values, alternatives, criteria, consequences, possible risks, and tradeoff relations between alternatives and between criteria are elicited and rethought. As a general principle, it is necessary to give the same attention to each one of those twelve stages presented in the previous section. One of the most common mistakes is one to give quite less attention to the problem structuring than to the analysis of the decision and to the synthesis. Likewise, one should not naively believe that the process is purely rational since intuition is always present in its exercise. Other difficulties that can come during this exercise are related to the occurrence of different points of view, even among experts, that can start from: (i) the usual inexistence of perfect and complete information; (ii) the always present uncertainty and imprecision; and, with no doubt, (iii) the size of the problem – i.e., the tessiture of relationships that may exist between elements of what seems to be the decision problem (which, taken as a whole, is called the decision system) and the other components (external, therefore, to that system) of the context in which the decision will be made.

Consequently, a transparent process, supported by reliable methods, will facilitate the structuring of complex problems, lend consistency to the decision-making process, and ensure validity in the analyses as well as transparency in the parameters and hypotheses adopted (Baker et al., 2001). For its technical importance to the process, it is necessary to clearly identify the seven stages – not sequential but interactive – of the decision analysis. They are depicted in the following paragraphs.

Firstly, identifying and assigning the decision-making agents and the decision makers. Secondly, listing the alternatives, being all those candidates acceptable to solve the problem at issue. In some cases, it will be easy to identify which are the alternatives; in others though, it will be necessary to define them progressively. There may also be cases where it can be necessary to reduce a long list of alternatives to a smaller list, simpler to manage; at first, it is possible to accomplish that in many ways, as, for example, eliminating the alternatives which do not meet, at all, some of the criteria, thus selecting a basic and representative set of alternatives or, still, determining a relatively small number of critical criteria for assessment and selection of those alternatives which have a better performance, in accordance with those criteria. Using one of those techniques, even if there is no theoretical limit to the number of alternatives to be assessed, it is considered that the gathering of information for many alternatives may be an exhaustive task, especially if the number of criteria is relatively large.

Thirdly, setting the relevant criteria. The definition of alternatives and criteria, as seen above, will usually be an interactive process, in which new alternatives can suggest new criteria and vice versa. Eventually, a criteria hierarchy will be formed; the most frequently used criteria hierarchy is linear and has the shape of a tree, in which each criterion is progressively decomposed, starting from the highest node (or criterion) to those located further down; through this technique, it is formed, from a father-criterion (the highest node in the hierarchy), a criteria family. It can be noticed that there are few formal procedures that support the structuring of a criteria hierarchy; this is an ability acquired with practice. In fact, there is no “correct” hierarchy for any problem, and it is possible to develop alternative criteria structures. However, soon after the construction of a criteria tree (or hierarchy), it is possible to judge whether this representation is helpful to the decision analyst by using five factors, suggested by Keeney and Raiffa (1976), according to Table 1.

Table 1 – Five factors for decision analysis.

Factor	Description
Completeness	if the tree is complete, all the criteria which are relevant to the decision maker will be included in it
Operability	all the criteria in the lowest level of the tree must be sufficiently specific so that the decision analyst is able to use them in the problem solution process
Decomposability	it must be possible to assess the performance of an alternative concerning a criterion, independently of its performance regarding other criteria
Absence of redundancy	if two criteria reflect – partially or fully – the same reality (for example, environmental impact and noise pollution), then one of them is clearly redundant; the danger of redundancy lies in the fact that it may entail, at least, one double score, causing the recommendation to generally be spurious

Minimum size	if the tree is relatively very large, any decision analysis will be impossible, from a practical point of view

Source: Keeney and Raiffa (1976)

With regards to the absence of redundancy, a practical way of identifying redundancy is to establish whether it is somehow possible to modify the recommendation to which one has got – by using a multi-criteria method –, if a given criterion is eliminated from the tree. If the criterion elimination does not change the choice of the best alternative, then it shall not be necessary to include the criterion in the analysis. In relation to the large problems, in order to ensure that this will not occur, the criteria should not be broken down beyond the level at which they can be assessed, and common sense should always prevail. Still, sometimes it is possible to reduce the size of the tree through the elimination of criteria that do not make it possible to distinguish between the alternatives.

Fourthly, assessing the preference on the criteria. There are many ways to accomplish this stage, depending on the MCDA method used. In this stage, it can be used scales through which the consequences of each alternative related to each one of the criteria will be represented, whether they are quantitative (as, in a project, the value of internal rate of return) or not (as the relevance from the point of view of environmental impact mitigation). Fifthly, determining the relative importance of the criteria. This decision analysis stage consists of assessing the criteria. As in the fourth stage, there are many ways to set the weights, depending on the multi-criteria method chosen. The important thing is that the weighing measures concerning the criteria are expressions of the exchange relationships (the tradeoffs) between criteria: for example, a criterion may be considered twice more important than another, which will bring consequences to the calculations to be made (by a multi-criteria method). Those weightings reflect, from the decision maker point of view, how much one is willing to give in, concerning to losses in terms of a criterion, since it is possible to gain using the other criterion, and the idea of an exchange relationship comes from there.

Sixthly, determination of satisficing solutions. These, as seen above, will result from a selection procedure (at least from a better alternative to the final choice by the decision maker, or, eventually, from a subset of the best alternatives), ordering (ordering the set of viable alternatives from best to worst), classification (in which the alternatives are classified into pre-established categories) or a detailed description of the alternatives (often expressed by means of logical rules, such a description may be used as a preliminary to a selection, an ordering, or a classification). Leoneti & Pires (2017), state that the most known MCDA method includes: (i) Analytical Hierarchy Process (AHP), by Saaty (1980); (ii) *Elimination et Choice Traduisant la Realité* (ELECTRE), by Roy (1968); (iii) Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE), by Brans & Vincke (1985); (iv) Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), by Hwang & Yoon (1981); (v) Measuring Attractiveness by a Categorical Based Evaluation TecHnique (MACBETH), by Bana e Costa & Vansnick (1994); (vi) Multiattribute Utility Theory (MAUT), by Keeney & Raiffa (1976). Additionally, the *TOmada de Decisão Interativa*

Multicriterio (TODIM), by Gomes & Lima (1991; 1992), and the *VlseKriterijumska Optimizacija I Kompromisno Resenje* (VIKOR), by Opricovic (1998), can be cited.

Finally, in the last stage, the analyst seeks to introduce realistic modifications (i.e., likely to come to reality) in the variables and parameters used by the multi-criteria method employed, to test the extent to which the results obtained are robust.

2.4 The subjective dimension of the Multi-Criteria Decision Analysis approach

The illustrated twelve-stage process is referred to as decision analysis. Since it considers at least two conflicting criteria, this decision analysis is very appropriately named Multi-Criteria Decision Analysis. Consequently, it can be said that MCDA is decision theory put into practice. However, this practice cannot always guarantee the same decision outcome, and the reason for this is easily understood: the context—or scenario—in which the decision is made can change. This is particularly true in the case of the preferences of the decision-makers.

Multi-criteria methods consider the decision maker's preferences as weights (subjective probabilities), which are assigned to the set of criteria under analysis to guide the decision-making process among the alternatives being evaluated. In fact, “decision-making occurs only when multiple criteria and trade-offs are present [...] and it is a function that goes beyond simple measurement and search, aimed at managing, resolving, or dissolving the conflict of trade-offs [...] between alternatives”, states Zeleny (2011, p. 77) in his article addressing the paradigms of multi-criteria decision-making. The preferences are essentially represented by binary relations, i.e., between two objects – the alternatives. According to Roy and Bouyssou (1993) there are four main categories of preference, which are depicted in TABLE 2.

TABLE 2 – Categories of preferences.

Category	Description
The indifference	when there are clear and positive reasons which justify an equivalence between both alternatives. Example: “I am indifferent between to watch movie A and movie B, because, in fact, I do not like the idea of watching none of them (because both are movies about catastrophes, and I, hypothetically, do not like this movie genre)
A strong (or strict) preference	when there are clear and positive reasons which justify a significant preference for one of the two alternatives, as opposed to the other. Example: “I strongly prefer to watch movie C instead of watching movie D, because movie C is a classic detective movie which has been very highly rated by my friends who have watched it (and I have not yet), whereas D is a movie on catastrophes (and I prefer much, but much more, the first genre to the second)

The weak preference	when there are clear and positive reasons which do not imply a strict preference in favor of one of the two alternatives, as opposed to the other, but those reasons are insufficient to deduct a strong preference from an indifference between those two alternatives. (Thus, those reasons do not allow to isolate one of the two precedent reasons – indifference and strong preference – as being the only one appropriate.) Example: "I weakly prefer to watch movie E to watching movie F, because E is a romantic movie and F is a movie about catastrophes (and, although I am not exactly a romantic movies fan, I do not like watching movies about catastrophes)
The incomparability	when there are not clear and positive reasons justifying one of three preceding situations. As an example, suppose I have three program options for tonight – Option 1: "accepting a dear lady friend invitation to watch, with her, movie A, which the cinematographic criticism informs that it is about catastrophes""; Option 2: watching, by myself, movie C, an important classic detective movie, which I have never watched"; and Option 3: "watching, by myself, movie A". It can be said that these three options are incomparable, for one of the two possible mutually exclusive reasons: because (i) I value Option 1 infinitely more than the other options and, at the same time, I value Option 3 infinitely less than Option 2; or because (ii) Option 1 is so unreal (what I lament), that I cannot even compare it to the other two ones and, simultaneously, I value Option 3 infinitely less than Option 2.

Source: Roy and Bouyssou (1993)

Therefore, a new set of values may arise, making it obsolete the initial set of values on which the practice of MCDA is based. In addition, new information may also emerge over time, and by introducing new parameters, invalidate the recommendations to which the initial process has ended.

2.5 On the satisficing solution

Now it can be said, admitting that decision-making in general occurs in the presence of a dynamic scenario, i.e., it evolves with time, that a good decision is that which solves a problem with basis on MCDA and available data at the decision time. As that scenario changes, better decisions, pressed on that same basis, may crop. Therefore, MCDA has a crucial role, of an eminently technical nature, in the decision-making concerning complex decision processes. It enlightens, by means of a wide structuring of the problem and an analytic approach, through application of methods, the search for the best solution to a problem. Since multiple and conflicting decision criteria are being dealt with simultaneously, it is possible to imagine that the good solution sought will meet, to different degrees, the various goals which characterize the decision problem. Thus, based on Simon's (1982) ideas, it can be said that a satisficing solution is being sought, which represents the best possible compromise among the multi-criteria decisions. Following the cited author, it is recognized that rationality in decision-making is always limited by three main factors inherent to the participants: (i) their cognitive capacities are not infinite; (ii) their personal values and motivations do not always coincide with those of the organization in which they are inserted as decision-makers; and (iii) their knowledge of the problem they are trying to solve is usually partial. Thus, it is understood why they are moving, not towards a solution ideally the best possible according to all decision criteria, but towards, at least, a satisficing solution.

Consequently, it turns out indispensable to characterize some of the main participants involved in decision theory practice. The decision maker, also called decision owner, is ultimately responsible for the decision impact. It can be a single person or a group of people, and the recommendation on which decision to make is produced by this participant. The decision-making agent is the individual or group of individuals who, directly or indirectly, makes calculations, generates estimates, and elicits preferences and value judgements used throughout the decision analysis. The decision analyst is the professional connoisseur of the decision theory basics and methods, who is assigned the task of managing the structuring of the problem, its analysis, and the production of recommendations to the decision make. It can also be said that problem modeling and solution are the essential activities of the decision analyst, who constantly interacts with the decision-making agents, and with the decision maker itself. Consequently, the roles played by the decision maker and the decision analyst are complementary, even if the direct responsibility lies with the first one and not with the second one.

After their characterization, the decision makers are treated differently by the multi-criteria decision-making methods. According to Leoneti & Gomes (2022), the first approach considers rationality as the process itself, known as procedural rationality. From this viewpoint, employing objective data and a formal analysis process is considered sufficient to surpass subjectivity and intuition. This form of rationality pertains to the degree to which the process leading to the desired solution is adequately rational. This feature allows some of the MCDA methods to deal with the assumption of a *homo sociologicus* decision maker, providing means to model its particularities and correct any deviation, creating measures to test the consistency of the judgments made. Other MCDA methods assume general value functions, or utility, to model the expected rationality of a universal decision maker. In these methods, rationality is universal, aligned with the perspective of *homo economicus*.

The constructivist approach of MCDA is based on the *homo sociologicus* perspective of the decision maker, and, therefore, is considered a prescriptive approach. According to the constructivist approach, the structuring of the problem advances in an interactive way – i.e., by means of interactions between the decision analyst (a decision theory connoisseur) and the other participants in the decision process (i.e., the decision-making agents) – in a way consistent with the values, goals, consequent criteria, preferences of those agents and the decision maker itself. On the other hand, the prescriptive approach consists in, from a description of all the elements pertinent to the problems, including a description of the decision maker preferences, to propose (through the decision analyst) prescriptions to the decision maker, with basis on normative hypotheses. By the prescriptivist approach, the involvement of the actors (or decision-making agents) into the process is restricted to the problem structuring. Because it is easier to adapt to the scenarios in constant evolution, the constructivist approach to MCDA has considerably increased in its relative importance in the last two decades, thus relegating the prescriptivist approach to the background.

Independently of the approach, MCDA does not seek, therefore, an optimal solution to a given problem, as it happens in the traditional Operational Research, but a trade-off solution, in which the consensus between the parties involved should preferably prevail. From this perspective, the criteria used, as well the importance granted to them, have a fundamental role in the results obtained. This sort of analysis enables the decision process to be treated in a more transparent way, thus increasing its credibility. However, it should be noted that the decision problem approach, under the perspective of MCDA, does not aim to offer to the decision maker a definitive solution to its problem, electing a unique truth represented by the alternative selected. This approach aims to support the decision process, recommending actions in tune with the preferences expressed by the multiple decision-making agents.

2.6 On the pros and cons of the multi-criteria approach

The MCDA approach applied to a complex decision process generally implies the advantages as follows: (i) constitution of a base for the dialogue between the different decision-making agents; (ii) a concrete possibility of working with subjectivities, uncertainties and imprecisions or ambiguities always present in such a process; (iii) visualization of each potential satisficing solution as a compromise between the conflicting distinct points of view. As could be seen above, the MCDA methods serve to select, order, classify, or describe in detail the alternatives about which the decision will be made. Those methods can be used combined or not. Thus, for example, a certain method can be used to classify a set of viable alternatives in four categories: the very good, the good, the mediocre ones and those out of the question; after that, it can be, by means of another method – which should however be consistent with the previous method –simply order only those considered very good and, with that, obtaining the best alternative among all of them.

At the same time, an awareness was being developed in the spirit of that it should not be intended that the usage of those new methods would lead us, necessarily, to an optimal solution – in the sense of a solution ideally the best possible according to all the points of view pertinent the problem –, but to a solution which represented a satisficing compromise between such points of view. Consequently, the MCDA methods are used in the analysis preceding the decision making. However, one cannot ignore the fact that the application field of those methods also includes efforts in the sense of to assess the extent to which a decision already made has met or not the problem goals. Therefore, it is said that one may use the MCDA methods before or after implementation. In the first case, it is said that an ex-ante analysis (of decision), i.e., before the decision is made, serves to generate recommendations for the decision making itself. In the second case, it is said that analysis (of decision) is ex-post, i.e., after the decision is made, seeking, with this analysis, to learn from decisions already made.

In spite of the fact that the vast majority of MCDA methods are quantitative, qualitative methods are also available (Bohanec et al., 2013; Moshkovich and Mechitov, 2013). Although there is, in the decision analyst's toolbox, a very high number of MCDA methods than the four categories of problems – selection, ordering, classification, and description – for the solution of which this analyst is called, usually the choice of a particular method is guided as opposed to other methods, in a solid knowledge of a reasonably large number of methods on the part of this professional. Such knowledge includes the suitability of applying each method to the problem, herein considered the following main aspects: (i) the nature of the problem to be solved (i.e., selection, ordering, classification, and description); (ii) the possible ways of data collecting and compiling; (iii) the relationship structure among the problem goals; (iv) the type of communication expected between the analyst and the decision maker, mainly during the decision-making analysis stages. A quite common mistake made by the novice analyst consists in trying to solve a certain decision problem by means of commercially available software with no knowledge about what is exactly inside the software. However, no software should ever be used without the analyst knowing well, under the various possible nuances, the analytical method embedded in it.

Consequently, nothing replaces the knowledge of a basic and wide set of MCDA methods. For an overview of the various MCDA methods developed and in common use for the last 30 years sources of information such as Ehrgott et al. (2010); Figueira et al. (2005) Stefanoiu et al. (2014); Zopounidis and Pardalos (2010); and Zhang and Xu (2017) are recommended. Examples of reviews of methods focusing on applications of MCDA to particular problems can be found in Baki (2021); Li et al. (2021); Radulescu et al. (2021).

3 FINAL CONSIDERATIONS

Although from its birth in the late 60's until the present a vast number of applications of MCDA has focused on spot applications of methods, the trend observed at the beginning of the 21st century is the development of different domains based analytical processes that are oriented towards the treatment of massive data as well collaborative decision-making. Quite often, MCDA methods are embedded in these analytical processes. Particularly, when optimization or probabilistic approaches are not feasible, MCDA methods offer a robust alternative for decision-making, since the methods excel in handling complex decision problems involving multiple, often conflicting criteria by providing a structured framework for evaluating and comparing alternatives. These methods accommodate subjectivities, uncertainties, and imprecisions inherent in real-world decision-making processes. By integrating various criteria and stakeholder preferences, MCDA methods facilitate a comprehensive analysis that balances different objectives and constraints. This approach ensures that decision-makers can identify satisficing solutions that represent the best possible compromises, even in the absence of precise optimization or probabilistic models. Consequently, MCDA methods enhance the robustness and reliability of decision-making in complex scenarios, for which their foundation is provided in the current paper.

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