Chapter 1

PARADIGMS AND CHALLENGES

Bernard Roy
LAMSADE
Université Paris-Dauphine
Place du Maréchal De Lattre de Tassigny, 75775 Paris Cedex 16
France
roy@lamsade.dauphine.fr

Abstract The purpose of this introductory part is to present an overall view of what MCDA is today. In Section 1, I will attempt to bring answers to questions such as: what is it reasonable to expect from MCDA? Why decision aiding is more often multicriteria than monocriterion? What are the main limitations to objectivity? Section 2 will be devoted to a presentation of the conceptual architecture that constitutes the main keys for analyzing and structuring problem situations. Decision aiding cannot and must not be envisaged jointly with a hypothesis of perfect knowledge. Different ways for apprehending the various sources of imperfect knowledge will be introduced in Section 3. A robustness analysis is necessary in most cases. The crucial question of how can we take into account all criteria comprehensively in order to compare potential actions to one another will be tackled in Section 4. In this introductory part, I will only present a general framework for positioning the main operational approaches that exist today. In Section 5, I will discuss some more philosophical aspects of MCDA. For providing some aid in a decision context, we have to choose among different paths which one seems to be the most appropriate, or how to combine some of them: the path of realism which leads to the quest for a discussion for discovering, the axiomatic path which is often associated with the quest of norms for prescribing, or the path of constructivism which goes hand in hand with the quest of working hypothesis for recommending.

Keywords: Multiple criteria decision aiding, imperfect knowledge, aggregation procedures.

1. What Are the Expectations that Multicriteria Decision Aiding (MCDA) Responds to?

The purpose of this introductory chapter is to present an overview of what MCDA is today. Since the 60s, this discipline has produced, and it still produces, a great number of theoretical as well as applied papers and books. The major part of them will be presented in the following chapters of this book. It is important at the outset to understand their specific contributions are in terms of enlarging the operations research field and, more generally, to bringing light to decision making contexts. That is why I shall begin this chapter by considering the three following questions: what is reasonable to expect from MCDA? Why is decision aiding is more often multicriteria than monocriterion? What are the main limitations to objectivity which must be taken into account? The next section will be devoted to a brief presentation of three basic concepts which can be viewed as initial and fundamental keys for analyzing and structuring problem situations. In practice, it is very important to draw attention to questions such as: what is the quality of the information which can be obtained? What is the meaning of the data which are available or can be elaborated? In Section 3, I shall examine how the existing models and procedures take into account various types of answers to such questions which refer to a given problem's real world context.

Another difficulty in an MCDA context comes from the fact that comparisons between potential actions must be made comprehensively, with respect to all criteria. Various aggregation techniques which will be described in detail throughout the successive chapters of this book have been proposed and used in order to overcome this kind of difficulty. In Section 4, I shall present a general framework for positioning the main operational approaches in which these aggregation techniques come into play. Some more general philosophical considerations will complete this introductory chapter.

1.1 What Is Reasonable to Expect from Decision Aiding (DA)?

Decision aiding can be defined (see [61]) as follows: Decision aiding is the activity of the person who, through the use of explicit but not necessarily completely formalized models, helps obtain elements of responses to the questions posed by a stakeholder in a decision process. These elements work towards clarifying the decision and usually towards recommending, or simply favoring, a behavior that will increase the consistency between the evolution of the process and this stakeholder's objectives and value system. In this definition, the word "recommending" is used to draw attention to the fact that both analyst and decision maker are aware that the decision maker is completely free to behave as he or she sees fit after the recommendation is made. This term is increasingly used in DA to replace "prescription". The latter is, in many cases, inappropriate (see [34, 58]) for designating what a team of analysts accompanying a decision making process might achieve.

Thus defined, DA aims at establishing, on recognized scientific bases, with reference to working hypotheses, formulations of propositions (elements of responses to questions, a presentation of satisfying solutions or possible compromises, ...) which are then submitted to the judgment of a decision maker and/or the various actors involved in the decision making process. According to the case, DA can thus reasonably contribute to:

- analyzing the decision making context by identifying the actors, the various possibilities of action, their consequences, the stakes, ...;
- organizing and/or structuring how the decision making process unfolds in order to increase coherence among, on the one hand, the values underlying the objectives and goals, and, on the other hand, the final decision arrived at;
- getting the actors to cooperate by proposing keys to a better mutual understanding and a framework favorable to debate;
- elaborating recommendations using results taken from models and computational procedures conceived of within the framework of a working hypothesis;
- participating in the final decision legitimization.

For a deeper understanding of the bases reviewed above, the reader can refer to [12, 13, 19, 20, 40, 48, 59, 68].

1.2 Why Is DA More Often Multicriteria than Monocriterion?

Even when DA is provided for a single decision maker, it is rare for her or him to have in mind a single clear criterion. Thus, when DA takes place in a multi-actor decision making process, it is even rarer for there to be *a priori* a single, well-defined criterion deemed acceptable by all actors to guide the process. This process is often not very rational. Each actor plays a more or less well defined role which gives priority to her or his own objectives and value system.

In both cases, it is necessary to take into consideration various points of view dealing with, for example, finance, human resources, environmental aspects, delays, security, quality, ethics,... By considering each pertinent point of view separately, independently from the others, it is generally possible to arrive at a clear and common elicitation of preferences regarding the single point of view considered. This naturally leads to associating a specific criterion to each pertinent point of view. Each of these criteria is used to evaluate any potential action on an appropriate qualitative or quantitative scale. In most cases, there is no obvious and acceptable arithmetic rule which can keep account of these heterogeneous scales by substituting a single scale based on a common unit for each of them (see Section 4 below).

Such a scale, bringing a common unit into play, must be introduced a priori when we want to avoid a multicriteria approach, i.e., when we prefer to choose what is called a *monocriterion* approach. This choice, in many decision making contexts, might:

- lead to wrongly neglecting certain aspects of realism;
- facilitate the setting up of equivalencies, the fictitious nature of which remains invisible;
- tend to present features of one particular value system as objective.

On the contrary, a multicriteria approach contributes to avoiding such dangers by:

- delimiting a broad spectrum of points of view likely to structure the decision process with regard to the actors involved;
- constructing a family of criteria which preserves, for each of them, without any fictitious conversion, the original concrete meaning of the corresponding evaluations;
- facilitating debate on the respective role (weight, veto, aspiration level, rejection level,...) that each criterion might be called upon to play during the decision aiding process.

Additional considerations about relative advantages on monocriterion and multicriteria approaches can be found in [10, 14, 21, 56, 61].

1.3 Can MCDA Be Always Totally Objective?

In many cases, those who claim to shed light objectively on a decision in fact take a stand – consciously or unconsciously – for an a priori position or for a prevailing hypothesis which they then seek to justify. Arguments for making a decision are thus put forward more in the spirit of advocacy than in that of an objective search (see [3, 32]).

In what follows, we will only consider situations in which DA is motivated by a strong desire for objectivity. Even in such situations, it is important to be sensitive to the existence of some fundamental limitations on objectivity. Their origins lie in the following facts:

a) The borderline between what is and what is not feasible is often fuzzy in real decision making contexts. Moreover, this borderline is frequently modified in the light of what is found through the study itself.

b) Even in cases for which DA is provided for a well-defined decision maker, his or her preferences very seldom seem well-shaped. In and among areas of firm convictions lie hazy zones of uncertainty, half held belief, or indeed conflicts and contradictions. Such sources of ambiguity or arbitrariness concerning preferences which are to be elicited and modeled are even more present when the decision maker (entity for whom or in the name of whom decision aiding is provided for) is a mythical person, or when decision aiding is provided in a multicriteria context. We have to admit, therefore, that the study itself contributes to eliminating questioning, solving conflicts, transforming contradictions and destabilizing certain convictions. Any interaction and questioning between the analyst and the decision maker, or any actors involved into the decision making process, may have some an unpredictable or imperceptible effect.

c) Many data (see Section 3 below) are imprecise, uncertain, or ill-defined. There is a real risk of making them say much more than they mean. Moreover, some of them only reflect features of a particular individual value system.

d) In general, it is impossible to say that a decision is a good one or a bad one by referring only to a mathematical model. Organizational, pedagogical, and/or cultural aspects of the whole decision process which lead to making a given decision also contribute to its quality and success.

Rather than dismissing or canceling the subjectivity which results from the limitations of objectivity described above, decision aiding must make an objective place for it. (For a pedagogical overview of MCDA approaches, see [58, 59, 64].)

2. Three Basic Concepts

From the beginning to the end of work in MCDA, three concepts usually play a fundamental role for analyzing and structuring the decision aiding process in close connection with the decision process itself. The presentation of these concepts in the three following sub-sections is obviously succinct. It nevertheless aims to draw attention to some important features.

2.1 Alternative, and More Generally, Potential Action

By *potential action,* we usually designate that which constitutes the object of the decision, or that which decision aiding is directed towards. The concept of *action* does not *a priori* incorporate any notion of feasibility, or possible implementation. An action is qualified as potential when it is deemed possible to implement it, or simply when it deserves some interest within the decision aiding process.

The concept of *alternative* corresponds to the particular case in which modeling is such that two distinct potential actions can in no way be conjointly put into operation. This mutual exclusion comes from a way of modeling which in a comprehensive way tackles that which is the object of the decision, or that towards which DA is directed. Many authors implicitly suppose that potential actions are, by definition, mutually exclusive. Nevertheless, such an hypothesis is in no way compulsory. In many real world decision aiding contexts, it can be more appropriate to adopt another way of modeling such that several potential actions can be implemented conjointly (see examples in [55, 61]).

In all cases, A will denote the set of potential actions considered at a given stage of the DA process. This set is not necessarily stable, i.e., it can evolve throughout the decision aiding process. Such an evolution may come from the study's environment, but also from the study itself. The study may shed light on some aspects of the problem, which could lead to revising some of the data and then, possibly, to modifying the borderline between what is and what is not feasible.

By a, we will denote any potential action or alternative. When the number of actions is finite ($|A| = m$) we shall let:

$$A = \{a_1, a_2, \ldots, a_m\}.$$

When modeling of actions can be done by referring to some variables x_1, x_2, ... it is possible to write:

$$a = (x_1, x_2, \ldots).$$

In such cases, A is generally defined by a set of analytic constraints which characterize the borderline between what is feasible and is not feasible. Multiobjective mathematical programming constitutes an important particular case of this type of modeling (see [25] and Part VI).

In another type of modeling, the value of each variable x_i $(i = 1, 2, \ldots, n)$ designates a possible score on an appropriate scale X_i built for evaluating actions according to a specified point of view or criterion. In such cases, A can be viewed as a subset of the Cartesian product $X = \prod_{i=1}^{n} X_i$. This type of modeling is commonly used in multiattribute utility theory (MAUT) (see Part IV). Let us observe that this type of modeling necessitates some precautions: since each potential action is identified with the n components of its evaluation, it loses all concrete identity; in particular, two actions having the same evaluations $x_1, \ldots, x_n$ are no longer distinguishable.

More details and illustrations of the concepts and ways of modeling presented above could be found in [61, Chapter 5], [84, Chapter 1], and [36].

2.2 Criterion and Family of Criteria

The reader, who is not yet familiar with some of the terms used in this subsection, will find more precise definitions in [64, Chapter 1, Appendix 1, Glossary].

Let us remember that a criterion g is a tool constructed for evaluating and comparing potential actions according to a point of view which must be (as far as it is possible) well-defined. This evaluation must take into account, for each action a, all the pertinent effects or attributes linked to the point of view considered. It is denoted by $g(a)$ and called the *performance* of a according to this criterion.

Frequently, $g(a)$ is a real number, but in all cases, it is necessary to define explicitly the set X_g of all the possible evaluations to which this criterion can lead. For allowing comparisons, it should be possible to define a complete order $<_g$ on X_g: $(<_g, X_g)$ is called the *scale* of criterion g. To be accepted by all stakeholders, a criterion should not bring into play, in a way which might be determinant, any aspects reflecting a value system that some of these stakeholders would find necessary to reject. This implies in particular that the direction to which the preferences increase along the scale (and more generally the complete order $<_g$) is not open to contest.

Elements $x \in X_g$ are called *degrees* or *scores* of the scale. Each degree can be characterized by a number, a verbal statement or a pictogram. When in order to compare two actions according to criterion g we compare the two degrees used for evaluating their respective performances, it is important to analyze the concrete meaning in terms of preferences covered by such degrees. This leads to distinguishing various types of scales:

a) *Purely ordinal scale:* Scale such that the gap between two degrees does not have a clear meaning in terms of difference preferences; this is the case with:

- a *verbal scale* when nothing allows us to state that the pairs of consecutive degrees reflect equal preference differences all along the scale;
- a *numerical scale* when nothing allows us to state that a given difference y between two degrees reflects an invariant preference difference when we move the pair of degrees considered along the scale.

This type of scale is often called a qualitative scale.

b) *Quantitative scale:* Numerical scale whose degrees are defined by referring to a clear, concrete defined quantity in a way that it gives meaning, on the one hand, to the absence of quantity (degree 0), and on the other hand, to the existence of a unit allowing us to interpret each degree as the addition of a given number (integer or fractional) of such units. In such conditions, the ratio between two degrees can receive a meaning which does not depend on the two particular degrees considered; this is another way of defining quantitative scales which are also called *cardinal* or *ratio scales.*

c) *Other types:* In MCDA, we do not always work with scales belonging to one of the above two extreme types (especially interval scales). The most interesting intermediate types are presented in [41, Section 2] and [64].

In MCDA, it is essential to know which type of scale we are working with to be sure of using its degrees in a meaningful way. According to the type of scales considered, certain kinds of reasoning and arithmetical operations are significant in terms of preference (see Chapter 2).

Moreover, the use of the degrees in a significant way must take the following fact into account: the difference between two degrees that are sufficiently close together may be non significant for justifying an indisputable preference in favor of one of the two actions. This stems from the procedure used to position the two actions on the scale considered. This procedure can appear insufficiently precise (with regard to the complexity of the reality in question), or insufficiently reliable (with regard to uncertainty concerning the future) for founding such an indisputable preference on such a small difference. I will come back to this subject in the next section.

In most cases, the first step of DA consists of building n criteria with $n > 1$ (see 1.2 above). They constitute what we call the *family F of criteria.* In order to be sure that F is able to play its role in the DA process correctly, i.e., in laying the foundations for convictions, communicating concerning the latter, debating and orienting the process towards the decision, and in contributing in some cases to legitimating this decision, it is necessary to verify that:

- what is apprehended by each criterion is sufficiently intelligible for each of the stakeholders;
- each criterion is perceived to be a relevant instrument for comparing potential actions along the scale which is associated with it without prejudging their relative importance, which could vary considerably from one stakeholder to another;
- the n criteria considered all together satisfy some logical requirements (exhaustiveness, cohesiveness, and non redundancy) which insure coherence of the family (for more details, see [64, Chapter 1, Appendix 1, Glossary], [67]).

It is important to observe that none of the above requirements implies that the n criteria of F must be independent. The concept of independence is very complex, and if dependence is desirable, it is necessary to specify what type of independence is needed. Multicriteria analysis has led to important distinctions between structural independence, preferential independence, and utility independence (see [37, 54], [61, Chapter 10], and [67, Chapter 2]).

Additional developments concerning this basic concept of criterion can be found in [1, 2, 4, 5, 7].

2.3 Problematic as a Way in which DA May Be Envisaged

The word "problematic" is used here in the sense indicated by the heading. Other expressions such as "statement", "problem formulation" or "problem type" have been used as substitutes, but in my view, they are inappropriate and may lead to misunderstanding.

Let us underline first that DA must not be envisaged solely in the perspective of solving a problem of choice. In some cases, DA consists only of elaborating an appropriate set A of potential actions, building a suitable family F of criteria, and determining, for all or some $a \in A$, their performances sometimes completed by additional information (possible values for discrimination thresholds, aspiration and/or rejection levels, weights,...). For designating this manner of conceiving of DA's aim without seeking to elaborate any prescription, or recommendation, we use the term *description problematic* often coded $P.\delta$.

In MCDA, the word *problematic* refers to the way in which DA is envisaged. This means that the problematic deals with answers to questions such as the following: in what terms should we pose the problem?, what type of results should we try to obtain?, how does the analyst see himself fitting into the decision process to aid in arriving at these results?, what kind of procedure seems the most appropriate for guiding his investigation? In addition to $P.\delta$, three other reference problematics are currently used in practice. They can be briefly described as follows (for more details, see [52], [61, Chapter 6]):

- The *choice problematic* ($P.\alpha$): The aid is oriented towards and lies on a *selection* of a small number (as small as possible) of "good" actions in such a way that a single alternative may finally be chosen; this does not mean that the selection is necessarily oriented towards the determination of one or all the actions of A which can be regarded as optimum; the selection procedure can also, more modestly, be based on comparisons between actions so as to justify the elimination of the greatest number of them, the subset N of those actions which are selected (which can be viewed as a first choice) containing all the most satisfying actions, which remain non comparable between one another.

- The *sorting problematic* ($P.\beta$): The aid is oriented towards and lies on an *assignment* of each action to one category (judged the most appropriate) among those of a family of predefined categories; this family must be conceived on the basis of the diverse types of treatments, or judgments conceivable for the actions which motivate the sorting. For instance, a family of four categories can be based on a comprehensive appreciation leading to distinguishing between: actions for which implementation (*i*) is fully justified, (*ii*) could be advised after only minor modifications, (*iii*) can only be advised after major modifications, (*iv*) is unadvisable. Let us observe that categories are not necessarily ordered as it is the case in the above examples.

- The *ranking problematic* ($P.\gamma$): The aid is oriented towards and lies on a *complete* or *partial preorder* on A which can be regarded as an appropriate instrument for comparing actions between one another; this preorder is the result of a *classifying* procedure allowing us to put together in classes actions which can be judged as indifferent, and to rank these classes (some of them may remain non-comparable).

The four problematics described above are not the only possible ones (see [10, 11]). Whatever the problematic adopted, the result arrived at by treating a given set of data through a single procedure is (except under unusual conditions) not sufficient for founding a prescription or a recommendation (see Section 4 below).

3. How to Take Into Account Imperfect Knowledge?

DA cannot be correctly provided without trying to analyze and to take into account reasons and factors which can be responsible for contingency, arbitrariness, and ignorance in the way the problem is envisaged and procedures implemented. In addition to their subjective characteristics, these reasons and factors may take on various forms whose presence and/or importance greatly depends on the decision making context considered. Their presence comes essentially from three sources (for more details, see [16, 57]):

- *Source* α ($S.\alpha$): The imprecise, uncertain and, more generally, poorly understood or ill-defined nature of certain specific features or factual quantities or qualities present in the problem.

- *Source* β ($S.\beta$): the conditions for implementing the decision taken; these will be influenced by:

  - The state of the context at the time the decision is implemented if it is a once-and-for-all decision;

- The successive states of the context if the decision is sequential.

- *Source* γ ($S.\gamma$): the fuzzy or incomplete, sometimes unstable and easily influenced character of the system or systems of values to be taken into account; these values involve, in particular, the system and most often the systems of preferences which should prevail in order to evaluate the feasibility and relative interest of diverse potential actions, by considering the conditions envisaged for implementing these actions.

Considering the problem formulation, a study of these three sources must shed light on that which appears imprecise, uncertain, unstable or ill-defined. This can leads, for instance:

- starting from $S.\alpha$, to delimiting a domain of reasonable instantiation values for various data and parameters;
- from $S.\beta$, to building a set of scenarios describing different possible future contexts;
- from $S.\gamma$, to eliciting a set of weight vectors; for this purpose, it is important to remember that it makes no sense and is theoretically incorrect to specify measures of relative importance for the criteria without considering the nature of the overall evaluation model which will be used, i.e., without having defined the type of mathematical aggregation rules (see next section) which allow us to derive comprehensive preferences.

The DA process must clearly take into account all the results of this study. To do so, many approaches (formalisms, models, methods, ...) have been proposed. A panorama of such approaches can be found in Chapter 11, and in [39, 76]. These approaches rest upon various concepts, tools and theories; the main ones are:

- probability theory mainly used in MAUT (see Chapter 7), but also used in many other approaches, particularly for building criteria when uncertainty can be characterized by a probabilistic distribution;
- possibility theory [22, 24];
- multi-valued logic (see Chapter 3, [80]);
- concept of discrimination thresholds and quasi or pseudo-criterion (see Chapter 2, and for more details, [35, 70, 71, 72, 87]) mainly used in outranking methods (see Chapter 4).
- concept of fuzzy binary relations [18, 23, 27, 28, 44, 53];
- rough sets theory (see Chapter 13).

Whatever the formalism, the models, the methods used, it is generally indispensable to undertake a robustness analysis. According to which author uses it (*cf.* [66]), this term can cover different ways of proceeding. Nevertheless, the aim is always to distinguish the part of the results which can be firmly established in order to choose an appropriate method (*cf.* [85, 86]), to derive robust solutions (*cf.*[26, 33, 38, 50, 51]), or to formulate robust conclusions (*cf.* [62, 63, 78]). In [62, 63], the reader could find some comments on links and differences between robustness analysis and sensitivity analysis.

4. An Operational Point of View

As soon as more than one criterion comes into play, a crucial question arises: how can we take into account all criteria comprehensively in order to compare potential actions to one another? Let us consider two potential actions a and b together with their respective performances on the n criteria considered. More often, a will be better than b for some of the criteria, and b better than a for others. In such cases, in comparing a and b, on what basis can we found a *comprehensive judgment,* i.e., taking into account, in a comprehensive way, the n performances of a and the n performances of b. This problem is usually called the *aggregation problem.* In many of the chapters in this book, the reader will find a wide variety of solutions to this fundamental problem. In the present introductory chapter, I shall present only a general framework for positioning the main operational approaches provided for DA today (for more details on what the operational approach concept covers, see, [61, Chapter 11].

4.1 About Multicriteria Aggregation Procedures

The most frequently used decision aiding methods are based on mathematically explicit *multicriteria aggregation procedures* (MCAP). By definition, an MCAP is a procedure which, for any pair of potential actions, gives a clear answer to the aggregation problem. It brings into play:

i) various inter-criteria parameters such as weights, scaling constants, veto, aspiration levels, rejection levels,... which allow us to define the specific role that each criterion can play with respect to the others; some more technical parameters can also be present;

ii) A logic of aggregation: this logic should take into account:

- The possible types of dependence which we might want to bring into play concerning criteria,
- The conditions under which we accept or refuse compensation between “good” and “bad” performances.

In order to give a numerical value to inter-criteria parameters and more technical parameters, it is absolutely necessary to refer to the logic of aggregation of the MCAP considered. Outside of this logic, those parameters have no meaning.

For more details on the above considerations, see [15, 42, 60, 67, 69, 79].

Methods which are based on a mathematically explicit MCAP come under one of two types of operational approaches usually designated by the expressions approach based on a *synthesizing criterion* and approach based on a *synthesizing preference relational system.*

4.2 Approach Based on a Synthesizing Criterion

This approach is the most traditional. It can be characterized as follows: formal rules taking into account the n performances of any potential action $a \in A$ are defined so as to assign to a a well defined position (generally by means of a numerical value) on an appropriate scale.

The way the aggregation is addressed in this approach leads to defining a complete preorder on A. Most often, the formal rules consist of a mathematical formula which leads to an explicit definition of a unique criterion synthesizing the n criteria. This is the case with MAUT, SMART, TOPSIS, MACBETH, AHP, ... (see Chapters 7 – 10). The complete preorder on A can also be obtained by the use of a set of formal rules without any mathematically explicit expression of the synthesizing criterion, which remains implicit (see [6, 7]). In any case, this approach does not allow any incomparability.

Building a synthesizing criterion using such a multicriteria approach is not equivalent to a monocriterion approach. The dangers of the monocriterion approach have been presented above (see Section 1.2). Nevertheless, even if a multicriteria approach based on a synthesizing criterion contributes to reducing these dangers, it forces us to introduce a common scale (monetary scale, utility scale,...) on which performances of each of the n criteria have to be evaluated. Moreover, with this approach, imperfect knowledge (*cf.* Section 3 above) can be taken into account solely through probabilistic or fuzzy models.

4.3 The Operational Approach Based on a Synthesizing Preference Relational System

As is the first, this second operational approach is based on a mathematically explicit MCAP. A major difference with the preceding approach comes from the fact that here the MCAP does not work on each potential action a separately from the others, but it successively compares a to each of the other $b \in A$.

In other words, the aggregation problem is no longer addressed in terms of defining a complete preorder on A, it is now addressed in terms of pairwise comparisons so as to design a synthesizing preference relational system. Taking into account the n performances of a and the n performances of b, the role of the MCAP is to give an answer to the question: what is the preference relation which can be validated between a and b? Mathematical rules, which lead to answering this question, are based on:

- various inter-criteria parameters, as in the first approach; but also, unlike the first approach, on discrimination thresholds (see Section 3 above) and veto thresholds;
- a logic of aggregation which easily allows us to take into account (and this is much more difficult with the approach based on a synthesizing criterion), on one hand, some limitations to compensation, and on the other, no quantitative performances.

The synthesizing preference relational system can be reduced to a single binary relation, which can be crisp or fuzzy. But it can also bring into play more than one binary relation. In all instances, the advantages of this second type of MCAP relative to the first cause certain difficulties to arise when we consider the operational approach based on such an MCAP. These difficulties stem from the fact that:

- pairwise comparisons can cause some intransitivities to appear;
- incomparability can be the most appropriate conclusion for comparing certain pairs (a, b);
- consequently, a synthesizing relational preference system is not a tool which is immediately usable for elaborating a recommendation.

For these reasons, this second operational approach necessitates completing the MCAP by a second procedure called *exploitation procedure.* This procedure is conditioned by the problematic considered (see above 2.3).

This second operational approach has led to various methods, most of which are covered by the label of *outranking methods* . The second part of this book is devoted to them. Other works related to this approach are presented in Part V.

4.4 About Other Operational Approaches

All the operational approaches which are based on a mathematically explicit MCAP are not exactly in accordance with one of the two preceding approaches. Regarding this subject, the reader can refer to [8, 17, 31, 43, 75].

Finally, let us mention the existence of operational approaches which are not based on a mathematically explicit MCAP, when this procedure remains implicit. Such approaches often make use of interactivity. A formal procedure is then conceived for asking questions of the decision maker or some other actor.

This procedure leads to an ad hoc sequence of judgments and a progression by trial and error. These judgments have only a local meaning because they refer to the neighborhood of one or a very small number of actions. For more details on this kind of approach, see Chapter 16, [29, 45, 46], [67, Chapter 7], [77,81, 82, 83, 84, 89, 90].

In any case, whatever the operational approach considered, there is a possible confusion which should be avoided. Except under very unusual conditions, the results arrived at by treating a set of data through any appropriate procedure should not be confused with a well founded scientific recommendation. Repeated calculations using different but equally realistic versions of the DA problem (sets of data, scenarios,...) are generally necessary to elaborate a recommendation on the basis of robust conclusions stemming from the multiple results thus obtained. The statement of the proposals which make up the recommendation should be submitted to the assessment and discernment of the decision maker and/or the actors involved in the DA process (see [34, 47, 63, 64, 65, 66, 78]).

5. Conclusion

The final objective of MCDA is, of course, to help managers to make "better" decisions. But what is the meaning of better? This meaning depends, in part, on the process by which the decision is made and implemented. This, combined with limitations on objectivity described above (see Section 1.3), shows that we cannot hope to prove scientifically, in a decision making context, that a given decision is the best. In other words, it is impossible to consider that in every situation there exists, somewhere, the right selection, the right assignment, the right ranking which could be considered and discovered or approximated independently of any procedure. This implies that the concepts, models and procedures presented in this book must not be viewed as being conceived from the perspective of discovering, with a better or a worst good approximation, a pre-existing truth which could be universally imposed. They have to be seen as keys capable of opening doors giving access to answers and/or expectations as described in Section 1.1.

Thus conceived, methodological decision aiding based upon appropriate concepts, models and procedures can play a significant and beneficial role helping us to make our way in the presence of ambiguity, uncertainty and an abundance of bifurcations in order to guide the decision making process.

To achieve this goal, three non exclusive paths can be envisaged:

- the path of realism which leads to the quest for a description for discovering;
- the axiomatic path which is often associated with the quest for norms for prescribing;

- the path of constructivism which goes hand in hand with the quest for a working hypothesis for recommending.

(for more details on each of these paths, see [58]). In a DA process, it is important, when following one or a combination of such paths, to shed light on:

- those aspects of reality which give meaning, value and order to facts;
- the influence exerted upon this reality by observing it, organizing it, provoking within it certain forms of debate, or even having certain tools placed there.

Personally, I consider that the path of realism can only play a role in producing certain descriptions of physical, institutional, socio-economic, financial or psychological systems which form the decision making context. Insofar as such descriptions are produced by other disciplines than DA strictly speaking, the contribution of DA comes essentially, in my opinion, from the constructivism path taken in conjunction with (observing certain precautions) the axiomatic path. Interesting developments and other points of view can be found in [9, 12, 30, 36, 40, 49, 73, 74, 88, 91, 92, 93].

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II

FOUNDATIONS OF MCDA