From mono-criterion to multi-criteria decision aid: a necessary but unfinished evolution in operational research

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Abstract: The aim of this paper is to discuss the evolution process from the mono-criteria decision making paradigm to the multi-criteria decision aid paradigm. This process is based on the fact; in general, the decision-maker desires to consider simultaneously several heterogeneous and conflicting dimensions instead of optimising one single objective such as minimising the cost or maximising the profit. This paradigm shift has led to a different way of using mathematical reasoning and tools within the discipline of operational research. Basically, a shift that has meant a return to the roots of the decision making process in order to develop models that attempt to integrate explicitly the decision-maker's preferences where he/she will be playing the main role during the decision-making process. In this paper we will look at some epistemological aspects of this evolution and point out that this mission of integrating explicitly the decision-makers preferences within the multi-criteria decision aid models remains unfinished.

Keywords: mono-criteria decision making; orthodox model; multi-criteria decision aid; MCDA; preference modelling.

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1 Introduction

Operational research, as a discipline, has been developed along two distinct paradigms, namely the mono-criterion and the multi-criteria decision aid (MCDA) paradigms. Scientific developments of the first paradigm were undertaken based on models that postulate the existence of a single 'objective' (economic) function. In effect, it was admitted implicitly that, to help the decision-maker (DM) to make the optimal choice, there was a general rule that applies to all, a single objective function that all must recognise in order to determine the direction in which the evolution of the system under study must evolve. In this sense, decision theory or analysis arose from the very ambitious attempt to help the DM to make choices whose consequences are still poorly known, against a future that is uncertain and, sometimes, in a decision-making environment marred by ambiguity and imprecision. In this regard, decision-making as a pure rational exercise is the core principle of this paradigm. However, there are many concrete examples of decision-making situations where the consequences cannot be reduced to a single objective function; in fact, these consequences are often multiple and are evaluated in terms that range widely from the monetary to comfort. These heterogeneous dimensions are usually conflicting. Calling into question the principle of rationality, Simon (1976) has brought about in operational research philosophical changes now evident in the concept of satisfaction which has been adopted, added to the classical concept of optimisation or even replaced it.

In the case of the MCDA paradigm, it was developed to address, in part, the anomalies detected within the mono-criterion paradigm and has contributed to several changes in the orthodox decision-making model, especially at a philosophical level. This new paradigm is characterised by thinking patterns that take into account the fact that multiple viewpoints must be considered simultaneously in the decision-making process. In addition, several research studies have focused on decision-aid models where the DM plays a dominant role in the different decision-making phases.

In our view, the relevant question is: What is the quality of this evolution and its future? To answer this question, we will outline the history of the discipline in the section entitled 'From a mono-criterion to a multi-criteria decision theory' and offer a critique of the main results, from an epistemological standpoint, in the section entitled 'Critique of

multi-criteria modelling. In the fourth section we will be presenting some concluding remarks.

2 From mono-criterion to MCDA theory

2.1 The axiomatic and constructive approaches in decision-making theory

Developments in decision theory are driven by the need to deal with so-called complex decision-making situations and, if we go back far enough, they can certainly all be said to be at the outset functional or utilitarian. However, with steady effort, researchers in this field tend to idealise, to abstract and synthesise data experience, then through a logical process produce some deductions. Thus was born pure mathematics, by successive steps, each of which can be seen as an abstraction or a generalisation of the previous step. In fact, this movement is not linear. As theoretical results take hold, they can be applied to solving problems that gave rise to the study in abstract terms as well as to other for that matter. In addition, when talking about mathematics within the context of decision theory, we are referring rather to applied mathematics and optimisation techniques well known in operational research.

Analytical reasoning in decision theory generally unfolds in following three stages: a series of experiments which can be concrete or already abstract, derivation of properties which are considered axioms, and, from these axioms, other properties and relations are logically derived and ultimately used to solve the decision-making situations at hand. As emphasised by Roy (1993), the term axiom has two quite different definitions: "unprovable but obvious truth for anyone who understands the meaning (first principle)" or "an intellectually obvious assertion, an assumption from which logical consequences are derived for the purpose of developing an axiomatic system". According to Piaget (1970), "logic proceeds through a set of axioms and must therefore avoid psychologism or the tendency to move from fact to norm", and he adds: "logic is much more than the axiomatisation of a language".

The system of axioms is also referred to as the mathematical model of the real problem in that the axioms are accepted at the outset as propositions that are true and need not to be proven, because they are either a summary of experience or may have been demonstrated elsewhere. In other words, the axioms of a theory and assumptions of a theorem play the same role from a logical standpoint: they are starting points. What is essential then is to resort only to logical deduction, that is, the promptings of intuition can no longer be brought to bear in a more or less disguised manner, since any recourse to intuition should be aware a conscious and be the object of a new axiom. Indeed, the traditional decision model has its origins in the axiomatic approach which, in a given decision-making situation aimed, for instance, at combine various elements, consists in aggregating simultaneously several dimensions, taking a position in the face of risk, transcribing in formal terms the requirements governed by a form of rationality aimed at deducing the logical consequences (Roy, 1993). This model is based on the assumption that there is a single economic function and that the decision-making process is reduced to finding a maximum or minimum value (extremum) of a single criterion, which is aggregated using the economic function, a value that results in the 'optimal' solution. The search for this solution is based likewise on the assumption that this solution exists for any decision making situation. This assumption imposes constraints that are sometimes

difficult to verify in practice, as in the case of the optimal solution as a whole, the stability of the entire set of solutions and complete transitive comparability of the DM's preferences.

However, in practice, the DM's preferences are often imprecise, incompletely formulated, non-transitive and may change throughout the process. In addition, there are incommensurable goods which can only be modelled through a relationship of a lexical nature, one that does not meet the requirements for modelling preferences in economics and decision theory. It should be noted in this regard that Léon Walras wanted to model economics on Newtonian physics and, to this end, has modelled preferences and established the expected utility theorem. His approach illustrates quite well the desire of what can be called the 'scientification' of economics through the use of mathematics. Yet it now appears that the Walras' approach has certain weaknesses that can only be addressed with the latest mathematical developments such as catastrophe theory and chaos theory. Hence the need for caution when developing the assumptions and axioms that will enable the mathematical formulation of decision-making situations dealt with using the tools of operations research and decision theory.

The optimisation criterion, in the orthodox decision model, creates an instrumental bias for modelling, because, in practice, the comparison of two potential alternatives rests on what we might call the consequences. The again, these consequences are usually multiple, heterogeneous and intermingled. A too formal, too rigid conceptual framework of the work to be performed often leads to the isolation of a key element in order to find the solution to the decision-making situation. It is as if the DM has been evacuated from the decision-making process or become an abstract entity. In other words, the degree of interaction, as Piaget sees it, between the analyst and the DM is very low and sometimes non-existent.

The constructivist approach has made a different use of mathematics in operational research and has done so as part of a shift in paradigm and philosophy, namely the use of mathematics from an optimisation perspective to one of satisfaction or, in other words, a move from a decision theory (the orthodox model) to a theory of decision aid (Roy, 1993).

The MCDA theory is characterised by a pattern of thinking that creates a climate of exchange and interaction among the DM and the decision-making environment. It allows the DM to integrate several factors quite diverse in nature, and avoid optimising a single objective. In practice, this translates into the search for the alternative of the best compromise where the objectives are often conflicting. Indeed, the proposed solution is simply a recommendation to the DM and the final choice is up to him or her. In fact, the decision-making process can be seen as an evolutionary and iterative process towards the most satisfactory recommendation for the DM. This conception of the decision aid reinforces the idea that the mathematical model is a partial and limited representation of the decision-making situation and the recommendation proposed by this model is one among others. What is at work here is a philosophy of satisfaction, not the optimisation perspective as understood within the traditional orthodox decision making model.

This paradigm shift has led to a particular use of mathematical reasoning in the field of operational research, a shift that has meant a return to the roots of the decision making process in order to understand and grasp the concerns of the DMs and give them the opportunity to express their preferences instead of rushing to make an indiscriminate use of mathematical tools. The DMs express their preferences while interacting with their environment, and not with the mathematical model. The analyst's role in decision theory

is to help the DMs navigate the decision-making process, so as to make a more informed choice, and not deciding in their place.

In the next subsection, we will be discussing the two paradigms, namely:

a mono-criterion paradigm

b MCDA paradigm.

2.2 The mono-criterion paradigm

Developments in statistical decision theory (the orthodox decision-making model) are based on the concept of the pure rationality of the DM developed by the followers of Logical Positivism of the Vienna Circle. This theory is based on the four following axioms:

1 the existence of a solution to any decision- making situation

2 the optimum solution as a global solution obtained through a specific algorithm

3 the stability of the set of potential solutions (the entire set of alternative)

4 the complete transitive comparability (in the mathematical sense) of the DM's preferences (Roy, 1985).

Research in decision theory is linked to two, quite distinct, schools of thought in operational research. The first seeks to explain the behaviour of the DM, an individual or a group, during the decision-making process and, to the end, shows how the DM mentally proceeds to make a decision, taking into account the expected impact for a range of alternatives. The second proceeds by analysing the decision-making situation for which the decision maker is asked to grapple with. This analysis involves studying all the available alternatives and consequences with a view to better understand the nature and structure of decisions. In this sense, this school of thought or approach does not seek to capture the mental processes of the DM, but rather to facilitate the task by examining carefully, to the extent possible, the potential impacts of the most important options.

The followers of these two schools of thought have become increasingly active in the discipline of operational research as seen in the number and quality of publications in statistical decision theory and the prevalence of the mono-criterion paradigm where the pure rationality of decisions forms its core principle and where any questioning of this principle may jeopardise all decision theory models that are based on the four axioms mentioned earlier. However, with the advent of the MCDA theory, proponents of statistical decision theory have continued to pursue their research, despite the presence of several anomalies, as defined by Kuhn (1983), in order to protect the core elements of this theory (mono-criterion paradigm).

Within this context, the main objective of the mono-criterion paradigm is 'streamline' the decision-making activity by optimising a single criterion, for instance, profit maximisation or cost minimisation. While this theory has the mathematical means and tools to formulate and solve problems related to decision-making, this formulation leads to a mathematical problem known as 'well stated', in that it is done in such terms that the solution is, by its very formulation, self-contained. Faced with this pattern of thinking, we can deduce that the decision-making activity is reduced to finding an extremum of the objective function, an extremum that results in the 'optimum' solution. Thus, the mono-

criterion paradigm tries to explain things using a single dimension and aiming for the optimum solution, a process that itself requires complete acceptance of the four axioms underlying the traditional decision model. However, as Roy (1985, 2010) has shown, it is difficult, if not impossible, to verify these axioms in practice and, as a result, they can be seen as weaknesses of the mono-criterion paradigm or anomalies according to Kuhn (1983). Either way, proponents of the paradigm are in large part criticised for having, on the one hand, rendered almost absent the dialogue between the decision maker and the analyst and, on the other, assuming the existence of a single utility value, which in our view, does not always capture the expected results.

This decision-making model has left DMs insecure because of the subjective nature of the decision analysis process, especially given that the relationship between the analyst and the DM is reduced to an 'observer-observed' phenomenon. Decision-making is primarily a human activity that impacts society. It is underpinned by the notion of value and, as such, subjectivity is an integral part of it or even its mainspring. A decision-making situation is generally an ill-defined and imprecise entity whose resolution cannot be reduced to a simple formulation of the existing decision-making situation, a formulation which is, itself, a partial representation of reality as perceived by the analyst, actors or stakeholders.

There are many practical situations where the consequences cannot be reduced to a single criterion, because they are usually varied and assessed in terms of money, comfort, prestige and range of other criteria. The mono-criterion approach is little concerned with the preferences of the DM, which are assumed known and stable. This approach has limitations because it supports solving decision-making situations without a real interaction with the DM. In fact, it is the mathematical model that enables the search for the so-called optimum solution. It is a model designed by the analyst, which does not necessarily reflect the preferences of the DM, and which, in our view, is far from able to properly reflect the complexity of most decision-making situations.

These anomalies became the basis for acceptable changes in decision theory, in so far as they help provide a solution to the resulting crisis, and these changes have been brought about by the of MCDA paradigm. In the next subsection we will be highlighting the essence of the MCDA paradigm.

2.3 The MCDA paradigm

This paradigm, which emerged in the late 1950s and early 1960s, and which brought together most of the proponents of the mono-criterion optimisation paradigm, saw researchers developing tools aimed at solving, in part, some mono-criterion conundrums. Scientific developments on a multi-criteria approach to decision-aid revolve essentially around two axes

a the axiomatisation of MCDA as a science

b the applications of this science in the field management.

Thus was born a range of models purporting to provide support for decision making as defined by Roy (1985). However, new puzzles emerged, for example, the weighting of

various criteria and the procedures for aggregating criteria, which are different from one multi-criteria method to another.

The MCDA is a new theory with its own concepts, approaches, models and methods designed to help the DM describe, measure, classify, select or reject a set of alternatives that could affect candidates, products or projects (Roy, 1985; Schärlig, 1985). This exercise is based on a reassessment that relies on scores, values, intensity of preference as well as a set of criteria, all of which may represent different items: objectives, goals, targets, benchmarks and utility functions.

The MCDA paradigm is characterised by a pattern of thought that takes into account the fact that the decision-making process is informed by several criteria (conflicting viewpoints) which must be taken into consideration. This paradigm finds its source and justification in the view that it is difficult, if not impossible, to optimise all the points of view facing the DM in most decision-making situations. As such, it is the responsibility of the DM to make choices, while the analyst role is to enable the decision-making process.

The main of objective of the MCDA studies is to develop models, more or less formalised, with a view to help and assist the DM to take the best decisions. This new approach is based largely on the original operational research scheme, which was underpinned by science as a way to guide and inform DMs in their decision-making process within organisations. In some sense, MCDA can be seen as an update of the original operational research scheme.

The MCDA scientific community are more concerned with the consistency among various stakeholders – while respecting their various objectives – in the new decision-making process and for whom the DM has become the cornerstone of all MCDA models that have been developed. This approach is based on the principle that the DM must be given a more prominent role in the modelling and solving phases of the decision-making process. In this sense, it is a return to the genesis of the process in order to try to understand and grasp the concerns of DMs and provide them the opportunity to express explicitly their preferences, while taking into account the organisational environment in which they operate. Thus, the role of the analyst is to help the DM in the decision-making process, not to decide on his behalf, as is often the case within the orthodox decision-making model based on one in criterion.

Unlike the mono-criterion paradigm, the MCDA paradigm in operational research provide a better representation of the decision-making contexts so because the solution proposed by the model is one among many and therefore it can be seen as a recommendation for the DM. This approach is based on satisfying philosophy, not of optimisation, within the mono-criterion model. The optimum solution, in the traditional sense of the term, does not exist, given the conflicting nature of the criteria involved. In fact, MCDA approach is a gradual conviction-led process rather than the discovery of supposedly pre-existing optimum (or preference). In this regard, the DM is involved from the beginning of the decision-making process to the recommendation phase. The choice available is not final, because the DM can intervene at any time through an iterative and learning process that allows him or her to seek out the best way to deal with the decision-making situation.

3 Critique of multi-criteria modelling

3.1 Decision maker or actor

Knowledge production within operational research discipline and the MCDA, which provide the basis for MCDA analysis, rapidly took on a mathematical expression. Originally, the project was design to provide DMs with a model that would result in a practical solution that is perforce optimal, mathematics being the guarantor of the proposed model's optimality as well as the rationality of the approach.

However, this project has encountered the following obstacles:

1 DMs do not always behave in a rational manner and their preferences are not unequivocal.

2 Conditions that a model takes into consideration may vary over time and, as such, cause the model to be seen in relative terms.

3 The implementation of the model, after a decision is made, is in itself a factor changing the conditions under which the model was designed, which once gain puts its conclusions in relative terms and makes its application necessarily recursive given that the model must be able to account for the conditions it modifies.

These three obstacles which operational research studies have encountered and still face are not of the same order, in that the second and third relate more to the conditions under which the model is applied, whereas the first deals with the nature of the model when it must take into account the rationality and the cognitive dimension of the DMs. Of course, these difficulties can be interrelated, as is the case if the rationality of DMs is one of the conditions for the application of the model. Besides, in many cases, the criticism directed at operational research raises these three difficulties, though the issue of rationality is certainly the difficulty that most worries critics for long time now. In fact, one might think that by transforming the models in such a way as to overcome the problem most of the thorns associated with the two other obstacles would then be eliminated.

3.2 The quest for the decision maker's psyche

The question of the rationality of the DM progressively became a focus for specialists in operational research discipline. Despite the evidence of the non-rational in the action of social actors, the vast majority of researchers in the humanities, for decades and still today, continue view human action in a phenomenological sense as conscious, intentional, strategic, self interested, free-willing, and therefore rational. Think, in sociology, of methodological individualism, symbolic interactionism, ethnomethodology as well as Marxist theories and their derivatives such as institutional ethnography or, in economics, most of the models not only in micro-economy, but also in macro-economy. In operational research, the evidence of the non-rationality of human actions has led researchers in three directions that we will be discussing in the next subsections.

3.2.1 Recourse to epistemology

The first of these directions is epistemology and the research work undertaken normally offer an historical review of mainstream epistemological schools of thought, from

positivism to logical positivism, sometimes to constructivism, where it is said that objectivity is an illusion, that science is historical and social, that scientific evidence is not free of controversy among specialists and that operational research must take into account the social or human dimension without which it has no practical consequence (Weinwurm, 1957; Raitt, 1974; Dando and Sharp, 1978; Ackoff, 1979a, 1979b; Rosenhead and Thunhurst, 1982; Astley, 1984, Roy, 1985, 1993; Déry et al., 1993). However, these assertions do not really concern the DM, for whom the operational research specialist is designing the model, but do relate to the work of the specialist. They remind specialists that their science is not objective, though it does not prevent their work, namely their historically constituted conceptual and methodological frameworks, from being objectifications of the world. They show that their science, built through countless exchanges between experts, although not objective, is not subjective, that it derives from the process of desubjectivation of the researcher, that no scientific work produces results that can be reduced to the subjectivity of the author (Laflamme, 1996). Epistemology reminds the scientist that, though science is not absolute, it does follow that the DM is irrational. It does not teach that scientific discourse and the psyche of the DM are identical. Certainly, while epistemology shows that all discourse is social and historical, and that the notion of objectivity cannot account for human discourse, it does not show that all scientific discourse is the same as any discourse of a social action or DM and that, to quote Gauthier (1982, 2005), the 'constructivism' of scientists is the same as the 'constructionism' of social actors. Scientific discourse is distinct because it must perforce be rational in the face of all the criticisms directed at it, the criticisms that scientists levy on themselves as well as the unavoidable methodological, logical and information requirements. The human psyche is both consciousness and unconsciousness, logical and illogical, moral science, constraint and freedom, spontaneity and reflection; it is emotion and reason; it is emoreason (Laflamme, 1995). In this sense, scientific discourse is an impoverishment of the human psyche and at the same time the elevation of the rationalising thought faculties in humans. Specialists in operational research can put their models at the disposal of the human psyche, but in no case can they design models that are the human psyche as they would be unacceptable in the field of operational research. Epistemology can highlight the forms of scientific discourse as well as its obstacles and, in doing so, it touches on the psyche of the social actor only peripherally. To achieve the complexity of the psyche of the social actor, it will require more of a hermeneutic that an epistemological framework. The epistemology of scientific discourse opens up the historicity of human discourse, but by describing and criticising the scientific discourse, it depicts the human psyche only marginally. Whoever, designing a model for a DM must want to do so rationally with the power of his or her knowledge. The person can only wish that the model is in sync with the human psyche, or worse, that the DM be, in his or her relation to the decision-making context, as restrictively rational as the proposed model. Why would anyone wish that humans are emptied of their emotions when acting? It is certainly useful for science to learn that its discourse is social and historical, and therefore not objective, which does not mean it is subjective. At the same time, epistemology has shown that the discourse of the actor, as DM, was also not objective, a truth that philosophy and psycho analysis have likewise discovered. However, in doing so, epistemology has not shown that scientific discourse was not rational; it has indicated the limits of rationality and highlighted the means to perfect it, that is to say to have it desubjectified. As well, it did not show that the human psyche was the equivalent to scientific thought. Positivism imagined a science that is objective,

neutral, to distinguish it from the thought of the actor as an actor; it is not the actor as an actor who has developed a theory of neutrality. Neutrality is, of course, an attempt at rationalisation, science being, of course, rational. The actor, as actor, is rational, but cannot live strictly on the plane of rationality, because he or she would be unable to love, identify with values, do things moral since morality is reasoning and adhering to values as well as putting emotions into action. Positivism, which had misunderstood the rationalisation of science, but properly understood that scientific knowledge could not be that of the actor as an actor, is an attempt to desubjectify scientific discourse while recognising that the psyche of the actor cannot be identical to scientific discourse. To undertake the epistemology of scientific discourse, within the confines of operational research and the MCDA theory, is not an attempt to become the DM's psyche, not to mention the fact that social actors often spring into action prior decision, that they may act under the influence of external conditions without knowing it, or act instinctively outside any reflective framework.

3.2.2 Integration of values

The second direction is that of values. To account for the non-rational part of DMs in their models, specialists in operational research have been focusing on tastes, preferences and values (March, 1978; Stewart, 1992; Munda, 1993; Henig and Buchanan, 1996; Korhonen and Wallenius, 1996; Shakun, 2001) that is the aspect of the psyche which, in their view, seems irrational. By reducing the non-rational to this aspect of subjectivity, they were able to persist in mathematical modelling, for example, by weighting the values and aggregating them into models using other terms eminently more rational. Against this background, while using more refined tools, they have also developed preference (Watkins, 1983) or satisfaction functions (Martel and Aouni, 1990). As such, the model takes less into account the preferences than the reaction of the DM, it being understood all the same that preference or satisfaction can be explained based on the preferences and the values of the DM. However, sensitive the model is to values or satisfaction, it leads to a significant reduction in the psyche of the DM and the non-rational part becomes then a personal matter. In other words, the more whatever the DM expresses is subjective, and therefore likened to his individuality, the more it is irrational. This assumption poses serious problems. It implies that preferences or satisfaction can be expressed with no rational basis. Of course, adherence to values is not strictly speaking all rational, but then again relationship with values, when expressed, cannot simply be viewed as wholly irrational. In fact, the actor cannot live out his or her relationship with values without reason. The relationship with values is emorational, in that it necessarily involves both the rational action of the mind and the recourse to emotion. Similarly, it cannot be reduced to subjectivity, since values are acquired, reproduced, expressed in a cultural and historical sphere that transcends the individual and, as such, involve communication with others and therefore are set in a frame at least partially discursive that implies some rational input. In addition, the consideration of preferences or values leaves out many other aspects of the strictly non-rational dimension of humans. Everything that is non-rational in humans cannot be reduced to just the subjective. Driven by a desire to be more in line with the complexity of the human mind, some operational research specialists, instead of integrating into their models the non-rational part of the human mind, as indicators of values or satisfaction, have attempted to use qualitative data (Weinwurm, 1957; Lockett, 1984) or non-numerical

analyses (Bowey, 1974). The intent is certainly laudable, since this type of data is able to translate a thought in its specificity, that is to say, to give access to an emorational logic. However, it has been of little use to the specialty, largely because the field is replete with mathematical models and qualitative data does not often lends itself to mathematical formulations. To overcome this difficulty, some specialists have even forced the qualitative into the nominal (Munda, 1993). Fortunately, this attitude has brought to light how some analysts pay little attention to the complexity of the human psyche. The modality of a variable can at best, whatever its nature, refer to the quality of a statement; it cannot correspond to a set of statements where the logic of the relationship between them can alone be an indication of the non-rational, or better still, the emorational.

3.2.3 Extending the notion of rationality

The third direction is that of bounded rationality. Aware of the issues raised by the use of the term rationality when applied to the thinking of decision makers, experts in operational research, like their counterparts in the social sciences, have exploited Simon's concept of bounded rationality (March, 1978; Shakun, 2001), a concept meant to recall the fact that the DMs rarely operate under conditions where they have all the information and all the time they need to make an optimal decision. The concept of bounded rationality refers much more to the conditions under which the reasoning was done than the reasoning itself and to resort to it means that reason is not bounded if the actor had all the information and the time required to deploy his or her judgment. But nothing is less certain. Why would the opinion expressed by DMs be structurally different if they had access to all the information available and had all the time in the world? Even so, would they be released from all their unconscious, emotions, adherence to values? Is a social actor even more rational when he or she is informed or has time? This concept of bounded rationality raises another problem in that it takes as a given that reason is bounded in so far it does not match the theoretical ideal, just as Marxists say that workers are alienated because their discourse is not in line with what theory predicts. However, as a matter of principle, if the object of a theory does not fit the theory is it not the theory itself that should be called into question? How can the reason of the actor or DM may be limited since it is what it is? By what right can the theory considers it limited? A DM is certainly limited by the social and historical constraints, his/her mental structure and social relationships. But in what is the DM limited because his or her rationality is not in line with that of the theory which speaks of or for him or her? The theory should be modelled in such a way that it matches what is given to observation. The theory can rightfully be developed so that it conceives of a rational DM, but it has no right to continue doing so if the object under study does not conform to this representation. The concept of bounded rationality hardly accounts for the complexity of the human psyche or the mind of the DM.

3.2.4 Decision makers psyche and modeling

Operational research has repeatedly stated its intention to take into consideration the thoughts of the DM, both rational and non-rational. It is, in this regard, commendable. However, all the models proposed this far do not require the inclusion of the psyche, thus creating the impression that operational research is more the science of decision aid than decision science (Roy, 1993). As such, it can provide the DM with a model in which it is

quite unnecessary to integrate his or her psyche, either because the psychological questions are pointless or the DM provides all the variables that he or she wants to be taken into consideration and the psychological aspects he or she wants excluded from the list (Martel and Aouni, 1992). In other cases, it will be necessary to explicitly incorporate the psyche into the models, be it the psyche of the DM or that of other actors the model cannot avoid taking into account because it is part of the nexus of external issues.

4 Concluding remarks

In this paper we have presented some epistemological developments behind the two well know paradigms within the discipline of the operational research, namely:

a mono-criterion paradigm

b MCDA paradigm.

Despite the effort to integrate explicitly the DM's preferences in the MCDA models and the attempts to involve the DM in the decision-making process, still this mission is incomplete and the MCDA scientific community needs to focus on how the DM's psyche, preferences and values can be explicitly integrated into the decision-making models. We have also discussed the evolution process from the mono-criteria decision making paradigm to the MCDA paradigm. We believe that this process is unfinished and still there is some room for some epistemological developments and theoretical axiomatisation.

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