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A critical reflection on optimal decision

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To the exemplary citizen, To the Man of science and culture, To my master and companion, To my dear friend Egídio Namorado

Abstract

A discussion and critique of the ideological framework that led to the preponderance of the concepts of utility and optimum as critical referents of decision in the modern age. The result of this critique is an appreciation of the limits of classical operational research, which can only be overcome by adopting a constructivist perspective. In the author's view, this is the approach that will viabilise a contribution to meet the demands imposed by the civilisational process.

Keywords: Optimal decisions; Constructivism; Multicriteria decision aiding; Technological risks

> I had not acquired the habit, so common [...] of ignoring the real world when it contradicts the theory.
>
> Herbert Simon

1. Introduction

We have to go back to the beginning of modernity, somewhere between the Renaissance and the Enlightenment of the 18th century, a time when the predominance of the so-called scientific reasoning came to determine the relationship between Man and Nature, to position the origins of the classical paradigm of operational research. However, truth has been more than a simple act of faith since the time of St. Thomas Aquinas, and thus the way has been open to Cartesian doubt and to free will, to the free and enterprising subject. Decision came to be under the tutelage of Man alone. It is clear that the historical process is not linear. Let us not forget that, while Galileo remained on the Index until a few years ago, in the 17th century the missionaries of the Society of Jesus were teaching Copernicus's system to the Chinese.

In short, the new relationship between Nature, Man and Freedom characterised classical rational thinking. As Lenoble (1969):

> Freedom is claimed in the name of Nature. [...] But, at the same time, Nature is increasingly more strictly determined for the physicist, for the chemist, for the biologist. [...] Nature determined and Freedom as a gift of Nature: this is the paradox which will bother modern thinking for a long time to come.

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And, Lenoble continues,

> Whether man is free or simply an irresponsible link of universal determinism, the result is the same: he behaves as though he was master of his fate, as d'Alembert remarked

The Cartesian view left an indelible mark on scientific method that is still with us. Utility and comfort are central ideas, particularly in the currents that are still dominant in Economics today, in decision theory in organisations and in operational research. Bacon and Descartes had already associated utility and comfort with the idea of scientific progress (Salomon, 1992).

In classical operational research, the preferences of the agents of decision are modelled a priori, starting from the principle that the model will be, in the Platonic sense, a faithful description of reality. It is supposed that in constructing the model the analyst has full information and is rational. All the values appear condensed into a single utility function, the monetary unit of measurement being adopted. Provided certain axiomatic presuppositions, the optimum is considered to be objectively true and of free will. What is required in particular is the independence of the alternatives in relation to the others and the basic principles of the paradigm of optimality, that is, the ability to establish a total pre-order in the set of alternatives. In situations of probabilistic uncertainty, the general archetype does not change, and is much used in operational research, in microeconomics and in subjective expected utility theory.

Our aim is to discuss some of the ideological and pragmatic consequences of the current rational model and to point out some attempts to overcome it in the area of operational research. However, it is first necessary to discuss its intrinsic limitations, at least in brief. As a choice based on the optimisation of a utility function is a particular case of the rational model, we will begin by mentioning some of its most important generic aspects, with a view to questioning the evolutionary process of operational research later. Sfez (1992) deals with this matter in great depth in *Critique de la décision*. In this work he begins by discussing the linear character of rational decision, in which the most important point is the fragmentation of decisions. Decomposition of systems is inevitable in the modern scientific method, but implies, fatally, that interactions between the parts are scorned. This becomes an important limitation when one aims to study and, perhaps, support decisions in complex systems. To overcome this, methodologies of a holistic or systemic nature have been proposed. These methods are, in our opinion, complementary to operational research rather than alternatives. Note that fragmentation of the political system is one of the essential characteristics of the Nation-State, the base of classical liberalism, and it ensures the separation and balance of powers. We do not go into this topic here. However, it must be noted that the organisation and foundations of the Nation-State, which emerged from the 18th century with the Enlightenment and the bourgeois revolutions, survived until the present, but are in crisis today. If this happens, it is for reasons of a systemic nature connected with the globalisation of the world-system. Second, the modern rational decision is mono-rational and social reality is clearly pluri-rational. This perspective opens the promising way for prospective research into possible alternative futures, based on essentially qualitative methodologies, but perfectly compatible with a new open vision of operational research. Third, there are philosophical questions about Freedom. Anyway, for our aims it is enough to take into account that a decision is, as somebody said, associated with a process, and may therefore be described as "a warmer tempo" for that process.

Finally, some more relevant specific reflections on utility theory:

- The psychologists Kahneman and Tversky (1979), among others, showed that human behaviour in the act of choosing diverges from subjective expected utility theory. This observation has several consequences, especially in neoclassical economics;
- The study of particular situations gave rise to paradoxes that have become famous in the speciality's literature, such as the Allais Paradox (see Allais and Hangen, 1979). In these

circumstances, the axioms of utility do not give the expected results;
- Arrow's famous Impossibility Theorem (Arrow, 1963) shows that it is not viable to group individual utility functions together in a single function of "social welfare"; and
- Wierzbicki (1994) draws attention to the following fact: In assuming that utility functions can describe the preferences of decision agents, i.e., that "real *rational* decisions are always made in the best perceived interests of the decision maker, this assumption is itself not rational in the normative, Popperian sense of the theory of science. Popper uses precisely the utility theory as an example of an irrefutable theory"

There is much more to be said. However, I am going to leave this matter for now, to return to it later when I defend a constructivist attitude to decision support, as a way of overcoming the weaknesses of the descriptive attitude, namely in utility theory. Our intention is not only to confront models of utility with a constructive attitude to decision support, but also, and principally, to defend the thesis that the constructive approach can be embodied in models and systems to provide effective decision support in very complex situations in the real world.

In the history of civilizations, energy, information and communications have always been determining factors in political, economic and social organization. The fantastic development of these domains, especially after the Industrial Revolution of the 18th and 19th centuries, has not stopped growing to this day, creating suitable conditions for the birth of globalisation. Man's dominion over Nature today is overwhelming. The capacities of the new technologies are fantastic, with implications in the most diverse domains of human action, from information technology to biotechnologies, from robotics to communications, from energy to space technologies, apparently creating conditions for all men to be able to live in a dignified way. However, poverty has not been eradicated in the least favoured countries, and, even in the rich countries of the West, there is a legion of newly excluded people. The inequality between rich and poor has doubled in the last thirty years. According to United Nations and World Bank data, technological unemployment, precariousness of employment, health risks caused by toxic waste and other industrial waste, the inferno of city traffic, the destruction of fauna and flora and, as a result, of biodiversity, have continued to increase. Natural disasters, connected with the action of Man, have also multiplied. Many of them have presumably been caused by climatic alterations: pollution of the air, water, the sea, recommendations to protect ourselves from sunlight because of the hole in the ozone layer, etc. We live in a time when uncertainty and complexity predominate. The positions of specialists and educated men are at opposite extremes: on the one hand, there are those who foretell the best of all worlds, as the current difficulties are transient problems, which can be perfectly solved by the system (the Green Revolution will resolve all the problems of hunger, Nuclear Energy those of power shortages, the PC and the Internet will bring knowledge and information to every home); on the other hand, there are those who point to the inevitability of destruction and civilisational catastrophe. We have no doubt that it is impossible for a clear-headed citizen not to have moments of pessimism, and that the compulsive optimists, consciously or unconsciously cloud the issues and are the messengers of the owners of a globalised world, who want nothing changed.

In this article we discuss some questions raised by the technological risks associated to the globalised world to motivate a reflection on the optimal decisions, in the framework of the classical operational research. It is based on part of an English version of the Inaugural Speech at the Universidade de Coimbra, on 18 October 2000. The original speech was published in Clímaco (2001).

2. Management technological risks

The technological risk is associated with the global society. A technological risk which has worried men for many generations. For example, Francis Bacon in *Novum Organum* (1620), quoted in Lenoble (1969) had already posed the question:

> The use of firearms has become general. Is it not to be feared that with the progress of science, and the hand of Man on Nature, the discoveries may not come to be used for nefarious ends?

It was Bacon himself who calmed himself next, writing:

> It can be hoped that good habits and religion will guide Man in the use of his power. Still more, his own interests will impose a certain prudence. The States will reach an understanding to limit the use of dangerous discoveries, and the chancellor of England already predicts the holding of an international conference prohibiting the use of firearms.

Simply, this prudence, proclaimed a thousand times, has never existed, and the current situation is much more complex and dangerous. In the global society there are megalopolises of an uncontrollable size and gigantic production units, many natural resources are almost exhausted and technology is increasingly more complex and sophisticated. If, to be absurd, we accept that it may become possible to build completely safe machines, this would not solve the problem, because there are always human operators, and the Man/machine binomial involves unavoidable risks (on this subject see Lagadec (1981)). As Beck (1992) says: "in advanced modernity the social production of wealth is systematically accompanied by the social production of risks". We all know of large-scale accidents, some with only local repercussions, others with consequences that do not respect territorial boundaries. Remember, for example, the rain with toxic dioxins on Seveso in 1977, caused by a large-scale chemical accident and the fusion of the core of one of the reactors at the Chernobyl nuclear power station in 1986, with more serious implications for the surrounding region, but with transnational consequences thousands of kilometers away.

There are risks of diverse types and amplitudes, and perhaps those where the likelihood of occurrence is very low and the consequences are of an incalculable dimension should be stressed. Another category of risks occurs to me, one that is very little spoken of, at least seriously, but which we cannot fail to mention. We mean the risks we leave for future generations, caused by current technical options, the transgenerational risks.

In this paper, the discussion is limited, in a generic way, to the decision procedures with which issues of technological risk are associated, without even the intention to refer separately to the cases of prevention and those of risk management. First, it is necessary to be aware that the perception of the actors involved depends on diverse factors, that is, the interests at stake, the frequency of accidents, the treatment they are given by the informative entities, the type and size of the equipment, the materials involved, etc. This applies to all the actors—to the citizens who may be affected and their organisations, to political agents and experts. Furthermore, decision procedures of this type raise difficulties of a varying nature which must be analysed. Let us begin with a question, which may be unrealistic from the pragmatic point of view, but is very real in the essence of things. The peoples should be masters of their technological fate. Inevitable risks on the model of western society, as we know it, are not an inevitability of Nature, as they would sometimes make us believe. They may be unavoidable if we want to maintain our current lifestyle. The question lies in knowing whether we have the opportunity to say "No". Obviously we do not, for several reasons. The words of one of today's politicians are very eloquent when he says "We have to choose between a potential nuclear catastrophe, using the power station after it has been repaired, and a certain economic catastrophe if we close it" (Salomon, 1992). We cannot hope for a swift alteration of this situation, but small giant strides could and should be taken. The first has to do with the autonomy of citizens (Castoriadis, 2000), that is, with their capacity for intervention in the life of the community and the strength that effectively well-informed public opinion would have. Second, we believe that the politico-legal system could also help. For example, is it allowable that decisions on the realisation of megaprojects, with implications for the future life of peoples, should be taken by simple majorities in parliaments? Let us think

about the massive production of electricity in nuclear power stations. It is impossible, with current knowledge, to say even approximately how many generations will be affected by a decision of this kind.

Let us now move on to the difficulties more directly related to decision procedures, which specifically involve issues of technological risk. First, there is the enormous technological complexity of much of today's equipment. For example, in large systems, designed to perform more than one task, which include subsystems with very strong connections, there are often unexpected interactions. In many cases these are non-linear, and are therefore impossible for the operator to predict. Charles Perrow calls our attention to the potential danger of these cases, and presents an eloquent illustrative example:

> In 1977 New York City experience a massive and very costly blackout. One key contribution to the accident was an operator's expectation about the default reading for current flowing over a particular line. Normally that line carried little or no current. The operator did not know there had been two relay failures – one that automatically lead to a high flow of current over that line; and a second that blocked the flow over the line. The operator treated the zero current as normal. In fact, it was abnormal, but only in this particular set of circumstances. This ambiguity led to a systematic, by-the-book sequence of actions to handle the problems that were showing up in other parts of the system, ending in the system being brought to a halt''. (Perrow, 1999)

Another classic difficulty has to do with the problem of equity, a determining factor in assessing whether a project is politically acceptable. For example, when deciding where to site potentially dangerous equipment which, as is well known, unleashes the not in my back yard (NIMBY) syndrome, one of the politically and ethically most important criteria is equity with regard to the population. But measuring this equity is far from simple, even considering only the technical aspects. As French et al. (1997) noted, based on the experience acquired from participating in an European project,

> the equity is not just a matter of defining a fair distribution of risk over a population of individuals. The fair distribution of risks over subpopulations (here villages) also needs to be considered. For this we shall need concepts of dispersive equity ...

Equity raises many other issues, but I do not believe we need to linger on them, so obvious are the sensitivity and difficulty of the problem. In processes of this type, the decision is always political, and we do not believe that any kind of delegation of competencies is politically legitimate. The final decision brings together fatally diverse controversial factors: there is no optimal solution. Public participation and the opinions and explanations of the experts are of the greatest importance in enabling the political power to assume its responsibilities in a properly informed way, facing risks and perhaps incomprehension of the final choice, leaning on the legitimacy conferred by the popular vote. For the process to be serious, it is essential to create conditions for effective public consultation, that is, for a critical reflection on the matter in question, which is only possible if the process is constantly monitored and there is open information, namely, discussion of the pros and cons of the viable alternatives. Popular intervention should not come down to impassioned and impulsive positions, charged with emotion. Such positions are very respectable, but show that we are still far from living in advanced democracies, even when the regimes in question are formally democratic. Let us point out two significant examples.

Everyone remembers that after the Chernobyl accident the fields of several countries were contaminated with radioactive substances, putting principally milk and fresh vegetables at risk. Michèle Rivasi relates, in a very interesting article (Rivasi, 1992), an episode that took place in France. At the time, it was reported in the media that France had been protected from the radiation by an anticyclone. In a certain area the population

did not believe this, and organised themselves, bringing in specialists to clarify the situation. After a relatively complicated process, they finally concluded that without an independent laboratory it was impossible to contradict the official version. This laboratory was set up, and the first study it carried out was precisely on the impact of the explosion at Chernobyl. Several hotspots were detected in the eastern part of the map of France. Michèle Rivasi points out that this is "a reality far from the averages made public by the official departments".

The second case is discussed in detail by Gusterson (2000) of MIT, and concerns the decision procedure, which took place between 1988 and 1990, relating to a nuclear waste incinerator to be built in Livermore, California. In the end the incinerator was not built, but the notable thing about the process is the professionalism with which the discussions were conducted in the public audiences, where each party in the dispute had a separate team of experts. As is obvious, there was also a lot of emotion and rhetoric, but this did not prevent the matter being studied and discussed throughout by those who argued against, which is, without doubt, a significant advance in the functioning of the democratic process. It is essential to create a minimum of confidence between the political power, the citizens and the experts, and in this aspect the political power and the experts have an added responsibility. Controversy helps to clarify positions, but a total lack of confidence impedes a calm and serious discussion. The citizens' autonomy is also indispensable. Only people who are informed and able to mix words with the experts and politicians can ever be full-bodied citizens in an increasingly complex society which requires the various options and their consequences to be studied in depth and clearly.

Furthermore, the expert inspection must be plural and explanatory. Physicists, chemists, biologists, sociologists, psychologists, economists, jurists, doctors etc. should give well-founded opinions. These opinions are essential, but, for various reasons, cannot be considered objective truths, nor even total and definitive. Herbert Simon tells us of an experience regarding this. He wrote:

> More than ten years ago, when two technicians at the Livermore laboratories improperly published some statistics that showed that the health risks resulting from the radiation immediately around the power stations were substantially greater than had been initially thought, the first reactions of the people connected with nuclear energy was to close ranks. Apart from some honourable exceptions, they did not say: "Let's look at this more closely. Let's nominate a committee of specialists to check the facts. On the contrary, the almost unanimous reaction was: "Why did these irresponsible people decide to open their mouths?" I had the opportunity to find out about these facts as a member of the Presidential Consultative Committee for the Sciences and I remember, naïvely, being surprised by the insensitivity of those "responsible people", given the depth of public concern. Many of these people were my friends or acquaintances, people of high integrity, people whose honesty I do not doubt. What prevented them from seeing the need for an impartial analysis of the facts was the "knowledge" they had acquired over ten years, working on the development of nuclear energy; the conviction that this new technology was good for Humanity ... (Simon (1989). This quotation was retranslated to English from a Portuguese edition of the original text).

When a problem becomes highly controversial, when it is surrounded by uncertainties and conflicts of values, it is very difficult to arrange experts, and even more so to acknowledge their legitimacy. The preconceived ideas of some technicians and politicians are another of the pieces of this complicated jigsaw. Pfeffer (1992) observes that, in many of life's circumstances, the experts perform the service of *hired guns* for company directors or for politicians, justifying preconceived decisions "scientifically". Finally, a legal appreciation is needed, given that there is increasingly more national or international legislation that intervenes in this material. This makes it essential to make a correct assessment of which options are unequivocally legitimate from

this point of view and which political institutions can legitimately make the decision. Social practice, which may or may not validate the laws and mix diverse knowledge and experiences, is perhaps another small step towards recognition of new rights (Ramonet, 2000), such as the right to protected nature or the right to a humanised city. However, in today's world, the utilitarian mono-rational ideology seems to be in good health, which will at least retard the progress towards more humanised societies. The "fatal attraction of the optimal" is above all else an ideological image of this view of the world. In other words, let us see: to celebrate Humanity's entry into the year 2000, the New York Times decided to issue a special publication dedicated to "The Best of the Millennium". Included in this supplement was an article by Frank Rich entitled "Better, Why?", where he says at a given stage:

> We tend to forget that almost all our notions for measuring, cataloguing and quantifying the best are relatively recent... It was in the 20th century, and especially in the American 20th century, that our incessant thirst for classifying almost everything became a cultural undertaking that reaches obsession ... The impulse that drives us to make lists and catalogues of the Best is very understandable at this *fin de siècle*. We live in a time when the volume of what we know about the Universe is more than we can absorb, and the desperate desire to understand has been one of our anxieties for thousands of years ... Do not be surprised that we cling more than ever to the idea of the Best—as an anchor and radar simultaneously, even if there is more disagreement about what it means than ever (Rich (1999)). This quotation was retranslated to English from a Portuguese edition of the original text.

Decision theory and classical operational research have also been developing optimisation models dedicated to the problems of risk. The best known are based on Cost–Benefit Analysis, and are therefore models that aim to minimise a utility function that supposedly groups various dimensions of risk. It is assumed that uncertainty is probabilistic and risk is estimated by Statistical Inference, aiming to model physical, chemical and biological aspects. Other mathematical models have been proposed, but with no alteration to the paradigm, for example, the Event Trees, which make use of the Bayes's Theorem, and which can incorporate subjective estimates. As in neo-classical economics, the advances consist of complicating the utility model to include new aspects of reality. Of the many improvements proposed, the attempts to integrate psychological issues such as aversion to risk, for example, stand out. However, the descriptive models of optimisation de per se are, in our opinion, inadequate to prescribe decisions in complex problems, as is the case of technological risk.

Edgar Morin writes, in *La méthode*:

> If optimisation involves the inclusion of disorder, uncertainties, speculations, competition, and antagonisms, then such an optimisation involves the unoptimisable ... (Morin, 1980).

3. From the classical operational research to decision aiding

Attempts to overcome the optimising rationale, designated absolute rationale by Perrow (1999), go back to the fifties, the time when Simon (1957, 1960), later awarded the Nobel Prize for economics, broke with the paradigm of optimality in his studies on decision in organisations, for reasons of an essentially cognitive nature. He concluded that the rationality of human beings is limited, for reasons that go beyond the specific characteristics of each individual, that is, because the mind works in a sequential way, by making comparisons. In these circumstances, he proposes that satisfaction should replace optimality, or rather, he considers that human beings, if they need to solve a problem, accept a solution when they judge it to be satisfactory. Some years later, operational research strengthened the course of overcoming the paradigm of optimality; it is fair to point out Russell Ackoff as a precursor in the United States and a group of personalities in England, of whom

we point out Jonathan Rosenhead. It is recognised that operational research has profound cognitive, social, political and ethical implications. It is therefore intimately interlaced with psychology, economics, political science and sociology. The evolution has been diversified and, in my opinion, the most promising School at present is based on a constructivist attitude, materialised by Roy (1985, 1999) in the so-called decision aiding science. It corresponds to a recent development in operational research, which has come to be located in a hinge position between mathematics and the social sciences.

Despite all these recent victories, it should be noted that the use of informal models dedicated to supporting human beings in building convictions has been known and practiced for a long time. A famous letter that Benjamin Franklin wrote to a friend is an eloquent example. He says:

> In the affair of so much importance to you, where in you ask my advice, I cannot, for want of sufficient premises, advise you what to determine, but if you please I will tell you how. When those difficult cases occur, they are difficult, chiefly because while we have them under consideration, all the reasons *pro* and *con* are not present to the mind at the same time ... To get over this, my way is to divide half a sheet of paper by a line into two columns; writing over the one *pro*, and over the other *con*. Then, during three or four days consideration, I put down under the different heads short hints of the different motives, that at different times occur to me, for or against the measure. When I have thus got them all together in one view, I endeavour to estimate their respective weights. (*apud* Zeleny, 1982)

Next, Franklin refers in detail to a simplification procedure for eliminating contrasting arguments, which, in his opinion, cancel each other out. Finally, he describes the process of choice in the following terms:

> I come to a determination accordingly. And, though the precision of algebraic quantities, yet when each is thus considered, separately and comparatively, and the whole lies before me, I think I can judge better, ... and in fact I have found great advantage from this kind of equation, and what might be called moral or prudential algebra. (*apud* Zeleny, 1982)

Benjamin Franklin is clearly aware of two issues, which are essential for building decision support models. First, he identifies the difficulty of concentrating on several matters simultaneously, that is, he recognizes that the attention, while being one of the great weapons of human beings, is also one of their main limitations. Furthermore, he uses a multidimensional model to study the problem, and tries to estimate a set of weights, but he avoids a simple aggregation of weighted sums for the final choice, preferring to combine the multicriterial analysis with his own experience and intuition. These are important lessons for the studies that are currently in progress in the field of decision support. As was said earlier, Bernard Roy considers that we are facing a rising science, decision aiding science. In recent decades, there have been studies and discussions on its validation, that is, on the possibility of instituting minimal conditions for verification and critical discussion. It is also Bernard Roy who describes it as follows:

> ... the goal of Decision Aiding (DA) is not to set forth objective truths. Rather more modestly, 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. In order to accomplish this goal, DA draws its support from models. These models are not necessarily (more or less simplified) descriptions of hard-liner reality. We could imagine, for example, the preferences that one of the actors might have in mind relative to numerous potential actions with very complex ensuing consequences. These preferences might evolve under the influence

> of decision-aiding or under the influence of other actors. Which is to say that the role of decision-aiding is not to discover hidden truths, but rather to contribute to constructing individual convictions, collective decisions and compromises between multiple, and often conflicting, rationalities, stakes and value ... DA cannot claim to unify or synthesize these systems of values, logical approaches to deal with information, rationalities or the foundations of legitimacy when two or more clash within the same decision-aiding process. Nevertheless, in a certain number of cases, DA should allow participants to structure debate and facilitate concertation, especially by helping to establish a climate of confidence and by providing a common understanding of the problem. (Roy, 1999)

That is, decision aiding science may lead to actions with prescriptive characteristics or simply advisory actions, depending on the circumstances. It is an attitude which frames the decision procedures, in a constructivist view, "based on clearly explained, but not necessarily formalized, models" (Roy, 1985). In this case, the help does not consist of showing the agent of decision or the various actors involved the course to follow, but rather of constructing a set of coherent recommendations that contribute to the clarification of the process. Thus, the goals and values of the decision maker(s) do not run the risk of being replaced by any old calculated rationale. Now, this methodological perspective is not so very far from the ideas of Michel Croizier, when he draws attention to the social character of limited rationality:

> Limited rationality is constructed by Man. Its limits do not appear by chance. They are developed and established from the game of human relationships within complex systems which have their own characteristics and regulations. (Croizier, 1983)

Perrow (1999) argues in the same way, designating this multilimited rationality by social and cultural rationality.

Conceptually, decision aiding science, permits, or even incorporates, both quantitative and qualitative models in assisting agents of decision, with a large spectrum of options, from the traditional models of Optimisation, to Statistical Inference, to the techniques of Artificial Intelligence, to the Cognitive Maps, imported from Psychology, and used with considerable success in the structuring of decision problems, etc. It is important to stress that the models of optimisation, for example, here play the part of a support tool, and are therefore only suitable for proposing a solution to the problem in question de per se in special cases.

In recent years, multicriteria models, group decision models and negotiation models have undergone great development, and, in many cases, are models rooted in constructivism. Obviously, they tackle questions that are very relevant in many decision processes. In particular, we cannot forget that negotiation is present in many real world cases, yet was ignored by operational research for decades. Use of multicriteria models lets us avoid one of the essential issues that has followed us throughout, that issue being the aggregation of the preferences of agents of decision in a single criterion, reducing everything to just one measure, usually in monetary units. Some multicriteria approaches propose the combination of algorithmic protocols with the experience and intuition of agents of decision in the process of preference aggregation. But, even if only formalized procedures are used to aggregate preferences, these are generally interactive, and need not be compensatory. Obviously, aggregation always implies loss of information, which means special care is needed.

New technologies allow very flexible interactive decision support systems to be constructed, which makes it easier to put a constructivist view of operational research into practice. In addition, these decision support systems can even be used symbiotically with wider-ranging tools of a systemic nature, or with qualitative prospective analyses. Croizier (1983) recognises that operational research is established as a particular case of action methodology, and we add that the constructivist approach is blurring the borders between various levels of this methodology.

It must be remarked that quantitative models have to be used with great caution. There is no doubt that "arithmomorphism" (Roy, 1999) must be fought. However, there is an essential pre-condition for this—we must study carefully the quantitative models and methods, so that we can understand their potentials, and their limitations too. In science it is crucial to avoid making extrapolations that go beyond the possibilities of the models used. On the other hand, it can be said that open decision support systems, which can integrate quantitative and qualitative models, and perhaps the actors' experience and intuition about the decision process, have not been found to be efficient. On these matters it is advisable to remember a sentence from Einstein (*apud* Haimes, 1997):

> So far as the theorems of mathematics are about reality, they are not certain; so far as they are certain, they are not about reality.

That is, reality is integral, it involves complex social processes, and therefore the synergies between different scientific areas will help us to understand it, so that we can intervene better. There are cases in which the use of mathematical models resolves decision problems by itself, but they are rare, especially when dealing with complex problems.

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The last but not the least, it must be remarked that whenever the bibliographical references used are not in English, we decided to make the translation of the quotations to English.

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