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Multicriteria modeling and result analysis

by

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The ELECTRE method can be successfully used in structured decision problems where a complete set of actions is defined and a consistent family of criteria can easily be elaborated. Many sources of uncertainty, imprecision and ignorance are present (Roy, 1989) and induce difficulties in the definition of the multicriteria (MC) model parameters, which are related above all to the performances of each alternative on each criterion and to the importance of the criteria. An application of ELECTRE is also possible when the decision problem is only partially structured, but in this case there is also uncertainty in relation to the aspects that have to be considered meaningful and several knowledge elements should be acquired to reduce uncertainty. A different methodological approach and some tools are proposed in literature (see for instance Rosenhead, 1989) to deal with unstructured or ill-structured problems.

Some years ago ELECTRE III was tentatively used to support the structuring of a valid model in relation to some technical problems that were presented as particularly complex and not well structured (Balestra et al., 2001; Cavallo and Norese, 2001). In both these situations, the problems were connected to specific research fields rather than to decision contexts.

The request to support model building for a new and not sufficiently known problem situation was first considered unusual, but at the same time challenging. ELECTRE, which was well known because it had already been applied to resolve a structured decision problem in the same technical context (muscle fatigue evaluation), was specifically requested to test the modelling hypotheses and the proposal was accepted because data already existed, in terms of different possible measures of the muscle fatigue electrical manifestations that were not numerically adequate for a statistical data analysis approach, and the fact that the data had been directly acquired by the research group was considered as a guarantee of good knowledge of their meaning.

In a second case, the situation was similar: a research context, with a large number of data to be analysed to identify the main reasons for slope instability and erosion phenomena, and a subset of more detailed data, which was interesting but numerically inadequate for a statistical data analysis. ELECTRE was only used in this case for the subset while Multivariate analysis was instead used for the other data, to create more possibilities of validating each conclusion.

The result of the first ELECTRE III application to both problems was considered unacceptable. The two distillation procedures produced totally different results and, more critically, results without any correlation to the few certainties present in the research field. In one case, there were

many analysed actions[3] and the rankings showed classes of 20 ex equo actions, at the same level, and therefore also a very limited discriminating capability of the model. In the other case, there were few analysed actions (a variable number of actions, from six to eighteen, in relation to the twenty-two situations that required the ELECTRE III application) and there was a distance of six classes between their positions in the two distillations in several cases.

The modelling hypotheses were reanalysed and the structure of the model changed but the result was again meaningless. At this point, the possible reasons for these disastrous results were searched for in the model and analysed and each of them tested, changing one element of the model at a time (in this case the role of each specific criterion in the model structure rather than its importance). A cyclic learning process developed, other experts in the research field were involved in the analysis of both the modelling hypotheses and their evident global unacceptability. New modelling hypotheses were defined and the results of each ELECTRE application became more reasonable. At this point, a tuning action on the parameters allowed the global MC model to be considered enough 'robust' and to be accepted in the research field.

These experiences using ELECTRE III with models developed in relation to not well-structured problems were useful in the formative process to transfer knowledge to the students on the use of the ELECTRE method in decision aiding situations.

The description of some MC models is interesting for the students, but not sufficient for them to acquire the capacities necessary to structure a good model in real situations. A consequence is often the use of 'an old model in a new decision problem', but this natural attitude can become critical in the training process. The concept that the specific decision situations, in a general decision context, can be at least partially different and can require different models is not easily accepted. The idea that each decision aiding intervention requires some problem and decision context analysis and model structuring steps, before the definition of all the model parameters, is automatically accepted but not often made operational. Each suggestion of combining modelling and validation activities obtains almost the same results. The request of analysing the results after each implementation of the method results in a very limited activity, which is often not consistent with the nature of the results and not sufficient to produce a valid conclusion.

In order to limit the criticality of this situation, where a new proposed problem is often perceived as complex and not well structured, I started elaborating simple result analysis exercises to stress the ideas that a result may present critical elements and that obtaining a result should not considered automatically the end of an application. I then proposed sensitivity analysis exercises, where the parameters that contribute more to the variance of the outputs have to be identified, and robustness analysis exercises where, after some oriented tests, a final conclusion has to be produced. The different perspectives of these exercises underline the fact that the relationship between outputs and model parameter setting should always be analysed.

A growing complexity in the proposed exercises produced a first result, in terms of better comprehension, at least for some students, and was considered above all as a preparatory step to pass to the real learning process: an MC decision aid laboratory. In this laboratory real, or at least realistic, decision situations are proposed to the students. The problems are quite simple, but are perceived as complicated and unstructured decision situations by the students, because of their inexperience. When, for the first time in the laboratory, the students face a decision problem, they are in a situation that can be described as complex, because they develop an ELECTRE application for a decision problem that they perceived as unstructured, even though it is structured or at least partially structured.

The large number of students in this kind of laboratory (more than 2000 over the last seven years) allowed an interesting observation to be made on how a new practitioner reads decision aiding problems and how he/she can acquire an acceptable expertise in using MC methods. The laboratory was initially only oriented to the use of ELECTRE III. A new decision problem was proposed each time, with some possible actions and an available database to extract elements for structuring and detailing an MC model. The demo version of ELECTRE III that can be unloaded from the LAMSADE site was used, with its limits[4], to stress the idea that "data are not

[3] In (Cavallo and Norese, 2001) the data were related to two situations, the first required a model with 80 actions and the second a model with 300 actions.

[4] The demo of the ELECTRE III/IV SW accepts only six actions and five criteria.

criteria" and that a good model includes only the (few) significant elements of the problem, but has to be complete and not redundant. Only at a second stage, do the students pass to the normal version of ELECTRE III. The ELECTRE TRI method was proposed in the laboratory only in the two last years.

While assisting in the laboratory, we realized that the students easily understand the meaning of the various ELECTRE model parameters analysing the results of each application of the method to a model and changing the model parameters step by step. But the connection between "good" results and attention to the structuring of the model, in terms of problem definition and identification and development of adequate criteria, is more difficult to transfer. The general idea is that "my criteria are obviously good, but the weights and the thresholds may be changed to improve results that are not acceptable".

Four years ago, in order to improve their approach to the problem, the organization in the laboratory was changed. A database that is useful for a decision context was also proposed in this case, but the students were required to formulate a specific decision problem in the proposed context and to support a real (or realistic) decision maker. If, for instance, the decision context is the location of an industrial facility in a district area, a problem formulation may be the location of a production plant in the leather sector, in the automotive or in other different sectors but also the decentralization of some production processes in a new plant, or the location of a new warehouse for the distribution of perishable goods. If the decision context is a personal selection, a problem formulation may be related to a multinational company that needs managers and assistants who have to move to the different plants, but may also refer to a small company that needs salesmen for its different markets, in Italy, in Europe and elsewhere.

The students, who work in couples, generally identify their tutor of a previous stage in an enterprise, a relative or an acquaintance who has or can have a specific problem in relation to the proposed general decision context as their decision maker. When they do not know a possible decision maker they can choose an assistant or myself as their decision maker. In this case, we must avoid any support or suggestion but we become the "problem owners". In this laboratory, the students find the same difficulties that are described in (Balestra et al., 2001; Cavallo and Norese, 2001) but, after a first disastrous result, it is simple for us to suggest (and demonstrate) that a richer and detailed problem formulation can reduce their difficulties in model building and the first model is partially changed or globally reorganized.

The presence of several incomparabilities in the results, that are evident in the ELECTRE III partial graph or in the assignment to non adjacent categories by the two ELECTRE TRI logics, is now more easily interpreted as a possible consequence of an incomplete model or a superficial structuring of the strategic dimensions of the problem and/or a non consistent definition of the relevance of each strategic aspect in the problem. Sometimes, the non-operational definition of the actions (i.e. a generic plant location in a site, without any indication of the plant characteristics and/or the location motivations) is the cause of the problem and the real reason is always the problem formulation that is not correctly or not sufficiently made explicit. When these possible reasons are analysed and eliminated step by step the number of incomparabilities is always reduced and can easily be related to a structural problem of some specific actions that present conflictuality in the evaluations.

ELECTRE TRI Assistant (ETA), which is included in Version 2.0 of the ELECTRE TRI SW tool proved useful. The presence in the SW of a tool that supports the model definition reinforces the idea that a good model is not a normal starting point but one of the main results of a decision aiding intervention. The inclusion of ETA in the SW system is often perceived as an answer to the difficulties of the decision aiding process, and to be more concrete and more acceptable than the explanation of what a constructive approach to the problem is. Other SW systems, such as IRIS, will be tested in the laboratory over the next few years.

One limit of the available ELECTRE SW tools is the absence of a section dedicated to result analysis with, at least, the possibility of comparatively visualizing the results that were produced in connection to different modelling scenarios, when the problem structure is defined step by step and the results significantly change, or in a robustness analysis, where the results of a set of acceptable model versions have to be compared to define a robust conclusion. A good tool is, for instance, the SURMESURE diagram (see figure 1) that was proposed in (Simos, 1990) and is described in (Rogers et al., 2000).

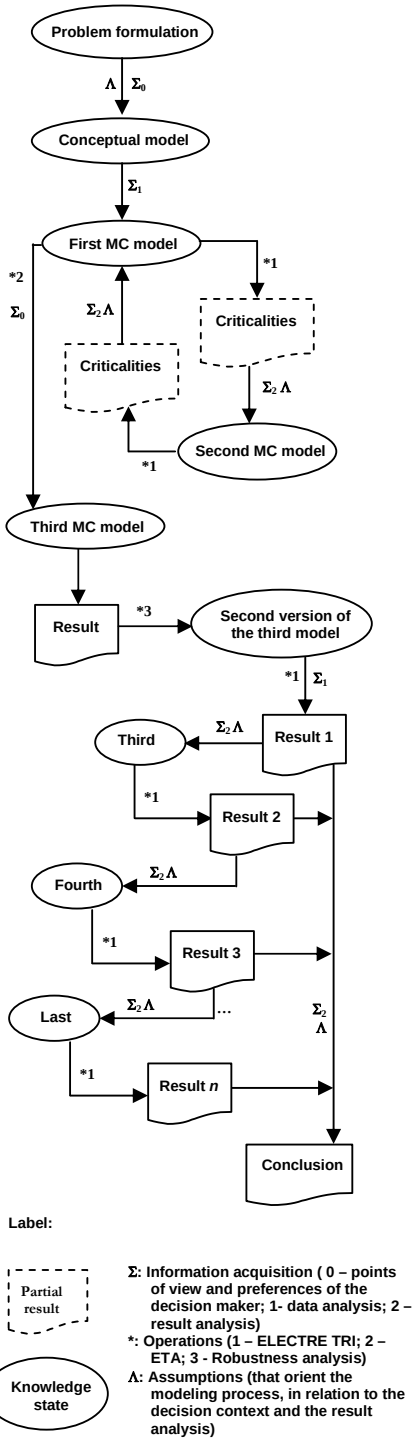

Figure 2 – Map of a modeling process

Another useful support could be a map of the main steps of model structuring, detailing and tuning, of the feedback cycles to marginally or globally redefine the model (and sometimes the problem formulation) and the elements of knowledge that can be acquired from the analysis of a previous result. I found the most useful to be the map (see figure 2) that is described in (Lendaris, 1980).

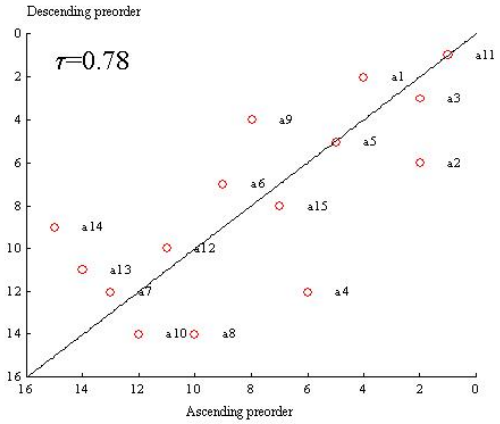

Figure 1 - SURMESURE diagram of the first modeling hypothesis results

Some tools, which are directly proposed to support the structuring of problems and models, are explicitly oriented to an MC approach to the problem[5]. When the students use one of these tools in the laboratory, to structure a specific "unstructured but not so complex" problem, they acquire skills in modelling that they successfully use to adequately apply an ELECTRE method to face more structured MC decision aiding problems. The integration of "structuring assistants" to stimulate structuring skills in the users can be essential for MC decision aid.

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[5] See for instance STRAD (Friend, 1989), EXPERT CHOICE or MACRAME (Norese, 1995).

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