Multi-Criteria Decision Analysis and Multi-Objective Optimization

at the Delft University of Technology, Faculty of Mathematics and Informatics

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Multi-Criteria Decision Analysis (MCDA) and Multi-Objective Optimization (MOO) have been investigated in our faculty since the early eighties. The research started with three different studies: the nomination procedures in a university, the evaluation of non-linear programming software, and the evaluation of alternative energy-research proposals. The decision makers, who usually had a strong background in science and technology, always questioned the scale sensitivity, the dependence on the units of measurement, the dependence on the method employed, and the rank preservation of the final scores. Hence, we altered the original AHP, the method which we originally employed. With the Multiplicative AHP so obtained we carried out several strategic-planning projects in close cooperation with the Energy Study Centre, North-Holland, under the auspices of the Ministry of Economic Affairs. In the late eighties we were also engaged in contract research commissioned by the Directorate-General XII (Science and Technology) of the European Community, Brussels, and by Schlumberger Research Laboratory, Paris.

A generous grant of the Delft University Research Committee (MCDA project TWI 90-06) supplied the financial means for a large-scale project with a challenging goal: the development of robust MCDA methods for the allocation of scarce resources to the competing decision alternatives. In the nineties we have been concerned with the following issues:

· Scaling of human judgement via geometric scales for the Multiplicative AHP and via arithmetic scales for the Additive AHP and SMART. The scales are based upon studies in acoustic and visual perception.

· Comparative studies of well-known cardinal MCDA methods (SMART, the AHP) and an ordinal method (ELECTRE) under compatible input conditions, that is, within an explicit and uniform model for the context of the decision problem.

· The power game in groups modelled via the assignment of power coefficients to the decision makers. This yields the basis for weighted voting via the AHP and SMART.

· The vagueness of human judgement and the development of fuzzy versions of the AHP and SMART.

· The assignment of weights in MOO in order to find an acceptable compromise, either via minimization of the weighted Chebychev distance with respect to the ideal vector, or via maximization of the weighted geometric mean of the objective functions.

· The reduction of conflicts via the pairwise comparison of concessions in negotiations between two or more parties.

· The tools for communication with groups of decision makers. In the eighties we worked with questionnaires so that the decision makers could leisurely answer the questions and return the responses via the mail. In the nineties we used electronic brainstorming and voting in the Group Decision Room of the Faculty for Systems Engineering and Policy Analysis.

· Resource allocation to competing decision alternatives, the goal of the MCDA project. This study, initiated in a project with the European Community, led us to the solution of distribution problems under the principles of fairness and equity. Several publications are under preparation now. The key concept is the desired-ratio matrix. In principle, there is such a matrix under each distribution criterion.

In the early nineties Leo Rog developed the REMBRANDT system for MCDA (Ratio Estimation in Magnitudes or deci-Bells to Rate Alternatives which are Non-dominaTed) as an amalgamation of the Multiplicative AHP and SMART. This has been our tool in many projects. The preference ratios can be expressed in their original magnitudes on a geometric scale or in orders of magnitude on an arithmetic scale. Thus, we applied logarithmic coding, a mode of operation which is common in psycho-physics, see the decibel scale in acoustics. REMBRANDT has been designed for group decision making, with power coefficients assigned to the respective members.

In the field of MCDA there are at least three competing schools: (1) the axiomatic school around Multi-Attribute Utility Theory, (2) the school around the AHP, and (3) the French school around ELECTRE. Some of our papers appeared to be controversial because they questioned the fundamentals of the AHP (the scale, the calculation of impact scores and final scores) and ELECTRE (the setting of thresholds, the basic idea of constructivism). The confrontations slowed down the publication of our manuscripts but they kept our ideas under a healthy pressure.

In our projects we also encountered strong resistance. In Brussels, for instance, because we proposed to model the power game between the member states of the European Community via weighted voting. This was unfeasible in the late eighties but in certain cases it is possible now. There are even barriers against MCDA in the MCDA community itself. Other projects, however, were encouraging. High-ranking officials of the Ministry of Public Health came to the Group Decision Room in order to evaluate the current diseases on the basis of seriousness, a multi-dimensional concept which plays an important role in any public-health policy. The results of the sessions contributed significantly to the Policy Document "Healthy and Well" submitted to Parliament in 1995.

Key publications

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4. Gennip, C.E.G. van, Hulshof, J.A.M., and Lootsma, F.A., "A Multi-Criteria Evaluation of Diseases in a Study for Public-Health Planning". European Journal of Operational Research 99, 236 - 240, 1997.

5. Honert, R.C. van den, and Lootsma, F.A., "Group Preference Aggregation in the Multiplicative AHP: the Model of the Group Decision Process and Pareto Optimality". European Journal of Operational Research 96, 363 - 370, 1996.

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13. Triantaphyllou, E., Lootsma, F.A., Pardalos, P., and Mann, S.H., "On the Evaluation and Application of Different Scales for Quantifying Pairwise Comparisons in Fuzzy Sets". Journal of Multi-Criteria Decision Analysis 3, 133 - 155, 1994.