MULTI-OBJECTIVE DECISION-MAKING IN NEGOTIATION AND CONFLICT RESOLUTION

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Summary

Historically, problems of multiparty decision making have been tackled within the disparate fields of game theory, organizational behavior, experimental psychology, international relations, and economics. Negotiation and conflict resolution as distinct fields of study and practice have emerged within the last four decades. During this period of time, multiobjective decision making has also coalesced as a field of study, and its methods have been applied to a diversity of decision problems in business and public policy. The last decade has seen the rise of computer-supported applications of these procedures, due to the superior ability of computers to process, store, and manipulate great quantities of data. As the complexity of joint decision-making problems continues to increase, we expect that the future will continue to present challenges and opportunities for multiobjective theory and computation as applied in negotiation and conflict resolution.

In this chapter, we first present an introduction both to multiple objective methods in which scalar value functions are explicitly quantified and to methods not involving such quantification. Following this, we review several common methods of negotiation analysis, again within the same two categories. In each category, practical examples are presented. Next we briefly discuss the role of computerized negotiation support—so-called negotiation support systems. We then summarize an actual application of multiple objective methods to stakeholder negotiation in a water resources management context.

1. Introduction

Negotiation is the process of joint decision making. It is communication between two or more individuals or groups who are trying to forge an agreement for mutual benefit. The need to negotiate often arises when mutually desired resources are insufficient to satisfy all parties or when there is disagreement on relative priorities among issues. Negotiation comes into play in attempts to resolve conflicts when it is not possible or desirable for an individual to act unilaterally. Everyone negotiates, from spouses attempting to decide where to go out for dinner, to stakeholders involved in energy-environmental decisions, to elected members of a legislative body, to diplomats in the international arena.

Historically, research on negotiation was carried out in isolation in a variety of fields. In the last four decades, however, negotiation has emerged as a topic of study in its own right. It was realized, for example, that game theory alone was not useful to negotiators. Game theorists typically seek equilibrium outcomes that would result from strategic interactions of fully rational players with complete knowledge of the rules of the game. But this quest has often failed to provide prescriptive theory and useful advice for negotiators. In real situations involving real negotiators, there may be several plausible equilibriums or solutions, and no *a priori* obvious way to choose among them. Also, one or more of the assumptions of game theory may be violated. For instance, an opposing party may fail to act rationally. Or the rules of the game or the utility functions of opponents may not be completely known to all players. Thus one may not know what moves or outcomes are possible, or one may know little or nothing about what the other party is thinking. Negotiation analysis made headway against this problem by relaxing assumptions of strict strategic sophistication (e.g., fully rational players cognizant of all the rules of the game), while asserting that creative use of often simple mathematical analysis could be of help in many ways.

Negotiation research has had relatively little formal interaction with the field of multiple objective analysis (also known as multi-criteria decision making, MCDM), which is also approximately four decades old. The focus of MCDM is usually on a single decision-maker who unilaterally chooses between alternatives whose outcomes (usually assumed to be known with certainty) differ on two or more “objectives”, “criteria,” or “attributes” (terms that we use synonymously in this chapter). Many multiple-objective, decision-making problems are formulated as linear, integer, or nonlinear mathematical programming problems, where a function of a vector of decision variables is to be optimized while constrained to remain within a feasible region. The focus is on alternatives on the boundaries of this region, termed the *efficient frontier* (Q, R, S, T,

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and W in Figure 1), for which simultaneous gains in all objectives or for all parties are not possible.

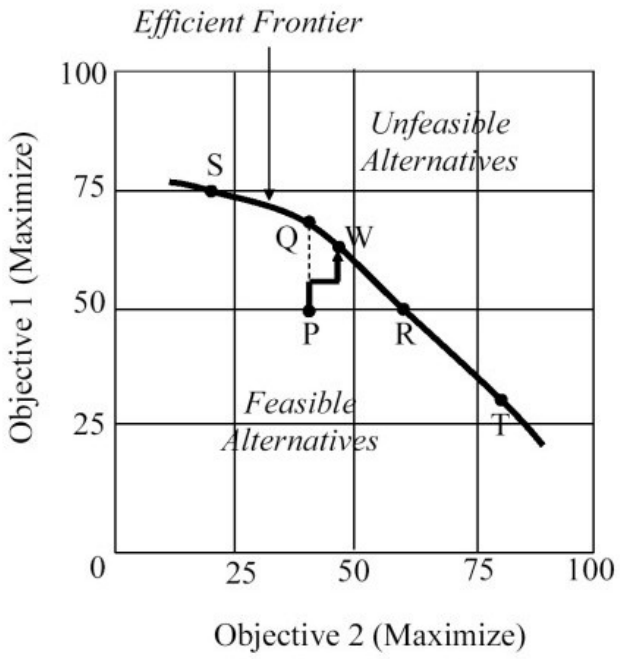

Figure 1: Tradeoff curve (Pareto or efficiency frontier) between two objectives or the interests of two parties

Often, solutions are sought by *interactive* MCDM methods, in which the decision-maker is assisted in seeking and exploring the efficient frontier by considering a sequence of alternatives in a step-by-step fashion. While early research in negotiation often emphasized simple mathematical analysis, multiple-objective decision-making makes use of sophisticated computer-assisted analysis to unveil the efficient frontier. Using such methods to assist negotiators in discovering and jointly exploring this region is one way in which multiple-objective decision-making is capable of making a useful contribution to negotiation. As an example, multi-objective mathematical programs of a nation's energy economy often have tens of thousands of decision variables, and are frequently used in policy debates to understand the tradeoffs between objectives such as economic growth, pollution control costs, employment, and emissions of air pollutants.

Another approach to multiple-objective decision-making emphasizes the importance of helping a decision-maker think carefully about his or her values concerning the objectives, quantifying those priorities if possible, and applying them to the decision or negotiation problem at hand. A variety of procedures and theoretical concepts have been developed to help decision-makers accomplish this. Seven distinct tasks in value quantification may be identified. The first one is qualitative. The objectives or criteria of concern must be identified and possible levels or ranges of agreement (these may be a continuum) on these criteria specified. Second, a reasonable value model is identified for scoring and combining the multiple issues. Later in this chapter, we summarize several alternative value models that might be used. The third step consists of defining

alternatives that are available and quantifying their performance on the objectives. This can involve specification of subjective probabilities when there are significant uncertainties, reflecting the individual's judgment about the relatively likelihood of different outcomes.

The fourth through seventh tasks are quantitative in nature. The fourth—"value scaling" of individual criteria—consists of the individual decision-maker (or representatives of a particular party in the negotiation) assigning relative values to the respective levels of each of the different objectives. Fifth—criteria weighting—addresses value tradeoffs, specifying how much achievement in terms of one issue one would be willing to forego in return for a given improvement in the achievement of each other objective. Sixth, the decision-maker uses the value scales and weights to create a multi-criteria model that combines, or "amalgamates", the criteria so that the alternatives can be ranked. Some methods create a scalar index of desirability (sometimes called a "value function") that can be used to order the alternatives. Other amalgamation methods instead involve systematic pairwise comparisons of alternatives, yielding a partial or complete rank ordering. Later in this chapter, we present a more complete typology of value quantification methods. The seventh step is to use the multi-criteria model to rank the alternatives, and then to subject those results to sensitivity analysis.

Theodore Stewart has suggested that MCDM processes for describing and exploring the efficient frontier and quantifying values can serve useful roles in three stages of negotiation:

- *Initial impact assessment and screening among a number of alternatives.* At this first stage, decision alternatives are generated and subjected to a preliminary screening by technical staff who are supporting a negotiation process. These staff may either be working for a particular party to the negotiations or for a neutral facilitator or sponsor. At this stage, multiobjective analysis is useful for structuring the comparisons of alternatives and for filtering out alternatives that are obviously inefficient or fail exclusionary criteria (such as physical infeasibility, or violations of budgets). Nonetheless, important value judgments may be made even at this stage. The result of this phase is a "short list" of options to present to negotiators and stakeholders, along with an initial characterization of the tradeoffs and uncertainties involved. This stage can also provide documentation of the screening process, which allows external parties to examine the assumptions and value judgments that were made in the course of developing and screening options.
- *"Within interest" structuring and evaluation.* The purpose of this second stage is to help individual parties to a negotiation or policymaking process develop a coherent position on the alternatives. Because members of a particular interest group will share values, it can often make sense to talk about a group's evaluation. But even though members of a group may share broad concerns and have a general sense of what their priorities are, they are unlikely to have specific and unanimous positions on particular valuation questions, such as the rate they are willing to trade-off particular quantified criteria. Multiobjective analysis can be useful here in several ways: to help people develop and articulate value judgments in a systematic way that can be used to compare alternatives; to gain insight into the implications of different judgments and ways of viewing the problem; and to identify consensus positions or disagreements within the group.

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- *"Between interest" negotiation and decision-making.* Once participants in a process acquire an understanding of the tradeoffs and develop an initial position on the alternatives, the next phase is communication and negotiation among the parties. The purpose of multiobjective analysis in this stage is to identify possible compromises and consensus, to understand the reasons for any remaining disagreements, and to document the results of the process. Such an analysis provides a framework for systematic discussion of tradeoff and uncertainties. In particular, MCDM strives to help parties focus on their fundamental objectives and interests during the bargaining process. Because these objectives are often at least partially shared by the parties, such a focus has been repeatedly found to be more likely to yield satisfactory compromises than "positional bargaining." In positional bargaining, each party instead musters arguments about why a particular alternative they prefer is superior to alternatives favored by the other parties. As the case study described later in this chapter shows, MCDM can identify options that are found attractive by most or all groups based on their objectives, and help explain the reasons for disagreements over other alternatives.

Note that at each of these stages, the purpose of multiobjective analysis is *not* to calculate the "right" answer. Rather, it is to build insight and understanding among participants in the process so that they can confidently make recommendations and choices. The implication is that an MCDM-based process should have the following characteristics.

- *Simplicity and clarity:* Users should understand the process and calculation procedures; "black-box" methods and unnecessary complications should be avoided.
- *Feedback:* Where people are unsure of their precise priorities, MCDM methods can help them better appreciate the problem, explore their feelings, form a coherent and defensible set of values, and understand the implications of those values for the decision. MCDM methods are most effective at doing this when they promote learning and allow people to adjust their judgments accordingly. Thus, users should be able to examine quickly and conveniently how alternative value scaling, weighting, and amalgamation judgments affect outcomes.
- *User control:* Stakeholders distrust processes that ask for value judgments and other inputs and then process them, proclaiming results without giving people a chance to reflect and adjust their inputs. People do not like to feel out of control, especially when their inputs are tentative. All recommendations and decisions should be the result of careful thinking by the users; MCDM methods should support that thinking, not replace it.
- *Efficient communication among participants:* Judgments, such as criteria weights or subjective probabilities concerning the performance of alternatives on the criteria, can be discussed in a structured group setting in order to allow for efficient sharing of insights and perspectives. Issues can be raised and either resolved or the reasons for differences of opinion clarified. A structured discussion procedure such as the Nominal Group technique allows individual judgments to be shared anonymously, and then discussed in a way that encourages participation by all group members and discourages dominance by more aggressive participants.
- *Patience:* When dealing with multiple stakeholders, significant time is needed to ensure that users understand and are confident in the process.

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- *Multiple approaches:* Ample empirical evidence shows that (a) different multi-criteria valuation methods are most appropriate for different individuals and (b) different methods can yield different recommendations. Thus, no single value elicitation method should be used for everyone. Users gain the most insight, satisfaction, and confidence by looking at the problem from different points of view with the help of more than one MCDM method, and then doing the hard thinking necessary to resolve inconsistencies among the results.

To be sure, there are a host of additional real-world considerations that help ensure that there will remain an art to the process of negotiation and conflict resolution. There is a role for creativity, experience, and sound intuition that can never be replaced by increased analytical sophistication or formal procedures. In addition to being efficient, a good negotiated settlement should aim to capture aspects of fairness. It should be wise, in that it should reflect experience and the most relevant information. It should be stable, which might mean that at a minimum a good settlement should be feasible and include provisions for renegotiation if a party is unable to follow through on its commitment. Such stability depends on relationships, so good negotiated settlements should seek to preserve amicability between parties. Finally, successful negotiators separate the people from the problem, evaluating the problem on its merits (that is, based on the ultimate objectives that the parties are concerned with). They seek to discover and focus on the underlying interests of parties, rather than on initial bargaining positions. As noted, MCDM methods contribute to this more constructive focus by emphasizing quantification of objectives; skilled facilitators use their ability to probe, empathize, and communicate to help parties to articulate their fundamental goals. Thus, to summarize, potential users of MCDM tools in negotiation must recognize that in many negotiation problems, analytical procedures can play a useful role—but that such tools by themselves are by no means sufficient to help disputants achieve agreements that are efficient, carefully thought out, and durable.

In the next several sections, we describe some general approaches in applying multi-criteria methods to negotiation and conflict resolution. First, we present methods that emphasize formal quantification of values for individual parties in negotiations (Section 2). We then summarize methods that emphasize mathematical description and analysis of tradeoffs between interests of different parties when their values have not been explicitly quantified (Section 3). Sections 4 and 5 conclude this Chapter with a summary of the need for computerized, multi-objective, negotiation support systems and a summary of a case study that illustrates the successful use of multi-objective analysis in negotiation.

2. MCDM Approaches to Quantifying Preferences of Individual Parties in Negotiations

We turn to the subset of MCDM approaches in which scalar value functions are elicited explicitly. The main goal is to evaluate, from an individual party's point of view, the complex tradeoffs that often characterize negotiation situations. As pointed out in the Introduction, these methods can be used for preliminary screening of alternatives, within-interest prioritization and alternative evaluation, and for identification of potential compromises and reasons for disagreements among parties. In multiparty

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negotiations, for example, the parties might be willing to disclose their value functions truthfully perhaps to a third party, an intervener, who can then use them in such a way as to seek an efficient agreement or compromise. This is what was done in the case study summarized in Section 5 of this chapter. Value and utility functions based on weighted sums can be used to accomplish this, and are applied to a simplified climate policy problem later in this section. Key to successful application of these methods is the recognition that people often do not enter negotiations with hard and fast opinions about what particular tradeoffs are desirable. Consequently, these methods should be applied in a way that allows people to explore the options and crystallize their general priorities into specific value judgments that can be used to rank alternatives.

These MCDM methods attempt to improve the quality of decisions involving risks, multiple criteria, and multiple interests by making choices more explicit, rational and efficient. This is attempted in three ways:

- By *communicating tradeoffs* among objectives and their uncertainties so that parties to negotiation can understand the relative advantages and disadvantages of alternatives;
- By moving the discussion away from alternatives and toward *fundamental objectives*. This helps negotiation because it encourages people to think about common interests and avoid the defensive discussions that result from anchoring on a preferred alternative. It can also help define new options that better satisfy group goals.
- By helping people to systematically reflect upon, articulate, and apply *value judgments*, resulting in logical and documented recommendations concerning which alternatives are most preferred by each of the parties.

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Biographical Sketches

Richard M. Anderson received his B.S.E. in Engineering Mechanics in 1991 from Johns Hopkins University in Baltimore, MD, and then worked for two years as a nuclear safety analyst for Westinghouse Electric Corporation in Pittsburgh, PA. He then returned to Johns Hopkins University, where he completed an M.S.E. in Mechanical Engineering in 1996 and an M.S.E. in Environmental Management and Economics in 1999. His research interests are in decision analysis and ecological management. Mr. Anderson completed his Ph.D. in the Department of Geography and Environmental Engineering within the program in Systems Analysis and Economics for Public Decision-Making in the Summer, 2002. He is a member of the Institute for Operations Research and the Management Sciences (INFORMS), the American Geophysical Union (AGU), and the International Association for Great Lakes Research (IAGLR).

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Michelle L. Bell is a Ph.D. candidate in the Department of Geography and Environmental Engineering at The Johns Hopkins University, Baltimore, MD. Her dissertation involves the integration of meteorological and air pollution modeling systems with public health research to estimate the human health impacts from changes in emissions or climate. She earned a B.S. from the Massachusetts Institute of Technology in 1992 and an M.S. from Stanford University in 1994, both in environmental engineering. Before coming to Johns Hopkins, Ms. Bell worked as an environmental policy analyst at Oak Ridge National Laboratory, developing environmental policy and guidance for DOE, EPA, and other federal agencies. Other recent work includes a re-analysis of the health impacts of the London Fog of 1952, published in *Environmental Health Perspectives*, and an evaluation of multi-criteria methods in the integrated assessment of climate change policy, published in the *Journal of Multi-Criteria Decision Analysis.*

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