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Decision Support

A fuzzy approach to cooperative *n*-person games

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Abstract

The object of this paper is to provide a systematic treatment of bargaining procedures as a basis for negotiation. An innovative fuzzy logic approach to analyze *n*-person cooperative games is developed. A couple of indices, the Good Deal Index and the Counterpart Convenience Index are proposed to characterize the heuristic of bargaining and to provide a solution concept. The indices are examined theoretically and experimentally by analyzing three case studies. The results verify the validity of the approach.

Keywords: Group decisions and negotiation; Bargaining capacity; Fuzzy logic

1. Introduction

Decision-making in complex and competitive environments is a difficult task. Several studies on this topic provide empirical evidence about the inability of individuals to make rational decisions under such circumstances, and refer the use of normative approaches (cf. Roth, 1995a,b; French, 1993). Organizational decision problems are commonly handled by decision support systems, which bring theoretical approaches into practice and aid decision makers to deal with complex situations mainly characterized by conflicting interests, dissimilar preferences, time pressure, and responsibility for acting on behalf of others.

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To reach a business agreement in multi-person, dynamic, and unstructured environments is usually an intricate task. Hence, the use of mathematical models and computational tools is convenient for bringing decision makers into more comprehensive frameworks. The success of such systems has come principally from the group decision-making approach (cf. Jelassi et al., 1990) and from special techniques of groupware based on computers (e.g. Marakas, 2003; Sauter, 1997). Group-decision models are mainly developed to reach acceptable decisions by applying a type of constitution, minimizing a distance (e.g. Cook and Seiford, 1978), using some criteria related to fairness, equity or democracy (cf. Bouyssou et al., 2000; Leyva and Fernandez, 2003; Fernandez and Olmedo, 2005; Hwang and Lin, 1987), or through decision models whose parameters are accepted by a significative part of the group (cf. Rogers et al., 2000). Nevertheless, important decisions related to negotiation, such as partner selections or the willingness to accept an offer (or counteroffer), remain as relevant issues for which most group decision approaches are not fully adequate.

Theoretically, a negotiation may be divided into two stages, which can be analyzed independently and integrated to determine a strategy for settling a convenient negotiation agreement. First, the so-called integrative stage looks for advantageous solutions for the disputing parts or negotiators. This stage considers differences in terms of priorities as well as more subjective aspects such as beliefs, risk attitude, or anxiety. On the other hand, the distributive stage looks for settlements in situations where an advantage for one of the parts could be a disadvantage for any other part (cf. Bazerman and Neale, 1992). A negotiation that occurs in a distributive stage is referred to as bargaining.

Usually, the current mathematical models for bargaining do not provide effective support to examine offers, deals, and partner selections (cf. Espin, 2000). Classical game theory approaches have been criticized for being unsatisfactory for analyzing real negotiations and coalition forming, mainly by selecting and examining illustrative counter-examples (cf. Raiffa, 1982; Espin, 2000). Different "values" have been proposed as unique solutions for n-person games under different considerations. Among these, the Shapley Value is the most elaborate and widely used although its axiomatic and intuitive justification has been sharply questioned (cf. Thomas, 1984). The Theory of Fuzzy Cooperative Games has also developed interesting models for bargaining, including fuzziness from the classical game theory perspective (cf. Mares, 2001; Tijs et al., 2003), but the lack of a natural connection between the theoretical framework and the practical aspects of actual negotiations remains as a lasting drawback.

A numerical index, named the Best Alternative to Negotiation Agreement (BATNA), is also frequently used. This index takes into account the benefits provided by the best alternative, given that an agreement is not achieved (cf. Bazerman and Neale, 1992; Fisher and Ury, 1983). However, it merely concerns a single aspect of a non-formalized concept called "bargaining capacity", which is discussed below. In fact, BATNA does not properly consider the strength of favourable arguments that each part has for bargaining and constructing coalitions during a negotiation. Hence, it is inadequate to select best counterparts by using BATNA.

A convenient settlement for a bargaining process may be considered as a good solution of the corresponding n-person game. By elaborating this idea a new solution concept for cooperative n-person games is proposed in this paper. We argue that in order to reach a consensual concept for the solution of an n-person game an important leap in the methodological perspective must be exercised, which would try to reflect the rich heuristic underlying actual bargaining situations.

The object of this paper is to expose the convenience of reaching settlements by means of the Good Deal Index (GDI), a matrix model for cooperative n-person games. The GDI is a permissive framework constructed upon Fuzzy Logic concepts whose main idea is to translate verbal statements into logical predicates. The GDI is a mathematical adaptation of important heuristics for bargaining which are recommended in specialized literature (cf. Bazerman and Neale, 1992). Some critical examples are used to demonstrate the quality of our proposal in contrast with classical approaches. Additionally, in accordance with the philosophy of the GDI a complementary index is developed; this is called the Counterpart