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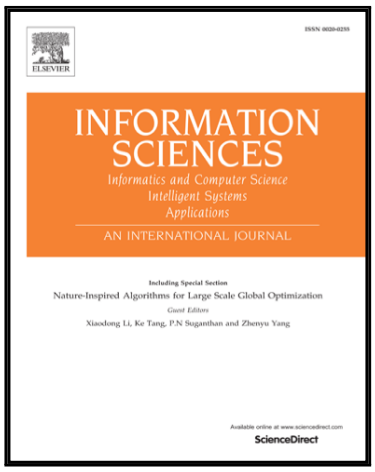

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Nonadditivity index and capacity identification method in the context of multicriteria decision making

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Abstract

Nonadditivity is an essential property of the capacities defined on the sets of decision criteria. Nonadditivity extends the additivity of traditional probability measures and enables capacities to flexibly represent the interaction phenomenon between the decision criteria. We propose the nonadditivity index to quantify the degree and kind of nonadditivity of a capacity, discuss some properties of this index, and present some tools to help decision makers determine the nonadditivity index of given subset. The nonadditivity index based capacity identification method is proposed and formulated in terms of linear constraints representing the decision makers' explicit or implicit preferences. A linear programming model is formulated as an aid for an optimal capacity identification. The proposed capacity identification method is illustrated on an example.
keywords: Multicriteria decision making (MCDM); Fuzzy measure; capacity identification; Nonadditivity; interaction index.

1 Introduction

In the field of multicriteria decision analysis, a capacity [8], also called a fuzzy measure [27], or nonadditive measure [9], is a normalized monotone set function [16, 25] on the decision criteria set. The monotonicity with respect to set inclusion, or more precisely, nonadditivity with respect to disjunct subsets, extends the additivity of the traditional probability measure and enables the capacity to adequately and flexibly represent the dependency, or interaction phenomena of multiple decision criteria [6, 17].

There are numerous studies that illustrate the benefits of using capacities in the decision making context, and replacing the traditional weighted averaging with the Choquet, Sugeno or another fuzzy integral [2, 4, 17, 18, 21, 23, 28, 35]. Nonadditivity of a capacity is a key ingredient of the richness of aggregation functions that model complementarity and redundancy of the inputs.

It is well known that the interaction among multiple decision criteria caused by the nonadditivity of a capacity can be measured by a cardinal probabilistic interaction index, notably the Shapley interaction index [15]. More detailed axiomatic properties of all kinds of cardinal probabilistic interaction indices can be found in literature [10, 11, 13, 16, 20]. However, the interaction index is not always consistent with the type of nonadditivity. For example, sometimes a superadditive capacity can have a negative value of some interaction indices instead of a positive value. This can cause a problem with its interpretation: it becomes more difficult for a decision maker to directly identify the sign and value of the interaction index for a given subset, especially if the subset consists of three or more decision criteria. In view of this situation, the focus of our paper is on an explicit treatment of nonadditivity of a capacity by means of the nonadditivity index, which reflects the degree and kind of nonadditivity of subsets of the decision criteria.

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