Information Sciences 258 (2014) 249–265

Contents lists available at ScienceDirect

Information Sciences

journal homepage: www.elsevier.com/locate/ins

Allowing agents to be imprecise: A proposal using multiple linguistic terms

Edurne Falcó [a], José Luis García-Lapresta [b,*], Llorenç Roselló [c,d]

[a] PRESAD Research Group, IMUVA, Universidad de Valladolid, Spain
[b] PRESAD Research Group, IMUVA, Dept. de Economía Aplicada, Universidad de Valladolid, Spain
[c] Dept. de Matemàtica Aplicada II, Universitat Politècnica de Catalunya, Spain
[d] ESADE Business School, Universitat Ramon Llull, Spain

ARTICLE INFO

Article history:
Available online 24 August 2013

Keywords:
Social Choice
Voting system
Linguistic assessment
Majority Judgement
Imprecision

ABSTRACT

In this paper we propose a decision-making procedure where the agents judge the alternatives through linguistic terms such as 'very good', 'good', 'acceptable', etc. If the agents are not confident about their opinions, they can use a linguistic expression formed by several consecutive linguistic terms. To obtain a ranking on the set of alternatives, the method consists of three different stages. The first stage looks for the alternatives in which the overall opinion is closer to the ideal assessment. The overall opinion is developed by a distance-based process among the individual assessments. The next two stages form a tie-breaking process. Firstly by using a dispersion index based on the Gini coefficient, and secondly by taking into account the number of best-assessments. The main characteristics of the proposed decision-making procedure are analyzed.

1. Introduction

Social Choice Theory shows that there is no voting system that is able to rank and choose alternatives in a completely acceptable way. In this regard, the well-known *Arrow's impossibility theorem* [2] shows, with absolute certainty, that there is no voting system that simultaneously satisfies several desirable properties.[1]

Arrow's pessimistic result imposes the limits of preference aggregation, but it does not stop the search for a procedure that fulfills some properties at the expense of others. One escape route for Arrow's impossibility theorem consists in allowing the agents to show their opinions not in a strictly ordinal way, but through numerical or linguistic assessments. A short review of one of the most known linguistic decision procedures is detailed below, as well as some of their extensions. Moreover, we provide an introduction to the issue of the imprecision of the agents, upon which our process is based. Finally, we summarize the proposal of the paper.

1.1. Majority Judgment

Balinski and Laraki [3,4] have proposed a voting system called *Majority Judgment* (MJ) which tries to avoid the unsatisfactory result of the Arrow theorem and allows the voters to assess the alternatives through linguistic terms, such as 'excellent', 'very good', 'good', etc., instead of ordering the alternatives by rank. Among all the individual assessments given by the

* Corresponding author. Tel.: +34 983 184 391.
E-mail addresses: edurne@eco.uva.es (E. Falcó), lapresta@eco.uva.es (J.L. García-Lapresta), llorenc.rosello@upc.edu (L. Roselló).

[1] Any voting rule that generates a collective weak order from every profile of weak orders, and satisfies independence of irrelevant alternatives and unanimity is necessarily dictatorial, insofar as there are at least three alternatives and three agents.

0020-0255/$ - see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.ins.2013.08.028

voters, MJ chooses the median as the collective assessment. Balinski and Laraki also describe a tie-breaking process which compares the number of assessments above the collective assessment with those below it.

These authors also carried out an experimental analysis of MJ [5] in Orsay during the 2007 French presidential election. In that paper the authors show some interesting properties of MJ and they argue that this voting system is easily implemented and avoids the need for a second round,[2] typical of French presidential elections.

Desirable properties and advantages have been attributed to MJ compared to the classical Arrow framework of preferences aggregation. Among these advantages is the possibility that voters show their opinions more faithfully and properly than in the conventional voting systems.

Besides MJ, other decision-making procedures in which the agents assess the alternatives through linguistic terms can be found in the literature. For instance in García-Lapresta [11] a general voting system that generalizes the *simple majority* through linguistic preferences is designed and studied. Similarly, in García-Lapresta et al. [12,14] a system which generalizes the *Borda rule* [6] is studied.

1.2. Majority Judgment extensions

It is worth pointing out that some authors have shown several paradoxes and inconsistencies of MJ (see [10,31,13,24], among others).

In order to reduce some of the drawbacks produced by MJ in small committees, García-Lapresta and Martínez-Panero [13] developed a proposal in which the linguistic information is aggregated by means of *centered OWA operators* [38], and a *2-tuple fuzzy linguistic representation* (see [18,23]). Another way of thinking was proposed by Zahid [41] who combined MJ with the *Borda Count* [6] in order to avoid some other inconveniences of MJ.

Moreover, in Falcó and García-Lapresta [7,8] an extension of MJ, based on the distances between the linguistic terms is proposed. These distances are induced by the parameterized family of Minkowski metrics and allow us to treat the problem in a more flexible way. The extension carried out in Falcó and García-Lapresta [7] chooses as the collective assessment, a linguistic term that minimizes the total distance to all the individual assessments (this would be the median, whenever the Manhattan metric is used). In addition, a method of choosing a unique collective assessment, in the case that several assessments fulfill the requirement, is provided. The contribution of Falcó and García-Lapresta [7,8] is also a refinement of the tie-breaking process that not only counts the number of assessments above and below the collective assessment (the median in MJ), but which also takes into account the specific assessments (above and below the collective assessment) by measuring the distances between them and the collective assessment.

1.3. Imprecise assessments

According to Zimmer [42], people generally prefer to handle the imprecision with linguistic terms rather than with numbers. Usually opinions are imprecise, therefore, trying to represent them by using a precise term is meaningless. In addition, Wallsten et al. [35] have shown empirically how most people are more comfortable using words rather than numbers to describe probabilities. As a result of this evidence and reflection, the program *computing with words* has been developed, where the agents express themselves through linguistic terms instead of numbers (see [20,39,40], among others).

Although the use of linguistic information brings the design of decision-making procedures closer to the imprecision that agents face when judging the alternatives, occasionally, the agents may be unconfident about which linguistic term to use. For this reason, it is interesting to allow the agents to judge in a more imprecise way, giving them the option of assessing several consecutive linguistic terms. For other papers regarding this issue, see Tang and Zheng [32], Ma et al. [22] and Rodríguez et al. [26,27].

Our proposal concerning the imprecision is based on an adaptation of the *absolute order of magnitude spaces* introduced in Travé-Massuyès and Dague [33], and Travé-Massuyès and Piera [34]; more specifically in the extensions devised by Roselló et al. [28–30] (see also [1]).

The authors of this paper have previously made an attempt to deal with imprecise assessments which was also based on the absolute order of magnitude spaces [9]. In that paper, they used a system of penalization for the use of a linguistic expression (a linguistic expression is the combination of several consecutive linguistic terms). The penalization function worked roughly as follows: the more linguistic terms an agent uses, the more that agent should be penalized.

1.4. Our proposal

In this paper we set up a decision-making procedure in which agents can express their assessments of the alternatives using a linguistic term from a predetermined linguistic scale. If they are not confident about which term to use, they can use a linguistic expression created by several consecutive linguistic terms.

[2] If there is no candidate with more than half of the votes, the second round consists of voting on the two candidates with most votes in the first round.