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Decision Support

Elicitation of criteria importance weights through the Simos method: A robustness concern

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ABSTRACT

In the field of multicriteria decision aid, the Simos method is considered as an effective tool to assess the criteria importance weights. Nevertheless, the method's input data do not lead to a single weighting vector, but infinite ones, which often exhibit great diversification and threaten the stability and acceptability of the results. This paper proves that the feasible weighting solutions, of both the original and the revised Simos procedures, are vectors of a non-empty convex polyhedral set, hence the reason it proposes a set of complementary robustness analysis rules and measures, integrated in a Robust Simos Method. This framework supports analysts and decision makers in gaining insight into the degree of variation of the multiple acceptable sets of weights, and their impact on the stability of the final results. In addition, the proposed measures determine if, and what actions should be implemented, prior to reaching an acceptable set of criteria weights and forming a final decision. Two numerical examples are provided, to illustrate the paper's evidence, and demonstrate the significance of consistently analyzing the robustness of the Simos method results, in both the original and the revised method's versions.

1. Introduction

A significant factor pertaining to the non-compensatory multicriteria decision aiding models (MCDA), such as the outranking methods (i.e. ELECTRE and PROMETHEE), is the criteria weighting, or the importance of the criteria. Generally, these parameters imprint the preferences of a single decision maker (DM) to the model. The existing methods, which are widely used to assess the criteria importance weights, could be classified into two categories: (i) direct assessment procedures, where the DM is asked to explicitly express the criteria weights in terms of percentages, and (ii) indirect methods, inferring the weights from pairwise comparisons of the criteria or reference alternatives. Most of these procedures use mathematical programming formulations (see the reference by Pekelman & Sen, 1974 or the MCDA survey by Figueira, Greco, & Ehrgott, 2005).

The second category of methods includes among others:

- the method of cards proposed by Simos (1990a, 1990b) that will be described in the following section;
- the method of centralized weights (Solymosi & Dombi, 1986), which requests from the DM a number of ordinal comparisons of criteria that are formulated as linear inequalities, in order to obtain the centroid of the vertices of a polyhedron;
- the TACTIC method (Vansnick, 1986) in which the relative importance of the criteria is depicted and assessed as a system of functional representations of relations;
- DIVAPIME (Mousseau, 1995), which has been adapted to the ELECTRE methods and is implemented by making pairwise comparisons of fictitious alternatives, in order to support the elicitation of importance variation intervals;
- the analytic hierarchy process (AHP), proposed by Saaty (1994), where the DM is asked to provide pairwise comparisons over the priority of criteria on a prespecified numerical scale; and
- MACBETH (Bana e Costa, De Corte, & Vansnick, 2012) which infers the weights as values of attractiveness from pairwise comparisons of the criteria on a qualitative scale, measuring thus the magnitude of attractiveness.

Recently, Bisdorff, Meyer, and Veneziano (2014) proposed a mixed integer linear programming model to infer the criteria importance weights from overall outranking statements, by maximizing the stability of the induced median-cut outranking digraph. The outranking statements are acknowledged by the DM during an MCDA procedure.

The method proposed by Jean Simos in 1990 has gained popularity and has been applied to different types of problems, due to its simplicity, and the convenience it provides to a DM to express

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her/his preferences. Specifically, it requires the construction of a hierarchy on the evaluation criteria, by involving the DM to a "playing cards" procedure, in order to attribute numerical values to them. Nevertheless, the process recommended by Simos and its revised version proposed by Figueira and Roy (2002) have some robustness issues. In particular, they arbitrarily calculate a unique weighting vector, even though there exist infinitely more weight vectors, also satisfying the preferential statements, which have been defined by the DM during the initial arrangement of the cards.

According to Figueira et al. (2005), a robustness concern consists of all possible ways that contribute in building synthetic recommendations based on robust conclusions. In the case of Simos method, a well-structured framework will be developed and used, in order to further facilitate the study of robustness concerns in outranking methods. Furthermore, the framework will address several other issues, affecting the quality of the outcome, in terms of robustness, such as the level of ratio z, introduced in the revised version of Simos (Shanian, Milani, Carson, & Abeyarante, 2008). In addition, the framework has to be appropriately adapted to support the implementation of the ELECTRE and PROMETHEE methods when interaction between criteria is taken into account (Figueira, Greco, & Słowiński, 2009) and when a multiple criteria hierarchy process is applied.

The aim of this paper is to expose the arbitrariness of the estimations made through the Simos method (robustness problem) and to propose amendment measures, in order to support DMs in identifying the preferable importance weights themselves. From this point of view, the methodological recommendations propounded in this paper should be considered as complementary and indispensable, when choosing to practice the method. All these rules and measures form a methodological framework, which, if adapted to the original or revised method of cards, can now be referred to as the Robust Simos Method.

A brief presentation of the Simos method in its original and revised versions, accompanied by an extended literature review of its implementation, is provided in Section 2. The robustness issues associated with the method are outlined in Section 3, while Section 4 proposes some robustness rules and measures. These formulate the Robust Simos Method, which supports the elicitation of a representative and "acceptable" set of weights. In Section 5, two numerical examples illustrate the paper's evidence and propositions. These experiments come to prove the massive impact of the instability of the weights on the robustness of the final results. The conclusions of this paper are in Section 6.

2. A review of the Simos methods

This section describes the original Simos method, as well as its revision by Figueira and Roy (2002). Section 2.2 presents the state-of-the-art, of the use of the method, in the scientific literature.

2.1. Description of the Simos method

The original Simos method consists of the following three steps, concerning the interaction with the DM and the collection of information:

1. The DM is given a set of cards with the name of one criterion on each (n cards, each corresponding to a specific criterion of a family F). A number of white cards are also provided to the DM.
2. The DM is asked to rank the cards/criteria from the least to the most important, by arranging them in an ascending order. If multiple criteria have the same importance, she/he should build a subset by holding the corresponding cards together with a clip.
3. The DM is finally asked to introduce white cards between two successive cards (or subsets of ex aequo criteria) if she/he deems that the difference between them is more extensive. The greater the difference between the weights of the criteria (or the subsets of criteria), the greater the number of white cards that should be placed between them. Specifically, if u denotes the difference in the value between two successive criteria cards, then one white card means a difference of *two times u*, two white cards mean a difference of *three times u*, etc.

The information provided by the DM is utilized by the Simos method for the determination of the weights, according to the following algorithm:

i. ranking of the subsets of ex aequo from the least important to the most important, considering also the white cards,
ii. assignment of a position to each criterion/card and to each white card,
iii. calculation of the non-normalized weights, and
iv. determination of the normalized weights.

The least qualified card is given *Position 1*, while the most qualified one receives *Position n*. The non-normalized weight of each rank/subset is determined by dividing the sum of positions of a rank, by the total number of criteria belonging to it. The non-normalized weights are then divided by the total sum of positions of the criteria in each rank (excluding the white cards), in order to normalize them. The obtained values are rounded off to the lower or higher nearest integer value.

Following the criticism of Scharlig (1996) that the method processes the information unrealistically, Figueira and Roy (2002) expressed objections to the way the Simos procedure determines the weights. One of the main issues indicated is that it elicits only one set of weights that satisfies the model expressed by the DM. However, other sets of weights could probably better fit the DM's preferences on the relative importance of the criteria. Such sets of weights cannot be obtained by the Simos' procedure. A second point of criticism is that the procedure processes criteria with the same importance (i.e. the same weight), in a non-robust way. If one tries to re-order the cards between two subsets, she/he realizes that the distance (difference of weights) between the subsequent subsets has changed in an uncontrolled way. This phenomenon occurs because the difference of weights between two successive subsets of criteria is automatically influenced by the number of existing cards in these subsets. The user however "does not have a real or absolute perception of the way in which the numerical values are determined by the procedure". Finally, Figueira and Roy do not agree with the rounding of the normalized weights to 100, because they perceive this as a non-realistic process.

In their effort to address these issues, Figueira and Roy (2002) proposed a revised version of the Simos method. In addition to the three-step data collection process, the new procedure introduces a fourth step, which demands from the DM to state *"how many times the last criterion is more important than the first one in the ranking"* (ratio z). This ratio is used in order to define a fixed interval between the weights of criteria or their sub-sets. The variable u denotes this interval: $u = (z - 1)/e$, where e is the number of different weight classes (namely single card, subsets of cards, and white card).

2.2. State of the art

The Simos method, although exhibiting considerably easy, almost naïve, data collection and implementation, has been extensively used in the scientific literature. Several authors have made use of the method, mostly combined with ELECTRE type methods, in order to assess the importance of the criteria weights. A review of the literature unveiled a very wide area of application, from energy planning and environmental evaluation problems, to project selection and mechanical engineering problems. Forty such applications are depicted in Table 1. It has also been noticed that many business and market surveys make use of the Simos method, in order to assign weights to the evaluation criteria, but they are rarely published.