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A Decision Support System for Improving the Inconsistency in AHP

María Teresa Escobar, Faculty of Economics and Business, Spain*
https://orcid.org/0000-0003-4419-1905

Juan Aguarón, Faculty of Economics and Business, Spain
https://orcid.org/0000-0003-3138-7597

José María Moreno-Jiménez, Faculty of Economics and Business, Spain
https://orcid.org/0000-0002-5037-6976

Alberto Turón, Faculty of Economics and Business, Spain
https://orcid.org/0000-0002-8807-8958

ABSTRACT

This paper presents a DSS aimed at helping decision makers reduce and improve their inconsistency in eliciting their judgements when using the analytic hierarchy process (AHP). The DSS is designed for revising the judgements of a pairwise comparison matrix when the row geometric mean (RGM) is used as the prioritisation procedure and the geometric consistency index (GCI) as the inconsistency measure. The procedure employed guarantees that both the judgements and the derived priority vector will be close to the initial values. The DSS allows different degrees of participation of the decision maker in the review/modification of the judgements: no participation (automatic mode); prior participation (semi-automatic mode); and ongoing participation (interactive mode). The DSS also includes options to incorporate other requirements of the decision maker, such as limiting the modified values to an interval or improving inconsistency by modifying the lowest number of judgements, among others.

KEYWORDS

Analytic Hierarchy Process, Decision Support System, Geometric Consistency Index, Inconsistency Improvement, Row Geometric Mean

INTRODUCTION

The analytic hierarchy process (AHP), proposed by Thomas L. Saaty at the end of the 1970s, is a multi-criteria decision technique that has become one of the most commonly employed approaches to the resolution of complex problems (Subramanian and Ramanathan, 2012; Zyoud and Fuchs-Hanusch,

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2017). Decision makers incorporate their preferences using pairwise comparisons and some degree of inconsistency is allowed when eliciting their judgements. Consistency is a particularly important issue as it is a requirement for the validity of the derived priority vector (Grzybowski, 2016).

Given a pairwise comparison matrix (PCM), $A = (a_{ij})_{n\times n}$ with $a_{ij} \cdot a_{ji} = 1$ and $a_{ij} > 0$, Saaty (1980) established that the matrix A is consistent if $a_{ij} \cdot a_{jk} = a_{ik} \forall i, j, k = 1, \ldots, n$. This is a desirable property that reflects a certain rationality, logic, or formal coherence. There are many factors that may cause inconsistencies in the judgements elicitation process, such as (Aguarón et al, 2020): (1) the ambiguity and complexity of the problem; (ii) the knowledge of the actors in the matter under consideration; (iii) the affective aspects (mood, emotions, personality features, attitudes and motivations) that condition the behaviour of the actors; (iv) the level of attention (errors in the response) during the assessment process; and (v) the rationality of the procedure followed when incorporating preferences, especially when working with subjective aspects.

To measure the inconsistency different indicators have been proposed in the AHP literature. Two of the most widely used are the Consistency Ratio (CR) associated with the eigenvector (EV) prioritisation procedure and the Geometric Consistency Index (*GCI*) associated with the row geometric mean (RGM) prioritisation procedure. Other inconsistency measures for pairwise comparisons were proposed in the literature. Brunelli (2018) presents a survey of them as well as a study of their properties and relations. With regards to the improvement of inconsistency in AHP, different procedures have also been described in the literature. An overview of these approaches can be found in Khatwani and Kar (2017).

Aguarón et al. (2021) proposed, for the first time in the literature, a procedure for improving the inconsistency when the Row Geometric Mean (RGM) is used to derive the priorities and the Geometric Consistency Index (*GCI*) is employed to measure the inconsistency. This is a sequential procedure that, at each iteration, identifies the judgement that would improve the *GCI* faster and with greater intensity. In the proposed procedure the decision maker intervenes at the beginning indicating its permissibility threshold, that is, the maximum variation, in relative terms, that they would accept to modify the initial judgements. Limiting the variations of the judgements by the permissibility threshold guarantees that both the final judgements and the derived priority vector will be close to the initial values, as recommended by Saaty (2003).

The objective of the paper is to present a DSS that implements the Aguarón et al. (2021)'s procedure proposed for reducing the inconsistency in AHP by adapting it to be used interactively. The DSS also calculates the minimum permissibility necessary to achieve an allowable inconsistency level (below the required threshold). The value of this parameter (minimum permissibility) provides relevant information about the decision problem, in line with the cognitive multicriteria decision making paradigm (Moreno-Jiménez and Vargas, 2018), that can be used by the decision maker as a starting point to set their own permissibility.

The DSS can then be used to obtain the final values of the judgements and the derived priorities in three different ways: automatically (without personal participation of the decision maker in the resolution process), semi-automatically (prior participation of the decision maker fixing the permissibility) or interactively (personal participation throughout the resolution process). In the last case, the decision maker intervenes more actively at each iteration of the algorithm implemented in the DSS. Participation refers to the selection of new values for the judgements that the decision-maker decides to modify (guided by the values suggested by the DSS) and the acceptance of the values in the final matrix. The greater the degree of participation of the decision maker, the greater the cost in terms of time and effort spent on applying the process, but also the greater the learning about the decision problem. The DSS is also designed to meet other possible requirements of decision makers.

The rest of the paper is organised as follows. Next section (Background) summarises the main theoretical results on which the DSS is based. The following section (A DSS for Improving the Inconsistency in AHP) presents the DSS, its modules and the different modes in which it can be