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A Decision Support System and Visualisation Tools for AHP-GDM

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ABSTRACT

The Precise Consistency Consensus Matrix (PCCM) is a decisional tool for AHP-Group Decision Making (AHP-GDM). Based on the initial pairwise comparison matrices of the individuals, the PCCM constructs a consensus matrix for the group using the concept of consistency. This paper presents a decision support system (PRIOR-PCCM) that facilitates the construction of the PCCM in the context of AHP-GDM, and the calculus of four indicators that allows comparison of the behaviour of group consensus matrices. PRIOR-PCCM incorporates the possibility of considering different weights for the decision makers and includes a module that permits the extension of the initial PCCM which can achieve the minimum number of non-null entries required for deriving priorities or establishing a complete PCCM matrix. It also includes two cardinal indicators for measuring consistency and compatibility and two ordinal indicators for evaluating the number of violations of consistency and priority. The paper introduces some new visualisation tools that improve comprehension of the process followed for obtaining the PCCM matrix and allow the cognitive exploitation of the results. These original contributions are illustrated with a case study.

KEYWORDS

Analytic Hierarchy Process (AHP), Compatibility, Consensus, Consistency, Decision Support System (DSS), Group Decision Making (GDM), Visualisation Tools

INTRODUCTION

Consensus is fundamental concept in decision making with multiple actors (Moreno-Jiménez et al., 2005, 2008, 2016; Choudbury et al., 2006; Yu and Lai, 2011), and this is especially true in Group Decision Making (GDM). In the scientific literature on group decision making, the term consensus is commonly employed to reflect the idea of agreement or compatibility between individual and collective preferences (Chiclana et al., 2008; Alonso et al., 2010; Dong et al., 2010; Wu and Xu, 2012; Zhang et al., 2017).

Of the different multicriteria approaches followed for decision making, the Analytic Hierarchy Process (AHP) (Saaty, 1980) is recognised as one that best captures the two fundamental issues inherent

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in the Knowledge Society (multiple actors and the integration of intangible aspects). AHP allows the application of most perspectives (determinist, stochastic, fuzzy etc.) used in the scientific literature with regards to the search for consensus (Saaty, 1980; Jensen, 1986; Ramanathan and Ganesh, 1994; Bryson, 1996; Herrera et al., 1996; Forman and Peniwati, 1998; Yeh et al., 2001; Moreno-Jiménez et al., 2005, 2008; Srdjevic, 2007; Saaty and Peniwati, 2008; Dong et al., 2010; Zhang et al., 2012,2014; Wu and Xu, 2012; Ren et al., 2016).

Another relevant feature of the Analytic Hierarchy Process is the possibility of evaluating the consistency of the pairwise comparison matrices (PCMs) used in order to capture the preferences of the Decision Makers (DMs). The idea of using the concept of consistency in group decision making was first proposed by the authors in 2002 (Moreno-Jiménez et al., 2002, 2005) and it has been extensively utilised in the scientific literature (Dong et al., 2010; Wu and Xu, 2012; Zhang et al., 2012, 2014).

Following this line of research, the authors proposed the Precise Consistency Consensus Matrix (PCCM) (Aguarón et al., 2016; Escobar et al., 2015), a decisional tool for AHP multi-actor decision making whose main aim is the construction of a consensus matrix based on consistency. Each entry of the new consensus matrix - known as 'the Consistency Stability Interval Judgement Matrix - belongs to all the Consistency Stability Intervals (CSIs) associated to each decision maker. This guarantees that the modifications made in the initial matrix do not exceed the maximum permitted level of inconsistency.

This current work presents PRIOR-PCCM, a Decision Support System (DSS) designed for constructing the PCCM and calculating behavioural indicators. The work also introduces some visualisation tools that help to understand the process followed in the application of the algorithm (construction of the consensus matrix) and aid the cognitive exploitation of the results (Moreno-Jiménez et al., 2014; Yepes et al., 2015; Moreno-Jiménez and Vargas, 2018). The DSS offers the scientific community a non-elementary calculation procedure for obtaining collective priorities in AHP-GDM and it provides indicators that allow the comparison of procedures for the construction of collective consensus matrices in AHP-GDM. PRIOR-PCCM facilitates interactive exploitation which reveals the critical points and decisional opportunities of the resolution process. Through the visual analysis of the results, a better understanding and dissemination of the extracted knowledge can be achieved.

The rest of the paper is structured as follows: Section 2 (Background) reviews consistency and AHP group decision making whilst explaining the basics of the decision-making tool (PCCM) and the algorithm followed for its construction; Section 3 includes a description of the DSS designed for the construction of the PCCM and presents the visualisation tools that can provide greater knowledge of the procedure; Section 4 details a case study which illustrates the use of the DSS and visualisation tools; and Section 5 summarises the main conclusions and briefly indicates possibilities for future research.

BACKGROUND

The Analytic Hierarchy Process (AHP)

AHP (Saaty, 1980, 1994) is one of the most popular multicriteria approaches, both from theoretical and practical points of view. AHP has been criticised, but it is extensively employed (Moreno-Jiménez and Vargas, 2018) because: (1) it is intuitive and realistic in scientific decision making; (2) using hierarchies and clustering it can integrate the large and the small; (3) it is capable of combining tangible and intangible aspects of problems by means of absolute pairwise comparisons that yield relative ratio scales of priorities; (4) it is flexible enough to consider dependencies between levels in a hierarchy with the extension of the AHP known as ANP (Analytic Network Process); (5) in group decision making it allows decision makers to construct group welfare functions that do not violate

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