From Qualitative to Quantitative Evaluation Methods in Multi-criteria Decision Models

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Thesis Summary

Keywords: option ranking, DEX methodology, copula functions

Received: March 26, 2014

This article presents a summary of the doctoral dissertation of the author with title "From qualitative to quantitative evaluation methods in multi-criteria decision models".

Povzetek: Članek predstavlja povzetek doktorske disertacije avtorja z naslovom "Od kvalitativnih do kvantitativnih metod vrednotenja v večparameterskih odločitvenih modelih".

1 Introduction

The thesis [1] addresses the decision making problematic of ranking a finite set of qualitative options that are sorted into a set of classes. In the decision problems of interest, the options are represented with qualitative attributes that form a decision table. The decision maker's preferences split the decision table into subsets of equally preferred options, called classes, so that options belonging to the same class are considered indistinguishable. In practice, this is often inadequate and hence one wants to further distinguish between options belonging to the same class, and consequently rank them. Furthermore, the wish is to obtain such rankings with least effort, i.e., using only the information already available in the decision table.

The thesis presents a modeling approach that combines qualitative and quantitative models.

The resulting quantitative model should be in some way consistent with the original, qualitative one and should be preferably constructed in an automatic or semi-automatic way from the information contained in the qualitative model. These are very important questions, both theoretically and practically. Theoretically, it is important for bridging the gap between both types of models and involves a number of theoretically interesting sub-problems, such as finding a suitable representation of a decision problem in different forms for different computational process, within the same decision-making process Practically, bridging this gap is important to overcome some limitations of qualitative models, such as low sensitivity and limited applicability for the ranking of options.

2 Methods used

The problem addressed here is directly motivated by decision expert (DEX) methodology [2, 3], that, in the process of developing a decision model, produces decision tables which can be interpreted either as a set of options or a set of decision rules governing the preference evaluation. The existing qualitative-quantitative method (QQ) [4] developed for solving the ranking problem, is based on the assumption that when qualitative data are suitably mapped into discrete quantitative ones, they form monotone or nearly linear functions. The main limitation of QQ is that in many cases it fails to model non-linear functions. There are other qualitative MCDM methods that also deal with this issue, however, none of them solves the problem stated above. To solve this issue, we propose and evaluate four different QQ-based methods for estimating a regression function.

The first method includes investigation of different impurity functions for estimation of coefficients in the linear regression equation used by QQ. The main contribution arising from this method is the usage of different non-linear functions instead of the standard least squares algorithm, that lead to full rankings of many non-monotone decision tables, for which QQ provides equal rankings (ties) of options or fails to fulfill the monotonicity of the rankings.

The second method introduces polynomial functions instead of the linear one in QQ. For that purpose the methods Constrained Induction of Polynomial Equations for Regression (CIPER) and New CIPER are employed for heuristic search of the best polynomial for a given decision table. Although polynomial functions outperform QQ, they usually fail to provide full ranking of options.

The third method redefines the option ranking problem as constraint optimization problem, and as such, investigates the usage of linear programming for defining its so-

lution. This intuitive approach mainly leads to overly stringent constraints that rarely form a feasible region for solutions.

The fourth research approach, which is the main focus of the thesis, changes the view of the decision tables from deterministic to stochastic. In this approach [5], the attributes are considered as random variables. Copulas are functions which connect marginal distributions of random variables and their joint distribution. The copula function is highly sensitive to small variations of input variables, thus providing distinct results for cases where linear regression used in QQ fails. One-parametric multivariate copulas are used for evaluation of symmetric decision tables, and fully nested Archimedean construction (FNAC) and partially nested Archimedean construction (PNAC), for non-symmetric decision tables. For the use copulas, the thesis presents new quantile regression equations for different position of the dependent variable in the FNAC and PNAC. The results from the real

Extensive numerical experiments for evaluation of the performance and applicability of the proposed methods were conducted which confirmed the usefulness of the methods, in particular the usage of copula-based method for ranking non-linear decision tables. Finally, the copula-based methods were successfully applied to two real-world cases: ranking of EC motors [6] and ranking of workflows.

3 Conclusion

The newly developed decision support methods for qualitative option evaluation and ranking within classes can be associated with three most relevant results. Firstly, the used approaches extend the space of solvable monotone and linear decision tables to the space of general discrete decision tables. Secondly, methods bridge the gap between qualitative and quantitative models in terms of improving qualitative methods' low sensitivity and limited applicability for the ranking of options within classes. Finally, the methods are applicable for ranking of qualitative options specified with non-linear and or non-monotone decision tables.

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