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Use of DEA and PROMETHEE II to assess the performance of older drivers

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Abstract

In recent years, there has been an increasing concern regarding the safety and mobility of elderly drivers. This study aims to evaluate the overall performance and ranking of a sample of 55 drivers, aged 70 and older, based on data from an assessment battery and a fixed-based driving simulator, by using the concept of composite indicators and multi criteria approach. To do so, drivers completed tests of an assessment battery of psychological and physical aspects as well as knowledge of road signs. Moreover, they took part in a driving simulator test in which scenarios that are known to be difficult for older drivers were included.

Composite indicators (CIs) are becoming increasingly recognized as a useful tool for performance evaluation, benchmarking and policy analysis by summarizing complex and multidimensional issues. One of the essential steps in the construction of composite indicators is aggregation and assignment of weights to each sub-indicator which directly affect the quality and reliability of the calculated CIs. In this regard, Data Envelopment Analysis (DEA) and Multi Criteria Decision Aiding (MCDA) have been acknowledged as two popular methods for weighting and aggregation and problem solving: ranking, sorting and choosing.

In this case study, on the one hand, we apply a DEA model to calculate the optimal performance index score for each driver. On the other hand, we apply a MCDA method to enrich the analysis of this problem by considering preferential information from Decision Makers (DM). This also results in a ranking of drivers in terms of driving performance.

The results of this study show that the best and the worst drivers identified by the two models are similar. These observations point out the interest of using PROMETHEE II (Preference Ranking Organization Method for Enrichment Evaluations) and DEA. The high correlation between these results confirms the robustness of our answers.

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1. Introduction

The number of elderly drivers is increasing as a result of demographic changes (Mathieson et al., 2013). Although driving helps elderly to maintain their independence and autonomy, ageing is associated with a decline in sensory, motor and cognitive abilities which affects the ability to drive safely. To help elderly drivers to be aware of their own abilities and weaknesses and to regularly check their driving performance, there is an increasing need for developing a reliable assessment procedure to determine whether a person is still fit to drive.

The aim of this study is to provide a method to screen older drivers and to assess their relative performance, using data from an assessment battery and a fixed-based driving simulator. Within a performance improvement framework, performance evaluation plays a critical role in identifying weaknesses and planning goals for improvement. In this regard, composite indicators (CIs) are increasingly recognized as a valuable tool for performance evaluation, benchmarking and policy analysis by summarizing complex and multidimensional issues such as driving performance. The quality and reliability of the calculated CI is however affected by the weighting and aggregation of the indicator values (OECD 2008). In this respect, Data Envelopment Analysis (DEA) and Multi Criteria Decision Aiding (MCDA) have been considered as two popular methods for problem solving. Evidently there is a strong correspondence between the problems tackled by DEA and the ranking problems in multicriteria analysis (Roy, B., 1985). Indeed, inputs and outputs in DEA should be viewed as criteria in MCDA. Moreover, Decision Making Units (DMUs) are as alternatives. Through others, this similarity has been clearly pointed out in the works of Belton and Vickers (Belton and Vickers, 1993) and has led to the creation of special interest groups to study the interactions between DEA and different approaches of MCDA. Among them we can cite the Doyle and Green work illustrating DEA as an aid to MCDA (Doyle and Green, 1993). Yılmaz and Yurdusev (2011) used a DEA method as a tool to solve a MCDA problem. Shang and Sueyoshi (1995), Liu (2003) and Takamura and Tone (2003) worked on DEA and AHP.

In this case study, we apply a DEA model; this optimisation method is able to calculate the best performance index score for each driver, taking the hierarchical structure of indicators into account. Based on the results, the best performers, as benchmarks, are distinguished from underperforming ones, and all drivers are ranked by computing their cross index scores.

On the other hand, we apply a MCDA method to enrich the analysis of this problem by considering preferential information from Decision Makers (DM). The PROMETHEE II outranking method is used to generate a complete ranking of drivers by pair wise comparison of all the drivers under study. This comparison is done for the raw and normalized data to quantify to what extent the normalization of the evaluations is impacting the drivers' ranking. Consecutively, we compute the correlation between the results.

The rest of this paper is organized as follows: in the next section we will introduce the indicators and related data. Section 3 will detail data analysis based on DEA and PROMETHEE II. In section 4 we will summarize and discuss the results. This paper ends with conclusions (section 5).

2. Indicators and Data

2.1. Participants

Subjects aged 70 and older were recruited through the Geriatrics department of the Jessa Hospital with flyers distributed in the hospitals, senior associations and senior flats via local media. Participants had to hold a valid driver's license and still be active car drivers, with no stroke in the last four months and without any indication for dementia as assessed with the Amsterdam Dementia Screening (ADS) test. They had to have the physical ability to complete tests of a clinical assessment battery and simulator driving. 77 volunteers agreed to participate. Among