Data Envelopment Analysis in Road Safety: Model Building Considerations

Yongjun Shen[1], Elke Hermans[1], Da Ruan[1,2], Tom Brijs[1], Geert Wets[1], and Koen Vanhoof[1]

[1] Transportation Research Institute (IMOB) – Hasselt University
Wetenschapspark 5 bus 6, 3590 Diepenbeek, Belgium
{yongjun.shen, elke.hermans, da.ruan, tom.brijs, geert.wets, koen.vanhoof}@uhasselt.be

[2] Belgian Nuclear Research Centre (SCK·CEN)
Boeretang 200, 2400 Mol, Belgium
druan@sckcen.be

Abstract: Data envelopment analysis (DEA) developed by Charnes, Cooper and Rhodes is a mathematical programming methodology to measure the relative efficiency of a homogeneous set of decision making units (DMUs) by obtaining empirical estimates of relations between multiple inputs and multiple outputs related to the DMUs. Since its first introduction in 1978, DEA has been quickly recognized as a powerful analytical research tool for modeling operational processes in terms of performance evaluations, benchmarking, and decision making, and it has been successfully applied to a host of different types of entities engaged in a wide variety of activities in many contexts. However, due to the ever increasing complexity of today's performance evaluation and decision making activities, such as in the road safety context, some interesting challenges have arisen with respect to the basic DEA models. From the road safety point of view, crash data (such as the number of fatalities and casualties) rather than the number of saved persons from the crashes are traditionally collected. Consequently, these should be treated as undesirable factors in the DEA model. Moreover, relevant factors determining the occurrence of crashes or the severity of casualties could be quantified by means of safety performance indicators (SPIs). Given the high number of factors (e.g., the use of protective systems) and corresponding SPIs (e.g., seat belt wearing rate in front seats, seat belt wearing rate in rear seats, helmet wearing, …), these indicators are best presented as a layered hierarchy. Therefore, simply treating all the indicators to be in the same layer of the DEA model obviously ignores the information on its hierarchical structure and further leads up to weak discriminating power and unrealistic weight allocations. In addition, when road safety management performance (e.g., the availability and ambition of national safety targets) is taken into account, qualitative rather than quantitative indicators are usually available in the form of ranking orders. This type of information should also be embodied in the DEA framework. To deal with all the issues mentioned above, some theoretical innovations in DEA are presented in this study and applied to the case of road safety performance evaluation of a set of European countries.