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Benchmarking road safety performance: Identifying a meaningful reference (best-in-class)

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ABSTRACT

For road safety improvement, comparing and benchmarking performance are widely advocated as the emerging and preferred approaches. However, there is currently no universally agreed upon approach for the process of road safety benchmarking, and performing the practice successfully is by no means easy. This is especially true for the two core activities of which: (1) developing a set of road safety performance indicators (SPIs) and combining them into a composite index; and (2) identifying a meaningful reference (best-in-class), one which has already obtained outstanding road safety practices. To this end, a scientific technique that can combine the multi-dimensional safety performance indicators (SPIs) into an overall index, and subsequently can identify the 'best-in-class' is urgently required. In this paper, the Entropy-embedded RSR (Rank-sum ratio), an innovative, scientific and systematic methodology is investigated with the aim of conducting the above two core tasks in an integrative and concise procedure, more specifically in a 'one-stop' way. Using a combination of results from other methods (e.g. the SUNflower approach) and other measures (e.g. Human Development Index) as a relevant reference, a given set of European countries are robustly ranked and grouped into several classes based on the composite Road Safety Index. Within each class the 'best-in-class' is then identified. By benchmarking road safety performance, the results serve to promote best practice, encourage the adoption of successful road safety strategies and measures and, more importantly, inspire the kind of political leadership needed to create a road transport system that maximizes safety.

1. Introduction

Road traffic injuries have been recognized as the leading cause of death by injury, and are predicted to rise to become the fifth leading cause of death by 2030 without effective and sustainable prevention (World Health Organization, 2013). Worldwide, over 1.2 million people are killed in traffic crashes each year, with an additional 20–50 million people suffering non-fatal injuries (World Health Organization, 2013). 25,845 people were killed in the EU28 as a consequence of road collisions in 2014 compared to 26,009 in 2013 (ETSC, 2015, 2014). Preventing deaths on EU roads is supported by a strong business case, and this potential for saving is far from being exhausted (ETSC, 2011). In 2010, the European Union renewed its commitment to improving the level of road safety; setting an ambitious target of cutting road deaths in half by 2020, compared to that of 2010 levels, following on from the earlier target set in 2001 of halving road deaths by 2010 (ETSC, 2013, 2010). It is, however, still a long way to reach the 15,500 target for 2020. This means that some additional effective actions and efficient measures must be taken by all EU Member States in a way of close cooperation.

Fundamentally, the essence of cooperation is learning from each other (Wegman et al., 2008), especially, with emphasis toward learning from those better-performing countries or jurisdictions (states, provinces, etc.), which have already obtained outstanding road safety practices. Action program formulation, and the ability to apply this knowledge into practice by means of benchmarking is an indispensable part of gaining maximum improvement in road safety, to which comparisons can be a starting point (Wegman et al., 2008). Comparing performances, and one step further benchmarking performances, have emerged as a preferred and promising approach for road safety improvement (Mooren et al., 2012).

Benchmarking of road safety is a process in which countries or jurisdictions (states, provinces, etc.) continuously measure and compare various aspects of their performance in relation to that of

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other countries or jurisdictions (states, provinces, etc.), including the so-called 'best-in-class' (Wegman et al., 2008). It consists of a series of core activities, among which two tasks are considered to be pivotal: (1) developing a set of road safety performance indicators (SPIs) and combining them into a composite index; and (2) identifying a meaningful reference (best-in-class), which has already obtained outstanding road safety practices. The benchmark results provide countries or jurisdictions with valuable information from better-performers that can be used as a basis for making appropriate decisions and taking necessary actions (e.g. policy making, target setting, countermeasures and program development, and assigning priorities) to improve their road safety performance (Chen et al., 2015). As it captures a comprehensive overall picture of road safety, beyond that of the traditional approach which only uses mortality rate, fatality rate, or risk (fatalities per head of population, vehicles, etc.), it provides optimal information related to road safety outcomes. It is becoming increasingly popular in recent years (e.g. Aarts and Houwing, 2015; Shen et al., 2015; Australian Automobile Association, 2014; Egilmez and McAvoy, 2013; Mooren et al., 2012); increasingly encouraged, advocated, and rapidly developing as an emerging approach for road safety improvement by governments, planners, and researchers, etc.

However, the practice of successfully conducting road safety benchmarking is not an easy task, as there is currently no universally agreed upon practice. Challenges exist in the whole process, especially for the aforementioned two important tasks. On the one hand, selecting a set of appropriate road safety performance indicators (SPIs), structuring them in a logical way, and subsequently combining them into a composite index, in a concise and comprehensive manner, is the key basis of conducting benchmarking successfully (Shen et al., 2015). On the other hand, the essence of benchmarking is to identify the commonly so-called 'best practices' (i.e. highest standard of excellence for products, services, or processes) against a meaningful reference, which is sometimes described as the performance of the 'best-in-class' (Wegman et al., 2008). And then making the improvements necessary to reach those 'best practices' (Bhutta and Huq, 1999). In addition, knowledge gaps with respect to these two tasks still exist in present road safety benchmarking programs. Hence, the aim of this paper is to develop an innovative, scientific, and systematic methodology for comprehensive benchmarking of road safety performance of a country or of sub-national jurisdictions; one that is specifically designed to successfully conduct the aforementioned two core activities in an integrative, concise and systematic way.

The remaining of this paper is structured as follows. We review the literature in Section 2. In Section 3, we describe road safety performance indicators (SPIs) and collect data used in this study. In Section 4, the Entropy-embedded RSR methodology is developed for benchmarking of road safety. Section 5 presents the application of the methodology to the benchmarking practice of road safety. The corresponding computational results are subsequently discussed in Section 6. The paper ends with concluding remarks and topics for further research in Section 7.

2. Literature review

2.1. Composite road safety performance index

Road traffic crashes result from a combination of factors related to components of the road transport system, including road users, vehicles, infrastructure, and the way they interact, which are integrated in a broader environment (Hermans et al., 2008a; World Health Organization, 2006; European Commission, 2004). Given the complex character of the road safety phenomenon, more and more indicators are being suggested for use in monitoring, evaluating, and comparing the status and progress of road safety. This is in opposition to the traditional approach, which only consider a few factors such as safety outcomes in terms of fatalities per head of population, vehicles, etc. (e.g. Bax et al., 2012; Wegman et al., 2008; Hakkert et al., 2007; Al-Haji, 2005; ETSC, 2001).

Road safety levels could be measured and compared on each indicator separately. However, comparing each indicator individually does not account for the aggregation of indicators, which may lead to partial or even incorrect results; as they describe road risk using different exposure information, from different points of view (Chen et al., 2015; Shen et al., 2012). On the other hand, when measuring or comparing road safety achievements, there is a need to reduce the dimensions of the problem (Wegman et al., 2008). In a word, there are several reasons why it is promising and attractive to combine all the road safety information in an overall indicator (Hermans et al., 2008a; Al-Haji, 2007), the composite index, of which the main characteristics can be summarized by three key words: 'simplification, quantification and communication' (Adriaanse, 1993).

Recognizing the limitation of the traditional approach by only using mortality rate or fatality rate, and the various advantages provided by composite index, such as public communication (Wegman et al., 2008), benchmarking (Wegman and Oppe, 2010; Hermans et al., 2009) and decision making (Bao et al., 2012), there is an increasing interest globally in the development of a composite road safety performance index. One that is specifically designed to capture a broader picture of road safety from an overall perspective, especially over the last decade (e.g. Bax et al., 2012; Hermans et al., 2008b; Wegman et al., 2008; Al-Haji, 2005).

Al-Haji (2005) suggested a Road Safety Development Index (RSDI) (see also Al-Haji, 2007), which involves eight dimensions of the road safety domain related to the human-vehicle-road-environment-regulation system; namely traffic risk, personal risk, vehicle safety, road situation, road user behavior, socio-economic background, road safety organization and enforcement. Each dimension involves one or several quantitative indicators, of which the applicability was analyzed based on available data. In order to combine the SPIs that belong to the aforementioned eight domains into a composite index (RSDI), three main approaches (objective and subjective) were applied; namely the simple average, the use of theoretical weights, and the Principal Component Analysis (PCA). The results from these different approaches were very similar, and enabled the countries to be ranked in accordance with their safety performance.

The SUNflower approach (Wegman and Oppe, 2010; Gitelman et al., 2010; Wegman et al., 2008) was used to develop an integral and comprehensive set of indicators, which worked with a composite index (the so-called SUNflower Index) to condense the vast amount of information related to road safety. These indicators are distinguished into three types, namely a road safety performance indicator (outcome indicator), an implementation performance indicator (process indicator), and a policy performance indicator (the quality of national road safety plans). In addition, the three types of indicators are embedded in a policy context: the structure and culture of a country, in an attempt to include some background variables. In order to combine the basic indicators into a composite index, weighting based on statistical models, Principal Component Analysis (PCA), and Common Factor Analysis (CFA) were used.

Hermans et al. (2008b) investigated the methodology of combining road safety information in a performance index, based on a set of appropriate SPIs that were developed by the European SafetyNet project (Hakkert et al., 2007). These SPIs were related to seven major areas which are central to the fields of activity in road safety in Europe, and necessary to bring about a significant improvement in EU countries, i.e. alcohol and drugs, speeds, protective systems, daytime running lights (DRL), vehicles, roads, and