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Identifying the most significant indicators of the total road safety performance index

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ABSTRACT

The review of the national and international literature dealing with the assessment of the road safety level has shown great efforts of the authors who tried to define the methodology for calculating the composite road safety index on a territory (region, state, etc.). The procedure for obtaining a road safety composite index of an area has been largely harmonized. The question that has not been fully resolved yet concerns the selection of indicators. There is a wide range of road safety indicators used to show a road safety situation on a territory. Road safety performance index (RSPI) obtained on the basis of a larger number of safety performance indicators (SPIs) enable decision makers to more precisely define the earlier goal- oriented actions. However, recording a broader comprehensive set of SPIs helps identify the strengths and weaknesses of a country's road safety system. Providing high quality national and international databases that would include comparable SPIs seems to be difficult since a larger number of countries dispose of a small number of identical indicators available for use. Therefore, there is a need for calculating a road safety performance index with a limited number of indicators ($RSPI_{ln}^{n}$) which will provide a comparison of a sufficient quality, of as many countries as possible. The application of the Data Envelopment Analysis (DEA) method and correlative analysis has helped to check if the $RSPI_{ln}^{n}$ is likely to be of sufficient quality. A strong correlation between the $RSPI_{ln}^{n}$ and the RSPI has been identified using the proposed methodology. Based on this, the most contributing indicators and methodologies for gradual monitoring of SPIs, have been defined for each country analyzed. The indicator monitoring phases in the analyzed countries have been defined in the following way: Phase 1- the indicators relating to alcohol, speed and protective systems; Phase 2- the indicators relating to roads and Phase 3- the indicators relating to trauma management. This will help achieve the standardization of indicators including data collection procedures and selection of the key list of indicators that need to be monitored. Based on the results, it has been concluded that the use of the most contributing indicators will make it possible to assess the level of road safety on a territory, with an acceptable quality score by focusing on the low-ranked countries. A smaller set of significant indicators defined in this manner can serve for a fast and simple understanding of a road safety situation and assessment of effects of measures undertaken. Also, this universal index approach is applicable in cases when a broader comprehensive set of indicators is analyzed, which provides a more accurate identification of weaker points and rank the countries in a more meaningful way.

1. Introduction

Due to the multidisciplinary nature of road safety, the policy makers must consider numerous contributory factors when making decisions. A wide range of such contributory factors can be combined by applying the composite index which has been used increasingly in international cross-country comparisons. No final position on a methodology for road safety composite index design has been adopted yet globally. That is why numerous authors have been working hard to improve the methodologies and methods for the most accurate definition of the composite index value. The accuracy of a composite index does not depend only on selected indicators, weight allocation and data aggregation methods, but also on the strength of correlation between indicators and road crashes and their consequences (Hermans et al., 2009).

Various combinations of road safety indicators result in various values of a composite road safety index (and consequently a meaningful countries' rankings). This is particularly obvious with the design of the

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road safety footprint which contains a combination of indicators (all layers), measured as a snapshot in time (Wegman et al. 2008), and enabling the identification of strong and weak points within the road safety system (Wegman et al. 2005).This leads to the question: *Which combination of road safety performance indicators gives a road safety performance index which is more precise, of higher quality and providing a simple understanding of a road situation?* The answer to this question is open and requires much more research, with as many indicators included as possible in order to achieve the key list of road safety indicators which, regardless of the observed territory, gives the most realistic picture possible of the road safety situation. The key list of road safety indicators identified in this way offers support for decision makers to know which road safety topics they perform well or badly as a basis of improvements. The weakness of identification of a key list of road safety indicators within a wide comprehensive set of indicators is in the existence and strength of the correlative relationship of indicators and the final outcomes and their mutual relations (multivariate analysis), especially in cases when indicators that are not measured in several time series are introduced in an analysis. The lack of a harmonized methodology for a composite road safety index design has as a consequence diversity in selecting the road safety indicators and calculation methods. Therefore, the research conducted in this work focused on the selection of "the most significant safety performance indicators" (SPIs) involved in the process of calculating a "road safety performance index based on a limited number of indicators" in cases when data are not available or are scarce.

The studies that have been conducted so far helped to make the comparison of territories, define earlier goal-oriented actions and identify the best-in-class practices. The authors of these studies suggested creating a composite road safety index (Al- Haji, 2005, 2007; Wegman et al. 2008; Shen et al. 2015a,b) by means of the most appropriate indicators, i.e. those having a high data availability and acceptability rate, as well as including as many indicators as possible, along with examining the robustness of the composite road safety index (Hermans et al., 2007, 2009; Hermans, 2009; Shen et al. 2011b). This is not so simple because indicator-related data in international and national bases are not always available and their definitions differ significantly. The compromise between the need (for as many indicators as possible) and the real situation (availability of only a limited number of indicators for specific countries) will mean identifying the most significant indicators (a comprehensive set of performance indicators). This set of indicators has the largest link with the final road safety rating. As the availability of data concerning the values of same indicators for a larger number of countries, in a defined time period is limited, the number of indicators included in a comprehensive set of indicators may vary. A composite index obtained on the basis of a broader comprehensive set of indicators provides a more accurate identification of good and poor road safety points on the territories. However, a composite road safety index with a limited number of indicators (obtained on the basis of a narrower comprehensive set of indicators) offers an adequate and efficient way of road safety monitoring and understanding and is an important driver for the development of a sustainable system of periodical measuring of indicators in low- ranked territories. The optimum selection of indicators allows for the simplest method of monitoring a road safety situation, comparing at the same time the largest number of territories possible.

The remaining of this paper is structured as follows: a short review of literature concerning the concept of a "composite index" in general and a "road safety performance index" is offered in Section 2.2. Section 3 gives a description of the study design, including: clearly given study objectives, basic concepts, data collection and selection of indicators. Relevant weighting and aggregation concepts are described in Section 4. Also, this section presents the methodology for identifying the most significant indicators. The results in terms of the correlative analysis, countries' ranking and identifying the most contributing indicators per country are discussed in Section 5. Section 6 is reserved for discussion of the most important results. This paper closes with the main recommendations for meaningful road safety performance index and conclusions and topics for further research.

2. Literature review

2.1. Background of the composite index concept

Saisana and Tarantola (2002) presented the methodology for designing a composite index, highlighting in particular methodological approaches and studies that have shown in which way and by means of which techniques a relevant composite index can be obtained for the observed criterion (for example: Human Development Index, Summary Innovation Index, Internal Market Index, Composite Leading Indicators, etc.). Later on, Saisana et al. (2005) made a step further and presented the technique of data uncertainty and sensitivity as a significant method for checking the quality of the obtained composite index. Further on, Nardo et al. (2005a) presented in detail and explained the process of selecting the indicators, techniques used for their processing and weight allocation methods and aggregation of indicators. They have also offered a detailed analysis of data uncertainty and sensitivity. The final deliverable of their work included a manual for making a composite index (Nardo et al., 2005b). This group of authors managed to classify the knowledge acquired until then and systematize the following issues: 1) steps for making a composite index; 2) frameworks for making a composite index while taking care of data availability, data relevance, usability of data, etc.; and 3) tools for defining a composite index (starting from the data processing techniques through normalization, to the weight allocation and aggregation of indicators methods and analysis of data uncertainty and sensitivity).

2.2. The concept of a composite road safety index

The states can improve their road safety on the basis of their experiences, systemic monitoring and cross-country comparisons (Bax et al., 2012). In order to secure a systemic monitoring of road safety and comparisons with other countries, it will be necessary to undertake the process of selecting relevant road safety indicators which will represent the current road safety situation in the best possible and most accurate way (Pešić, 2012). The development of the scientific thought on road safety indicators has been running very quickly over the last decade (Al-Haji, 2005; Vis, 2005; Wegman et al., 2005; Hakkert and Gitelman, 2007; Hakkert et al., 2007; Hermans et al., 2007; Gitelman et al., 2014; Bastos et al., 2014; Bastos et al., 2015, etc).

Several years ago, efforts have been put in establishing links among different countries world-wide. The inception phase has seen the comparison reports that dealt only with consequences of road crashes on the basis of which the countries used to compare their road safety levels. Further on, with the development and comprehension of road safety issues, methods for comparing road safety situations in specific areas have been also developed. In fact, academic circles have become aware that the road safety system is a multisectoral system dependent on multiple factors. Therefore, today's methods for road safety comparisons encompass a multitude of factors (and consequently a multitude of indicators) while tending to reduce all those indicators to the same scale and allocate them as most accurate weights possible to represent the specific features of the compared area. Depending on the purpose of the composite index, the phase of selecting the representative road safety indicators on a territory should start from the analysis of all categories (levels) of indicators from the Koornstra et al. (2002) and LTSA (2000) pyramid. The pyramid identifies four levels of indicators (top-down), as follows: final outcomes (e.g. deaths per 100.000 inhabitants); intermediate outcomes (safety performance indicators); policy performance indicators (safety measures and programmes) and background performance indicators (structure and culture). Over the last couple of years, efforts have been made to identify