

COMPARING ROAD SAFETY PERFORMANCE OF SELECTED EU AND AFRICAN COUNTRIES USING A COMPOSITE ROAD SAFETY PERFORMANCE INDEX

Millicent Awialie Akaateba[a]

[a] Department of Planning and Management, FPLM, University for Development Studies, Wa-Campus, P.O.Box 3, University Post, Wa-Ghana

Email: makateba@yahoo.com

Abstract

In recent time, the use of indices in the field of road safety has been growing rapidly in view of the ever complex character of the road safety phenomenon. This study which aims at contributing to the application of the composite road safety index used two approaches to compare the road safety performances of 20 selected EU and African Countries. In the first method a road safety index using simple averaging techniques for cross sectional data for 2006 was developed whilst in the second method, multi regression analysis was used with time-series data for six years (2001-2006). Results of the study revealed different country rankings of the composite road safety index from those produced from the traditional rankings based on fatality rates. The study concluded that the road safety index has the potential to become a major method of making international comparisons of road safety performances.

Keywords: Road Safety, Composite, Performance Indicators, Index, Country Ranking

1. Introduction

Road safety has been a key issue of concern globally due to the economic, social and human costs associated with road traffic crashes. The steady increase in traffic volumes over the past decennia and its associated traffic problems including road accidents has made road safety a major policy area where safety performance indicators can serve as supportive policymaking tools. Globally, it is estimated that over 1.2 million people die each year on the world's roads, and between 20 and 50 million sustain non-fatal injuries (WHO, 2009). As a result, in addressing national traffic safety problems, it is worth reviewing road safety performances in an international context so that the level of road safety can be compared over countries.

In recent years, the use of indicators and indices in the field of road safety has been growing rapidly in view of the ever complex and multidisciplinary character of the road safety phenomenon which requires the consideration of several factors by policy makers (Hermas, Van den Bossche and Wets*,* 2008*)*. These road safety indicators have taken their roots from other domains such as the Human Development Index used by the United Nations; the Technology Achievement Index used by the United Nations Development Programme; the Overall Health System Index used by the World Health Organisation (WHO); and the Environmental Sustainability Index used by the World Economic Forum among others.

The traditional approach to international comparisons of road safety performances across countries has largely focused on safety outcomes in terms of fatalities per population, vehicle fleet or exposures (i.e. fatalities per 100,000 population; fatalities per 10,000 registered vehicles or the number of fatalities per million vehicle kilometres travelled). Although there is no universally accepted exposure indicator that describes accurately the overall road safety situation in a given country, the use of each of these crash related indicators do not describe all the relevant components of the road safety problem in a comprehensive and concise way so as to indicate which aspects of road safety a country should focus on. Each crash related indicator will also have different effects on ranking countries in order of 'seriousness' of road safety problems leading to disagreements over which indicator is the best. Besides, international accident data are often characterised by such challenges and inconsistencies as lack of uniformity in accident definitions, under-registration of vehicles, underreporting and recording of accidents, random fluctuation among others (Odero, Garner and Zwi, 1997; Evans 2004).

To overcome the difficulty of making international comparisons of road safety performances and to allow for sufficient understanding of the processes that lead to road crashes and casualties, several studies have popularised the concept of road safety indicators (e.g. ETSC, 2001; SafetyNet, 2005; Al Haji, 2005; Wegman et al., 2008; Nardo et al., 2005; Hakkert, Gitelman, and Vis, 2007; Hermans et al., 2008). A safety performance indicator is defined as any measurement that is causally related to accidents and casualties and used in addition to a count of accidents and casualties in order to indicate the safety performance or understand the process that leads to accidents (ETSC, 2001).

Although countries could be compared on each safety performance indicator individually, the aggregation of individual road safety performance indicators into a composite index serves as a valuable tool for benchmarking the safety situation of a country given the large number of relevant road safety performance indicators. A major advantage of the composite index approach over the individual performance indicators is that it allows for the overall road safety picture of a country to be presented, the impact of safety indicators can be assessed and countries performance can be easily ranked based on the combined performance of essential road safety risk indicators (Safetynet, 2005). Composite indicators also provide a meaningful and realistic way in making comparisons across countries and are also very useful in generating the interest and attention of policy makers, politicians, the media and the public in road safety (OECD/ JRC, 2008). Country comparisons using composite indicator indices allows for the identification of best practices and successful interventions and policies that can be adapted by countries to reduce increases in road crashes and casualties.

Though considered as a valuable tool for road safety assessment, the selection of indicators, weighting method, transparency in construction and the overall methodology adopted for constructing the composite road safety performance index is a major prerequisite for its use and a strategy to avoid sending misleading policy messages to reduce criticisms leveled against the composite index approach by non-aggregators.

The aim of this study is not to decide which methodology is the best combination of indicators and weights to use but to contribute to the application of the composite road safety index approach in ranking the road safety performance of various countries. Although studies have been conducted on the use of the composite road safety index, these have largely focused on European countries (Al Haji, 2005; Wegman et al., 2008; Nardo et al., 2005; Hakkert et al., 2007; Hermans et al., 2008) with none on African countries. This study thus focuses on using a road safety index to compare the road safety performances of African and EU countries combined. Due to the small sample size and the nature of data required for this study, the study uses available data to develop a simple composite index for benchmarking African and European Union (EU) countries road safety performances using both a simple average of normalised indicators and multiple regression analysis.

2. Theoretical Framework

Some extensive research has already been undertaken regarding relevant factors (risk factors) related to road crashes and casualties (ETSC, 2001; WHO, 2004; Al Haji, 2005). These risk factors (covering human-vehicle-road-environmental-regulation interactions) are often generally related to road user behaviour (e.g. alcohol, speeding), vehicle (e.g. defects) and the road environment (e.g. bad maintenance) (WHO, 2004).

The layer of safety performance indicators was first explored by ETSC (2001) which assumes that accidents and injuries are only a tip of the iceberg since they occur as the 'worse case' result of unsafe operational conditions in the road traffic system. As a follow up to ETSC (2001), the SUNflower Approach views the road safety domain as a pyramid comprising of several layers. From bottom to top, these layers are: policy context/background conditions of the system (structure and culture); policy performance indicators (road safety policy measures and programmes);

safety performance indicators (intermediate outcomes); Number of people killed or injured (final outcomes); and the social cost of accidents/injuries at the apex (Koonstra et al., 2002; Wegman et al., 2005).

The European SafetyNet project (Hakkert et al., 2007) on safety performance indicators identified seven road safety risks domains as central to road safety activities in Europe. These are: alcohol and drugs, speed, protective systems, visibility, vehicle, infrastructure and trauma care. Each of these domains is characterised by a set of indicators, the selection of which is based on a selection criteria such as strength of relationship with unsafety, amount of contribution to accidents and the degree to which the risk factor can be influenced by policy (see for example ETSC, 2001 and Nardo et al., 2005). Indicator selection is often based on data availability and reliability, policy relevance and clarity (Litman, 2007; Hermans et al, 2009).

Although there is no universally agreed best or ideal method for the construction of a composite road safety index, the development of a methodologically sound and valid composite index is a new and challenging but a necessary concept in road safety today. Nardo et al. (2005) elaborated on ten steps involved in the creation of an aggregate index. The joint handbook by the Organisation for Economic Co-operation and Development (OECD) and the Joint Research Centre (JRC) of the European Commission also discussed ten steps in the construction of composite indicators OECD/ JRC (2008). Other researchers such as Al Haji (2005) and Hakkert et al., (2007) have developed related methodologies in the construction of composite indices. Figure 1 presents the theoretical framework for the road safety performance index.

2.1 Selected Safety Performance Indicators

Though literature on safety performance indicators is varied, the literature generally agrees on a group of relevant risk factors to road safety (see for example ETSC, 2001; SafetyNet, 2005; Hakkert et al., 2007; Hermans et al., 2008). The indicators for this study were selected on the basis of data availability and policy relevance especially in African countries. The selected indicators mainly related to safety outcomes and safety related risk factors as shown in Table 1. This allows for both the *inputs* and *outputs* of road safety to be included in the index as is done with the Composite Health Index. The non availability of data on behaviour related indicators in African countries such as those identified by SafetyNet (2005) for European countries constituted a major limitation to this study as such relevant behavior related indicators could not be included in the construction of the Road Safety Index. Though this limitation does not allow for the presentation of a comprehensive picture of the road safety situation of the study countries, the road safety index developed still gives a broad picture of road safety rather than just focusing on individual indicators. Besides, most of the selected indicators are already widely used in international indices which will make the road safety index easy to understand and more valid than relying on sample surveys for data on behaviour related indicators.

- *Personal Risk:* This indicator is often used to relate the number of road deaths to the size of a country (standardization for population: i.e. the number of inhabitants in a country excluding temporal visitors and tourists) by calculating the mortality, i.e. the number of deaths per 100,000 inhabitants. It is often used in epidemiological studies to compare the consequences of road accidents to other causes of deaths. Though the indicator has its limitations, the main advantage of using this indicator over other exposure measures is that, in many cases nearly all countries have relatively accurate population data that are available for several subdivisions, years and specific groups of road users (SafetyNet, 2005).

- *Traffic Risk*: In the absence of vehicle kilometres, road deaths in a country may be standardized for the total number of road vehicles owned by the country's population. Though not preferred to vehicle kilometres, vehicle fleet can be informative as certain information about vehicles such as age, type and physical characteristics and foreign vehicles that may not be readily available for vehicle kilometres may be available for vehicle fleet.

- *Road Conditions*: The type and condition of the roads on which vehicles are driven have been revealed to have some influence on accident rates. Roads with poor surfacing conditions, engineering defects or certain types of surfacing materials have direct consequences on the probability of an accident occurring. According to Bester (2001), countries with greater percentage of paved roads have low road deaths. In addition, motorways are said to be safer to drive on than other road types due to the segregation of vehicles according to speed (Al-Haji, 2005; Elvik and Vaa, 2004)

- *Adult Literacy:* A country with a large number of literate drivers will make it easier for road signs and regulations to be easily read and understood and thus result in low road accidents and fatalities all things being equal compared to one where drivers do not know or understand road signs (Bester, 2001).

- *Urbanisation:* Countries with higher levels of urbanisation are often associated with higher population and road densities, which have been shown to have fewer fatalities and lesser injury severities (Hakkert and Braimaister, 2002). This is because of the higher number/density of vehicles on the roads of urban areas, which result in lower speeds on such roads than on rural roads coupled with the ease of reaching medical services when an accident occurs in an urban area.

- *Quality of Medical Services (measured by life expectancy at birth):* The quality of health care delivery and ambulance services in a country can also have indirect influences on road fatality rates and injury severities as some road casualties die on the way to the hospital. Noland (2003) quoted in Al-Haji (2005) in a study on accident rates in developed countries indicated that improved medical care has resulted in a decline in traffic-related fatalities in such countries over the period 1970-1996.

- *Gross Domestic Product (GDP per capita):* Economic growth (or growth in GDP) is generally known to be accompanied by increased motorisation. Kopits and Cropper (2003) demonstrated how motorization rates have grown with income over time for a sample of countries and the consequent effect of this on road fatalities.

The rest of this paper is organized as follows. In Section 3, the general methodology for the study is discussed. Section 4 focuses on the results of the study which compares the rankings obtained from the Road Safety Index with traditional comparison methods whilst Section 5 ends the paper with a conclusion to the study and recommendations for further research.

3. Methodology

The study focused on twenty African and EU countries (10 each from each region). The criterion for selection was mainly based on the availability of required data (number of road deaths, registered motor vehicles, percent of roads paved, population, and socio economic indicators) for the study period (1997-2006). The selected EU countries are the Netherlands, Sweden, Great Britain, Germany, Luxemburg, Spain, Poland, Portugal, Czech Republic and Greece whilst the African countries are South Africa, Morocco, Mauritius, Algeria, Ghana, Niger, Ethiopia, Tunisia, Botswana and Guinea.

3.1 Data Sources and Quality

The study exclusively relied on data from secondary sources largely from international databases. These include the International Road Traffic and Accident Database (IRTAD); the United Nations Economic Commission for Europe (UNECE) Statistics; the World Road Statistics compiled by the International Road Federation; and national databases such as the UK Department of Transport, SVOW: Institute for Road Safety Research (Netherlands) and Arrive Alive Road Safety Website (South Africa) amongst others. Data on selected socio-economic indicators affecting road safety (e.g. percent of paved roads, adult literacy rate, percent of population urban, life expectancy at birth, GDP, etc) were taken from the World Bank Human Development Indicators Database and various editions (2003-2008) of the United Nations Development Programme (UNDP) Human Development Reports. Population data for the African countries was collected from the US Census Bureau international database whist that for the EU countries was obtained from the IRTAD database.

Although attempts have been made in this study to rely extensively on the use of officially published crash statistics based on police reports, there can still be some problems associated with data reliability and under-reporting as acknowledged by previous studies on regional and global road accident comparisons (see for example Naji and Djebarni, 1999; Odero *et al*, 1997; Jacobs, Aeron-Thomas and Astrop (2000)). Therefore, to minimise these problems of data reliability and make statistics from different countries comparable, this study made a 'best' estimate of the official statistics of some countries by making adjustments for differences in definition of road deaths and under-reporting using correction factors. Although some African countries indicate that they use a 30-day definition, for the purpose of this study, it was assumed that all African countries use a 24-hour definition of a road death due to the fact that most African countries use manual report forms that are often completed within 24-hours by the police. Therefore, though they officially define a road death as dying within 30-days for legal reasons, it is practically difficult to use such a definition because modifying previously submitted figures can be very difficult due to the manual systems used. As a result, in line with Jacob *et al* (2000), the study applied a 1.15 correction factor to the officially recorded deaths in the African countries.

It is generally difficult to determine a single correction factor for under-reporting of road accidents for all countries due to the lack of up to date and comprehensive studies/ literature on the topic and the varying levels of under-reporting across countries. As a result, this study made only a 'best estimate' of the under-reporting levels for the case study African and EU countries based on the few studies (see for example Elvik and Mysen, 1999; Jacobs et al, 2000; Mackay, 2003; ERSO, 2009) conducted on the topic that compared police reported fatalities with hospital records. The study applied an adjustment factor of 2.5 percent for under-reporting in the selected EU countries and 30 percent for the African countries. It must be stated that these adjustment factors are only estimates based on available literature and may be subject to change as contemporary studies are conducted on the subject.

3.2 Indicator Significance

The selected indicators were tested for statistical significance at 95 percent confidence interval (as independent variables against the number of road fatalities as dependant variable) to determine their relevance for the case study countries using data for the period 2001-2006 with multiple regression analysis. The results are shown on Table 2. The R^2 value obtained from the multi regression analysis was about 0.89, which is good and the t-statistic shows that all the seven selected indicators are statistically significant at 95 percent confidence interval. Although the education (adult literacy rate), urbanisation (percent of population urban) and road condition (percent of roads paved) are statistically significant, they have different coefficient signs than expected from theory.

However because these indicators are inter-related/correlated (as revealed by the Bivariate Pearson Correlation analysis on Appendix A) and partially corrects for each other in the road safety index they were not omitted in the development of the road safety index. Since it is the combined effects of all these indicators on road fatalities but not the individual indicator causal effects in each country that is of interest in this study, the multi-collinearity among the various indicators was ignored.

3.3 Constructing Road Safety Performance Index

Two approaches were used with the selected indicators to compare and rank the road safety performance in the case study countries. The first method involved developing a road safety index using simple averaging techniques (similar to methods used by the UN and the World Bank in constructing the Human Development Index) for cross sectional data for 2006 for the study countries whilst in the second method, multi regression analysis was used with time-series data for six years (2001-2006).

4. Analysis and Results

This section presents the analysis and results of the road safety index based on a simple average technique and that based on multiple regression analysis using time series data. Country rankings based on the personal risk and traffic risk indicators are also presented.

4.1 Road safety Index based on Simple Average Technique

This approach involved taking a simple average of the performance of each country in all the chosen indicators. However, prior to taking the simple average, all indicators were normalised/standardised to common units before integration to ensure that they are comparable/additive and to avoid some indicators like population or GDP (in 1000s) dominating others like adult literacy (in percent) or life expectancy (in years). A simple linear transformation approach was used to normalise the indicators. This involved calculating the distance between the actual value and the maximum and minimum values for each indicator using the formulae:

$$\text{Standardised value} = \frac{\textit{Actual value} - \textit{Minimum value}}{\textit{Maximum value} - \textit{Minimum value}} * 100 \ldots\ldots \textit{equation}\ (1)$$

Alternatively, if a lower value means a better road safety performance as in the case of personal risk and traffic risk, the indicator is standardised using the formula

$$\text{Standardised value} = \frac{\textit{Maximum value} - \textit{Actual value}}{\textit{Maximum value} - \textit{Minimum value}} * 100 \ldots\ldots \textit{equation}\ (2)$$

The normalised values of each indicator for each country as well as the average road safety index are presented in Appendix B. Although weights can be assigned to each of the normalised indicators, for the purposes of the present analysis, all indicators were assumed to have equal weights and a simple average of all seven indicators calculated as the road safety index. For example, the road safety index of 95.71 for Luxemburg as shown on Appendix A was derived by summing up all the normalised values of the seven indicators (86.11+99.94+90.50+100+100+93.40+100) and dividing the result by seven (total number of indicators). A higher index in the simple average technique indicates better road safety performance. Figure 2 shows the country rankings based on the simple average road safety index.

In view of the fact that the road safety index based on the simple average technique used equal weights, which may be biased/sensitive towards extremely high or low values in one or more indicators, an alternative approach using multiple regressions, was used so as to give weights (coefficients) to each of the indicators/variables considered. For instance, although Sweden had a high safety index (above 90 percent) for six of the indicators, its low record in percent of paved roads brought its rank down to sixth reflecting the sensitivity of the simple average technique to outliers. In addition, to ensure that the rankings are not based on only year 2006, which may be an untypical year for some countries, the multiple regression analysis uses data for six years (2001-2006) for all indicators for the case study countries.

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4.2 Road Safety Index based on Multiple Regression Analysis

The number of road deaths occurring in the case study countries for the period (2001-2006) was plotted as the dependent variable against data for the seven chosen indicators (independent variables) for the same period using multiple regression analysis and a regression equation (significant at 95 percent confidence interval, $R^2 = 0.87$) of the form below derived.

$$Log\ D = 0.5034 \log X1 + 0.5043 \log X2 + 0.5554 \log X3 + 0.9083 \log X4 + 0.5843 \log X5$$
$$- 3.3346 \log X6 - 0.5915 \log X7 + 1.0336 \ldots\ldots\ldots\ldots \text{equation (1)}$$

Where: *X1* = Population of a country

X2 = Number of registered motor vehicles

X3 = Percentage of paved roads

X4 = Adult literacy rate (%)

X5 = Percentage of population urban

X6= Life expectancy at birth (in years)

X7= GDP per capita (in US dollars)

Equation (1) above can be expressed in the form:

$$D = X1^{0.5034}\ X2^{0.5043}\ X3^{0.5554}\ X4^{0.9084}\ X5^{0.5843}\ X6^{3.3346}\ X7^{-0.5915}\ .10^{1.0336} \ldots\ldots \text{equation (2)}$$

This can also be written as

$$K = {}^{D}\!/_{X1^{0.5034}\ X2^{0.5043}\ X3^{0.5554}\ X4^{0.9084}\ X5^{0.5843}\ X6^{-3.3346}\ X7^{0.5915}\ .10^{1.0336}} \ldots\ldots \text{equation (3)}$$

Where K is a constant and for this study, K is known as the '*Road Safety Index'*

Based on equation (3), the number of deaths in each of the study countries in year 2006 was expressed as a function of the seven selected indicators in the same year and a road safety index produced for each country. Countries were then ranked based on this index with a lower 'K' value indicating a better road safety performance (i.e. lower death ratio with regards to the indicators considered) and a higher 'k' value indicative of a worse road safety performance (higher death rates with regards to the indicators considered). The road safety indices ('K') produced for each country from equation (3) and their resulting country rankings are presented on Figure 3.

4.3. Country Rankings using only Personal Risk or Traffic Risk

Figures 4 and 5 show international comparisons based on only personal risk (deaths per 100,000 population) and traffic risk in 2006. It can be seen from Figure 4 that when death rates are expressed in terms of deaths per 100,000 population, the poorer and less populated African countries such as Guinea, Niger and Ethiopia perform well and lead the list, followed by the EU countries whilst the rich African countries like Morocco, Tunisia and South Africa are at the bottom.

On the contrary, when the road deaths for the same countries are compared using deaths per 10,000 vehicles as shown on Figure 5, the initial ranking produced in Figure 4 is reversed. The low motorised countries like Niger and Ethiopia that were performing well and leading the ranking are now at the bottom, with worse performance than

South Africa and Morocco whilst the highly motorised and developed/ EU countries are ranked as best performing. This result agrees with earlier findings by Navin, (1994) that as motorisation level (number of vehicles per population) increases, the traffic risk (fatalities per vehicle) decreases.

In comparing the rankings produced by the road safety index as shown in Table 3 and from Figures 2 and 3, it can be observed that although the country rankings produced from the simple average technique and the multiple regression approach are not the same; they produce similar results in terms of the worst road safety performing countries. In both cases, South Africa and Ethiopia have been highlighted to have worst road fatality rates.

5. Conclusions and Further Research

The road safety index approached has emerged as a challenging but necessary task in road safety research as it offers road safety practitioners and policy makers a useful tool for ranking and benchmarking countries' road safety performances. Country rankings receive great attention from the general public and policy makers and as such, the methodological choices in developing the road safety index has become very important in road safety research globally in view of the fact that there is no agreement yet on the best technique for developing the index in Literature.

In this study, two methods were used to construct a simple road safety performance index for 20 selected African and EU countries. The first method involved developing a road safety index using simple averaging techniques (similar to methods used by the UN and the World Bank in constructing the Human Development Index) for cross sectional data for 2006 for the study countries whilst in the second method, multi regression analysis was used with time-series data for six years (2001-2006).

Although, the road safety index (based on multiple regression) produced different rankings from those based on only accident rates taking into account either population or vehicles it presents a better way of making international comparisons of road accidents across various countries. This is because it integrates several relevant aspects of road safety together into a simple and aggregate index, allowing meaningful comparisons to be made. The road safety index approach to making international comparisons is also more preferable and relevant in view of the fact that road safety is a complex phenomenon which is affected by a range of factors involving road environment-human-vehicle–regulation enforcement interactions which cannot be measured by only accident rates as a function of the number of vehicles or population. As a result, a simple and comprehensive approach that takes account of all relevant road safety performance indicators combined with weights is needed to make meaningful comparisons of road safety levels globally.

The road safety index therefore has the potential to become a major method of making international comparisons of road safety performance in the future similar to the popularity attained with the Human Development Index used by the World Bank to measure the annual achievements of countries as data on more indicators become available with time. Further studies on a wide range of countries using best needed (most preferable/ideal) indicators instead of best data available indicators is recommended. The selection of the weighting method and the inclusion of uncertainty and sensitivity analysis are also essential for the further development of the road safety performance index approach and should form the focus of further research on the Road Safety Performance Index Approach.

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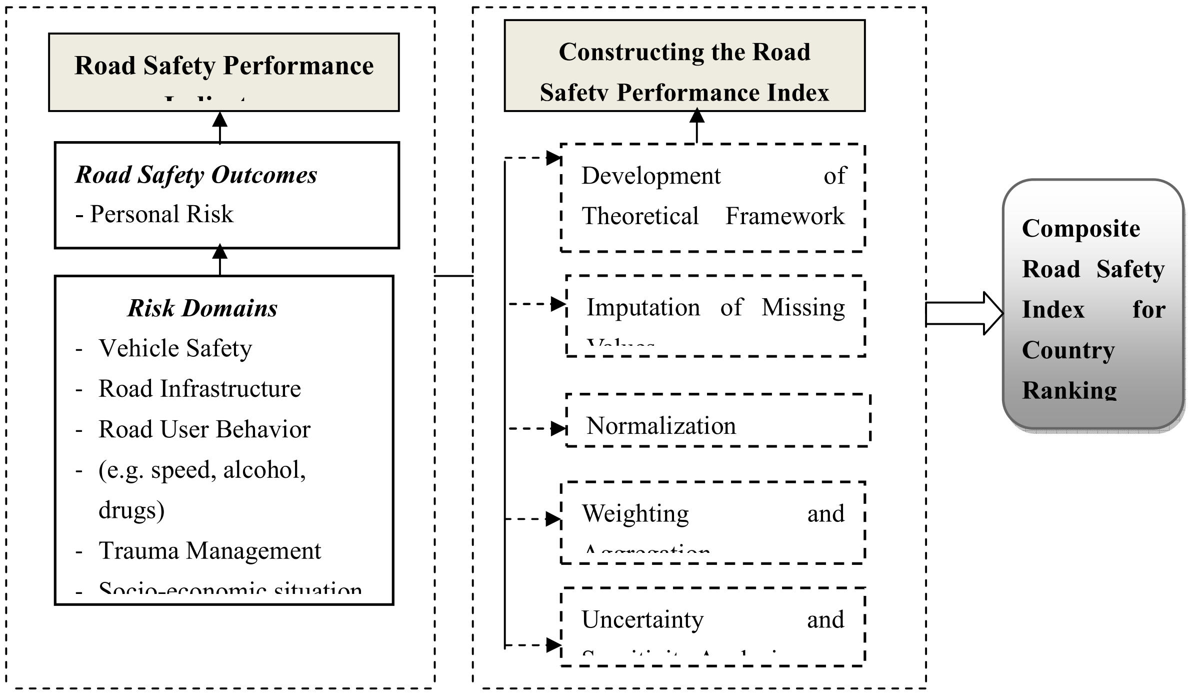

Figure 1. Theoretical framework for road safety performance index

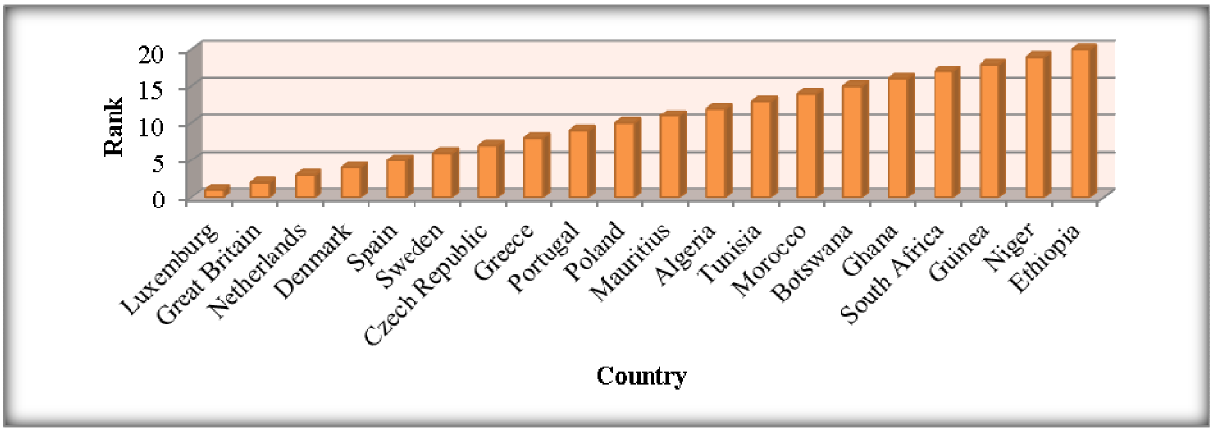

Figure 2: Road safety index among 20 EU and African countries for year 2006 based on a simple average road safety index) [Data source: IRTAD Database, IRF statistics 2001 &08 editions and national databases]

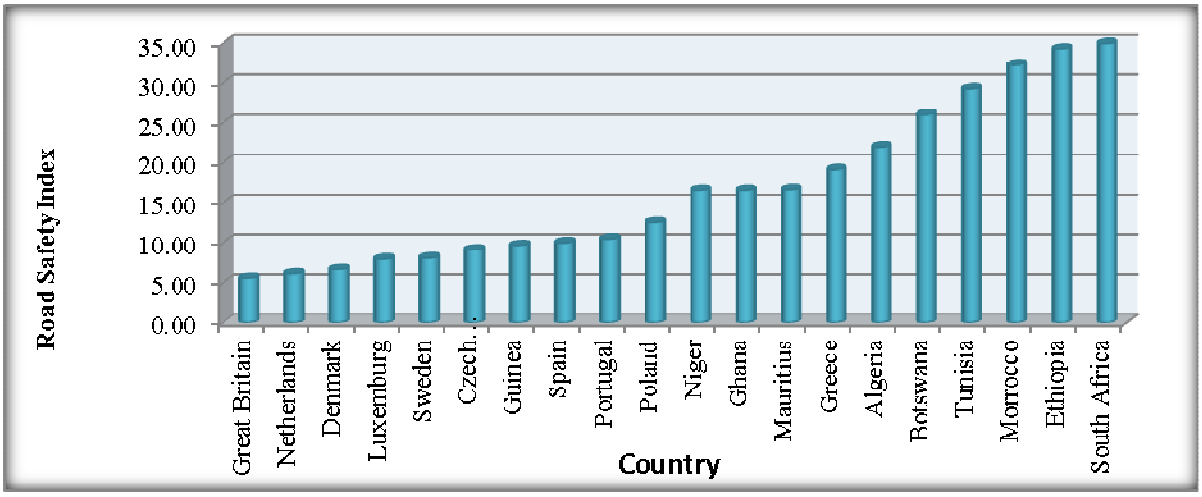

Figure 3. Road safety index among 20 EU and African countries for year 2006 based on equation (3) [Data source: IRTAD Database, IRF Statistics 2001 &08 editions and National Databases*]*

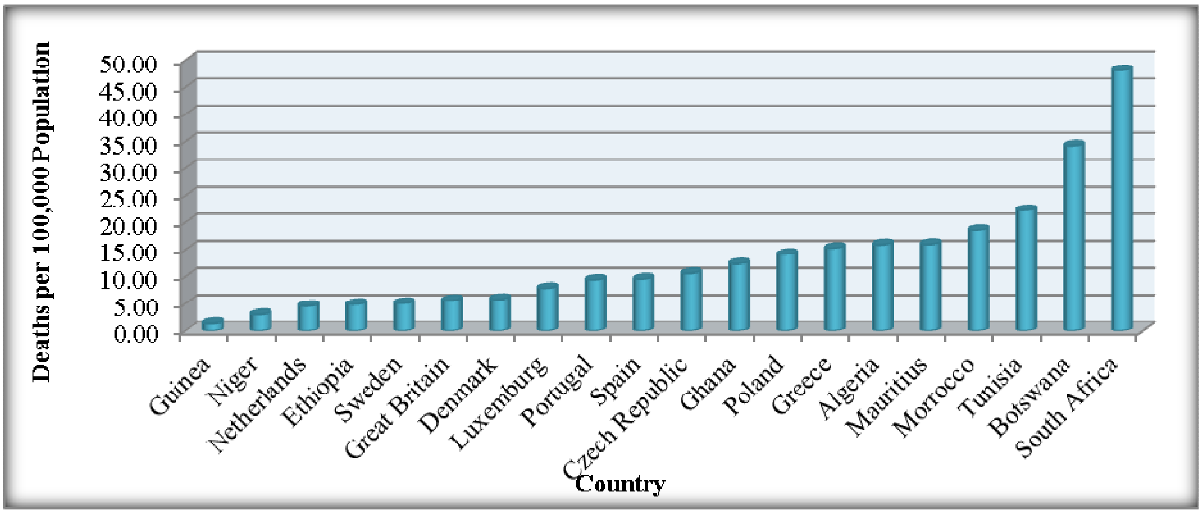

Figure 4. Road fatalities per 100,000 population among EU and African countries in 2006 [Data source: IRTAD Database, IRF Statistics 2001 &08 editions and National Databases]

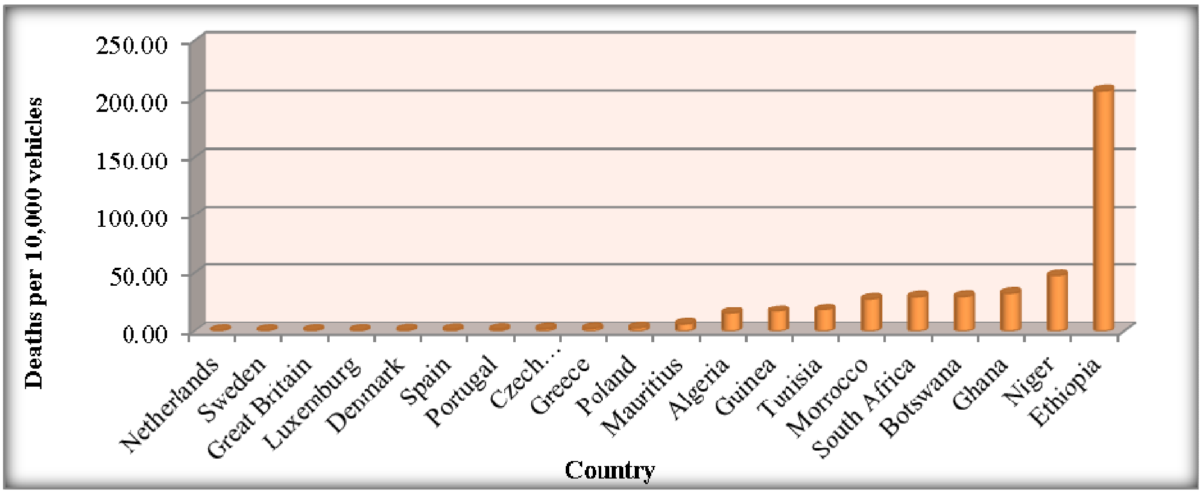

Figure 5.Road fatalities per 10,000 vehicles among selected EU and African countries in 2006. [Data source: IRTAD Database, IRF Statistics 2001 &08 editions, National Databases]

Table 1. Selected indicators for constructing the road safety performance index

Risk Domain	**Indicator Definition**
X1. Personal Risk	Fatalities per 100,000 population
X2. Traffic Risk	Fatalities per 10,000 registered vehicles
X3. Road Infrastructure	Percentage of roads paved
X4. Educational Level	Adult Literacy rate (%)
X5. Urban Population	Percent of population urban
X6. Health Status	Life expectancy at birth (years)
X7. Gross Domestic Product	GDP per capita ($US)

Table 2. Multiple regression results of indicators affecting road safety

Indicators tested	***Coefficients***	***t Statistic***	***P-value***
Population	0.5034	3.82	0.0002
Vehicles	0.5043	3.85	0.0002
Life expectancy at birth (in years)	-3.3346	-8.49	9.8E-14
Adult Literacy (%)	0.9083	3.39	0.0019
Urban Population (%)	0.5843	2.39	0.0187
Percentage of paved roads (%)	0.5554	4.94	2.7E-06
GDP per capita ($US)	-0.5915	-7.49	1.7E-11

Table 3. Rankings based on the two road safety index approaches and fatalities/10,000 vehicles

Country	Simple Average Ranks	Multiple Regression Ranks	Fatalities/ 10,000 vehicles Ranks
Great Britain	2	1	3
Netherlands	3	2	1
Denmark	4	3	5
Luxemburg	1	4	4
Spain	5	8	6
Sweden	6	5	2
Czech Republic	7	6	8
Greece	8	14	9
Portugal	9	9	7
Poland	10	10	10
Mauritius	11	13	11
Algeria	12	15	12
Tunisia	13	17	14

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Country	Simple Average Ranks	Multiple Regression Ranks	Fatalities/ 10,000 vehicles Ranks
Morocco	14	18	15
Botswana	15	16	17
Ghana	16	12	18
South Africa	17	20	16
Guinea	18	7	13
Niger	19	11	19
Ethiopia	20	19	20

APPENDICES

Appendix A. A bivariate pearson correlation analysis

Indicator	Popn.	Reg. Veh	Life exp. years)	Adult Lit. (%)	Urban pop (%)	Paved roads (%)	GDP per capita ($US)
Population	1	.466**	-0.058	-0.169	-0.166	-.259**	-.274**
Registered Vehicles	.466**	1	.662**	.716**	.723**	.547**	.673**
Life expectancy at birth	-0.058	.662**	1	.651**	.709**	.785**	.730**
Adult literacy rate	-0.169	.716**	.651**	1	.847**	.666**	.849**
Percent of popn. urban	-0.166	.723**	.709**	.847**	1	.691**	.880**
Percent of paved roads	-.259**	.547**	.785**	.666**	.691**	1	.755**
GDP per capita ($US)	-.274**	.673**	.730**	.849**	.880**	.755**	1

**. *Correlation is significant at the 0.01 level (2-tailed). .The table presents a correlation analysis among the seven selected indicators. The underlined figures indicates indicators that are highly correlated (i.e. above 0.70) which depicts that there is collinearity among the selected variables/indicators*

Appendix B. Normalised indicators and calculated road safety index for 2006

Country	X1	X2	X3	X4	X5	X6	X7	Index	Rank
Luxemburg	86.11	99.94	90.5	100	100	93.4	100	95.71	**1**
Great Britain	91.01	99.95	100	100	81.35	95.3	100	95.37	**2**
Netherlands	93.13	100	87.8	88.91	100	95.9	100	95.11	**3**
Denmark	90.54	99.82	94.6	100	87.62	91.8	100	94.92	**4**
Spain	82.46	99.7	82.4	98.89	72.6	100	97.7	90.54	**5**
Sweden	92.13	99.99	91.9	53.66	90.1	100	100	89.68	**6**
Czech Republic	80.25	99.35	78.4	100	54.31	85.9	100	85.45	**7**
Greece	70.24	99.24	60.8	90.91	77.89	95	97.1	84.45	**8**
Portugal	82.8	99.56	56.8	84.48	51.37	91.2	93.7	79.98	**9**
Poland	72.74	98.97	60.8	66.41	35.7	83	100	73.95	**10**
Mauritius	68.7	97.36	35.1	100	25.28	74.5	82.7	69.11	**11**
Algeria	68.85	92.94	64.9	66.96	17.3	72.6	64.9	64.06	**12**
Tunisia	55.28	91.32	67.6	62.08	16.11	76.7	68.2	62.47	**13**
Morocco	63.22	86.73	52.7	57.76	8.39	68.6	36.3	53.37	**14**
Botswana	29.76	85.71	56.8	25.28	30.8	0	75.7	43.43	**15**
Ghana	76.49	84.39	44.6	5.69	1.61	33	49.9	42.25	**16**
South Africa	0	85.81	59.5	8.31	21.52	3.77	83.6	37.5	**17**
Guinea	100	91.93	23	0	1.28	20.1	0	33.76	**18**
Niger	96.53	77.16	0	11.86	0	23	0.43	29.85	**19**
Ethiopia	92.51	0	0	10.31	0.22	10.4	9.21	17.52	**20**

Notes: Data for traffic and personal risk indicators are from IRTAD Database and IRF world road statistics, 2008 edition and country websites.

Data for the other indicators are from the World Bank world development indicators (statistical update 2008) report.

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