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Advancements in road safety management analysis

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Abstract

Road Safety Management (RSM) can be briefly defined as the tasks of preparing and implementing road safety policies. Many studies have been carried out on RSM, trying to identify success factors and reference best practice examples, but the complexity of the subject and the difficulty of quantitative data collection make it difficult a clear and comprehensive understanding. According to the EC-funded DACOTA research project, the weakest components of RSM systems in Europe are policy implementation and funding and the lack of knowledge-based road safety policy making.

The main objective of the research, undertaken within the FERSI's working group on Road Safety Management (RSM), is to better investigate in several European countries those two RSM key functions: funding and research. Particularly the study aims at 1) exploring the existing structures, processes and factors affecting funding and research performances; 2) defining an assessment framework able to measure single country performances with reference to the efficiency and effectiveness of road safety funding and research, possibly shifting from a qualitative to a more quantitative approach.

Based on the available knowledge on these two topics (research and funding), an assessment framework is defined and a set of qualitative and quantitative indicators for funding and research performance measurement is proposed. A desk analysis aiming at collecting available data useful to estimate the proposed indicators is conducted and a preliminary analysis with this subset of indicators is undertaken. A subset of research indicators (bibliometric) are used to estimate road safety research outputs performance of a country in terms of productivity and quality of research and international collaboration activities. Preliminary results show a positive correlation among them, even if the linear correlation turns to be not so strong. Countries are ranked on the basis of a composite index of all the three indicators.

Data related to the full set of indicators will be collected, in the next phase of the research, through a dedicated survey to experts in the field of road safety and the relationships among countries performance and the existing conditions potentially affecting research and funding will be studied.

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1. Introduction

1.1. Background

Road Safety Management (RSM) is defined as the tasks of preparing and implementing road safety policies, including defining goals and targets, programming, implementing interventions, evaluation, and research (Muhlrad, 2009). Based on the assumption that effective RSM delivers good road safety performance, Bliss and Breen (2009) and Muhlrad et al. (2011) proposed an ideal RSM model based on several “good practice” criteria.

In particular, Muhlrad et al., (2011), within the European research project DaCoTa, developed an *investigation model* for studying the various aspects of actual road safety policy-making and management processes in Europe. The investigation model allows assessing a RSM system performance by comparing it to an ideal RSM system with fully implemented RSM functions/tasks. The system performances are assessed through qualitative variables expressing desirable conditions for a RSM function, i.e. they inform about the presence of a particular condition/element (e.g. existing sustainable funding for road safety, existing agency dedicated to road safety monitoring...). According to DACOTA results, the weakest components of road safety management systems in Europe are policy funding and implementation and the lack of knowledge-based road safety policy making (Papadimitriou et al. 2012).

The DACOTA investigation model is good to provide a global picture of the main characteristics of the road safety management tasks in a country, highlighting the main aspects that could be enhanced. For instance, for what concerns funding, DACOTA found that long term budgets for implementing road safety programs are not estimated in most countries due to the difficulty of the task. Moreover, formal procedures for budget allocation to road safety activities are rare, especially in the case of regional and local authorities. Consequently, the agencies in charge of road safety measures implementation do not have dedicated resources, but have to rely to the general budget; this implies the eventuality of scarce financial resources in case of different priorities in policies.

The qualitative variables adopted in the investigation model can show us how far a country from the ideal conditions is, however it was not possible to provide evidence that ideal conditions corresponds to the highest level of road safety performance. Some researchers attempted to analyze the relationship between road safety management and road safety performance in terms of road accidents (e.g. Wong & Sze, 2011, Yannis et al, 2013). Nevertheless results suggest that a clear statistical relationship between RSM and the recorded number of road injuries and fatalities cannot be established (Yannis et al, 2013). On the other hand, a statistical relationship was found between RSM and “intermediate outcomes” (e.g. safety performance indicators) (Yannis et al, 2013).

It is recognized that several “good practice schemes” may exist, but it is difficult to compare a country RSM system to another. Two countries with similar schemes can behave very differently (in terms of effectiveness of the underlying processes, timing and quality of the results, etc) because of the existing internal mechanisms affecting a task performance.

Within this framework, the aim of the research, undertaken within the FERSI’s working group on RSM, is twofold:

- to define an assessment framework able to measure a country RSM system performance with reference to the efficiency and effectiveness of a RSM task.
- to better investigate the existing structures, processes and factors affecting a country RSM tasks performance;

Due to the complexity of RSM systems, that include several components (structures, plans, processes, outputs, tools, etc.), entailing a big difficulty even to describe them in a standardized way, the research focuses on the two weakest RSM tasks in Europe identified by DaCoTa: road safety *funding* and road safety *research*.

In the following, the research objectives and methodology are defined. Then, chapters 2 and chapters 3 describe respectively the assessment framework for funding and for road safety research and a set of qualitative and quantitative performance indicators are proposed. Finally, results from a preliminary evaluation of research performance derived from a subset of research performance indicators (bibliometric) are presented and discussed.

1.2. Research Objectives and Methodology

The objective of the work is to explore funding and research models and performance in Road Safety Management.

In relation to the funding task the aim is to analyze the different contexts of European countries, in order to identify funding schemes and the flow of resources among the different actors involved in the financing of specific measures. The focus of the work is mainly on the operational aspects of the funding process.

The aim is to define an assessment framework able to overcome the lack of practical and quantitative information on the funding process, currently mainly treated in qualitative terms or without a satisfactory level of detail.

With respect to road safety research, the study aims at identifying suitable indicators intended to provide an overview of the quality and performance of road safety research in a country. A framework to assess road safety research performance is proposed and a preliminary analysis is undertaken to assess research output performance based on research projects and bibliometric indexes.

The methodology employed is constituted by the following steps:

- Analysis of the results of DaCoTa questionnaire and literature, in order to identify RSM schemes for funding and research and to define an assessment framework.
- Definition of a set of indicators based on the developed framework aimed at quantifying the research and funding performances and describing qualitatively processes, factors and conditions affecting research and funding performances.
- Desk analysis aimed at gathering available data suitable to estimate a subset of the identified indicators; the data collection involves mainly research and is based on the consultation of the main institutional research projects databases, publication abstract and citation databases (e.g. Scopus).
- Survey data collection, based on a scheme related questionnaire, to estimate the developed funding and research indicators.
- Analysis of the relationships among RSM schemes, funding and performance indicators and factors affecting performance.

The paper addresses the first three steps of the proposed methodology, presenting results from a preliminary assessment of road safety research performance in European countries.

2. Road safety funding assessment framework

2.1. Schemes for funding

The elaboration of DACOTA data allowed the definition of potential schemes of financing road safety. In particular, for the countries with available data, five schemes can be identified, articulated in the following areas: road safety planning, type of funding and financing process monitoring (see Fig.1). The first scheme is constituted by countries like United Kingdom, Israel and Latvia that declare to estimate their budget for RS program, having a financing system centralized in the Treasury and putting in place a regular monitoring of the process through review and improvement of legislative instruments and procedure. The second scheme, where fall Italy and France, shares the same characteristics of the first, with the exception of the monitoring activity. The countries of Austria and Belgium declare not to estimate the budget for RS program and conduct regular monitoring activities. The funding is

linked to structures independent from Treasury (like RS funds and foundations). The Netherlands do not estimate the RS program budget, have a type of funding both dependent and independent from Treasury and put in place regular monitoring activities. Switzerland estimates the RS program budget, has a funding system independent from Treasury and does not conduct regular monitoring activities.

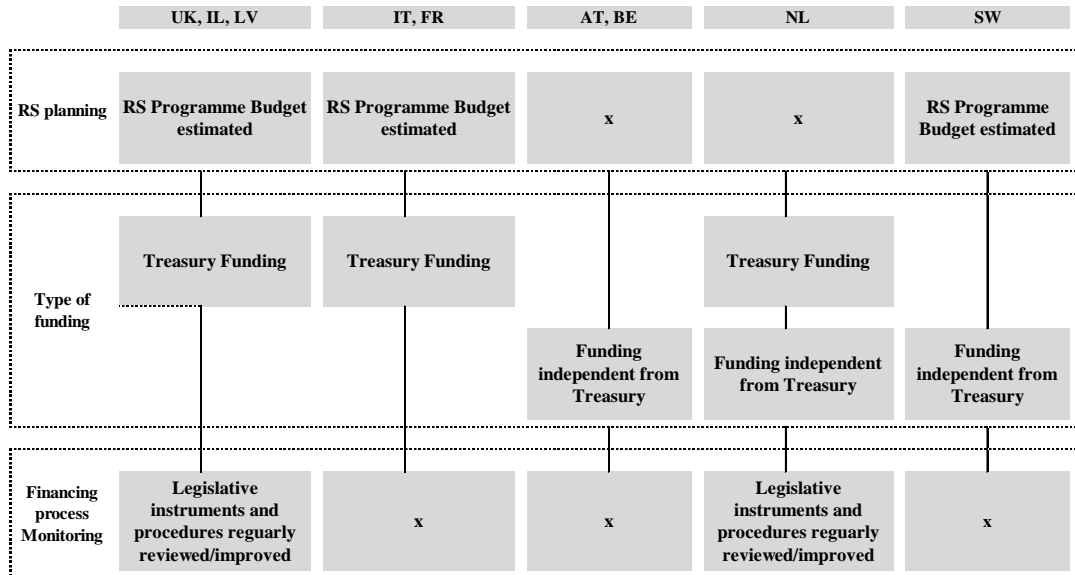


Fig. 1. Funding schemes according to DACOTA data.

The information obtained from DACOTA represent a valuable insights into the issue of the road safety measures funding but they are largely qualitative and do not allow to identify the operative funding mechanism with its strengths and weaknesses.

A general literature review and a desk analysis confirm that quantitative funding data for RSM are scarcely available, with the exception of the global financial provisions for some national Road Safety Plans, when adopted. In particular, information for areas of expenditures and data for local authorities are difficult to find. Furthermore, it is not always clear or properly detailed the mechanism of funding that links the Lead Agencies and the local authorities, especially in relation to the aspects of the procedure constituting critical elements.

In the Italian Road Safety Plan some elements that represent obstacles for the administrations in realizing and evaluating RS measures are identified. Among them, those related to the funding issue are constituted by the European stability pact and the time lag in the resource transfer from the State to local entities.

The stability pact has prevented local entities from managing their own scarce resources autonomously, with the consequence of further reducing the room for interventions.

The actual resource transfer from the State to local entities requires that the sums are firstly regionally budgeted and next transferred to local entities. This has constituted a strong disincentive for local communities that often have not participated to the competitive procedures for the funds allocation and sometimes, once inserted in lists, have asked the financing withdrawal.

2.2. Proposed indicators for road safety funding performance

The framework of road safety countermeasures is rather articulated. In fact, they can be addressed towards different targets like users, vehicles, infrastructures, governance, emergency system and the initiatives cover different field of application.

The investigation of the funding of the road countermeasures as a whole is then a complex task, in particular if we consider the large number of actors responsible for road safety measures implementation and the heterogeneity of funding sources.

For the present research it is proposed a “disaggregated approach”, through which to analyze specific measures (e.g. infrastructure interventions) and the actors responsible for their implementation at:

- National level;
- Regional/provincial level;
- Local level.

In particular, once selected the measures to investigate, the path of the resources needed for the implementation is reconstructed backward. This allows the identification of all the subjects with responsibility in funds allocation and constitute the basis for the achievement of two main outputs:

- definition of the measure funding scheme according to number and type of subjects involved, type of resources and type of procedures regulating the process (e.g competitive procedures);
- process evaluation through identification and detailed description of critical elements and estimation of a quantitative performance indicator.

The quantitative performance indicator proposed is related to the actual availability of resources and can be defined as:

Speed of disbursement processing: average time (days) elapsing between official resource allocation and liquidation.

A further output is constituted by the volume of resources available. Ideally, this figure is related to the measures selected in the analysis but, in presence of accounts systems not capable to produce it, general data on the national road safety plans are requested.

The analysis is based on surveys conducted through submission of a questionnaire (on line or vis a vis) to each actor responsible of the selected measure implementation and then to all the subjects playing a role in the funding process.

The research focuses mainly on a sub set of RS measures deemed to bring the most fruitful results according the objectives of the analysis. Namely, measures related to users, and infrastructure are taken into account.

In Table 1 are synthesized the characteristics of the approach proposed. For each of the elements of the analysis (resources available, funding scheme and funding scheme evaluation) it is provided the expected output, constituted by qualitative descriptions or quantitative indicators.

Table 1. Characteristics of the funding analysis.

Element	Indicator	Type of indicator
Resources available		
- Resources allocated	- Volume of resources allocated by the National Road Safety Plan	Quantitative indicator
	If available	
	- Volume of resources available for the measures analyzed	Quantitative indicator
Funding scheme		
- Type of measure(s)	Description	Qualitative indicator
- Subjects involved in funding and type of resources	Description	Qualitative indicator
- Type of procedures	Description	Qualitative indicator
Funding scheme evaluation		
- Performance	- Speed of disbursement processing: average days between official resource allocation and liquidation	Quantitative indicator:
- Criticalities	Description	Qualitative indicator

3. Road safety research assessment framework

3.1. Schemes for research

The need for a scientific based approach to road safety management and the importance of training a broad class of road safety professionals is recognized by several studies (Hauer, 2005; Schulze & Koßmann, 2011). A study on the impact of Sweden research on road safety suggests that quality of research is the base of a “Good research circle” (Kolbenstvedt et al. 2007), implying a positive impact on road safety performance.

One of the aims of the study is identifying suitable indicators intended to provide an overview of the quality and performance of road safety research in a country. This was firstly accomplished by quantifying research performance in terms of quality and quantity of road safety research output at country level.

An example of general research assessment framework is provided by the Research Excellence Framework (REF) in UK. REF identifies three elements for assessing the quality of research higher education institutions (REF, 2013): Quality of research outputs; Quality of research environment and Impact of research.

Research output is considered the most important element (REF assigned a weight to each element and the highest weight value is given to research outputs representing 65 per cent in the overall outcome awarded) and it refers to the quantity and quality of patents, articles, reports providing the results of a study and materials (such as manuals, books, textbook, describing knowledge).

Other countries, beyond UK, are adopting an assessment system based on the use of bibliometrics to measure the quality of research outputs of Universities and other research institutions (Guthrie et al. 2013). The number of papers produced by an institute, the number of citations per paper and other similar indicators are widely accepted by the international community. These indicators can be also used to assess the research outputs of a country. For instance, the SCImago Journal & Country Rank (SCImago, 2015) is a portal providing rankings of journals and countries based on scientific indicators developed from the information contained in Scopus® database. However, some limitations to the use of this database exist (Mañana-Rodríguez, 2014); and some issues may arise to assess those multidisciplinary research fields, like road safety, which are outside the categorization of the research adopted in these databases.

Quantity and quality of research can be influenced by the research management and environment. Several studies investigated the factors that can contribute to explaining the success of a research group. Verbree et al. (2011) report among the others:

- Funding availability, the amount and the type of funds (private, public, national, international...)
- Access to knowledge, skills, information, facilities, technology
- Research group size, combination of researchers and supporting staff (disciplines, age, gender...)
- Time spent in teaching and research
- Group management (motivation, communication)
- Network management (international collaboration)

Finally, there is the impact of research, capturing the long-term changes a research brings about. In the case of road safety, research impact includes the reduction or prevention of road accident risk and severity. However, since nowadays no study was able to evaluate the benefits for society of road safety research and a well-controlled study seems to be not feasible (Elvik et al. 2008). So it was decided to not include impact of research in the present framework.

The proposed assessment framework for road safety research is based on management and outputs of research. Research management captures the resources consumed in the implementation of research and the research conditions, while research outputs comprise the goods and services directly produced as a consequence of research.

Moreover, knowledge needs to be transferred to several end-users having the possibility to enhance the country road safety, in particular: decision makers, students, customers and stakeholders. In order to take into account this aspects, research exploitation measures are proposed, reflecting the initial impact of research and the current use and diffusion of road safety knowledge.

3.2. Proposed indicators for road safety research performance

The objective of this study is the assessment research outputs performance at country level. This means that the units of analysis are countries; all data need to be aggregated at the country level. However, it is expected that some information will not be available for most of the examined countries. To catch specific characteristics of road safety research management and organization, a second level of analysis is considered using research organizations as units of analysis.

Table 2. Research management indicators.

Element	Indicator	Scope	Data collection tool
Research management indicators			
- Funding	Average annual road safety research income in last 5 years	Country / Organization level	Survey
	Average percentage of funding from the government sector	Organization level	Survey
- Research portfolio	Average annual number of international project participation	Country / Organization level	Survey
- Staff	Number of Researchers in road safety	Organization level	Survey
	Number of Technicians and equivalent staff		
	Number of Other supporting staff		
Research outputs indicators			
- Productivity (basic research)	Published paper in decade per 1 million inhabitants	Country level / Organization level	Desk analysis
- Productivity (applied research)	Patents in decade per 1 million inhabitants	Country level / Organization level	Desk analysis
- Quality	Citations per paper published	Country level / Organization level	Desk analysis
- Collaboration activity	Research Project participation per 1 million inhabitants	Country level / Organization level	Desk analysis
Research exploitation indicators			
- Evidence based policy-making at national level	Research used for National Plan definition (Dummy variable)	Country level	Survey
	Research used for evaluation of national road safety programs (Dummy variable)		
	Stages of the ladder of knowledge utilisations derived from Bax (2011)	Country / Region / Municipality level	Survey
- Education	Annual PhD students in road safety	Country level / Organization level	Survey
	Number of Universities with dedicated road safety courses		
- Dissemination	Annual number of road safety workshops/lectures for central / local government	Country level / Organization level	Survey
	Relevant law, guidelines or recommendations available on-line (Dummy variable)		

In order to include the identified elements in the proposed assessment framework, two data collection tools have been selected for the evaluation:

- A desk analysis, mostly focused on research outputs performance.
- A survey among relevant stakeholders, aimed at collecting information on the other stages of the research process, with a wide range of characteristics and research activities.

In the following table (Tables 1) the description of the performance indicators proposed for each assessment element, the scope of the indicator and the selected data collection tool are reported.

4. Preliminary assessment of research performance

4.1. Data and Methodology

Data derived from a desk analysis was used to compare research output performance of European countries in terms of Productivity, Quality and Collaboration activity. The following countries were investigated: Austria, Belgium, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

The bibliometric data were retrieved from the SCOPUS international multidisciplinary database, while European research projects information were retrieved from the European Road Safety Observatory website¹. In this preliminary study, the productivity related to applied research (i.e. the number of patents) was not considered.

In SCOPUS database, road safety research related papers were identified searching for the following keywords in paper's name, abstract and key-terms: "traffic accident(s)", "road accident(s)", "road safety", "road crash(es)", "traffic safety". Only papers published in English during the decade 2005-2014 were considered in the analysis. Each paper was assigned to the country of the first researcher. In this way it was possible to calculate the total papers productivity in the investigated countries and the citations per paper for those countries.

For comparison purpose, research productivity and international collaboration activity (i.e. the number of projects) were weighted by population. Population was used as a proxy of the total workforce involved in road safety research in a country. This information is hardly available through a desk analysis and it was included in the survey.

An analysis of the relationship among the three indicators is carried out. Moreover, in order to rank countries according to research outputs performance, a global outputs performance index was developed by standardizing each indicator on the maximum score and then calculating the arithmetic mean of the three standardised indicators for each country.

4.2. Results

A total of 5,036 road safety papers and 49,422 citations was found. This means an average of 9.8 citations per paper.

The analysis of the relationship among the three indicators (Table 2) shows the presence of a positive correlation among the three indicators, i.e. a higher level of productivity corresponds to a higher number of citations per paper or a higher number of EC road safety research projects joined.

The linear correlation is not so strong; the variation is better shown by the scatterplot in Fig. 2.

Switzerland, the country with the best quality of road safety research, is not the country with highest productivity. Countries like Sweden and Norway show the highest productivity of papers. The group of countries corresponding to Serbia, Lithuania, Germany and Estonia shows a good research quality but a quite low productivity with respect to population. The case of Germany is quite strange in relation to the leading position in the automotive sector. This can be explained partly by the absence of papers in the country language and partly by the absence of applied research (i.e. number of patents) in the considered indicators.

¹ http://ec.europa.eu/transport/road_safety/specialist/projects/index_en.htm

Table 3. Correlation coefficient for outputs performance indicators.

	Citations/ Paper	Paper/population	EC RS Projects joined / population
Citations/ Paper	1		
Paper/population	0,427331	1	
EC RS Projects joined / population	0,366779	0,490328	1

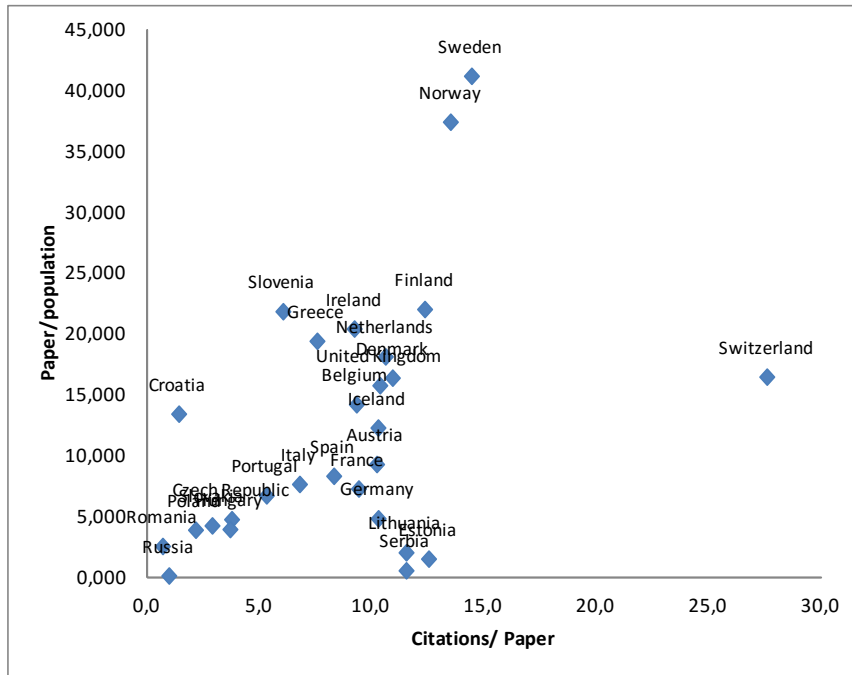


Fig. 1. Distribution of countries according to productivity and quality of road safety research.

Table 4. Ranking of European countries according to road safety research outputs performance.

Position	Country	Research Outputs Performance Index	Position	Country	Research Outputs Performance Index	Position	Country	Research Outputs Performance Index
1	Sweden	0,764	11	United Kingdom	0,316	21	Lithuania	0,205
2	Norway	0,656	12	Iceland	0,272	22	Italy	0,19
3	Switzerland	0,633	13	Czech Republic	0,264	23	Hungary	0,17
4	Finland	0,621	14	Slovenia	0,25	24	Croatia	0,148
5	Belgium	0,561	15	Portugal	0,244	25	Serbia	0,144
6	Austria	0,524	16	Spain	0,244	26	Poland	0,091
7	Netherlands	0,523	17	Slovakia	0,239	27	Romania	0,029
8	Denmark	0,472	18	Estonia	0,237	28	Russia	0,013
9	Greece	0,43	19	France	0,228			
10	Ireland	0,382	20	Germany	0,218			

Assuming that best performing countries are those with the highest performance in all of the three indicators measuring Productivity, Quality and Collaboration activity, the three indicators were standardised on the maximum score for each indicator and then weighted into an aggregate performance index. The ranking is shown in Table 3.

Sweden, Norway and Switzerland occupy the first three positions, followed by Finland, Belgium, Austria and the Netherlands.

The ranking presented constitutes a preliminary result and the second phase of the research (through the questionnaire survey) will allow to check it. Furthermore, the ranking is strictly dependent on the methodology employed and the consideration of publications in national languages as well as the results of applied research is certainly able to modify the positions of the countries analyzed.

5. Conclusion

Based on an analysis of available information and literature results, this study proposes two assessment frameworks to better understand and evaluate performance of two important functions of road safety management at country level: funding and research. Data on funding and research performance helps to inform strategic decisions about funding allocation and activities to enhance road safety research.

For each element of the framework a set of indicators, mostly quantitative, are identified to measure funding and research performance. Some indicators are collected through a desk analysis and some other through a survey.

The paper reports the preliminary results of the desk analysis, in relation to the road safety research issue, aiming at collecting indicators measuring road safety research output performance. The indicators can be used for benchmarking, in order to assess and compare countries performance. In fact, a country can assess the performance of its road safety research units, gauge its contribution to the creation of knowledge and technology and make decisions based on objective, quantitative data.

However the analysis shows some limitations. For instance, due to the multidisciplinary characteristic of road safety, the identification of road safety papers is not easy and it is linked to the selection of keywords to be used in the database queries. Increasing the number of keywords may lead to an increase and/or to a decrease of the papers not related to road safety. These aspects should be studied to improve the bibliometric analysis.

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