EXTERNAL COSTS OF TRANSPORT SYSTEMS: THEORY AND APPLICATIONS

Selected papers

edited by
Umberto Crisalli
Ernesto Cipriani
Gaetano Fusco

Società italiana
dei docenti di trasporti

Collana Trasporti

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Informazioni per il lettore

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Collana trasporti, diretta da Ennio Cascetta e Giovanni Corona

La collana trasporti ha iniziato le pubblicazioni ormai da oltre venti anni (1982), sotto la responsabilità scientifica di due prestigiosi studiosi della disciplina, i Professori Ilio Adorisio e Pier Paolo Sandonnini, che seppero caratterizzare i primi volumi per l'intelligente scelta degli argomenti ed il rigore del metodo seguito.
La responsabilità scientifica della collana è stata poi assunta nel 1992 dal Prof. Ennio Cascetta, uno degli attuali direttori, e dal Prof. Giorgio Salerno, che cessa la collaborazione e al quale vanno i nostri ringraziamenti per l'opera svolta.
Il settore dei trasporti sta attraversando una fase di notevoli cambiamenti, sia a livello internazionale che, ancor più, nel nostro Paese.
La crescita e, soprattutto, le modifiche strutturali della domanda di trasporto, la maggiore attenzione alla sicurezza e all'ambiente, la congestione sistematica di infrastrutture e servizi di trasporto, la flessione dei finanziamenti pubblici disponibili, l'avvio di un mercato concorrenziale dei servizi, lo sviluppo tecnologico dei veicoli e dei sistemi di controllo, l'evoluzione delle riflessioni sulla città e le sue opportunità localizzative, hanno fatto crescere enormemente la complessità dei sistemi di trasporto e dei problemi connessi alla loro progettazione e alla loro gestione.
In tutti questi anni, la collana con le sue pubblicazioni, ha saputo evidenziare alcune delle principali tematiche affrontandole con metodologie innovative e grande rigore scientifico che hanno portato a dei contributi originali per la disciplina e all'approfondimento delle problematiche.
La presenza nel panorama editoriale italiano di questa collana, sulla quale pubblicano abitualmente la Sidt (Società italiana docenti dei trasporti) e il Progetto finalizzato trasporti del Cnr, ha certamente consentito ai diversi autori di trovare un punto di riferimento ed un momento di incontro, pur se va ovviamente attribuito ai singoli il merito per la qualità, l'intelligenza e la validità degli argomenti.
Per il futuro ci auguriamo che questa iniziativa possa essere ancora di aiuto, e forse di stimolo, a tutti quegli studiosi e operatori che vorranno contribuire ad una migliore conoscenza dei trasporti ed alla soluzione dei tanto numerosi problemi del settore.

I direttori

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Preface

*By Agostino Nuzzolo**

In 2010 the city of Rome hosted the annual conference of the Italian Society of Transportation Scholars** (SIDT). The two-days conference was organized by the three Universities of Rome (La Sapienza, Tor Vergata and Roma Tre) to debate on the "External costs of transport systems".

On the first day the conference deepened on institutional and technical speeches related to "A research agenda on road safety" following the well-established SIDT conference format in which SIDT encourages discussion with managers of public administrative offices, institution delegates, local authorities and academics starting from opening contributions of people from different cultural backgrounds and with different points of view.

The second day of the conference was dedicated to the SIDT scientific seminar 2010, which was mainly attended by transport researchers debating on the conference theme.

This book contains a selection of the papers presented during the Scientific Seminar focusing on mathematical models and techniques to investigate the external costs of transport systems, including some case studies.

Selected papers are a part of the research activities of SIDT members contributing to the community debate on transport systems and related topics, such as land-use, economics, environment and energy for a sustainable development.

I wish to thank the editors, the scientific committee, the reviewers and all those involved for their valuable contribution and for the time they spent for the success of the conference.

* SIDT President, "Tor Vergata" University of Rome.

** SIDT gathers all the Italian University Professors and Researchers who study and teach topics of transportation systems.

Introduction

By Ernesto Cipriani[*]*, Umberto Crisalli*[**]*, Gaetano Fusco*[***]

This book contains a selection of the papers presented at the SIDT 2010 scientific seminar entitled "External costs of transport systems: theory and applications", held in Rome in June 2010, and organized by the Universities of Rome "La Sapienza", "Tor Vergata" and "Roma Tre".

This collection of works provides an overview on main advances in the field of the sustainable mobility and focuses on mathematical, technical and economic issues related to the assessment of externalities.

This book is the second edition of SIDT proceedings written in English. Papers have been reviewed according to international journal standards and are here briefly introduced in same order as presented at the scientific seminar.

The first paper, entitled "Benchmarking Italian Road safety Performance", evaluates the European status of road safety focusing on time trends of two indicators, Fatality Rate and Fatality Risk. They have been investigated by Luca Persia, Roberto Gigli and Angelo De Libero employing the Singular Value Decomposition technique. The main aim of the authors is to arrange the Italian location in the SunFlower+6 reference frame in order to verify if our Country is able to carry out road safety policies and programs shared through the European Community.

The paper "Investigating safety issues in two-way rural highways" by Vittorio Astarita, Giuseppe Guido, Frank F. Saccomanno, Alessandro Vitale, Demetrio C. Festa and Vincenzo Giofrè presents a methodology for road safety investigation on two-way rural highways based on performance

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indicators drawn from direct observation of vehicle trajectories extracted by using the software COSMOS suited for video analysis, and compared to vehicle positions and speed profiles from GPS measurements for a sample of vehicles traversing a given road segment.

A methodology for the integration of transportation models with fuel consumption and emission models is the object of the paper “A method for estimating traffic fuel consumption and vehicle emissions: an application to the Community Energy Plan of Salerno”. The authors, Armando Cartenì and Stefano De Luca, apply the proposed method to the city of Salerno for estimating global performance indicators accounting for the effectiveness of different transportation strategies and policies, such as renewal of vehicle fleet, change of modal split and flow density reduction.

Ennio Cascetta and Vincenzo Punzo are the authors of the paper entitled “Impact on vehicle speeds and pollutant emissions of a fully automated section speed control scheme on the Naples urban motorway” which deals with an empirical analysis carried out to investigate the impact of automatic section speed control on individual car travel times and pollutant emissions. The study shows the speed homogenization effect in driving behaviour guaranteed by the automated enforcement scheme on an urban motorway of Naples and highlights the eco-driving principles that are related to the adoption of such a control scheme.

The paper by Antonio Danesi, Marino Lupi, Federico Rupi, Joerg Schweizer, Licia Venturini is entitled “Reducing transport emission costs with Personal Rapid Transit: a case study”. It deals with the variation of external costs of urban transport achieved by the implementation of an innovative automated rail-based public transport, the Personal Rapid Transit (PRT), within the most valuable area in the city of Rimini where a limited traffic zone is adopted.

In the paper “Air quality model validation in urban area: a new approach using wireless pervasive sensor system”, Margaret C. Bell, Fabio Galatioto, Marco Migliore and Stefano S. Ristagno present an innovative inexpensive environmental sensor system called “mote”. Its measurements of pollutant concentrations, once validated against an actual precision system in a real case study of Palermo city, have been used to demonstrate the advantage of an estimation approach based on a combination of traffic flow and pollutant concentration models.

Considering that the application of taxes or charges on noise pollution is largely increasing to compensate negative externalities produced by airport operations, the paper “Airports noise charges and local communities: evaluation and implications on commercial flights” by Nicola Gualandi, Luca Mantecchini and Filippo Paganelli presents a methodology for

assessing the sustainability of the noise level at an airport or with reference to an airline.

The paper “An experimental evaluation of text reading for Variable Message Signs: an Italian case study”, by Gianfranco Fancello, Maria Grazia Carta and Paolo Fadda, describes an experiment based on eye trackers technique for the estimation of time required by drivers for fixing the gaze on the board as well as for realizing text and symbols of Variable Message Signs.

In the paper “Simulating the effects of different Road Pricing policies applied to a medium-sized urban area” by Matteo Ignaccolo, Giuseppe Inturri and Salvatore Caprì the evaluation of different road pricing policies is presented. Authors describe the application to a medium-size actual road network and underline the difficulties arising when such a kind of policies are adopted through simplified schemes.

A methodology for evaluating impacts on transport externalities derived from the introduction of a bike sharing system in the Rome city center is the object of the paper “Analysis of externalities related to the introduction of a bike sharing system in an urban area” by Antonino Tripodi and Luca Persia. Authors describe the results of demand models relative to specific user segments calibrated using a combined stated and revealed preferences survey.

In the paper “The Car Sharing Experience in Rome: why less is more” Sandro Bartolucci, Maria V. Corazza, Roberta Mainella, Antonio Musso and Michele Tozzi propose and elaborate a series of performance indicators in order to assess Car Sharing in Rome from operational and environmental viewpoints.

The paper “The lack of secure parking areas for freight transport in Lazio Region (Italy): identification of externalities” by Sandro Mantovani and Marialisa Nigro highlights the main issues of the current situation of heavy good vehicles parking areas, as derived from the Regional Freight Transport Plan of Lazio Region (2009). In particular, the lack of secure and safe parking areas for HGVs in Lazio region are underlined, the generated externalities are identified and measures to remove this lack are planned.

In the paper “Definition of an operational priority for security of road freight transport in parking areas” by Stefano Carrese, Marialisa Nigro and Stefano Saracchi, authors face again with the problem of heavy good vehicles parking areas and define an operational priority in order to minimize thefts inside freight nodes. Moreover a “willingness to pay for security” behavioral model is developed.

Agostino Nuzzolo, Umberto Crisalli and Antonio Comi are the authors of the paper entitled “Ex-ante assessment of road transport emissions: ap-

plication to the Italian case" which presents the application of a methodology for ex-ante assessment of short and middle term transport policies in terms of environmental sustainability to the Italian context. The methodology, based on a passenger and freight transportation model, has allowed to quantify the impacts due to different infrastructure and services policies implemented at national scale.

The paper "Risk analysis in railway system: an application on hot box detection system" by Giulio Margarita and Francesco Storace proposes a methodology for the assessment of the risk associated to possible accident scenarios combined with their admissibility in terms of frequency and severity, applicable to any railway environment.

The problem of internalization of external costs of freight transport in an industrial district is addressed by Annamaria Tiso, Mauro Dell'Orco and Domenico Sassanelli in their paper "A Coordination and Negotiation methodology as a tool to reduce external transportation costs". Authors propose a fuzzy logic based framework to model an e-community, where firms can exchange information and negotiate real time solutions among them.

In the paper "Definition of a transit service operating plan: the case of a new tramway line in Florence", a procedure for evaluating the performance of a new tramway line in Florence is presented. Results obtained by Massimo Di Gangi, Elia Ferreri and Antonio Pratelli are in accordance with reference intervals proposed by international public transport operators. The encouraging results allow in trusting that the proposed procedure for tram line operations plan analysis is suited for being applied in other similar instances of mass transit service operating plan.

The application of an Input/Output methodology for a comprehensive analysis of energy convenience in the transportation sector is presented by Alessandra Libardo and Dario Trabucco in the paper "A new approach on infrastructural planning: embodied energy as a benchmark of sustainability". Authors apply the proposed approach to the case of high speed rail and air transport systems, evaluating embodied energy connected to transport infrastructures, that is the amount of energy used for the production of materials, building activities, maintenance operations and daily services.

In the paper "Analysis of drivers' behavior in different environments: experiments with a driving simulator" Riccardo Rossi, Massimiliano Gastaldi and Gregorio Gecchele analyze the driver fatigue in a monotonous environment by separating the effect of fatigue from those due to casual factors. Mixed effects models are used by authors to highlight tendencies resulting from data collected with driving simulator in a laboratory environment.

Functionality of a road-rail level crossing intersection is the object of the paper “Analytical and simulation model for car-following flow analysis at level crossings” by Alessandro Baldassarra, Emilio Giannitti and Stefano Impastato. Authors implement both analytical and event-based simulation models for the evaluation of the effect of different level crossing typologies on road user behaviour.

In the last paper of the book, entitled “Emissions and delay minimization on highly congested corridors through traffic signal setting”, Guido Gentile and Daniele Tiddi present a network optimization tool for determining traffic signal settings while minimizing total emissions. To estimate emissions, the Copert IV model is applied, taking as input the results of a macroscopic dynamic traffic flow model based on the General Link Transmission model.

The editors would like to express their gratitude to people who contributed to the organization of the seminar as well as to the publication of the book. Time and effort of the participants, conference secretariat, scientific committee and reviewers have been valuable for the overall success of the seminar.

A special thanks has to be given to Chiara Danesi and Filippo Biasi for their continuous assistance in the organization, and to Livia Mannini for her precious support in the final editing of this book.

1. Benchmarking Italian road safety performance

By Luca Persia[*]*, Roberto Gigli*[**]*, Angelo De Libero*[*]

1. Introduction

Road accidents are very complex phenomena, which comprehension, at different levels, requires adequate data availability and analysis methods. Depending by goals, from identifying single accident causes to valuating national trends and aggregate policies of intervention, we pass from "microscopic" data and valuations (as in the case of in-depth investigation for accident causation analysis), to "macroscopic" analyses, based on aggregate level databases (e.g. CARE) and interpretive and predictive statistical analysis instruments.

In this paper we report the outcomes of a study, which focused on the macroscopic aspects of the phenomenon, that had as goal the comprehension and interpretation of the dynamics of road accidents in Italy during the last years.

The interpretation of the data, traditionally not based on scientific criteria, apart from cases where the results of a determinate policy are easily recognizable (e.g. the introduction in Italy in 2003 of a driving license whit the penalty point system), does not allow to separate the effects of the various factors which jointly affect the phenomenon.

The comprehension of the phenomenon, paying attention to its aggregate characteristics, passes through two fundamental steps. The first one concerns the data availability, referring both to the accident data and to the sizes related to the phenomenon itself, indispensable for its comprehension. The second one concerns the employment of adequate statistical methods for the data interpretation.

The adopted approach is based on the dynamic benchmarking of the

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Italian situation against the other European Countries, carried out during a sufficiently long lapse of time, in order to rate the temporal evolutions.

We referred to a method developed in the programs SUNflower (2002), SUNflower+6 (2005) and SUNflower NEXT/SAFETYNET (2009), in which the safety road problems of different European Countries were analyzed and compared.

The method aims at the comprehension of the existing relationships between the final outcomes of the phenomenon and, by a hierarchical order, its determinants:

- social costs of the road accidents;
- dead and injured;
- road safety performance indicators (use of safety belts, use of the crash helmet, driving under the influence of alcohol and drugs);
- adopted policies and measures;
- socioeconomic and cultural characteristics of the Country.

Preliminary important and expensive work part, in terms of resources, concerned collecting the necessary data for the analyses. Indeed the data of the European Road Safety Observatory were employed, which presented in most cases gaps about our Country. These gaps were filled with a widespread data collection and statistical analysis operation over the unavailable data, that led to have the 83% of the necessary data, for Italy, so as to apply the method (85% is the average data availability for the other considered Countries).

2. Dynamic benchmarking analysis of the Italian road safety condition

2.1 Objectives

The most immediate way to measure a phenomenon extent, as the road accidents, is the direct computation of the so-called final outcomes of the phenomenon, i.e. the deaths, the injured, the accidents themselves or the economic equivalent value of the recorded loss because of the accident. Of course an approach of this kind provides an immediate and absolute idea of the observed phenomenon, but it imposes at least an attentive consideration that gives account of the deficiency of any reference to the structural-dimensional characteristics of the Country, State or community, more generally, that generated the phenomenon.

In other words the way to normalize these measures seems obliged, taking as reference point some of the indicators for risk exposure, most fre-

quently used in the field of road safety; first of all the measures which concur to define the demographic dimensions of a country, the population, and the size of the private mobility system, i.e. the circulating vehicle fleet and the average yearly distance travelled.

In this study attention focuses on time trends of road safety performance indicators belonging to the Final Outcomes Group (according to the SUNFlower+6 nomenclature), which progress along a lapse of time synthetizes the efforts made by each country to actuate policies and programs, that contrast against the diseconomies ingrained in the private motorization.

The aim of this analysis update is, basically, to arrange the "Italy case" in the SunFlower+6 reference frame, to verify if our Country is able to carry out road safety policies and programs shared through the European Community, as the other Countries that already are study subject in SUNFlower+6, and in which way.

For the comparison and interpretation of the accident trends the Singular Value Decomposition (SVD) technique was employed. This technique allows to recognize similarities or dissimilarities between different real situations, through the synthetization of the original series (rates time series) in limited components number, which enclose the characteristics of the starting series.

2.2 Base data and the construction of the indicators

This study required the development of two operations: the update of the databases, in order to extent, through time, the already available time bases, and the research, the collection and the congruity verification of the whole data set related to the Italy case.

Of course, to prepare the working database we referred to the data set, that was already employed within the SUNFlower+6 project, collected from the primary sources, at international level, and from national sources for what concerns the Italian case. Regarding the international sources we referred to the IRTAD database, and CARE Safetynet ERSO database (European Road Safety Observatory); the latter held the so-called RED indicators (Risk Exposure Data), the data related to population and circulating vehicle fleet, employed in this study to develop the indicators.

To collect the Italian data we referred to the data sources at European level, now quoted, but also to the national statistical sources as ISTAT, ACI, CNT (Conto Nazionale dei Trasporti), AISCAT, Association that combines the dealership firms Autostrade e Trafori.

Fig.1 shows the trends of the four basic measurements (deaths, resident population, circulating vehicle fleet, and vehicles per kilometer) in the ten Countries under observation.