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The use of international data on fuel sales and vehicle fleet for the estimation of yearly national traffic volumes

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Abstract

International comparisons are frequently used to assess the road safety performance of a country or to monitor its development over time, at a national or regional level. In most instances either accident or injury risks have to be considered, which results in the need for a quantitative estimation of the amount of travel, namely traffic volumes. Only in special cases may risks be indirectly compared using methods of induced exposure.

The required data on traffic volumes is not always readily available. This is especially true if old data or data from several countries for a long period are to be used, as in comparative time series analysis. Several simplifying assumptions can be adopted to bypass this lack of data but often the estimates resulting from these simple assumptions are not entirely satisfactory.

Between 1996 and 1998 the European Union (EU) sponsored, within the scope of the 4th Research Framework Programme, a COST Action (COST 329) to analyse and establish a common methodological framework for description and analysis of safety developments—past and future—that could also represent the effect of interventions. Researchers from 14 European countries participated in this action. One activity carried out was the development of a method for estimating the traffic volume of countries where such data is not available, using data on vehicle fleet and fuel sales in the studied country and mathematical models fitted to existing data (from other countries) on fuel consumption, vehicle fleet and traffic volume. In the European context, this method is especially useful for some Eastern and Southern European countries.

In this paper the mentioned method is described, the results of its application to Portugal are presented and ways to use it in other countries to estimate their traffic volumes for the period 1980–2000 are described.

Keywords: Road safety; Accident risk; Traffic volume

1. Introduction

Road safety analysis requires adequate data on accidents and casualties (up-to-date, complete, systematic and reliable), on factors expected to influence accident risk and severity (namely road characteristics, vehicle speed or class, driver characteristics or safety devices used) and on conditions that may represent exposure to risk (population, number of vehicles or traffic volume).

International comparisons are frequently used to assess the road safety performance of a country and monitor its development over time, at a national or regional level. In most instances either accident or injury risks have to be considered, which results in the need for a quantitative estimation of exposure; only in special cases may risks be indirectly compared, using methods of induced exposure. Risk assessments are made with some measure of the amount of travel, namely traffic volumes.

Gathering yearly national exposure data for road transport is a complex task, involving the execution of expensive traffic or travel surveys, on a regular and systematic way. In the case of traffic volume estimations, some countries have no national

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system for counting traffic; instead, they use data on fuel sales and estimations of fuel efficiency of the vehicle fleet (when available) to calculate traffic volumes.

For this reason, it is not always the case that the required data on traffic volumes is readily accessible (ETSC, 1999). This is especially true if old data or data from several countries for a long period are needed, as in comparative time series analysis (ETSC, 2003 and EC, 2004).

Sometimes, this lack of data may be bypassed using several types of assumptions. One often used assumption is that exposure (kilometres driven) may be represented directly by fuel sales (tons of fuel), a figure that is assumed to represent fuel consumption; the resulting comparisons involve ratios of accidents or victims per tonnes of fuel. Another often used assumption states that the average distance driven by car or truck equals a certain amount of kilometres per year (for instance 10 000 km per year for cars).

Frequently, the estimates resulting from these simple assumptions are not entirely satisfactory. As an example, the first above mentioned assumption ignores the effect of the increasing trend in energetic efficiency of cars and trucks. This weakness may be a major handicap, since it is well known that current vehicles are more efficient than vehicles produced 10 or 20 years ago.

This situation has justified the interest in an improved (but simple) method for estimating traffic circulation at a national level.

Between 1996 and 1998 the European Union (EU) sponsored, within the scope of the COST program (European Co-operation in the field of Scientific and Technical Research), a COST Action (COST 329) to analyse and establish a common methodological framework for description and analysis of safety developments—past and future—that could also represent the effect of interventions. Researchers from 14 European countries participated in the action (Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, The Netherlands, Norway, Portugal, Spain, Sweden and United Kingdom).

Within the aggregated data working group, one activity carried out was the analysis of the possibility of developing a method for estimating the traffic volume (measured in vehicle × km) of countries where such data is not available, using data on vehicle fleet and fuel consumption in the studied country and mathematical models fitted to existing data (from other countries) on fuel consumption, vehicle fleet and traffic volume. This seemed especially useful for some Eastern and Southern European countries (namely Portugal). A method for such estimates was successfully developed, fitting models to data for the period 1982–1995, and used to produce estimates for Portugal (Cardoso, 1999).

Recently, the National Civil Engineering Laboratory (LNEC) was commissioned by the Portuguese Traffic Directorate (Direcção-Geral de Tráfego) to use the method to update the estimates and to enlarge the estimating period to years 1980–2000 (Cardoso, 2003).

2. Model form

A regression model was fitted to data on traffic volume, gasoline sales, diesel sales, car and truck fleets, from a sample of COST 329 participating countries.

The general form of the model is given by the following equation:

$$\mathrm{TV}_{it} = a_i \times f_t \times (b_{it} \times \mathrm{GAS}_{it} + c_{it} \times \mathrm{DIS}_{it}) \tag{1}$$

where TV_{it} is traffic volume in country i, during year t; a_i is country factor, dependent on vehicle fleet figures for country i; f_t is common trend for the unitary fuel efficiencies b and c; b_{it} is energetic efficiency in gasoline consumption in country i, during year t; c_{it} is energetic efficiency in diesel consumption in country i, during year t; GAS_{it} is gasoline sales in country i, during year t; DIS_{it} is diesel sales in country i, during year t.

Basically, this equation states that gasoline and diesel sold in a country are used in the production of its traffic volume. Additionally, it is assumed that there is a general time trend (f_t) in the yearly average distance travelled per tonnes of fuel sold (the energetic efficiency of fuel consumption), common to all studied countries. Furthermore, in each country, the yearly average distance travelled per tonnes of fuel sold is supposed to be related to a factor specific to that country (a_i). Differences between energetic efficiency of each fuel type in each year and country are represented by specific factors (b and c).

Factor a_i is mainly influenced by overall features of each country, namely the composition of its vehicle fleet, the road network characteristics and the overall rod transport activity. Variable f_t reflects the overall development of fuel consumption efficiency in all reference countries (the ones used for model fitting). Factors b and c are used for uniformization of energetic efficiency of different types of fuel.

It may be assumed that there is a common factor (k_{it}) relating the energetic efficiencies for gasoline (b_{it}) and diesel (c_{it}). Eq. (1) may then be written as:

$$\mathrm{TV}_{it} = a_i \times f_t \times (\mathrm{GAS}_{it} + k_{it}\mathrm{DIS}_{it}) \tag{2}$$

It may be assumed also that this factor (k_{it}) depends on the composition of the vehicle fleet and that a truck consumes four times more fuel than a car.[1] If there is no information on the composition of the car fleet (number of gasoline cars versus number of diesel cars), an estimate of the time series for k_{it} can be made using the following general equation:

$$k_{it} = \frac{k_{\mathrm{truck}} \times \mathrm{truck}_{it} + k_{\mathrm{car}} \times \mathrm{car}_{it}}{\mathrm{truck}_{it} + \mathrm{car}_{it}}$$
$$k_{\mathrm{car}} = 1;\ k_{\mathrm{truck}} = 0.25 \tag{3}$$

[1] This hypothesis is in accordance with French (Jaeger and Lassarre, 1997) and Portuguese data (GEP, 1990).