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Social Norms and Traffic Safety

A cross-country analysis in the EU-15

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Samenvatting

Het doel van dit onderzoek is het bepalen van de determinanten die de verschillen in verkeersveiligheid in een aantal Europese landen verklaren. Hiervoor werd gebruik gemaakt van een panel data regressiemodel met data van 15 Europese landen over de tijdsperiode 1995-2002. De verkeersveiligheidssituatie van een land werd uitgedrukt in het aantal verkeersdoden (30 dagen). Mogelijke verklarende variabelen omvatten ondermeer infrastructurele, transport-, socio-economische en demografische indicatoren. Bovendien werd de impact van sociale normen, uitgedrukt in het corruptieniveau van een land, op de verkeersveiligheid getest.

In het uiteindelijke model werden volgende significante verklarende variabelen weerhouden: de Corruption Perceptions Index (corruptieniveau), Alcoholconsumptie per capita, het Bruto Nationaal Product per capita en het totaal aantal gereden passagierskilometers.

Summary

The objective of this study is to determine the factors which explain for the discrepancies in road safety levels in several European countries. The analysis is based on a panel data regression model which uses data of 15 European countries from 1995 to 2002. The road safety level of a country is expressed as the number of traffic fatalities and infrastructure, transportation, socio-economic, demographic variables were considered as possible variables. Also the possible significance of social norms, expressed by the corruption level of a country, is tested.

The final model includes the Corruption Perceptions Index, Alcohol Consumption per capita, Gross Domestic Product per capita and the Road Traffic Volume in passenger kilometers.

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1. INTRODUCTION

Road transport safety is not equally distributed across Europe. There exists a so-called North-South-Divide in European traffic safety. While Northern European countries have developed and implemented plans and policies that have significantly improved road safety, the South of Europe generally lies below an EU-average.

Although improving road safety is nowadays on top of the Belgian government's agenda, still a lot of work needs to be done. In comparison to Sweden, the Netherlands and the United Kingdom, the traffic safety situation on Belgian roads is extremely poor. The health risk in Belgium, in terms of the number of fatalities per million inhabitants, amounts to 145 in 2001. The best performing countries in Europe account for less then half the road risk in Belgium. In order to make up arrears, the Belgian government has formulated the objective to reduce the number of road fatalities to at least 750 in 2010 (50% reduction compared to the year 2001).

This study concentrates on explaining differences of road safety levels in the European Union (EU-15[1]). The aim is to identify the factors, which determine the cross-country differences, through a panel data regression model. An important angle in this research is the importance of attitudes of European citizens towards road safety policy and legislation.

In a preliminary study by Vereeck and Deben (2003), a significant correlation was found between traffic fatalities and the rule of law in 13 European countries. Although most European countries adopt about the same traffic safety policy, in imitation of the SUN-countries, there are enormous differences in their results (i.e. traffic safety level). From this perspective, the objective of this study is to explain the cross-country differences in the traffic safety level of the EU-15 countries by introducing a variable that explains for the attitude of the national population towards formal laws. The hypothesis states that social norms or national culture are more important than formal laws.

[1] EU-15, i.e. Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

2. TRAFFIC SAFETY

The World Health Day 2004 was principally dedicated to the improvement of global traffic safety. The WHO/World Bank's 'World Report on Road Traffic Injury prevention', presented at this day, highlights the tremendous global burden of mortality caused by traffic crashes. Each year, about 1,2 million people are killed in road crashes and between 20 million to 50 million people are injured on the world's roads. About 90% of all road traffic injury deaths occur in the low- and middle-income countries: 35% in South East Asia, 24% in the Western Pacific, 13% in Africa, 11% in the Americas, 7% in the Eastern Mediterranean Region. The European region accounts for 10% of all road fatalities (WHO, 2004a).

The WHO warns that, without appropriate action, the traffic safety problem will worsen. Road traffic fatalities are predicted to increase by 67% by the year 2020. While in high-income countries a decline of some 30% is forecasted, the trends for the low- and middle-income countries predict a huge escalation in road crash mortality (WHO, 2004a).

In spite of the positive predictions for the European Region, the number of road crashes nowadays is enormous. Each year, an estimated 127 000 people are killed in the WHO European Region (52 countries) and about 2,4 million are injured on European roads (WHO, 2004b). In the countries of the European Union, involvement in road accidents is one of the three leading causes of death and hospitalization for EU inhabitants and it is the leading cause of death for EU citizens under 50 years old (ETSC, 2003). Furthermore, the direct and indirect costs of these road crashes have been estimated at 160 billion euros, i.e. 2% of EU GNP (EC, 2003). Although there has been a regular improvement in traffic safety (since 1970 road traffic safety is improving with a 50% reduction of road fatalities) this situation is still socially unacceptable and difficult to justify to the citizen (EC, 2003).

Since the EU-15 countries are the focus of this study, we will take a closer look at the distribution of traffic safety in the EU. Table 1 gives an overview of the road fatalities in the European countries since 1995.

Table 1: Number of road fatalities in EU-15 – 1995-2002

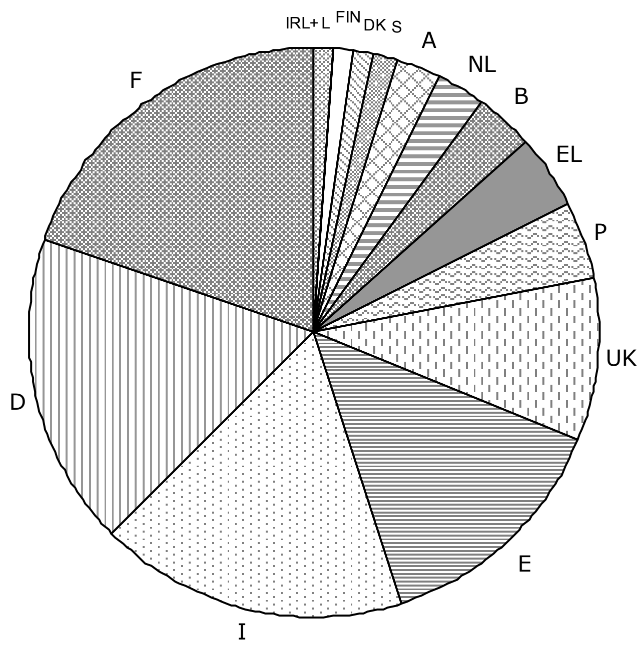
Country	1995	1996	1997	1998	1999	2000	2001	2002	Δ1995/2002	Δ2001/2002
Austria	1210	1027	1105	963	1079	976	958	956	-20,99%	-0,21%
Belgium	1449	1356	1364	1500	1397	1470	1486	1315	-9,25%	-11,51%
Denmark	582	514	489	499	514	498	431	463	-20,45%	7,42%
Finland	441	404	438	400	431	396	433	415	-5,90%	-4,16%
France	8891	8541	8444	8918	8487	8079	8160	7655	-13,90%	-6,19%
Germany	9454	8758	8549	7792	7772	7503	6977	6842	-27,63%	-1,93%
Greece	2411	2157	2105	2182	2116	2037	1880	1654	-31,40%	-12,02%
Ireland	437	453	473	458	414	418	412	376	-13,96%	-8,74%
Italy	7020	6676	6713	6314	6633	6410	6682	6736	-4,05%	0,81%
Luxembourg	70	71	60	57	58	70	69	62	-11,43%	-10,14%
Netherlands	1334	1180	1163	1066	1090	1082	993	987	-26,01%	-0,60%
Portugal	2711	2730	2521	2126	2028	1874	1671	1655	-38,95%	-0,96%
Spain	5749	5482	5604	5957	5738	5777	5516	5347	-6,99%	-3,06%
Sweden	572	537	541	531	580	591	583	560	-2,10%	-3,95%
United Kingdom	3765	3740	3743	3581	3564	3580	3598	3581	-4,89%	-0,47%
EU-15	**46096**	**43626**	**43312**	**42344**	**41901**	**40761**	**39849**	**38604**	**-16,25%**	**-3,12%**

Source: 1995-2001: CARE (EU); 2002: ECMT

In the selected European countries (EU-15) an overall reduction of 16,25% of road deaths is observed. The road fatalities drop from 46096 (1995) to 38604 in 2002. But still every day, at least 108 road users (figures of 2002) die due to traffic accidents in Europe. In order to continue this improvement of traffic safety level in the EU, the European Commission has set some ambitious objectives. The EU has set a target of reducing fatalities by 50% between 2000 and 2010. This means that the number of road fatalities should drop to 20 000 fatalities in 2010. Each year, this corresponds to an average reduction of traffic deaths by 2000. It will only be possible to achieve this target if the EU and his member countries, take additional actions that reduce the risk more rapidly than in the past (EC, 2001).

Figure 1 displays the road fatality distribution in the EU-15. France, Germany, Italy and Spain account for 67,42% of the total of 38 604 road deaths in the EU in 2002. France and the UK have about the same number of inhabitants, but France has about twice the number of fatalities as the UK as its risk is twice as high.

Figure 1: Road fatality distribution in the EU-15 (2002)[2]



Source: Figures ECMT

Obviously the European countries differ in land area, population size, motorization rate, road network length, road traffic volume …. So to compare the road safety situation between countries, it is necessary to relate these figures to another transportation or demographic variable.

There are a number of possible ways to express fatality rates (Elvik and Vaa, 2004). Which rate is used, is often dependent on data availability. The most common is called the 'health risk', that is the number of fatalities per 100 000 inhabitants. This measure expresses the impact of the traffic system on human health. Another commonly used

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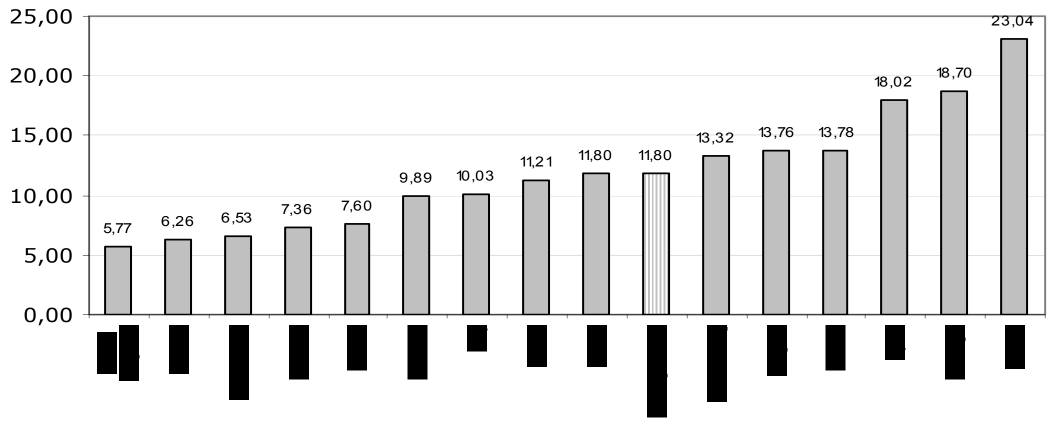
[2] A=Austria; B=Belgium; D=Germany; DK=Denmark; E=Spain; EL=Greece, F=France, FIN=Finland; I=Italy; IRL=Ireland; L=Luxembourg; NL=The Netherlands ; P=Portugal; S=Sweden; UK=United kingdom

rate is referred to as 'traffic risk'. Traffic risk relates the number of traffic deaths to the number of motor vehicles registered in a country. The disadvantage of both rates is that they do not take into account the traffic intensity on the roads, or the usage of the motor vehicles by the inhabitants of a country. In order to solve this drawback, the most proper method is to consider the number of road fatalities in relation to the road traffic volume.

In figure 2 the fatality rates (fatalities per billion passenger kilometers) in the EU-15, are sorted in ascending order. The United Kingdom, Sweden and the Netherlands are by far the safest countries with fatality rates of 5.77, 6.26 and 6.53 respectively. In a Dutch study (SWOV, 2002) these countries are referred to as the 'SUN-countries' (**S**weden, the **U**nited Kingdom, the **N**etherlands). In the last decade their traffic safety policy and the related policy implementation approaches were many times an object of study in order to adopt their best practices.

Figure 2: Number of fatalities per billion passenger km (2001) in EU-15



Source: road fatalities: CARE(EU); passenger km: Eurostat Free Data (EC)

These figures also point out that traffic safety differs significantly among European countries. The highest road fatality risk (Greece) is about 4 times greater than the lowest. With exception of Italy, the Southern EU countries, Luxembourg, Belgium and Austria have fatality risks above the average for the EU-15.

The question is 'which factors explain these significant differences in traffic safety between the EU-15 countries? Throughout a panel data study on the EU-15 countries, this study tries to reveal the determinants of the traffic safety level of a country.

3. Social norms and formal laws

3.1 Traffic Safety Policy and Regulation

3.1.1 Formal laws and their effects

It is generally agreed that there is a multitude of factors having an effect on the road safety level of a country (Bester, 2001). The most obvious among these are driver's speed, motorization rate, the condition of the road infrastructure, the quality and safety level of vehicles … The attitude and behavior of the driver population is often mentioned as the most important factor.

In order to alter unsafe driver's conduct and to make road driver's behavior as predictable as possible, authorities has issued traffic rules to regulate traffic behavior. The idea is everyone drives more safely when these rules are complied with than when they are infringed upon (Elvik and Vaa, 2004).

That traffic legislation has significant positive effects on traffic safety, has been proven by a number of studies. Elvik (2004) estimated the potential safety impact of full compliance with traffic regulations in Norway. The potential effects are measured in reduction of the number of people killed or injured in traffic. Elvik only considered those traffic rules where the respect for the regulations and the effects on the number of accidents are sufficiently well known to allow an estimate. Table 2 gives an overview of Elvik's estimates for Norway. According to these figures, the number of fatalities and injuries could be reduced by 48% and 27% if the most frequent traffic law violations were eliminated. Compliance with speed limitation and proper use of protective equipment (such as seatbelts and safety helmets) generates the largest impact on traffic safety. Although one should be cautious about the accuracy of estimates, due to possible overestimation, it seems clear that better respect for road traffic legislation would improve traffic safety.

Table 2: Potential for reducing the numbers killed and injured in traffic in Norway assuming 100% respect for road traffic legislation

Main group of regulations	Percentage decrease in number (95% confidence interval)	
	Injured	Killed
Speed limits	- 9 (±5)	- 15 (±8)
Use of safety equipment	- 5 (±3)	- 14 (±8)
Drink driving regulations	- 3 (±2)	- 10 (±7)
Other behavior regulations in traffic	- 8 (±6)	- 7 (±5)
Technical requirements for vehicles	- 1 (±1)	- 1 (±1)
Driver requirements	- 1 (±1)	- 1 (±1)
Total potential	**-27 (±18)**	**- 48 (±30)**

Source: Elvik (2004), p.224

Zaidel (2002) refers to a number of other research studies which reveal the same positive effect of full compliance with traffic regulation:

- Elvik (1999): Preliminary similar estimates for Sweden suggest that by eliminating traffic violations, the number of fatalities in Sweden could be reduced by 76% and the number of casualties by 48%.
- Evans (1991) found that the number of fatal injuries in the United States could be reduced by 40% if just drunk driving was abolished.

One can conclude that if these estimates are valid for Norway, Sweden and the United States, it is likely that similar gains could be made in most other motorized countries. The European Transport Safety Council's Enforcement Programme states that if traffic rules were thoroughly enforced, more than 14 000 lives could be saved and 680 000 injuries avoided on the European roads each year (EC, 2004, p.6).

3.1.2 Cross-country comparison of traffic regulation and policy

Table 3 gives an overview of some important aspects of traffic regulation in the European countries. Setting speed limits is of significant importance for increasing road safety. The problem of excess and inappropriate speed is the most common and the most sever road safety problem. While driving speed increases both crash frequency and crash severity increase. Many research studies point out that the potential for reducing fatal injury is substantial (ETSC, 1999). Also driving under the influence of alcohol (or drugs) is regarded as highly dangerous. Drink driving probably increases the risk of road accidents more than any other forms of improper driving behavior (Elvik and Vaa, 2004).The maximum gross vehicle weight is only one aspect of regulation set for commercial transport. Commercial transport, carried out using large, heavy vehicles, can represent a particular risk on the traffic environment (Elvik and Vaa, 2004). It is likely that because of the greater mass of lorries, once an accident occurs, the consequences are more severe.

Table 3: Traffic Rules in the EU-15 countries

Country	Speed limit, cars (in general), km/h			Blood alcohol limit, grams of alcohol in 1 liter of blood	Maximum gross vehicle weight	
	Built-up areas	Outside built-up areas (one lane roads)	Motorways		General, tonnes	Combined transport, tonnes
United Kingdom	48	96	112	0,8	40	44
Sweden	30-50	70	110	0,2	60	60
Netherlands	50	80	120	0,5	50	50
Denmark	50	80	110	0,5	48	48
Finland	50	80-100	120	0,5	60	60
Germany	50	100	-	0,5	40	44
Italy	50	90	130	0,8	44	44
France	50	90	130	0,5	40	44
Ireland	48	96	112	0,8	40	44
Luxembourg	50	90	130	0,8	44	44
Belgium	50	90	120	0,5	44	44
Austria	50	100	130	0,5	40	44
Spain	50	90	120	0,5	40	44
Portugal	50	90-100	120	0,5	40	44
Greece	50	90	120	0,5	40	44

Source: EC(2003b), table 3.1.10

Since the United Kingdom, Sweden and the Netherlands are perceived as the best performing countries in terms of traffic safety performance, their traffic safety regulation is of special interest. As table 2 shows, the setting of traffic rules is approximately the same in all European countries. The speed limit in built-up areas in all the countries is around 50 km/h. On rural roads, outside the built-up areas, speed limits range from 70 to 100 km/h and on motorways a maximum of 130 km/h is allowed. Although Germany has no general speed limit on highways, the recommended speed limit is 130 km/h. As for drinking and driving, there are currently three different limits in use: 2, 5 and 8‰. Accident analysis supports a limit of 5‰ (ETSC, 1999). Experience shows that lowering the blood alcohol limit to 5 has a positive effect on the offence rate as well as on crash injuries. Most European countries under review have set the limit accordingly. Germany and Spain changed the BAC-limit (Blood Alcohol Concentration) from 8‰ to 5‰ in respectively 1998 and 1999. Sweden is the only European country with a BAC-limit of 2‰. The United Kingdom, Italy, Ireland and Luxembourg are the countries with a limit above the European recommendation, i.e. 8‰. Other safety rules, such as mandatory child's seat in vehicles and the use of seat belts, are implemented in all the investigated countries.

A more in-dept analysis of the international comparison of traffic safety policies and regulation is the study conducted by Deben en Vereeck (2003). The starting point of their analysis was the set of traffic safety measures implemented by the so called SUN-countries (i.e. the best practicing countries, Sweden, the United Kingdom and the Netherlands). In earlier research, it was pointed out that these measures were highly effective in means of reducing traffic fatalities and accidents. In their study, a comparison of the following road safety policy issues was made: general policy goals, seat belt usage and child's seats, speed enforcement, alcohol, drugs and financial incentives.

A first conclusion was that although the best performing countries differ in their situational context (for example land area, total network length, total vehicle kilometers, vehicle ownership, inhabitants, infrastructure, motorization rate …) these countries achieve good results by setting a similar package of road safety measures. Furthermore, although Belgian and Dutch road users do function in similar environments and their policy makers have adopted about the same strategy, the related results in terms of traffic safety level defer significant between Belgium and the Netherlands. In fact, although Belgium has implemented the best practices, this does not result in the expected reduction of traffic casualties.

In general, Deben and Vereeck concluded that the traffic safety policies of the investigated European countries approximately are comparable with those of the SUN-countries. It was also pointed out that the demographic and infrastructural setting in a country can only have a minor impact on the effectiveness of road safety measures. This can only mean that the discrepancy in road safety situation between the different European countries should be sought elsewhere. The authors suggest that there are possibly differing national attitudes towards regulation.

3.2 National attitudes and social norms

The previous section established evidence that the authorities of the EU-15 countries approximately adopted the traffic safety policy of the best performing countries. Nevertheless, figures of road fatalities and accidents show that not every government is equally successful in implementing those strategies. The issued traffic laws clearly do not lead to the desired driver behavior. This leads to the conclusion that not the actual traffic regulation is primordial for effective traffic strategies, but that the ability of a population to accept and respect this policy is of overriding importance. If this hypothesis is true, one should find international discrepancies in attitudes and behavior towards traffic regulation and the traffic policy itself.

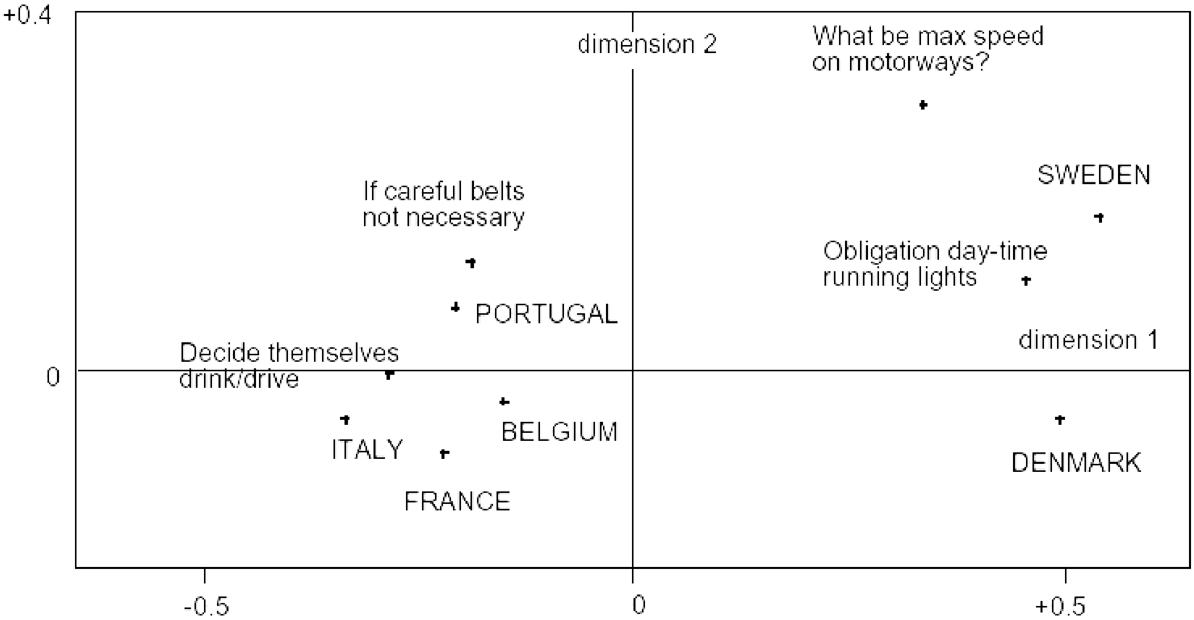
The only large-scale research on differences among European driver attitudes is the SARTRE project (Social Attitudes to Road Traffic Risk in Europe). The main purpose of the SARTRE-studies is to compare the attitudes to road safety of drivers from different countries (SARTRE, 1995). This objective is mainly driven by the planning of a unified European traffic policy and legislation. If nationality is a relevant factor in driver's attitude and behavior, this would necessarily have implications for European traffic policy. The findings of the SARTRE-studies are based on representative surveys carried out in European countries in 1991, 1996 and 2002. Each year, the researchers used identical questionnaires with the same methodological criteria in order to uncover differences and similarities in opinions, attitudes and behavior amongst European drivers. In the next paragraphs, some conclusions concerning differentiated national attitudes and behavior of the SARTRE-studies are presented.

In the first SARTRE-study (SARTRE, 1995), one part was dedicated to the interpretation and description of the dimensions along which European car drivers differ on matters of road safety measures in general and speeding. In order to reduce the complexity of a large set of data, a non-linear canonical correlation analysis (CCA) was used to identify three general dimensions from two sets of variables, i.e. variables indicating nationality (country dummies) and variables indicating driver attitudes, opinions and behavior concerning road safety measures. In CCA, a weighted sum of variables is constructed for each set of variables in such a way that these weighted sums have a maximum correlation with one another. These weighted sums can be seen as dimensions underlying the differences between countries. The correlations between the variables in the analysis and the dimensions (weighted sums) are called canonical loadings. To interpret the results of the CCA, one uses graphical plots (two-dimensional) of these canonical loadings along the obtained dimensions. The general reference point in such a plot is (0,0). If variables lie closely together, this means that there is a close relationship between these variables in the sense that low values on one variable will tend to be associated with low values on the other. In addition, the further the variables are from the origin either in opposite directions or in the same direction, the stronger the relationship between these variables will be.

In the analysis of international differences in opinions on road safety measures, the researchers identified three general dimensions i.e. 'the degree of strictness in matters of traffic safety', 'the economic prosperity of the countries' and 'preferences of speed limits in towns and on main roads'. Especially the first dimension is of interest, since this dimension reveals the more general attitude towards traffic safety.

Figure 3 plots the main opposing countries and questions along the first dimension 'degree of strictness' in matters of road safety. Throughout this dimension two general clusters can be identified: at one side a cluster of countries (Sweden and Denmark) with a stricter attitude on traffic safety and on the other side a group of countries (Belgium, Italy, France, Portugal) with a less strict attitude.

Figure 3: International differences in opinions on road safety measures. A plot of the first dimension 'degree of strictness in matters of traffic safety'



Source: SARTRE (1995), In-depth analysis, p.40

This first dimension clearly shows a so-called 'North-South-divide'. The 'Scandinavian' countries prefer lower maximum speeds on motorways, advocate day-time use of vehicle lights and are strict in matters of drinking and driving, as well as the wearing of seat belts. The more 'Mediterranean' countries have relatively less strict attitudes towards the mandatory use of seat belts and drinking and driving. Furthermore, these countries are not in favor of making the use of vehicle lights during day-time compulsory. The 'degree of strictness' also illustrates that there are differences between countries in beliefs about government intervention and individual responsibility. The citizens of the Mediterranean countries postulate more individual freedom in traffic conduct and are less in favor of state interference.

Since the canonical loadings are based on correlations of re-scaled variables, the interpretation of the magnitude of the differences between countries is less straightforward. The figures in table 4 indicate the extent of the differences between the various questions and countries positioned along the first dimension.

Table 4: Percentage of respondents agreeing with different measures

Country	Obligation to use lights daytime	Decide self drink/drive	If careful belts not necessary	Maximum speed limit on motorways in km/h	
	In favor	Strong agree	Agree	110	140-150
Sweden	91%	2%	4%	47%	2%
Denmark	86%	2%	14%	17%	4%
France	14%	30%	21%	6%	31%
Italy	13%	27%	31%	7%	30%
Portugal	23%	27%	27%	4%	23%

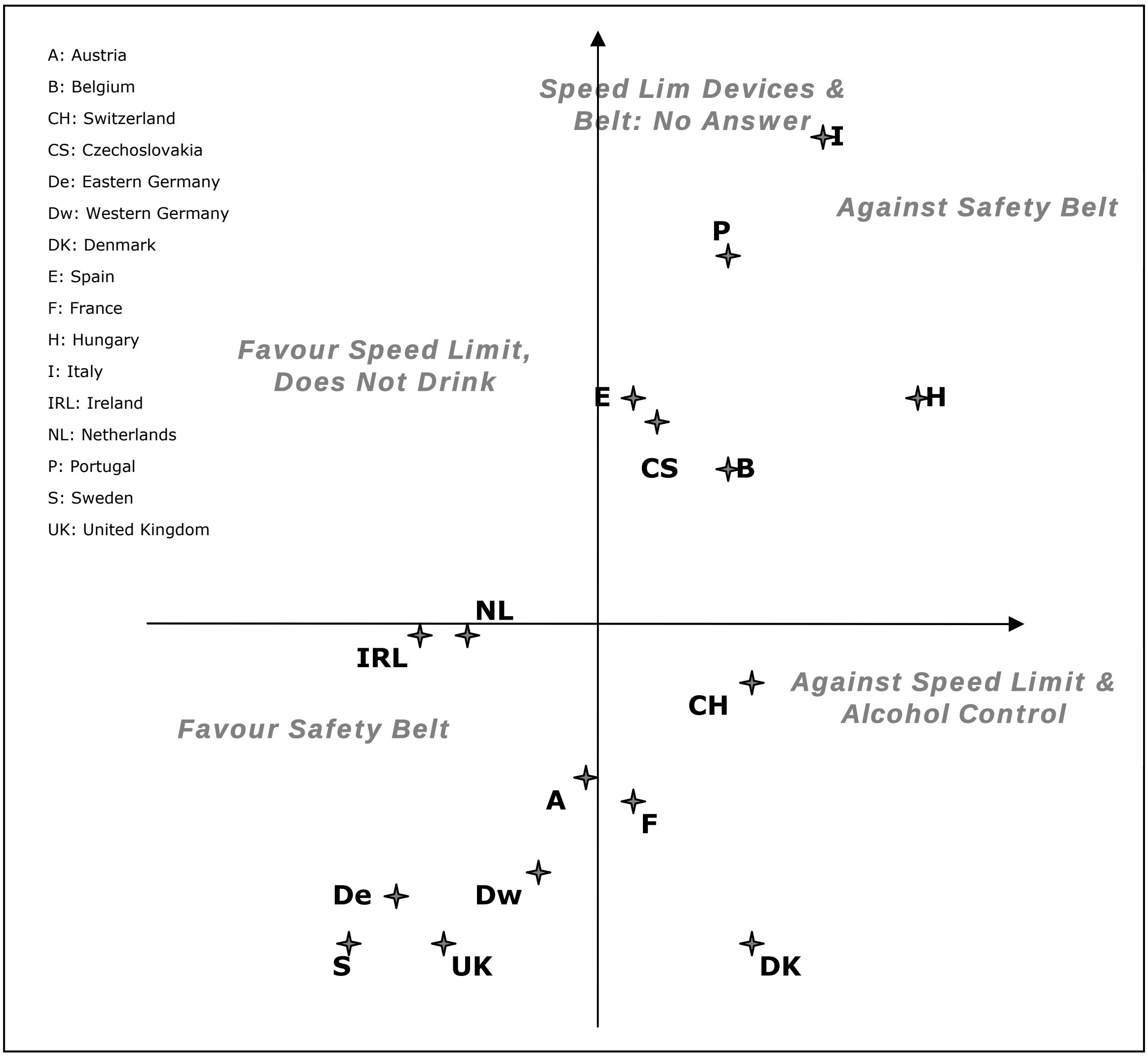
Source: SARTRE (1995), In-depth analysis, p.41

A close correlation is also observed between public opinion and attitudes and existing official legislation (SARTRE, 1995). This link is established in two-ways. First, one can assume that national social climate or social norms influence the political acceptance and implementation of traffic safety measures. Second, it is clear that public experience with the rule of law creates more or less support against new measures. One can suppose that the regulation in a country is both a cause and effect of the national 'moral climate' or social norms.

While the 'degree of strictness' revealed differing national attitudes towards traffic safety measures as a whole, also the opinions of three basic traffic laws was investigated: i.e. speed, alcohol and seat-belt. Again researchers found notable disparities between countries (figure 4).

On the matter of opinions and behavior related to wearing seat belts, the most favorable countries are Sweden, United Kingdom, Germany, Denmark, France, Austria, Ireland and the Netherlands. The inhabitants of Italy, Belgium, Portugal, Hungary and Czechoslovakia are definitely opposed to the mandatory use of seat belts. In case of alcohol and speed measures, the oppositions are less marked among European countries. The Irish and Dutch drivers appear to be most in favor of speed and drunk-driving regulations, and Danish, Swiss and Hungarian drivers less.

Figure 4: Countries and the links between opinions on the three measures



Source: SARTRE (1995), In-depth analysis, p.72.

In the SARTRE-study (SARTRE, 1995), also an interesting relation between religion and attitudes towards legislation was found. Although this analysis was not conducted at the national level, this also could explain some national differences. The researchers found that the degree of religiousness correlates with positions about speed and alcohol. The more religious drivers are, the more they approve of the speed measures and the more they comply with alcohol measures. Furthermore, it was found that there were distinct opinions between drivers of Catholic and Protestant obedience. Catholics generally oppose seat belts, whereas Protestants are in favor of this measure. This finding is in line with the European distribution of religious beliefs. Protestants are believed to be stricter and the adherence of the protestant or Reform Churches is common in the Northern European countries.

The results of the second SARTRE-study (SARTRE, 1998) confirm the results of the first one. Again European patterns of opinion differences were found along a North-South line. These differences are caused by general societal norms regarding drinking of alcohol and personal autonomy. The Northern EU-countries tend to completely reject any personal freedom in drinking and driving; a higher proportion of drivers do drink, but these drivers more often than others make efforts not to drive after drinking. Furthermore, the inhabitants of these countries are more in favor of wearing seat belts and are more obedient towards speed limits. On the contrary, the Southern countries are far more lenient in regard to personal freedom. These countries are less in favor of wearing seat belts and although there are fewer drivers who drink, these drivers adapt their driving behavior less often to their drinking habits.

The researchers Golias and Karlaftis (2002) also used the data of the second SARTRE-questionnaire to compare the self-reported driver behavior (not attitudes) of European drivers. The objective of this study was to determine whether regional differences in driving behaviors exist. On the one hand, their findings suggest that international differences in self-reported behavior toward speeding and general reckless driving do not appear significant. On the other hand, the analyses of self-reported behavior of Europeans towards seat belt use and driving under influence reveal important regional disparities. Northern European drivers report a significantly higher compliance with drinking and driving laws and seat belt use regulations than do Southern and Eastern European drivers.

Naturally, the dynamics of international differences or similarities is far more complex than illustrated here, but that was not the focus of this study. The data analyses of the SARTRE-questionnaires prove that the attitudes and behavior of drivers in each country have a common part and a typical part due to nationality and the social norms of a country. In one respect, drivers of European countries show similarities (for example demographic and socio-economic factors) in relation to risk-taking behavior. But on the other hand, the analyses prove that nationality partly explains for differing attitudes and behavior amongst European countries. On the societal level, inhabitants of a country show less or more support and respect for public regulation. The mental frame for these opinions and attitudes probably derives from more general societal norms. The factors contributing to these social norms lie in history, culture, political and law experience, mentality …

Following this line of reasoning, a panel data model for explaining the variance of traffic fatalities, introduced in this study, should also contain a variable which indicate for characteristics of nationality and social acceptance of rules by the country's inhabitants.

4. THE FRAMEWORK AND VARIABLES

4.1 A macroscopic model

To determine which factors influence a country's traffic safety situation, a macro model will be used. In general, the form of a macroscopic model can be written as Y = F(X) where Y is the dependent variable and X is the vector of explanatory variables (Van den Bossche and Wets, 2003). The explanatory variables on society level generally give clues about the signification and the nature of the relation with the dependent variable. In section 4.3 potential explanatory variables will be discussed.

4.2 Road safety data and the dependent variable

National traffic safety can be expressed in a number of ways: the number of fatalities, the number of accidents, the number of casualties (i.e. the number of accidents with fatalities), the number of injury accidents, the number of hospitalizations from a crash … Which indicator you choose, mostly depends on the objective of the study. In the case of cross-country analysis, the researcher must be aware of differing definitions of road accident data.

A special report of the IRTAD (1998), in cooperation with the OECD's Road Transport Research Programme, contains update information on national definitions and comparability of data on roads, traffic and accidents. According to IRTAD, international comparisons of road safety situations between countries are not very reliable because of different standards and levels of accident registration. It is well known that accident data are not a trustworthy source, due to underreporting. Only statistics about road fatalities are homogenous with the use of the international definition (fatality = a killed person within 30 days) and are reliable by means of reporting. From this point of view, the most appropriate indicator for a country's traffic safety situation in this study would be the number of road deaths.

In a macroscopic model, the dependent variable can be described in terms of a number or as a rate. By dividing the number of fatalities by another transportation or demographic variable, this rate expresses the probability of being killed in a road crash. Examples of such rates are fatalities per capita, per km of road, per vehicle or passenger car, per vehicle-km. It is better to retain the raw number of fatalities, instead of a fatality rate, if some explanatory variables include the denominator of the fatality rate. For example, it is not recommended to model fatality rates per distance traveled if exposure is an explanatory variable because of spurious correlation and not a real relation between the two variables.

Due to the above discussion of data comparability and rating and also to data availability, the absolute number of fatalities is selected as the most appropriate dependent variable to be included in the model.

4.3 Explanatory variables

4.3.1 Literature

Road accidents, and thus road fatalities, occur as a result of a potentially very large number of (causal) factors (OECD, 1997). In the literature there is a wide range of variables included in accident models (Fridstrøm and Ingebrigtsen, 1991; Page, 2001; Beenstock and Gafni, 2000; Zlatoper, 1987; Hakkert and Braimaister, 2002; Partyka, 1983 and 1987; Wagenaar, 1983; Wintemute, 1985; Bester, 2001; Scuffham and Langley, 2002; Gaudry and Lassarre, 2000; Elvik and Vaa, 2004). Table 5 lists some broad categories of possible explanatory variables, i.e. exposure, vehicle fleet characteristics, road network characteristics, social and economic factors, population characteristics, safety policy, road user characteristics and weather conditions. Obviously, this is not a comprehensive list and some variables could fit in several categories.

Table 5: Possible explanatory variables for road fatalities

Nature of Variable	**Variables**
Exposure	Fuel sales; Traffic Volume (in km, pkm or tkm) by road classes, road users, mode of transport; population; total number of vehicles; number of passenger cars; level of vehicle ownership; number of hours spent in traffic;
Vehicle Fleet Characteristics	Number of registered vehicles; Composition of the Vehicle Fleet (passenger cars light commercial vehicles, trucks, buses, …); New driver's licenses; distribution of vehicles by age; average age of the Vehicle Fleet; Technical controls at Vehicle Inspectorate; Airbag equipment rates;
Road Network Characteristics	Total length of the road network; Road Network Density (km/m² of land area); Distribution of lengths by road classes (motorways, rural roads, urban roads, …); Condition of Infrastructure; total expenditure in roads engineering; total expenditure in road investments; maintenance expenditure per km road;
Social and Economic Factors	Gross Domestic Product per capita; Households income; Households final private consumption; Consumption prices; Fuel prices; Industrial production; unemployment rate; active population; urban population; education level; criminal level; suicides; accident costs; medical services;
Population Characteristics	Population size; Population density; Composition of the population; proportion of population by age classes and gender:
Traffic regulation; enforcement and safety policy	Speed limits; Seatbelt wearing laws; driving blood/breath alcohol limits; minimum age for driving; Motor vehicle safety standards; number of convictions for drinking and driving; number of convictions for other road traffic offenses; Total expenditure in road safety actions; Total expenditure in road police; publicity safety campaigns;
Road User Characteristics	Seatbelt wearing rates; Helmet wearing rates; Average driving speed; alcohol consumption per capita; alcohol sales;
Meteorology	Levels of snow and rain; minutes of daylight; temperature; ice;

4.3.2 Selected explanatory variables

The aim is to identify the most influential variables for a better understanding of causes of fatalities between countries. As in most areas of the social sciences, there is no established economic theory indicating which explanatory variables should appear in a causal model of fatal crashes (Scuffham and Langley, 2002). Often some interesting variables, which explain for a lot of variation in the dependent variable, are unquantifiable or have not been measured. For example, design and maintenance of roads are not negligible in the accident process, but there is a lack of variables linked directly with this road condition. Often statisticians try to avoid this drawback by using some kind of proxy, i.e. a variable that gives an indirect indication of the unquantifiable factor. For example, it is impossible to measure exactly the percentage of road users who drink and drive, but we can use alcohol consumption as an indicator for the drinking habits of a country’s inhabitants.

In the next paragraphs, a selection of possible explanatory variables is examined. The selection is based on both literature and data availability. Also the expected causal relationship between the dependent variable, i.e. the number of fatalities, and the explanatory variables will be explained by means of earlier research on traffic fatalities and accidents.

a. Exposure

It is paramount to include some measure of exposure, as this is likely to be the single most important determinant of any accident toll (OECD, 1997). In most accident models, exposure plays a key role among explanatory factors (Elvik and Vaa, 2004; Noland and Quddus, 2004; Scuffham and Langley, 2002; Bester, 2001; Page, 2001; Van den Bossche and Wets, 2003; Hakkert and Braimaister, 2002; Gaudry and Lassarre, 2000; …). In these models, exposure is described in several different ways such as passenger car ownership, total vehicle stock, traffic volume in vehicle kilometers or ton-kilometers … Even total population size, population density and employment measures are considered as indication for exposure.

In this study, two measures of exposure will be used. Firstly, the exposure of passenger cars in terms of distance traveled (passenger kilometers) is considered. This indicator will be expressed either as raw numbers or as a rate with population size as denominator (p-kms/capita). Secondly, the effect of commercial transport is also included. It is well known and documented that lorries are involved in a considerable percentage of fatal accidents in most countries (Hakkert and Braimaister, 2002). It is likely that because of their greater mass, once an accident occurs, the outcome will be more severe. In addition, one expects that lorries drive a much greater distance per year compared with other types of vehicles. In the presented model, national haulage, expressed in ton-kilometers, serves as indicator for exposure of commercial transport. In this study, national haulage is understood to mean the commercial transport on national territory by national or international lorries. Again, either raw numbers or national haulage per km of road will be used.

b. Alcohol consumption

Driving under the influence of alcohol has a strong and direct relationship with the incidence of road accidents resulting in death or severe injury (ETSC, 2001). Therefore, alcohol consumption per capita (pure liters of alcohol per population aged 15+) is used as a potential explanatory variable. The expected effect of an increase in the consumption of alcohol is an increase of road fatalities. Although this variable can be questioned (i.e. alcohol consumption does not reveal real drinking habits), a number of studies used this indicator (for example Page (2001), Zlatoper (1987)).

c. Economic factors

Kopits and Cropper (2005) examined the relationship between traffic fatality risk and economic growth. Initially, the growth of motor vehicles accompanied with increasing economic conditions brings an increase of road traffic accidents. Today, this is the case in developing countries. But at higher income levels, however, economic factors tend to be negatively related to road deaths. As income increases, levels of vehicle safety may increase and, consequently, the number of accidents may decrease. Also government road expenditures may increase resulting in better transport infrastructure (Scuffham and Langley, 2002; Bester, 2001). In this study Gross Domestic Product (GDP) per capita is used as a proxy for income.

Another possible explanatory variable reflecting economic conditions is the unemployment rate. However, the effect of unemployment is rather ambiguous. Research studies reveal opposing effects. Wagenaar (1983) hypothesized the causes of these two types of effects. On the one hand, high rates of unemployment would lead to less motor vehicle travel and so decreasing exposure to a crash. On the other hand, high unemployment could lead to higher levels of mental stress in the population. This may cause more aggressive driving patterns and a consequence may be increased crash rates. Which effect dominates is a matter for empirical testing.

d. <u>Population</u>

Young drivers between 15 and 24 are typically over-represented in fatality figures. Youngsters are considered as high-risk group for several reasons: insufficient experience of driving, a greater appetite for risk and an attitude which is less respectful of the traffic rules (EC, 2003). Especially car accidents in the weekend have become the main cause of death of young people. Because of fatigue, the use of drugs … accident risk increases during the weekends. So, the higher the proportion of young people in the population, the higher the number of road accident fatalities (Elvik and Vaa, 2004). Therefore, the percentage of youngsters aged 15-25 as a share of total population will be included in the model.

A second possible variable is the proportion of population who lives in urban areas. Driving on rural roads increases the probability of death given an accident (Zlatoper, 1987). Due to lower speed limits urban crashes are often less severe. The urban population concentration expresses the urban trips and consequently the probability of having a more or less severe road accident (Page, 2000). According to these reasoning, if a high proportion of the population lives in urban areas, there are fewer accident fatalities that there would otherwise.

e. <u>Social norms – the Corruption Perceptions Index</u>

Section 3 (Social Norms and Formal Laws) revealed that the success of a governments safety policy is not dependent on the implementation of good policy rules alone. Citizens' acceptance and respect for traffic regulation and governance as whole, is primordial. Furthermore, analyses of self-reported behavior and attitude towards road safety measures tend to differ amongst European countries. In this respect, the macro model should contain some variable which gives an indication of the law-abiding attitude and behavior of a country's population.

Following the hypothesis of Vereeck and Deben (2003), the Corruption Perceptions Index (CPI) of Transparency International will be used as a proxy for the general attitudes and social norms of citizens towards regulation. The goal of the CPI is to provide extensive perceptions of corruption within countries (Lambsdorff, 2003). These perceptions enhance the understanding of real levels of corruption from one country to another. The CPI is a composite index which makes use of surveys of businesspeople and assessments by country analysts. It consists of credible sources (for example Freedom House Nations in Transit, the Opacity Index of PricewaterhouseCoopers, The World Bank …) using diverse sampling frames and different methodologies. All sources use a homogeneous definition of 'levels of corruption' such as the misuse of public power for private benefit. The yearly CPI-score of a country ranges between 10 (highly clean) and 0 (highly corrupt).

But what is the logic behind the relation between corruption and law-abiding attitude and behavior of a country's population? Vereeck and Deben (2003) explain this relation as follows: The corruption level of a country gives an indication of the tolerance of the population towards evasion of rules, i.e. the extent of general acceptance of violation of legislation. In a country with high corruption levels, it is assumed that the citizens are more inclined to violate the rules themselves and this behavior will endanger the traffic safety environment. On the other hand, in countries with little corruption law-infringing behavior is less tolerated. Social mechanisms or norms pressure the citizens to rather stick to the rules.

The correlations between the CPI-index and the traffic safety level of a country reinforce this line of reasoning. Correlations between the CPI-index and the number of fatalities per 100 000 population were computed over the period 1995-2002 and these figures show a consistent and significant negative relation between corruption and traffic safety. In other words, the best performing countries are those countries where corruption figures are low. Furthermore, the countries where corruption figures are high have poor results in terms of traffic safety.

4.4 A statistical model

4.4.1 A panel data regression model

To explain for cross-country differences in fatalities, a panel data regression model will be estimated. A panel or pooled regression analysis combines time series with cross-sections. The general form of a multiple linear panel regression model is as follows:

$$\mathrm{Y}_{it} = \beta_0 + \sum_{k=1}^{K} \beta_k \mathrm{X}_{itk} + u_{it} \qquad i = 1,\ldots,\mathrm{N}; \quad t = 1,\ldots,\mathrm{T} \tag{1}$$

with Y = dependent variable

X = independent variable

β = estimates of the model (intercept and slope coefficients)

N = number of cross sections

T = length of time series for each cross section

K = number of independent or explanatory variables

u = error term

Panel data can enrich empirical analysis in ways that may not be possible if we use only cross-section or time series data (Gujarati, 2003). For example, limited number of spatial units and limited number of available data over time lead data sets to violate basic assumption of standard statistical analysis if regressions of time series or cross section are used. In case of panel data, N x T observations are investigated. Overall, by combining time series of cross-section observations, panel data give more informative data, more variability, less collinearity among variables, more degrees of freedom and more efficiency (Gujarati, 2003).

In particular, equation (1) will be estimated using data for 15 European countries over the period 1995-2002. Data for these countries were mainly retrieved from European publications or databases: Data on road fatalities were provided by the CARE-database (Community Road Accident Database of the European Commission) and publications of the European Conference of Ministers of Transport. The on-line Eurostat-database

(European Union in figures) of the European Commission was the source for the demographic variables and road network information. The European Regional Office of the Word Health Organization provided figures on urban population (Health for All Database) and alcohol consumption (Alcohol Database). The sources for GDP per capita and unemployment rate were OECD (National Accounts) and the AMECO-database (Annual Macro-ECOnomic database). The CPI-indexes were provided by Transparency International. Missing data were completed by several sources such as the statistical pocketbook 'Energy & Transport in figures' of the European Commission and the OECD's 'Environmental Data Compendium 2002 – Transport'. Descriptive statistics of variables used are reported in table 6.

Table 6: Summary sample statistics – 120 observations (NXT)

Variables	**Mean (X)**	**Standard Deviation (S)**	**Minimum**	**Maximum**	**S/X**
fatalities	2 678.79	2 852.59	57	9 454	1.06
CPI	7.5489286	1.6863855	2.99	10.00	0.22
Population	23 703 079.26	25 514 352.19	409 700.00	82 349 925.00	1.08
Share of youngsters (%)	13.0850917	1.7237014	11.0157301	17.5884990	0.13
% urban population	76.3375000	12.5216218	56.0000000	97.4000000	0.16
Alcohol consumption (in l per capita)	9.3041071	2.3446014	4.2000000	15.5000000	0.25
GDP per capita (at price levels and PPP's of 2000 in US dollars)	24 814.10	6 584.58	13 932.54	48 783.91	0.27
Unemployment rate %	7.7107143	3.6680838	2.1000000	18.8000000	0.48
Road Traffic Volume (RTV) pkm	230 865 258 929	260 997 931 265	4 700 000 000	745 200 000 000	1.13
Road Traffic Volume (RTV) pkm per capita	9 522.41	1 651.53	5 623.80	12 292.36	0.17
Road Vehicle Stock of passenger cars (RVS p) (in million)	10.8562614	12.9430940	0.2290000	44.3830000	1.19
Road Vehicle Stock of passenger cars (RVS p) per 1 000 inhabitants	419.6539237	88.4010156	210.9045335	624.0254102	0.21
National Haulage in tkm	80 431 892 857	98 247 192 022	1 873 000 000	353 000 000 000	1.22
National in tkm per km of motorway	32 990 898.63	23 629 769.73	8 746 232.67	129 027 523	0.72
Road Network Length of Motorways	3 108.41	3 604.05	72	11 786	1.16

4.4.2 Preliminary tests

Collinearity

High levels of correlation within the explanatory variables violate the assumption of independence that is built in the theory of regression analysis. Collinearity occurs when two or more independent variables move up and down more or less together throughout the data sample (OECD, 1997). In such case, it is impossible to separate the influence of that particular variable from that of the others. Highly correlated variables will lead to biased coefficient estimation and unexpected coefficient signs (Van den Bossche and Wets, 2003).

A remedial measure to reduce the problem of multicollinearity is to simply drop one or several collinear predictor variables from the model. But in omitting a variable from the model, one should be cautious about the problem of specification bias or specification error (Gujarati, 2003). Specification bias arises when the model used in the analysis is incorrectly specified. If literature indicates the relevance of a variable for a regression model, one should be careful in dropping this variable due to multicollinearity. In case of accident models, a measure of traffic exposure is essential and will not be omitted from the model.

Therefore a correlation analysis is performed on the possible explanatory variables. First a collinearity analysis using Pearson's correlation coefficients is conducted. Variables with strong correlations (Rho > 0,6) will be omitted from the model. The following variables were investigated: the CPI-index, proportion of youngsters (15-24 years old), total population size, share of urban population, alcohol consumption per capita, GDP per capita, unemployment rate, road traffic volume in passenger kilometers (RTV pkm), RTV pkm per km motorway, RTV pkm per capita, road vehicle stock of passenger cars (RVS p), RVS p per capita, national haulage and national haulage per km motorway.

This first correlation analysis shows a number of variables correlating with each other. The total population size correlated strongly with other explanatory variables, e.g. RTV pkm (Rho = 0.98118), RVS p (Rho = 0.99129), national haulage in tkm (Rho =

0.97181). Consequentially, this variable will be omitted. Furthermore, the combination RTV pkm (or RVS p) and national haulage (raw figures) should be excluded from the model due to high correlation coefficients (Rho = 0.96940). Instead the rate combination RTV pkm (RVS p) per capita and national haulage per km motorway can be used.

Subsequently, an analysis of multicollinearity is conducted on the remaining variables. Unfortunately, there are no collinearity diagnostics available in the SAS-procedure for estimating data panel models. As an alternative the COLLIN option of the REG (regression) procedure in SAS is used. For each variable, the REG procedure produces the proportion of the variance of the estimate accounted for each principal component. A collinearity problem occurs when a component with a high condition index contributes strongly (variance proportion greater than about 0,6) to the variance of two or more variables. The conducted analysis points out that there are probable multicollinearity problems with the variable 'proportion of youngsters' (variance proportion = 0,76617). When this variable was left out, the diagnostics did not indicate multicollinearity problems anymore.

As a result of collinearity occurrence , the explanatory variables which can be included in the model are: the CPI-index, share of urban population, alcohol consumption per capita, GDP per capita, unemployment rate, road traffic volume in passenger kilometers per capita (or passenger cars per capita) and national haulage per km motorway.

Structure of the error term

The TSCREG (Time Series Cross Section REGression) procedure of SAS software will be used to run the regression analysis (SAS Institute Inc., 2004). SAS provides several estimating methods dependent on the structure of the error term: one and two-way fixed and random effects models based on OLS (Ordinary Least Squares) estimates; models with GLS-type estimators (Generally Least Squares), i.e. Fuller and Battese method (variance component model), Da Silva method (mixed variance component moving-average model) and the Parks method (autoregressive model).

So before actual regression analysis of panel data can be conducted, one should first check if the assumptions of the OLS estimates are not violated. Particularly, problems of heteroscedasticity (unequal variance of the error term) and autocorrelation (if the disturbance to any observation is influenced by the disturbance term to any other observation) are investigated because using the OLS procedure and pooled data tend to generate these drawbacks (Podestà 2002). Again the TSCREG procedure of SAS does not provide diagnostic tests on those violations, nor provide output of the predicted and residual observations. Therefore, a first regression analysis is conducted by the MIXED procedure to estimate a similar panel data model. The MIXED procedure estimates a broad class of linear mixed models, which includes some panel data models. The regression analysis is done on the assumption that there is no heteroscedasticity or autocorrelation and then a postmortem examination on the residuals is conducted.

To detect heteroscedasticity, residuals squared $\hat{u}_i^2$ are plotted against Y_i and the explanatory variables to see if they exhibit any systematic pattern. As expected throughout literature, i.e. error terms of cross-sectional data tend to be heteroscedastic, the plots show patterns differing with patterns associated with homoscedasticy (equal variance). Further, the residuals $\hat{u}_t$ were plotted against $\hat{u}_{t-1}$ to detect autocorrelation. The plots suggest that there is positive correlation in the residuals indicating first-order positive autocorrelation.

4.4.3 Model procedure

Due to the above discussion of violation of OLS-assumptions and literature review on problems with panel data (Podestà, 2002), the presence of heteroscedasticy and autocorrelation of the panel data is assumed. SAS uses the Parks (1967) method which is based on less restrictive assumptions concerning the behavior of the regression disturbance than the classical regression model (Podestà, 2002). The Parks-method combines the assumptions concerning serial correlation, contemporaneous correlation and panel heteroscedasticity. The random errors u_{it} have the following structure:

$\mathrm{E}(u^2{}_{it}) = \sigma_{ii}$ (heteroscedasticity)

$\mathrm{E}(u_{it} u_{jt}) = \sigma_{ij}$ (contemporaneously correlated)

$u_{it} = \rho_i u_{i,t-1} + \varepsilon_{it}$ (autoregression)

where

$$E(\varepsilon_{it}) = 0$$

$$E(u_{i,t-1}\varepsilon_{jt}) = 0$$

$$E(\varepsilon_{it}\varepsilon_{jt}) = \phi_{ij}$$

$$E(\varepsilon_{it}\varepsilon_{js}) = 0 \qquad (s \neq t)$$

$$E(u_{i0}) = 0$$

$$E(u_{i0}u_{j0}) = \sigma_{ij} = \phi_{ij} /(1 - \rho_i \rho_j)$$

The model assumed is first-order autoregressive with contemporaneous correlation between cross sections. The Parks methodology has an important limitation, i.e. the number of explanatory variables can be no larger than the number of time-series observations. This limitation can be solved by imposing more structure on the variance and covariance parameters in the model, but this could not be implemented with the TSCREG procedure.

4.4.4 Estimated model

Following previous literature (Page, 2001; Beenstock and Gafni, 2000; Zlatoper, 1987; Fridstrøm and Ingebrigtsen, 1991; Noland and Oh, 2003; Noland and Quddus, 2004; Bester, 2001; Kopits and Cropper, 2005 …), an exponential regression model, in particular a log-linear model will be estimated:

$$\mathrm{Y}_{it} = e^{\beta_0} \sum_{k=1}^{K} \mathrm{X}_{itk}^{\beta_k} e^{u_{it}} \qquad (2)$$

$$\ln \mathrm{Y}_{it} = \beta_0 + \sum_{k=1}^{K} \beta_k \ln \mathrm{X}_{itk} + u_{it}$$

This model is still linear in the parameters, linear in the logarithms of the variables Y and X, and can be estimated by GLS regression of Parks (1967). An attractive feature of a log-linear model is that the slope coefficients β_k measure the elasticity of Y_{it} with respect to X_{itk}. In other words, a change of x% in one of the explanatory variables induces a change of y% of the fatalities. Furthermore, since the number of fatalities is always a positive number the exponential formulation (2) is a natural choice. The results of the panel data regression, conducted by the Parks method, are presented in section 5. Empirical results and Discussion.

5. EMPIRICAL RESULTS AND DISCUSSION

5.1 Overall results

Table 7, 8 and 9 summarize the statistics of the estimated ‘best’ model. Several criteria were used in deciding on the best model:

- A high proportion of the variation in the dependent variable must be explained by the model – in other words, a high value of R^2 (> 0,70);
- The significance level of the constant as well as all explanatory variables must be less than 10%. This will ensure relatively low standard errors and high t-values;
- Simultaneous inspection of R^2 and the fit statistics of the model, i.e. increasing R^2 is not allowed at the expense of decreasing fit quality.

Table 7: Fit Statistics Park’s method

Fit Statistics			
SSE	58.7719	DFE	115
MSE	0.5111	Root MSE	0.7149
R-Square (Buse)	0.9949		

SSE = Error Sum of Squares; MSE = Mean Square Error; Root MSE = $\sqrt{MSE}$; DFE = Degrees of Freedom for Error

Table 8: Parameters estimates Park’s method

Variable	Estimate	Standard Error	t Value	Significance level Pr > |t|
Intercept	-2.14217	0.4423	-4.84	<.0001
ln Road Traffic Volume in pkm	0.854767	0.0209	40.98	<.0001
ln GDP per capita	-1.42474	0.0504	-28.27	<.0001
ln Corruption Perceptions Index	-0.21723	0.0237	-9.18	<.0001
ln Alcohol Consumption per capita	1.084225	0.0532	20.39	<.0001

Using both a backward and forward selection procedure on the basis of significance, the final best model relates the number of fatalities to 'Road Traffic Volume in pkm', 'Gross Domestic Product per capita', 'Corruption Level' and 'Alcohol Consumption per capita'. All explanatory variables are significant at the 0.0001 level (table 8). Table 9 lists the first-order autocorrelation coefficients (Rho or ρ) estimated through the Park's method. The limits for Rho are -1 and 1, with 0 indicating no serial correlation and 1 perfect positive correlation in the residuals. As assumed before estimating this model, the residuals of each cross-section show positive correlation.

Table 9: Estimates Rho (first-order autocorrelation)

Country	Rho
Austria	0.968431
Belgium	0.812234
Denmark	0.890821
Finland	0.965599
France	0.597472
Germany	0.602239
Greece	0.842596
Ireland	0.991805
Italy	0.452934
Luxembourg	0.659891
Netherlands	0.284782
Portugal	0.893716
Spain	0.979966
Sweden	0.991805
United Kingdom	0.991805

The model was conceived to show the macroscopic net effects of each variable on the number of fatalities. These effects have to be understood as averages for a country and a period over time. All the explanatory variables have the expected signs (table 8). If a country’s corruption level, i.e. the CPI-index with 0 (highly corrupt) and 10 (clean), drops with 1% (and thus the corresponding CPI-index increases with 1%), then the number of fatalities fall by 0,22%. Regarding exposure factors, one can conclude that these have a negative effect on the traffic safety level of a country. In other words, increasing exposure leads to an increase of the number of fatalities. The drinking behavior in a country also shows the expected effect. If alcohol consumption per capita rises with 1%, the number of road deaths increases with 1,08%. The estimate for GDP per capita or income level of a country’s household shows the largest net effect on road fatalities. Increasing income levels by 1% induce a decrease of road fatalities with 1,43%.

5.2 Belgium in comparison with the SUN-countries

If the estimates of this model are correct, one should find differences in variable levels between countries. To state this, a comparison will be made of the mean values of the explanatory variables of a country with a high road safety level and one with a poor road safety level. In particular, the comparison will be made between Belgium and the SUN-countries (table 10). As stated in section 2. (Traffic Safety), the traffic safety level in Belgium lies far below of that of Sweden, the United Kingdom and the Netherlands. In 2001 the number of fatalities per billion passenger kilometers in Belgium, respectively Sweden, the United Kingdom and the Netherlands is 13.76, 6.26, 5.77 and 6.53.

Table 10: Summary statistics explanatory variables 1995-2002 – SUN-countries and Belgium

Variables	Mean SUN-countries	Mean Belgium
CPI	8,89 *min. 8,22* *max. 9,5*	6,18 *min. 5,25* *max. 7,10*
Alcohol Consumption per Capita	7,39 *min. 5,63* *max. 9,08*	8,7 *min. 8,08* *max. 9,31*
GDP per capita	24 878 *min. 21 969* *max. 27 222*	24 640 *min. 22 889* *max. 25 050*
Road Traffic Volume in pkm	279 687 500 000 *min.* 86 800 000 000 *max.* 634 000 000 000	104 800 000 000 *min.* 97 470 000 000 *max.* 109 420 000 000
Road Traffic Volume in pkm per capita	9 728 *min. 8 500* *max. 10 533*	10 251 *min. 9 616* *max. 10 590*

As estimated through the model, the CPI-index is negatively related to the number of road fatalities. The mean value of the CPI-index in the SUN-countries over the period 1995-2002 is very high (8,89) indicating that in these countries corruption figures are very low (the maximum value of CPI-index is 10). Belgium, on the contrary, is a country where corruption seems to be common good. The overall corruption level in Belgium is even higher than the EU-average (CPI-index Belgium: 6,18; EU-average: 7,55).

Alcohol consumption per capita (in liters pure alcohol) has a positive effect on the number of traffic fatalities. The Swedish, English and Dutch people consume about 7,39 liters of pure alcohol each year. Again, the Belgians score worse on this indicator for national alcohol drinking habits. Yearly, a Belgian consumes approximately 8,7 liters of pure alcohol.

In this study, GDP per capita is used as a proxy for income. We assumed that income levels are related to the levels of vehicle safety and government road expenditure. As income rises, we expected a reduction in the number of road fatalities. The parameter estimate for GDP per capita confirms this assumption. The SUN-countries as well as Belgium have mean income levels around the EU-average.

Concerning the influence of exposure figures, the used panel model estimated a positive effect on traffic fatalities for the road traffic volume in passenger kilometers. To compare the SUN-countries with Belgium, these figures should be related to some factor. Related to the population for instance, the inhabitants of the SUN-countries drive an average of 9728 km per year. The Belgian drivers are above this average with 10 251 km per year.

6. Conclusion and Recommendations

Road safety is not equally distributed across Europe. Northern European countries seem to be more successful in improving and maintaining their road safety standards. This study concentrated on uncovering possible causes of these discrepancies in road safety levels in the European Union. Moreover, the aim was to identify the factors which explain for the variance in road fatalities between European countries from 1995 to 2002. An important angle in this study is the presumed relevance of national social norms indicating the attitudes and behavior of the inhabitants towards road safety policy and legislation.

The macroscopic net effects on road fatalities of a number of variables have been tested by means of a panel data regression model. In the final best model, four explanatory variables were retained, i.e. the Corruption Perceptions Index, Alcohol Consumption per capita , Gross Domestic Product per capita and Road Traffic Volume in passenger kilometers.

As expected, the Corruption Perceptions Index established a negative effect on the number of road fatalities. This index was used as a proxy for the general attitudes and social norms of citizens towards traffic legislation and policy. Furthermore, it gives an indication of the tolerance of the population towards evasion of rules or in general the moral climate in a country. In countries where corruption figures are low (corresponding with a high Corruption Perceptions Index), it is assumed that law-infringing behavior is less tolerated resulting in a more safe traffic environment. The variable Alcohol Consumption per capita was used as a proxy for the drinking habits of a population. The estimated positive effect of this variable on traffic fatalities confirmed the outcomes of earlier research. The economic factor, Gross Domestic Product per capita, gives an indication of road infrastructure and vehicle conditions. As estimated through the model, the better the economic situation, the better the traffic safety level of a country. Finally, the exposure variable, expressed by passenger kilometers shows a positive effect on the number of traffic fatalities.

What are now the (practical) implications of this study for government's policy and strategy on traffic safety? First of all it must be pointed out that the variables which appear to be significant for a country's road safety level are also the most susceptible to policy actions. For example, information campaigns could alter driver's attitudes and behavior towards drunk driving and enhance public transport. The insignificant variables (and thus not included in the final model), such as the share of urban population and the percentage of youngsters, are (obviously) less pliant.

Secondly, the variables used to explain the differences in road safety levels in the investigated countries indicate the relevance of attitudes and behavior towards traffic safety. On the one hand, the Corruption Perceptions Index of a country indicates a more general national atmosphere towards traffic legislation and policy. And on the other hand, there are variables in the model indicating more concrete forms of attitudes and behavior in traffic (i.e. Alcohol Consumption per capita and Road Traffic Volume in passenger kilometers).

The significance of the Corruption Perceptions Index in relation to traffic safety is of great importance. It can be stated that the inhabitants of the investigated countries differ in their willingness to comply with traffic rules. However, this willingness is imbedded in national culture or history and is not easy to modify by government's policy. Nevertheless, policy makers should take this possible problematic nature of social norms into account while setting traffic policies and legislation. First of all, policy makers need to be sure that an initial broad base of public support or social legitimacy exists when considering a particular road safety measure. Without this support, the acceptance and the possible implementation of this measure will be jeopardized. It is conceivable that moderate or low support for a certain measure could be enhanced by persuasive communication or by experiences or feedback about the positive results of the new measure. If majority support for certain measures does exist (or is created) one should be aware that they are strictly and consistently enforced. Secondly, there is the necessity of transparency of traffic rules. A government can only demand law-abiding behavior, if the road users clearly know which rules to comply with. In this respect is public communication of overriding importance.

7. References

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