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# An exploration of road safety parameters in Belarus and the European Union

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**Abstract**

The objective of the present paper is, through analysing basic road safety parameters in Belarus and the European Union (EU), to explore, compare and outline the key parameters contributing to road fatalities in the recent years in Belarus and EU.
Initially, the action plans and safety performances for both Belarus and EU Member States are assessed, based on various indicators and specific time periods. The assessment revealed that during the period 2000–2010, although road fatalities in Belarus decreased about 25%, the overall road safety performance is rather weak compared to the majority of EU States (-43%). During the period 2011–2013, Belarus achieved a noticeable decrease by another 25% reduction in road fatalities, a performance figuring among the best in EU.
As to address the parameters related to road fatalities, lognormal regression models were developed and applied to vehicle fleet and demographical data for Belarus and the EU and elasticity values were calculated for the identification of the comparative effect of each variable.
The examination of Belarus and certain neighbor EU States revealed that there are some important road safety similarities. In both cases, an increase in the percentage of pedestrian fatalities is related to vehicle type. The results of this research could be proved beneficial for the identification of appropriate measures addressing the underlying road safety issues in Belarus.
In conclusion, it was found that the current road safety performance in Belarus is improving rather slowly and requires further effort from all road safety authorities and other stakeholders in Belarus. Belarus presents the second worst performance in

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pedestrian fatalities compared to the EU Member States, and therefore special emphasis should be given to road safety measures (behaviour, infrastructure, vehicle) focusing on pedestrian safety.


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*Keywords:* road safety; Belarus; EU; modeling

## 1. Introduction

Worldwide, road safety remains an issue of general concern with major societal and economic impacts. In many countries road accidents have become one of the major causes of death and road safety is regarded as an issue of public health. Although the number of road fatalities and serious injuries is overall decreasing, there are significant differences on the road safety level in the various countries.

In an area where road safety standards as well as road traffic rules and regulations vary widely, the European Union (EU) experienced over 25,900 fatalities and approximately 1.4 million injuries in more than 1 million car accidents in 2013 (CARE, 2015). However, significant differences on the road safety level are also observed within EU. Specifically, EU members may be listed in three different groups based on the number of fatalities per million registered passenger cars. Through this categorization (Yannis et al 2007; Bialas-Motyl 2007; ETSC 2006), North--west countries perform best with Sweden, the United Kingdom and the Netherlands recording the lowest number of fatalities per million passenger cars during the last years. In contrast, countries in southern Europe (Italy, Greece, Spain and Portugal) display a clearly lower road safety level. Finally, the highest rates of fatalities per million registered passenger cars are found in eastern countries, many of which have recently entered EU. Such differences indicate that systematic efforts are required in order to achieve a more uniform road safety performance all over EU and reach the adopted target of halving the overall number of road deaths in the European Union by 2020 starting from 2010 (European Commission, 2010).

South-eastern European countries are among the worst performers in road safety. Although some improvement has been achieved during the last years, with the decrease of road accidents, fatalities and injuries in the area, the numbers remain higher than the average in the EU. This poor performance may be partially attributed to several deficiencies in road safety management, road infrastructure and road user behaviour in these countries (ROSEE, 2014).

Belarus, although not an EU member, has many common characteristics with the eastern EU countries. During the last decade, Belarus is continuously developing as indicated by the increasing total Gross Domestic Product (GDP). As a consequence, the number of registered vehicles is also increasing and road safety becomes more and more a matter of concern.

Looking at road safety statistics from 2006 to 2010, Belarus recorded more than 478,000 accidents, with 7,320 fatalities and about 38,500 injured people. The number of road fatalities per million inhabitants is an indicator of the current level of road safety in each country (ETSC, 2015). In Belarus, in 2010, 1,199 road accident fatalities were recorded and the fatality per population rate reached 126 fatalities/million inhabitants. At that time (2010), the respective rate in the EU27 was 61 fatalities/million inhabitants.

This difference may be attributed to many factors; among others the strong commitment of the European Commission on road safety as also stressed in the latest relevant policy (European Commission, 2010; European Commission 2011). Similar efforts were also introduced in Belarus, where in 2006 the Council of Ministers approved the Concept of Road Safety in the Republic of Belarus aiming at reducing road accident fatalities by 25% in 2015 compared to 2005. However, there are several obstacles that prevent the improvement of road safety in Belarus. Road safety is not managed on an evidence base and there is not sufficient funding for related research. Funding is not available either for the implementation of the Plan of the Concept of Road Safety. In addition, there is not a specific body in charge of road safety. The Belarusian Police have some involvement but the responsibility is dispersed amongst a number of ministries and agencies (BeSafe, 2014).

The objective of the present paper is to explore key parameters contributing to road safety in Belarus through the analysis of basic road safety data. In addition, road safety trends in Belarus are compared to those of EU member countries, which based on the different socio-economic and road safety characteristics are categorized in three distinct groups, namely; North-west, South and East.

On this purpose the latest general trends in road safety in Belarus were recorded and socio-economic parameters were selected to explore the impact of each one of them to the number of road fatalities. A lognormal model was developed for Belarus and for the selected groups of EU countries. Dimensionless elasticities were used for the direct comparison of all model parameters, in order to identify differences and similarities in road safety performance in the examined countries.

## 2. Outline of basic road safety figures

Based on the 3rd Road Safety Action Plan (European Commission, 2003), the European Union had set itself an ambitious target of halving the yearly number of road fatalities between 2001 and 2010. In 2010, nearly 31,000 people were killed in the EU27 as a consequence of road accidents. Around 300,000 were seriously injured and many more suffered slight injuries. Although the overall target was nearly achieved, the 43% reduction in road fatalities has proved to be a turning point in motivating EU members, in particular those facing the greatest challenges, to reduce the number of road fatalities.

In Belarus, the road safety situation began to change radically after the year 2006 when 1,726 people died as a result of road accidents. Ever since, there is a continuous effort at State level aiming to reduce the number of fatalities in road accidents. During the same year (2006), a national road safety action plan titled “The Concept of Road Safety of the Republic of Belarus for the period 2006–2015” was released. One of its primary goals was to reduce the number of fatalities in road accidents in 2015 by at least 500 people compared to 2005 (1,673 fatalities).
Figure 1 shows the percentage change in road fatalities between 2001 and 2010 in EU members as well as in Belarus.

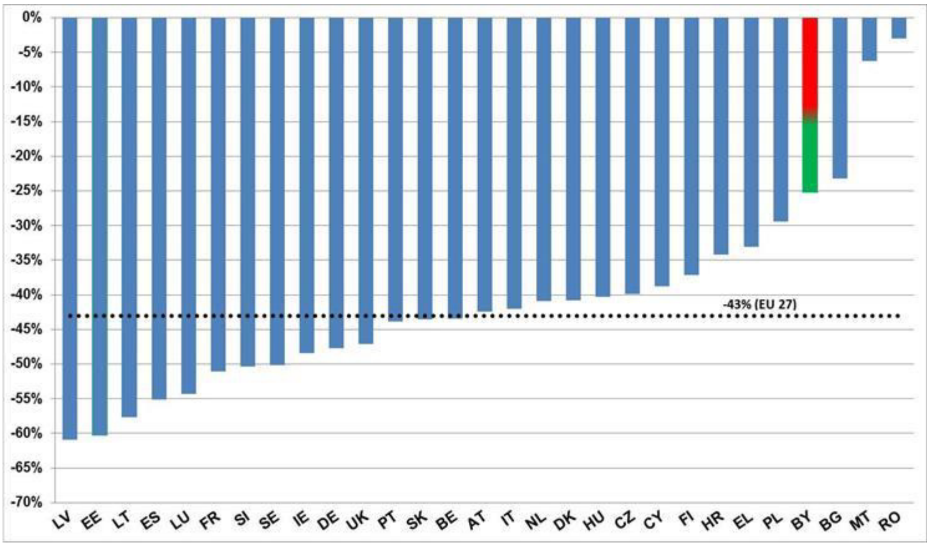


Fig. 1. Percentage change in road fatalities in EU and Belarus between 2001 and 2010.

In 2010, the European Union renewed its commitment to improve road safety by setting a target of further reducing road fatalities by 2020 by 50% compared to 2010, thus retaining the level of ambition regarding the priority and importance in addressing this major concern.

On the other hand, the results of the Belarusian road safety action plan for the period 2006–2015, can already be seen during the current decade during which the road fatality trends in Belarus show a remarkable improvement and place the country among the best performing European countries. For example, in 2014, the number of road fatalities, though still a major issue, decreased to 757, a figure which is far beyond the expectations set in 2006.

However, a more precise and descriptive manner in utilizing road fatalities to point out the current level of road safety between countries, is to associate the number of road fatalities per million of inhabitants (road mortality). Figure 2 provides the relevant comparison regarding EU members and Belarus for 2010 and 2014 respectively.

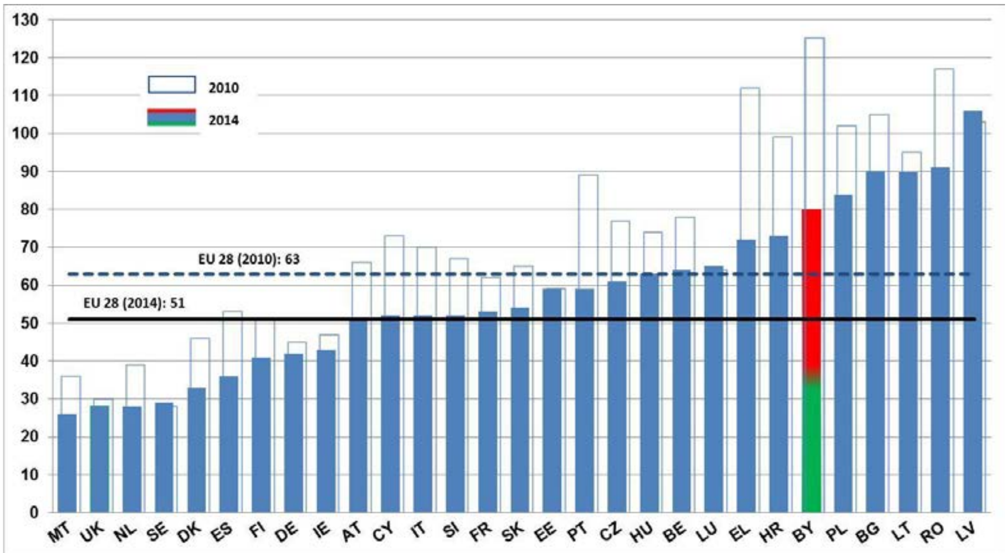


Fig. 2. Road fatalities per million of inhabitants in EU and in Belarus in 2010 and 2014.

As far as Belarus is concerned, it can be seen that although in 2010 the country performed worse than all EU members, a significant improvement is noticed four years after (2014), which classifies Belarus among the best performing eastern EU members. Specifically, road fatalities in 2014 decreased by more than 36% in comparison to 2010.

## 3. Methodology

In order to compare the road safety level in Belarus and in EU member countries, EU countries were grouped into three groups based on general socio-economic characteristics as well as on the overall road safety level. The group of “North-west Europe” included Austria, Belgium, Denmark, France, Germany, Ireland, Luxembourg, Sweden, the Netherlands, Finland and the United Kingdom. The group of “South Europe” consists of Spain, Portugal, Malta, Greece, Cyprus and Italy. Finally the “East Europe” group was formed by Czech Republic, Latvia, Lithuania, Poland, Slovakia, Slovenia, Bulgaria, Estonia, Hungary, Croatia and Romania.

The road safety level of each country or group of countries is expressed by the rate of road fatalities per population per year. The parameters examined are the total number of registered vehicles and the GDP per capita in each country. For all countries, demographic, vehicle fleet and GDP per capita data used in the analysis were extracted from the Eurostat database. Data on road fatalities in the EU countries were found in CARE and for Belarus in national sources. Available data covered years 2005–2014 in the case of Belarus, North-west EU and East EU member countries and period 2005–2013 in the case of South EU members.

In order to develop a statistical model which would describe the road safety level for each case, several types of models were investigated. Lognormal regression was finally selected for its simplicity but also for its adequateness for such international road safety comparisons. Four models were finally developed, each one referring to one of the countries and group of countries examined. The statistical significance of the relationship between the dependent and the independent variables was assessed by calculating the $R^2$ value (Mc Carthy, 2001). For each independent variable, the t-value was also used as a measure of the statistical significance of each parameter (Leech et al, 2005).

In order to make possible the comparison between countries, focus was given to the estimation of the responsiveness and sensitivity of the dependent variable with respect to changes in each independent variable. On this purpose, the elasticity of each independent variable was calculated (Washington et al, 2003).

## 4. Model development

During the development of each lognormal regression model, three independent and one dependent variable were used. The independent variables were: the number of registered vehicles (motorcycles are not included), the percentage of motorcycles in the total fleet and the population of each country or group of countries. The natural logarithm of road fatalities per population per year in each case was examined as the dependent variable. Lognormal model was selected because of the more adequate depiction of the road fatalities' time series. All five models were developed according to the following model structure:

$$y = 10^{a_0 + a_1 x_1 + a_2 x_2} \tag{1}$$

where
y – log(fatalities/population)
$x_1$ – Gross Domestic Product (GDP) per capita
$x_2$ – the number of registered vehicles (total fleet)

The results of the lognormal regression for all cases are shown in Table 1.

Table 1. Lognormal regression results for all cases.

| | Belarus | | | North-West EU | | | South EU | | | East EU | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | coeff. | t-value | elasticity | coeff. | t-value | elasticity | coeff. | t-value | elasticity | coeff. | t-value | elasticity |
| constant | -3.483 | -57.612 | - | -3.077 | -8.044 | - | -2.773 | -2.132 | - | -3.429 | -21.00 | - |
| GDP per capita | $-9.204 \times 10^{-5}$ | -6.831 | 0.102 | $-3.696 \times 10^{-5}$ | -3.170 | 0.282 | $9.616 \times 10^{-5}$ | 1.986 | 0.521 | $-5.894 \times 10^{-5}$ | -3.36 | 0.137 |
| GDP per capita | - | - | - | - | - | - | $-3.666 \times 10^{-8}$ | -4.757 | 0.848 | - | - | - |
| $R^2$ | 0.854 | | | 0.557 | | | 0.815 | | | 0.585 | | |

For Belarus, $R^2$ value was calculated equal to 0.854. This value indicates a high statistical fit of the proposed model. For the rest of the cases, $R^2$ values are lower though adequately high.

All four models were depicted on one chart. For each case both curves for actual and model values of fatalities were drawn (Figure 1).

The elasticity of each independent variable was calculated based on the formula:

$$e_i = \frac{\Delta X_i}{\Delta Y_i} \cdot \frac{X_i}{Y_i} \tag{2}$$

where
$X_i$ – the average value of each variable $x_i$
$Y_i$ – the average value of log(fatalities/population)

Elasticity is useful because it is dimensionless unlike any estimated coefficient of regression parameter, which depends on the units of measurement of each parameter. In this way, it is possible to express quantitatively the impact of each independent variable on the dependent. In combination with the sign (±) of the coefficients it is also possible to identify whether an increase in each independent variable results in an increase or a decrease in the independent one.

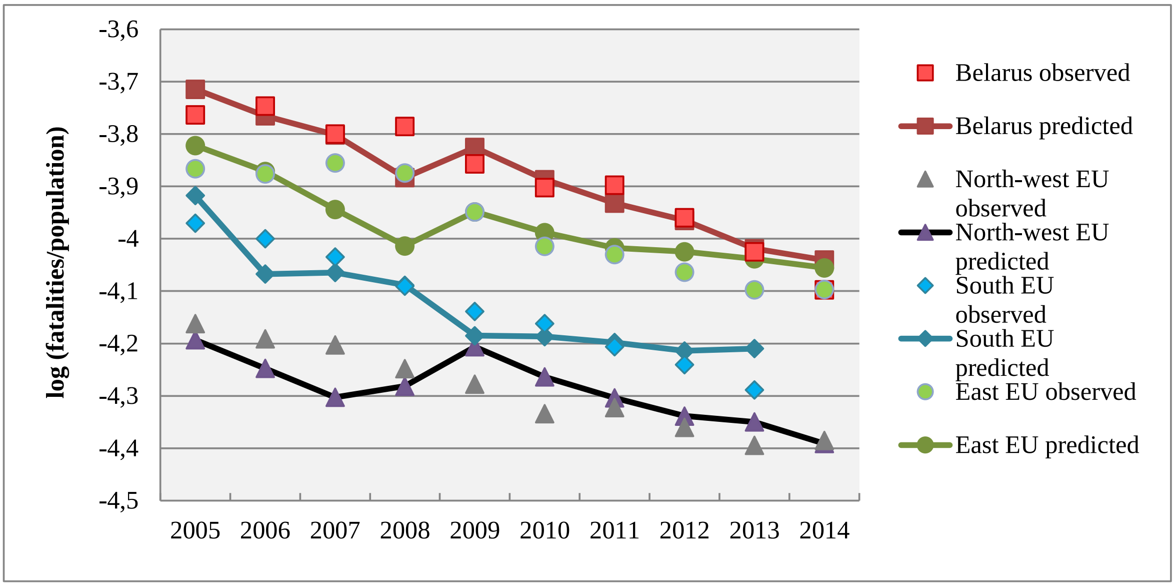


Fig. 3. Actual and model values of fatalities.

## 5. Model application

In the models developed for Belarus, North-west EU and East EU member countries only GDP per capita was included as an independent variable due to the high correlation with the total fleet, based on the r value. On the contrary, both GDP per capita and the total fleet were included as independent variables in the model for South EU members. Based on the sign of the respective coefficient (Table 1) it was found that GDP per capita is negatively associated to fatalities per population in Belarus, North-west and East EU member countries. On the other hand, when total fleet is also taken into account like in the South EU members' model, the GDP per capita has a positive impact on fatalities per population while the total fleet has a negative one.

Based on the elasticity values shown in Table 1, the four models can be further explored and compared to each other through the comparison of elasticities calculated for each case. The kind of impact that each independent variable has on the dependent variable can be identified based on the sign (±) of the corresponding coefficient in each model.

In the case of Belarus, elasticity value for GDP per capita was $e_1 = 0.102$. An increase in the GDP per capita results in a decrease in road fatalities/population. Specifically, a 1% increase in the GDP per capita results in a 0.102% decrease in road fatalities per population.

Following the three groups of EU member countries were examined. For the first case of North-west EU members the elasticity of GDP per capita was calculated $e_1 = 0.282$. In this case, an increase in the GDP per capita by 1% causes a decrease by 0.282% in road fatalities per population.

In the case of South Europe, the elasticity values for GDP per capita and for the total fleet were calculated equal to $e_1 = 0.521$ and $e_2 = 0.848$ respectively. In combination to the coefficients in this model it was found that an increase by 1% in the GDP per capita has as consequence an increase by 0.521% in road fatalities per population, while an increase by 1% in the total fleet results in a decrease by 0.848% of the road fatalities per population. It is clear, that the GDP per capita has a lower impact on road fatalities per population in comparison to the respective impact of the total fleet.

Finally, in the East EU members, an increase of the GDP per capita results in decrease of the number of road fatalities per population. The relevant elasticity value was calculated $e_1$ = 0.137 indicating that a 1% increase in GDP per capita will lead to a 0.137% decrease in fatalities per population.

In total, it seems that the impact of the GDP per capita is higher in the number of road fatalities per population in South EU member countries, followed by North-west and East EU members and lowest in Belarus.

## 6. Discussion

Road safety is an issue of great concern in Belarus and in the EU where the level of road safety differs significantly among the member countries. The objective of this paper was to explore key parameters contributing to road safety in Belarus through the analysis of basic road safety data. In addition, road safety trends in Belarus are compared to those of EU member countries, which based on the different socio-economic and road safety characteristics are categorized in three distinct groups, namely; North-west, South and East EU members. On this purpose, lognormal regression was applied to socio-economic data. A lognormal model was developed separately for Belarus and for three groups of EU member countries with similar characteristics. Then elasticity values were calculated for each variable included in each model. The examination of the different cases was based on the comparison of elasticity values within and between groups of countries.

The calculation of the dimensionless elasticity for each examined variable was adopted as a simple and suitable technique for completing the purposes of this research, allowing the direct comparison of different cases of variables and models. A single model for all cases should probably have been more accurate but definitively more difficult to develop and more complicated to analyse, especially when available data do not cover the same period in all examined countries. Moreover, the use of elasticities was found adequate for the comparison of basic road safety parameters among the selected broader groups of EU countries – and not separately for each country; something that a single model would impose.

The examination of Belarus individually, revealed that there is still room for significant improvement of road safety. The number of road fatalities per population was found to be affected by the GDP per capita but not by the total fleet. While debatable, this result may indicate that there is a specific level of motorization over which the effect on road safety can be recorded. In addition, the examination of the number of vehicles per population as an independent variable instead of the absolute number of vehicles could provide a better insight of the influence of fleet changes on the road safety level. An increase in the GDP per capita was found to lead to a decrease in road fatalities per population. This result could be partially attributed to the improved infrastructure and the newer and better maintained vehicle fleet that may come with the GDP increase. It should also be noted that the exploration of other parameters related to users (e.g. age, drink-driving), infrastructure (length of specific road types, etc.) or vehicles (e.g. age, maintenance, safety systems etc) could probably lead to more complex but also more accurate results.

The results for Belarus were very similar to those concerning East EU member countries, a finding which was rather expected based on the general background and the particular characteristics of these countries. On the other hand, a negative relation between GDP per capita and road fatalities per population was also found in the case of North-west EU members. In that case though, the quantitative impact of the increase of GDP per capita on road fatalities per population was more than double the respective impact in the case of Belarus and of East EU members. This is perhaps an indication that the impact of GDP per capita is also strongly associated to other parameters, not explored in the present research.

Another interesting finding was that the total fleet also has an impact on the number of road fatalities per population in South EU countries. In addition, in these countries the GDP per capita has the adverse kind of impact on road fatalities in population than in Belarus, North-west and East EU countries.

The results of this research revealed the role of basic socio-economic parameters on road fatalities' macroscopic trends. Such information may be very useful for all decision makers designing the national road safety policies (Kanellaidis et al., 2012). Common characteristics of neighbouring countries may explain similar road safety performance, and relevant findings may be exploited by all those who attempt to identify future road safety trends and propose countermeasure policies. It is obvious that some of the selected parameters to be explored can be more useful for the design of policies and countermeasures and some others are useful mainly for macroscopic estimations.

Given that road safety is a multidisciplinary and multivariate scientific field, every proposed action and measure should be developed and supported through strategies in the areas of engineering, enforcement, education and emergency medical services taking into consideration social and economic aspects as well. However, the implementation of certain countermeasures does not give any real benefit in terms of accident reduction if the proposed action is not based on thorough road safety engineering experience and practice (Cafiso et al., 2011; Montella, 2007; Montella and Mauriello, 2012; Montella et al., 2013). As a consequence, successful road safety measures implemented for years in one or more countries may not be the most appropriate for countries with different characteristics and research should focus on measures addressing properly the traffic risk particularities in different countries.

Road safety trends may be explained based on various parameters. Parameters such as socio-economic characteristics can be modeled explicitly while others such as traffic and driver behaviour may be handled indirectly due to lack of the necessary data. Further research comprising more parameters, more complete time series data and exploration of alternative and/or more complex models could be used for the identification of future road safety trends through the respective performance in various countries.

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