Road Safety Macro Assessment Model: Case Study for Hungary

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Abstract

Road traffic crashes are a considerable concern in motorized countries because of their impact on society, economy. The number of accidents has decreased since 2000. This paper gives an overview of road safety on Hungary's road network and reviews the efforts that were done. Statistical prediction of road traffic crashes is described based on the findings of the scientific literature. Using the data provided by the Hungarian Central Statistical Office for the number of crashes and related factors for the period from 2002 to 2017, a new relationship is established between crashes and a number of related factors in an attempt to improve the models' prediction power and to investigate the effect of adding new predictors on the strength of the models.

Keywords

traffic safety, prediction, traffic accidents

1 Introduction

Road traffic accidents are a considerable problem for motorized countries (Hegyi et al., 2017). Accident statistics show a relatively low level of traffic safety in Hungary compared to other developed countries of EU (Ghadi et al., 2018; Kosztolanyi-Ivan et al., 2016). In the European Union, the road accidents are considered as top one death cause in the age group of 45-year and younger ones (Holló and Kiss, 2015). Two major factors that affect traffic accidents are population (Fig. 1 (a)) and motorization (Fig. 1 (b)). Both factors analyzed in this article.

The population has been decreasing in the investigated period from 10.2 millions to 9.7 millions, meanwhile the number of passenger cars are increasing from 2.6 millions to 3.4 millions (Berta et al., 2018). Many transport policy instrument took place in Worldwide, in EU and in Hungary (Török, 2017) that have significantly contributed to the motorization growth. Motorization as a ration of passenger cars divided by 1000 inhabitants is constantly increasing since 2002 (Fig. 2).
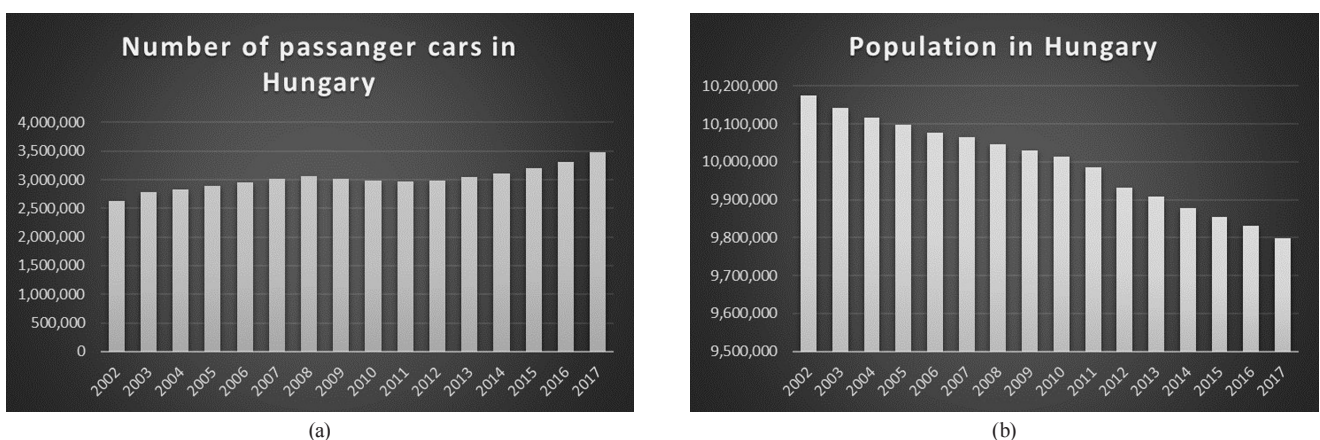

Fig. 1 (a) Number of passenger cars and (b) inhabitants in Hungary between 2002 and 2017
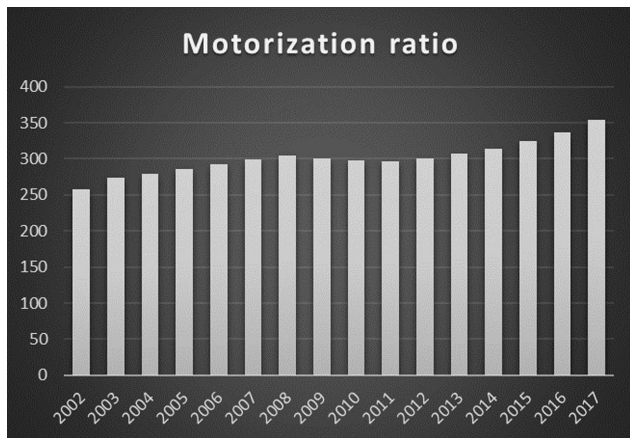Source: Hungarian Central Statistical Office

Fig. 2 Evolution of motorization in Hungary between 2002 and 2017
Source: Own edition based on the Hungarian Central Statistical Office

2 Road safety assessment

Hungary started to witness a modern motorization development since the 1970s which was reflected on the vehicle ownership and consequently on accidents. Therefore, active political commitment were done against road accidents since early 2000s (Fig. 3).

To be able to compare influencing parameters firstly statistical normalization (Mahalanobis et al., 1937) were calculated. All variables were transformed to 0 average and 1 deviation and then visualized (Fig. 4).

Regression equations in the scientific literature attempt to predict the number of accidents per year and particularly significant employed variables include the Average Daily Traffic (ADT) (Abdel-Aty and Radwan, 2000), paved roadway length (Miaou, 1994), population (Young et al., 1997), number of registered vehicles (Lord et al., 2005) and GDP (Bishai et al., 2006), speed, geometric road parameters (Sipos, 2017), etc.

Fig. 3 Fatal accidents in Hungary between 2002 and 2017
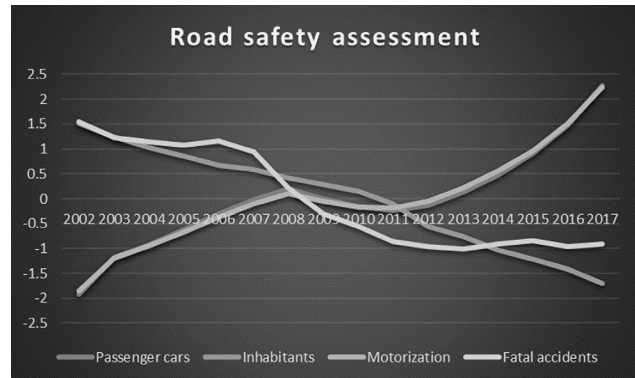Source: Hungarian Central Statistical Office

Fig. 4 Road safety assessment between 2002 and 2017
Source: Hungarian Central Statistical Office

The collected data of the number of accidents and related factors covered a period of 15 years from 2002 to 2017 and related to the national road network. The data were provided by the Hungarian Central Statistical Office (Table 1).

3 Model development

Section 3 is concerned with developing a multiple linear regression model by which the prediction of number of accidents in Hungary can be achieved.

As can be noticed from the time series data, the number of accidents decreased in the last couple of years.

The regression model for predicting the number of accidents can be expressed in the following form:

$$NA = A + B_1(V) + B_2(P) + B_3(G) \tag{1}$$

Table 1 Road safety assessment normalized data between 2002 and 2017

Year	GDP [USD/inhab.]	Registered passenger cars	Fatal accidents	Population
2002	−0.772	−1.915	1.542	1.517
2003	−0.630	−1.180	1.228	1.240
2004	−0.509	−0.925	1.137	1.021
2005	−0.383	−0.625	1.082	0.858
2006	−0.193	−0.301	1.158	0.679
2007	−0.086	−0.010	0.942	0.590
2008	0.169	0.205	0.224	0.413
2009	0.168	−0.002	−0.305	0.290
2010	0.304	−0.150	−0.555	0.148
2011	0.498	−0.231	−0.865	−0.096
2012	0.537	−0.140	−0.966	−0.555
2013	0.745	0.132	−1.008	−0.753
2014	0.928	0.465	−0.902	−1.021
2015	1.087	0.909	−0.847	−1.207
2016	1.134	1.488	−0.960	−1.421
2017	−2.998	2.279	−0.905	−1.702

where:
- NA: The predicted number of accidents,
- A: The constant coefficient of the regression line,
- V: Number of registered vehicles,
- P: Population,
- G: Gross Domestic Product,
- B_1, B_2, B_3: the regression coefficients.

Linear regression analysis was carried out using MS Excel.

The multiple-correlation coefficient (R) reflects the linear correlation between the observed value and the predicted value, it shows how strongly the independent variables can affect the predicted value of accidents. R^2 is the coefficient of determination which indicates the certainty of making prediction using the model i.e. its prediction power. The high value of R^2 indicates a high prediction power with 82.4 % of the accidents are due to the selected independent variables included in the model.

The developed model is:

$$NA = -9.49 + 0.32(V) + 1.16(P) - 0.14(G). \qquad (2)$$

4 Model validation and analysis

Section 4 presents the validation procedure for accident prediction model only. The model resulted in an F statistic value of 24.49 as produced by MS Excel. The critical value of $f = 15.05$ ($\alpha = 0.05$, $df = 15$), since the calculated F is greater than critical f, the model is significant at the 5 % significance level.

The multiple linear model allows easily to analyses the factors as the slope of linear terms could easily readable (Table 2).

Based on the results of Table 2 it can be stated that in the investigated period:
- 1 % increase in number of registered passenger cars caused 0.32 % increase in fatal accidents,
- 1 % decrease of in population caused 1.16 % decrease in fatal accidents – please note that there was a continuous decrease of population in the investigated period,
- 1 % increase in economic activity (GDP) caused 0.14 % decrease in fatal accidents – please note the opposite direction of tendencies.

Table 2 Analysis of factors

	Constant [−]	Vehicles	Population	GDP
Slope	−9.49	0.32	1.16	−0.14

5 Further research possibilities

The authors recommend to continue the research in the following three directions:

1. On one hand, the number of deaths not only depends on the Average Daily Traffic, but also on the mileage of vehicles. The investigated period includes the global financial crisis started in 2007. During these years there was a significant decrease in motor mileage in Hungary. More accurate values can be calculated from the domestic gasoline and diesel fuel consumption database, provided by the Hungarian Petroleum Association. It is necessary to evaluate the reduction of fatal accidents taking this into consideration.

2. On the other hand, a special category should also be analyzed. This is the case of cycling deaths and the change of separated cycling route lengths. The reason for this is that unfortunately Hungary was performing the worst place in the EU countries in 2015, in the "Cyclist fatality rates per million populations by country" category (European Commission, 2018). Conclusions can be drawn from the change in length of the separated cycle tracks. The Hungarian Public Road Nonprofit PLC became the official manager of the national bicycle road network and the bicycle routes parallel to the main road in 2018, also provides detailed database information on bike routes.

3. Last, as a result of electromobility as an EU objective, the number of new electric cars, cars with advanced active and passive accident prevention systems and the carsharing service will be increased in the coming decade in Hungary. In the long term, the spread of self-driving cars is also expected. These changes affect the examined parameters P, V and G. For a future forecasts these factors also should be analyzed.

6 Conclusion

Traffic safety in Hungary was found continuously a serious problem and is growing over the years. Most Hungarians have been personally affected by the trauma of a road accident and the cost to the community in terms of economic loss and personal suffering is enormous. A statistical model that can be used for prediction of the number of fatal accidents on Hungarian roads (NA) was developed. The model is multiple linear regression and incorporates as independent variables the population (P), number of registered vehicles (V) and Gross Domestic Product (G) (see Eq. (2)).

The model produced a very high R^2 value of 82.4 % which means that the independent variables included in the model explain 82.4 % of the variations in the accident data. This model is easy to use and able to analyses the effect of parameters on road safety.

Authors are aware of more sophisticated models, but lack of coherent and long term data for Hungary is hardly available.

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