

Road Traffic Accident Mortality and Economic Development: The Case of Bosnia and Herzegovina

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Abstract: This paper examines the relationship between the relevant parameters of traffic safety and the most important parameter of economic development, gross domestic product. In particular, the paper estimates the effects of the model of the rate of motorization and road traffic mortality in relation to the number of inhabitants and the number of motor vehicles, which are further used for the projection of mortality and the number of motor vehicles by 2030.

Keywords: Traffic Accidents, Mortality, Economic Development, Roads.

INTRODUCTION

The road transport system of Bosnia and Herzegovina (hereinafter B&H) comprises of 21,678 km of classified roads. The rate of motorization, number of motor vehicles per 1,000 inhabitants, is influenced by economic status of the country and its population and the availability of other mode of transportation. This rate in B&H, as of 2016 was, 283.7 motor vehicles registered per 1,000 inhabitants. Every year, more than 11 thousand traffic crashes occur on B&H roads in which more than 300 people lose their lives (312 in 2016), and more than 11 thousand people were injured. Therefore, about 30 traffic crashes happened every day in B&H, and on average one person loses his/her life and about 29 persons were injured every day. These are very devastating and worrying data, and what is particularly worrying is the fact that young people (age 19-29) are the most affected in these crashes. What is also worrying is the fact that individuals and government institutions, responsible for traffic safety in B&H, are still talking about the causes of traffic accidents in very general way, and very often make conclusions about traffic safety based on superficial observations that are not based on expert analyses and serious professional or scientific work.

The economic development of each country contributes to the improvement of the conditions for a quality life of people in all segments, and therefore in the health segment and in the decline in mortality rates. However, the mortality of people in traffic accidents on the roads is a notable exception. In many developing countries, traffic deaths are increasing when compared to the number of people. The situation in the developed countries is somewhat different. In these countries, for some longer periods of time, mortality per capita has declined significantly, so this downward trend, which started in the OECD

countries in the 1970s, continues today. As far as B&H is concerned, the situation cannot be consistently described even by examples of developing countries, and especially not by examples of high-income countries. The reason for this is the specificity of this country in terms of its government structure, and in which the state of confusion, controversy and inconsistency of economic and transport policy measures has lasted more than twenty years. This paper examines the relations between the relevant parameters of traffic safety and the most important parameter of economic development, gross domestic product. In particular, the paper estimates the effects of the model of the rate of motorization and road traffic mortality in relation to the number of inhabitants and the number of motor vehicles, which are further used for the projection of mortality and the number of motor vehicles by 2030.

RESEARCH BACKGROUND

Several economic studies have analyzed the relationship between economic development and road traffic fatality rates. Some of those studies concluded that traffic fatality rates tend to increase in initial developing phase, and then decrease as the country's economy expands. As an example, Elizabeth Kopits and Maureen Cropper [1], in their article titled "Traffic Fatalities and Economic Growth" supported by The World Bank (2003), examined the impact of income growth on the death rate due traffic fatalities. They also examined impact of income growth on fatalities per motor vehicle and on the rate of motorization (number of motor vehicles per population) using panel data for 88 countries. They estimated fixed effects models for fatalities per population, vehicles per population, and fatalities per vehicle, and use these models

to project traffic fatalities and motor vehicle fleet. They found that the relationship between motor vehicle fatality rate and per capita income at first increases with per capita income, reaches a peak, and then declines. This is because at low income levels the rate of increase in motor vehicles outpaces the decline in fatalities per motor vehicle. At the levels of higher income, the opposite happens. They also found that projections of future traffic fatalities will grow by approximately 66 percent between 2000 and 2020. The authors also predict that fatality rate will rise to approximately 2 per 10,000 persons, while it will fall to less than 1 per 10,000 in high income countries. Van Beeck, et al (2000) examined nonlinear relationship between traffic fatalities and economic growth [2]. They found that traffic fatalities in industrialized countries have decreased as income has increased. They partly attributed this reduction to declines in mobility growth (growth in vehicle per capita). Mobility growth tends to increase rapidly at the onset of industrialization, and then tends to level off. Also Wang, et al (2003) have similar findings in their time series analysis of economic growth and traffic fatalities in China. This study found that China has seen a rapid rise in the absolute number of traffic fatalities. Schuffham and Langley (2002) similarly examined the time series relationship between real gross domestic product (GDP) and traffic fatalities in New Zealand [3]. They found real GDP per capita and automobile crashes to be negatively correlated. They think that this trend was potentially caused by "supply side effects", such as better road infrastructure. Hasselberg and Laflamme (2004) also found that Swedish children from families with higher disposable incomes were likely to experience traffic accidents than their lower income counterparts. Schuffham (2003) in his work [4] analyzed the impact of the unemployment rate on traffic fatalities in New Zealand. However, he found that reductions in unemployment were associated with increases in the number of traffic fatalities. He believed this could be attributed to the reduction in vehicle miles traveled for work and leisure associated with unemployment. It is not clear which of these factors is dominant. Bishai et al. (2006) in their work [5] explored why traffic fatalities increase with GDP per capita in lower income countries and decreases with GDP per capita in wealthy countries. They concluded that at a threshold of around 1,500-8,000 dollars per capita economic growth no longer leads to additional traffic deaths, although crashes and traffic injuries continue to increase with growth. The negative association between GDP and traffic deaths in rich countries may be mediated by lower injury severity and post-injury ambulance transport and medical care.

FATALITY RISK, RATE OF MOTORIZATION AND GDP PER CAPITA

Road traffic fatality rates (F/I – number of fatalities per number of inhabitants) are the product of the rate of mo-

torization (V/I – number of motor vehicles per number of inhabitants) and fatalities per vehicle (F/V – number of fatalities per number of motor vehicles):

$$(F/I) = (V/I) \times (F/V)$$

In order to estimate statistical models relating to these ratios to the GDP per capita it is useful to examine how these quantities change depending of income. It is widely recognized that the rate of motorization rises with income implying that one should find large differences in number of vehicles per capita across countries at different stages of development and within countries as per capita income grows [1].

Table 1. presents data on rate of motorization and GDP in B&H and its changes. Figure 1. plots the road traffic accident fatalities trend in B&H and its two entities, Federation of B&H (FB&H) and Republic of Srpska (RS) in the period 2004-2016 and Figure 2. shows rate of motorization per GDP per capita. In the observed period, the rate of motorization in B&H increased about 42%, while GDP increased about 87% (Figure 3.) At the same time, the road traffic accident fatalities fell from 424 to 312, a decrease of 27% (Figure 1.). There is a strong trend correlation with polynomial function for the motorization rate depending on GDP per capita values. This correlation shows that motorization rate grows faster at lower GDP values, and then grows slower at higher GDP values. In our case, the average growth of the motorization rate for the GDP per capita values between five and eight thousand dollars, was 14.3%, and for the GDP per capita values between eight and eleven thousand dollars, the average growth was 1.5%.

Table 1. Rate of Motorization and GDP in B&H and its changes

Year	Number of Motor Vehicles (000)	Rate of Motorization (Number of Motor Vehicles per 1000 Inhabitants)	Cumulative Relative Changes (%)	GDP (USA \$ per capita)	Cumulative Relative Changes (%)
2004	673.8	195.4	-	5049	-
2005	688.6	199.7	2.2	6192	22.6
2006	717.4	208.1	6.4	7141	37.9
2007	750.5	217.7	12.8	8758	60.5
2008	769.6	231.0	18.6	10676	82.4
2009	816.4	236.8	21.1	9865	74.8
2010	818.7	237.5	24.0	10038	92.3
2011	830.3	240.8	25.4	9971	91.6
2012	857.5	248.7	28.7	9873	90.6
2013	885.1	256.7	31.9	10211	94.0
2014	910.4	264.1	34.8	9666	88.7
2015	936.9	271.7	37.7	9245	84.3
2016	978.2	283.7	42.1	9523	87.3

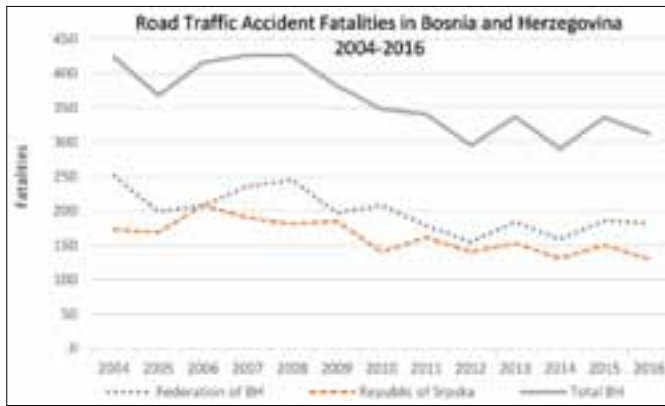


Figure 1. Road traffic fatalities in B&H

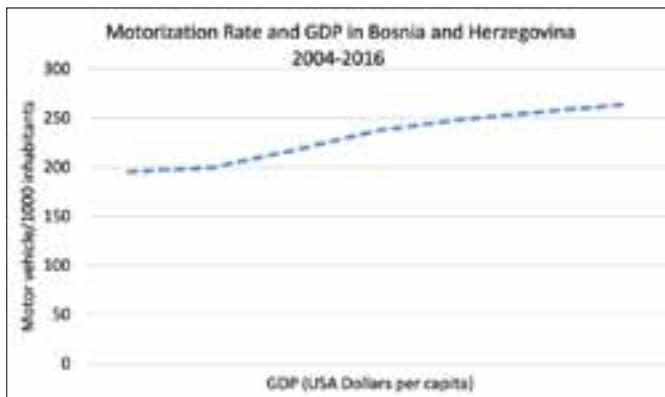


Figure 2. Motorization rate and GDP per capita in B&H

We carried out an assessment of the equations for mortality in traffic accidents in relation to the number of inhabitants, to the number of motor vehicles and in relation to the degree of motorization, depending on the GDP per capita using the following polynomial forms:

$$\begin{aligned} (F/I) &= A_1(GDP)^2 + B_1(GDP) + C_1 \\ (V/I) &= A_2(GDP)^2 + B_2(GDP) + C_2 \\ (F/V) &= A_3(GDP)^2 + B_3(GDP) + C_3 \end{aligned}$$

Also, we made an estimate of the equations for cumulative relative changes in the number of motor vehicles and the changes in GDP per capita in the observed period, using the following logarithmic forms:

$$\begin{aligned} CRC_{mv} &= A_4 \ln(GDP) + B_4 \\ CRC_{GDP} &= A_5 \ln(GDP) + B_5 \\ CTA_{F_{mv-GDP}} &= A_6 \ln(GDP) + B_6 \end{aligned}$$

where:

- (F/I) – traffic accident mortality per100 000 inhabitants
- (V/I) – number of motor vehicles per 1000 inhabitants
- (F/V) – traffic accident mortality per 10 000 motor vehicles
- GDP – gross domestic product (dollars per capita)
- CRC_{mv} – cummulative relative changes of number of motor vehicles
- CRC_{GDP} – cummulative relative changes of GDP per capita

$CTAF_{mv-GDP}$ – changes of traffic accident fatalities per motor vehicles depending of GDP
A, B, C – coefficients

For the analyzed period (2004-2016), given the changes in GDP values were rounded ranging from a minimum of 5 to a maximum of 11 thousand dollars, and for the purpose of simpler calculation and clearer graphic representation the following replacement for GDP values was made:

$$GDP = \frac{GDP_{max} - GDP_{min}}{(n) \times 1000} + i$$

where:

- GDP_{max} – maximum value of GDP in analyzed period (11,000)
- GDP_{min} – minimal value of GDP in analyzed period (5,000)
- n* – number of intervals in analyzed values of GDP in 1,000 (*n* = 6)
- i* = 0, 1, ..., *n*

For example, for an actual value of GDP of 8,000 in given equations, the following number is used:

$$GDP = \frac{11\ 000 - 5\ 000}{6 \times 1000} + 3 = 4$$

After the calculation we obtained the values of the coefficients A, B, C for the equations set, and the proportions of the variance (R^2) of dependent variable that are predicted from the independent variables. These values are presented in Table 2.

Table 2. Equations coefficients and variance values

Equation	Coefficients			Variance (R^2)
	A	B	C	
(F/I)	$A_1 = -0.1442$	$B_1 = 0.6197$	$C_1 = 11.2670$	0.6758
(V/I)	$A_2 = -0.6155$	$B_2 = 17.4630$	$C_2 = 173.860$	0.9779
(F/V)	$A_3 = -0.0552$	$B_3 = -0.0789$	$C_3 = 6.2097$	0.8993
(CRC_{mv})	$A_4 = 15.8690$	$B_4 = -2.6235$	-	0.9499
(CRC_{GDP})	$A_5 = 28.4090$	$B_5 = 28.2650$	-	0.8470
$(CTAF_{mv-GDP})$	$A_6 = -6.8140$	$B_6 = 18.8990$	-	0.9666

Based on the values of the variances given in Table 2, we can notice that the strongest correlation exists between the motorization rate - number of motor vehicles per inhabitant (V/I) and GDP, $R^2 = 0.9779$ (Figure 2.), and, in accordance with this, there is a cumulative change in the number of motor vehicles per number of inhabitants and GDP per capita, $R^2=0.9499$ (Figure 4.). The second strongest correlation is between changes in mortality in road traffic accidents in relation to the number of motor vehicles and GDP, $R^2=0.9666$. The average change in road traffic mortality rates on roads in B&H, depending on GDP, amounted to 9.4 percent per 1,000 dollars of GDP, and the average annual change in GDP

was \$ 428 (Figure 5). The weakest correlation is between mortality in road traffic accidents in relation to population (F/I) and GDP, $R^2=0.6758$.

Based on previous research, the review of which is given in section two of this paper, and based on the results of our research, it can be concluded that there is a logical correlation between the level of income in one country (GDP) and mortality in traffic accidents on the roads. This statement can also be accepted in the case of Bosnia and Herzegovina, bearing in mind the specificity of the overall economic situation in this country, especially the fiscal policy, which can have a significant impact on certain data on the real value of GDP compared with other countries

Namely, since the domestic currency exchange rate (convertible mark - KM) is fixed and is not dependent on the conditions and trends in the money market or economic trends, it is necessary to pay attention to the comparison of data presented in this paper with data from other environments. In this respect, a more thorough research is needed with real valorization and other economic indicators, such as production, productivity, consumption and employment.

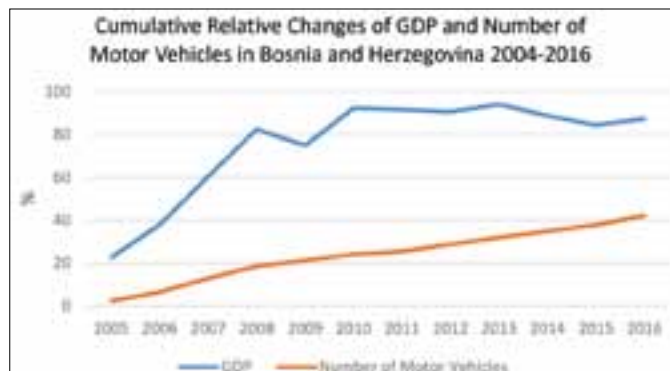


Figure 3. GDP and number of motor vehicle cumulative relative changes



Figure 4. Road traffic accident fatalities and GDP per capita in B&H



Figure 5. Road traffic accident fatalities depending of GDP per capita

PROJECTIONS TO 2030

Based on the equations presented in the previous section we projected the values of some indicators related to road traffic accident mortality and B&H economy for 2030. This projection and its relation to base 2016 year is shown in Table 2. Projection of indicators related to traffic accident mortality and economic development of B&H for 2030 shows that the number of motor vehicles will increase by 56 percent and it will reach the amount of over 1.5 million, while GDP per capita will double, related to 2016. Traffic accident mortality related to number of inhabitants will decrease by 8 percent, and by 28 percent, related to the number of motor vehicles.

Table 2. Projection of some indicators related to traffic accident mortality and economy in B&H

Indicator	2016	2030	2030/2016
Number of motor vehicles	978 229	1,525925	1.56
GDP (dollars/capita)	9523	19236	2.02
Motorization rate (motor vehicles/1000 inhabitants)	283.7	442.6	1.56
Number of fatalities/ 100000 inhabitants	9.0	8.3	0.92
Number of fatalities per 10000 motor vehicles)	3.2	2.3	0.72
Total number of fatalities per year	312	286	0.92

Therefore, the total number of road traffic accident mortality in 2030 is projected to be 286. These projections and estimates of the income level assume that the new policy will take place in B&H because of the country's aspiration to become a candidate for the EU membership in 2018, and a member of this Union by 2025.

CONCLUSIONS

The paper analyzes the relevant parameters of traffic safety on roads and the most important parameter of economic development - gross domestic product (GDP) per capita in Bosnia and Herzegovina. It was noted that the number of motor vehicles in the analyzed period increased by about 42%, while GDP increased by around

87%. At the same time, the number of those killed in traffic accidents has been reduced by around 27%. Also, it was noticed that there is a significant correlation with the polynomial functional dependence between motorization and GDP per capita. This correlation shows that the degree of motorization is growing faster at lower GDP values and then grows slower at higher GDP values per capita.

The average increase in the degree of motorization at GDP values between five and eight thousand dollars in B&H was about ten times higher than for values of GDP per capita over eight thousand dollars. Regarding the territorial representation or administrative units, it can be concluded that there is a distinct similarity between the economic and participation in mortality in traffic accidents on roads. Projection of indicators related to traffic accident mortality and economic development of B&H for 2030 shows that the number of motor vehicles will increase by 56 percent, while GDP per capita will double, in comparison to 2016. Traffic accident mortality related to number of inhabitants will decrease by 8 percent, and by 28 percent, related to the number of motor vehicles.

FUTURE WORK

The paper points to the need for cautious use and interpretation of the presented data and the results of the research due to the fact that the course of the local currency (convertible mark - KM) is fixed, and it is not dependent on the state and movements on the money market or on economic trends. In this regard, the paper emphasizes the need for further research, and recommended evaluation other economic indicators, such as production, productivity, consumption and employment

REFERENCES:

- [1] Koptis, E., Cropper, M.: *Traffic fatalities and economic growth*, Policy Research Working Paper 3035, Washington, D.C., World Bank, 2003.
- [2] Van Beeck, EF., Borsbom, GJ., Mackenbach, JP.: *Economic Development and Traffic Accident Mortality in the Industrialized World, 1962-1990*, Int. J. Epidemiol, 2000.
- [3] P.A. Schuffham, J.D. Langley: *A Model of Traffic Crashes in New Zealand, Accident Analysis and Prevention*, Volume 34, Issue 5, Pg. 673-687, 2002.
- [4] P.A. Schuffham: *Economic Factors and Traffic Crashes in New Zealand*, Applied Economics, Volume 35, 2003
- [5] Bishai, D., Quresh, A., James, P., Ghaffar, A.: *National Road Casualties and Economic Development*, Health Econ., 2006
- [6] World Business Council for Sustainable Development, *Mobility 2030: Meeting the Challenges to Sustainable Development*, Geneva, 2004.
- [7] Howard, E., Breen, J.: *Review of Road Safety Management Capacity in the Republic of Serbia and Proposals for an Investment Strategy*, Washington, D.C., World Bank – GRSF, 2007.
- [8] European Traffic Safety Council – Economic Research Center, *Economic Evaluation of Road Traffic Safety Measures*, Round Table 117, Reports by H.Baum and K-J Tohnscheid (Germany), P. Wesemann (Netherlands), A. Evans (United Kingdom), U. Persson (Sweden), Paris, 2000.
- [9] Bhalla, K., Ezzati, M., Reich, M.: *A Risk-Based Method for Modeling Traffic Fatalities*, Risk Analysis, 27 (1), p. 125-136, 2007.
- [10] Kulovic, M., Dogdibegovic-Kovac, B.: *Road traffic accidents and economic factors in Bosnia and Herzegovina*, (in Bosnian), IPI Bilten, Zenica, 2018.
- [11] Bliss, A., Breen, J.: *Implementing the Recommendations of the World Bank Report on Road Traffic Injury Prevention – Anex 1*, Washington, D.C., World Bank – GRSF (Global Road Safety Facility), 2009.
- [12] Statistical Year Books, Statistical Institute of Federation of Bosnia and Herzegovina, 2004-2016.
- [13] Statistical Year Books, Statistical Institute of Republic of Srpska, 2004-2016.