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A data-driven study of road traffic accidents in Albania: Nonlinear regression applications in the transportation system

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Abstract: A significant unanticipated issue for the study of transport systems is the occurrence of road traffic accidents, resulting in the number of cases, injuries, and fatalities. The Albanian transport system has suffered from negligence and a lack of investment. Consequently, road traffic accidents have increased while current efforts to improve road safety remain minimal compared to the growing traffic volume. The research aims to provide an overview of road traffic accident statistics in Albania using data from 2015 to 2024, offering insights into the current situation and future projections. Furthermore, three key attributes—road traffic accidents, population projections, and the number of registered vehicles during the study period—have been considered in developing a nonlinear road accident prediction model. The data on road traffic accidents, in terms of the total number of road traffic cases (C), road traffic fatalities (F), and road traffic injuries (I), were used from road traffic accidents in Albania as dependent variables. The Andreassen model has been adapted to develop a regression model suitable for Albania's data, where population projections and the number of registered vehicles are taken as independent variables. Moreover, this paper aims to model the evolution of road safety as a function of the level of motorization and population projections, emphasizing that the increase in the number of vehicles leads to a decrease in the number of traffic fatalities, and an increase in the number of accident cases, as well as in the number of injured per vehicle. The study results allow planners to estimate future road traffic accidents in the country.
Keywords: *Accident prediction model, Albania, Motorization level, Population projections, Road traffic accidents.*

1. Introduction

The transport system proves to be the most difficult to make more sustainable, as it is growing rapidly Loo and Banister [1] robust transport infrastructure has the potential to profoundly improve a country's economic growth, urban development, and social mobility [2-4]. Traffic safety management plays a crucial role in intelligent transportation systems, encompassing a broad research area where it is essential to analyze and predict the impact of incidents on traffic [5]. According to the World Health Organization (WHO), lower-income populations have higher mortality rates than higher-income populations, making predicting and preventing accidents a necessary condition, especially in developing countries where the mortality rate is higher due to road traffic accidents [6]. Road networks facilitate the free movement of products, services, and people, contributing to the economic development of

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countries [7]. An important unanticipated outcome for studying road transport systems is road traffic accidents (*RTAs*) in terms of the number of cases, injuries, and fatalities. It is imperative to ensure a safe and efficient road network with a high level of service, as *RTAs* have a detrimental impact on public health and the economy [8].

Studies suggest that after the introduction of personal vehicles to individuals, time trends in road injuries usually begin with a large increase in injury rates [9]. While improvements in vehicle safety standards and road technology, which are part of a 'globalization model', lead to downward trends in accident rates. This is supported by the statistical significance of the distribution of vehicle fleet age, which acts as an intervening variable between domestic and global accident rates. The rising number of vehicles on the road is closely tied to economic growth worldwide, particularly in rapidly developing nations [10]. As economies expand, transportation activities increase due to a higher volume of economic transactions, cultural and political engagements, and overall social interactions [1]. In recent years, economic progress—especially in low- and middle-income countries—has led to a surge in vehicle ownership, making road networks more complex and hazardous [11].

By 2030, it is projected that nearly 70% of the world's population will reside in urban areas, placing immense pressure on transportation infrastructure. This urban shift will significantly increase the demand for mobility, surpassing the current system's capacity. In response, global efforts are focused on reducing road traffic deaths and injuries by at least 50% within this timeframe. Notably, low- and middle-income countries, which own about 60% of the world's vehicles, account for a staggering 92% of global road traffic fatalities [12]. Developing nations tend to experience significantly higher fatality rates per licensed vehicle compared to industrialized countries. The combination of economic growth and increased vehicle usage has, therefore, escalated road transport risks [6]. Additionally, as urbanization accelerates and vehicle numbers soar, traffic-related incidents increasingly disrupt both transportation systems and social life [5]. In Albania, road safety remains a critical social concern and a fundamental element of sustainable development, yet it remains under prioritized and underfunded. Road traffic accidents (*RTAs*) are a significant health and economic challenge for the country [13]. Albania faces notable difficulties in ensuring road safety compared to neighbouring countries, particularly due to rapid economic expansion and growth in the transportation sector. To prevent an increase in traffic accidents as travel demands rise, targeted measures must be implemented. These include improved driver training and testing, vehicle safety checks, better road user behaviour, and enhanced infrastructure safety. Studies suggest that implementing well-coordinated, multi-sectoral road safety strategies could reduce fatalities by 50% [12].

The road transport sector in Albania has been under increasing pressure due to rising vehicle numbers and urban expansion. One of the most concerning consequences of this trend is the growing incidence of road traffic accidents [13]. Although Albania has witnessed a decline in total accidents in recent years, the number of fatalities per 10,000 inhabitants has increased significantly [14]. Extensive research highlights the need for a proactive and predictive approach to road safety. Various studies explore different methodologies for analysing *RTAs*, considering factors such as socio-economic conditions, engineering advancements, and policy frameworks. However, existing regulations often fall short of effectively preventing accidents [15-18]. Due to their accuracy and reliability, road accident prediction models have become an essential tool in traffic safety research. Each country's unique socio-economic conditions directly influence the state of its road transport system [5]. Moreover, studies indicate a strong link between the rise in *RTAs* and global trends in population growth and vehicle registrations [19-22]. Over the past decade, Albania has recorded a significant number of road traffic accidents, making accident reduction a national priority [13, 23]. The country's road network is insufficient, with many poorly maintained roads, inconsistent fuel quality, and limited alternative transport options. Despite a growing number of vehicles, Albania's transport sector is still dominated by older models—most vehicles are over 15 years old, making them less safe compared to those in other European countries [24].

This study introduces a model that examines how road safety correlates with population growth and vehicle registration rates. The analysis confirms a relationship between these factors and the prevalence of road traffic accidents in Albania. Using nonlinear regression techniques, data from 2015 to 2024 was analysed to provide insights into current trends and future projections. Key variables—*RTAs*, population projections, and registered vehicles—were considered in developing a nonlinear accident prediction model. The Andreassen model was adapted to fit Albania's data, using population projections and vehicle numbers as independent variables. Meanwhile, road traffic data, including total accident cases (*C*), fatalities (*F*), and injuries (*I*), were treated as dependent variables. The findings suggest that as vehicle numbers increase, fatalities tend to decline, but the overall number of accidents and injuries per vehicle rises. Statistical evaluations indicate that the Andreassen regression model is well-suited for estimating RTAs in Albania, providing valuable insights for future transportation planning.

2. Literature Review

Several researchers have contributed valuable insights into road safety and accident analysis. A study by Oprea, et al. [25] applied nonlinear regression methods based on Andreassen [26] empirical laws to accident data in Bucharest. The authors proposed a methodology that could be widely applied in both micro- and macro-level urban traffic studies. Their findings confirmed that as traffic volume increases, the rate of road accidents tends to decline, reinforcing Smeed's law. The study also emphasized the importance of driver awareness, particularly in congested areas. In India, models analysing accident data across major metropolitan cities have been developed using the Smeed and Andreassen equations [27]. By examining traffic trends over 25 years (1977–2001), researchers estimated *RTAs* for seven major cities in 2007 and 2010. The models performed well, with minimal differences between predicted and actual accident rates.

A separate study Tsuboi [28] investigated traffic safety in developing countries by analysing historical trends from advanced nations. Researchers applied Smeed's equation, linking fatal accident rates to population growth and vehicle numbers. The study found that traditional parameters did not account for accident reduction, prompting the inclusion of new variables, such as traffic signal installations. Drawing from Japanese and Indian data, the revised model assessed the effectiveness of traffic signals in reducing fatalities. The findings suggest that while traffic signals play a crucial role, additional measures—such as intelligent traffic management systems—are needed for sustained safety improvements. Another study Ray and Bhaduri [29] conducted in Kolkata in 2017 developed accident prediction models using advanced statistical methods. By analysing key factors influencing *RTAs*, researchers established a relationship between accident rates, registered vehicles, and population growth. The study applied multiple models, including Smeed's and Andreassen's equations, demonstrating their effectiveness in forecasting accident trends. While fatalities showed a declining trend, the total number of accidents remained high, emphasizing the need for further safety measures.

3. Some Data and Statistics on the Road Traffic Accidents in Albania

Road safety is often assessed based on the number and severity of *RTAs*. A comprehensive approach requires collecting substantial accident data to identify and address transport system weaknesses through appropriate safety interventions [30]. Given the multiple causes of road accidents and the rising fatality rates in developing countries, efforts to reduce accidents must begin with identifying the primary contributing factors [31]. In Albania, road safety management is overseen by the Inter-Ministerial Committee for Road Safety, which is responsible for policy and strategic planning. The country has implemented an Accident Information System to monitor incidents across the national road network. Traffic police officers are tasked with accident investigations and reporting [13].

According to Albania's Institute of Statistics (INSTAT), in 2024, road traffic accidents claimed approximately 175 lives, equating to 60 fatalities per million people—higher than the European Union average of 46 per million. Additionally, 2,080 individuals sustained injuries, many of whom will face long-term disabilities and financial hardship. The number of accidents in 2024 increased by 29.6%

compared to 2023, though mortality rates declined from 14.9 to 10.5 per 100 accidents. Driver behaviour remains the leading cause of accidents, rising by 33.2%, while pedestrian-related incidents have also increased by 6.9% [32]. Despite these challenges, there has been a gradual decline in the overall number of fatalities. Looking ahead, [33] suggests that Albania should aim for near-zero road transport fatalities by 2050, aligning with long-term global road safety goals.
The main reasons for the increase in the number of accidents are [31].

- Increased traffic flow on main roads.
- Increased speed above permitted limits.
- Failure to comply with traffic rules by drivers and other road users.

The description of the accident incidence is not the only factor necessary in road safety, we must also take into account other factors such as the population projections, the number of registered vehicles, information on the persons involved in the accident and/or fatalities [34]. It is also necessary to obtain detailed accident data, to compare the types of accidents and the road users involved with the data on road safety indicators [35]. From the analysis of road accidents in our country with loss of life, the highest percentage is occupied by traffic violations by drivers, while the second place is occupied by failure to respect road traffic rules by pedestrians. The number of accidents is considered problematic given the decreasing population in our country and the increasing level of motorization [13]. Passengers are the group of road users that make up the highest percentage of seriously injured people, accounting for around 21%. Motorcyclists also make up a significant proportion of those who are seriously injured, accounting for around 26.8% of seriously injured people in 2024. During the last years, 2015 – 2024, the majority of people who were seriously injured were pedestrians (26.3%), passengers (25.2%), and motorcyclists (23.8%). The percentage of drivers who use alcohol is decreasing, the opposite happens with drivers who drive at speeds above the allowed rates, a percentage which results in an increase and is not in line with the trends required as an objective for the years under study [32].

For improved road safety, positive trends refer to the continuous improvement of engineering solutions such as road infrastructure that directly contributes to road traffic accidents, improving the quality of vehicles in use, and improving the driving skills of the population in general [34, 36, 37]. The road infrastructure in Albania needs improvement as it supports tourism, which is one of the most important sectors in the country's economy. There has been a dramatic increase in the number of vehicles over the last 10 years, as well as a decrease in the number of fatal accidents over the last two years, but the country still has the highest number of victims per hundred thousand vehicles in the South-Eastern European region. Despite the measures taken and the progress achieved so far, there is still much to be done in the field of road infrastructure. Road safety remains a major social and public health issue, as the number of accidents with serious or minor injuries has increased significantly over the years [13, 32]. According to the forecast of the study conducted by Malka and Bidaj [38] the number of vehicles in our country will continue to increase based on the historical average annual growth and the rate of income growth. The motorization rate in Albania is 314 vehicles per 1,000 inhabitants, 55% more compared to 2018. The number of fatalities from road traffic accidents has decreased by 10.3%, resulting in a 41.7% decrease in the mortality index per 10,000 vehicles compared to the same year [39].

4. Methodology

4.1. Data Collection

In this research, population projections and the number of registered vehicles, factors used as independent variables, during the period under consideration, 2015-2024, are provided by official domestic and non-domestic sources, respectively, World Population and the General Directorate of Road Transport Services of Albania [40, 41]. Dependent variables such as the number of road traffic cases, the number of road traffic victims, and the number of road traffic injuries are provided by the

Albanian Institute of Statistics (INSTAT) [32]. According to INSTAT, about 15,994 road accidents in Albania have occurred during the last 10 years, and about 19,349 people have been involved in road accidents, divided into 2,110 fatal cases, as shown in Table 1.

Table 1.
Statistical Data for the period under consideration, 2015-2024.

Year	Fatalities	No of Cases	No of Injuries	Population	No of Vehicles
2015	270	1,992	2,422	2,898,632	411,121
2016	269	2,032	2,509	2,897,867	443,227
2017	222	1,978	2,389	2,898,242	479,217
2018	213	1,718	2,078	2,894,231	500,894
2019	227	1,498	1,817	2,885,010	499,779
2020	181	1,234	1,417	2,871,954	539,497
2021	197	1,376	1,663	2,849,635	593,280
2022	164	1,165	1,435	2,827,608	639,379
2023	192	1,285	1,539	2,811,655	699,337
2024	175	1,666	2,080	2,791,765	738,299

During the years 2015-2024, the number of registered vehicles has increased by approximately doubling, while population projections have decreased due to emigration. Referring to the same period, the number of fatalities in road traffic accidents has decreased, while the number of accident cases and injuries has increased.

4.2. Development of the Prediction Model

One of the objectives of this study is to predict the future trend of road traffic fatalities ($RTFs$), road traffic cases ($RTCs$), and the number of road traffic injuries ($RTIs$) related to population projections (P) and the number of vehicles (V) in Albania. Using the nonlinear regression method, a mathematical model is created that represents the relationship between the displacement and time of a landslide to further predict its deformation trend [42].

Two types of attributes, namely population projections and number of vehicles for the period 2015-2024, were considered as independent variables for the development of a nonlinear road traffic accident prediction model. This type of model is proposed by Andreassen [26] and is given by the equation:

$$C = kV^{M_1}P^{M_2} \quad (1)$$

Where

k- Constant.

V- Number of registered vehicles.

P- Population projections.

M_1- Square coefficient of the number of vehicles registered.

M_2- Square coefficient of the number of populations.

After transforming equation (1) and the logarithm to the base e, the nonlinear model in equation (1) can be expressed in a linear form as follows in equation (2).

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \quad (2)$$

Where

$$Y = lnC, \beta_0 = ln\,k, X_1 = ln\,V, X_2 = ln\,P, \beta_1 = M_1, \text{ and } \beta_2 = M_2.$$

The values of β_0, β_1, and β_2 are calculated using the multiple linear regression (MLR) method with the dependent variable of Y, and the independent variables X_1 and X_2.

Furthermore, using the least squares regression method (LSR) to estimate the above-mentioned parameters, must go through the use of the expressions in equation (3).

$$\hat{\beta} = (X^T X)^{-1} X^T Y \quad (3)$$

Where X is the matrix form of the multiple regression model consisting of a column of ones and two column vectors of the observations on the independent variables.

Thus, in terms of initial variables, the expression (4) is carried out, resulting in the number of predicted road traffic cases *C*.

$$C = e^{\beta_0} V^{\beta_1} P^{\beta_2} \quad (4)$$

Using the same methodology, the expression (5) is carried out, resulting in the number of predicted fatalities *F*.

$$F = e^{\beta_0} V^{\beta_1} P^{\beta_2} \quad (5)$$

As a final step, using the same methodology with the number of road traffic injuries I as the dependent variable, it was carried out in a nonlinear form by equation (6) as a function of registered vehicles and population projections.

$$I = e^{\beta_0} V^{\beta_1} P^{\beta_2} \quad (6)$$

For all three scenarios, ANOVA analysis was performed, and *R*-Squared coefficients, variable significance t-Stat), and model statistical significance *F*-Stat were calculated. Tests of models were made with the actual data, and a test of overall regression for a better understanding of the trend and tendencies was conducted.

4.3. Test of Overall Regression

Overall test-statistic F for whether slopes, β_j, j=1, 2 of the regression model are zero is given by the following equation [43].

$$F = \frac{R^2/q}{(1-R^2)/(n-q-1)} = \sim F(q, n\text{-}q\text{-}1) \quad (7)$$

Where, R^2 is the coefficient of determination, n is the number of years under consideration, and q is the number of parameters we have to estimate.

Coefficient of determination is given by equation (8).

$$R^2 = \frac{SSR}{SST} = 1 - \frac{SSE}{SST} \quad (8)$$

Where regression sum of square SSR=$\sum(\hat{y} - \bar{y})^2$ and where total sum of square SST=SSR+SSE and where sum of squared residuals SSE=$\sum e^2$.

Test statistic is distributed as F(q, n-q-1) when H_0: $\beta_j = 0$ is true, so we reject H_0 if F>F(α, q, n-q-1).

5. Simulation and Results

The nonlinear regression method used in this study uses three data sets defined as road traffic accidents, in terms of the total number of road traffic cases (*RTCs*), road traffic fatalities (*RTFs*), and road traffic injuries (*RTIs*), to be regressed as a function of population projections and registered vehicles. The total number of observations is 10, each year represents an observation value that should be regressed.

5.1. Estimation of RTCs

Using equation (1) and the *MLR* method, we obtain the mathematical expression as follows in (9).

$$C = e^{245.3} V^{-1.73} P^{-14.45} \quad (9)$$

The values of $\tilde{C}$ represent the estimate of road traffic cases (C), which are evaluated by equation (9), and are presented in Table 2. From the simulation results (Table 2), it is noted that the estimation of the total number of accident cases shows that the predicted values are slightly higher than the actual values. This may be related to the fact that within these years, the increase in the total number of accidents is insignificant compared to the increase in the number of vehicles and the decrease in the population. However, the gap has started to narrow again, attributed to the fact that the further increase in the number of road traffic accidents.

Table 2.
Simulation results on estimated *RTCs* referred to the nonlinear regression model.

Year	No of cases (C)	Estimated $\tilde{C}$	Error (%)
2015	1,992	2,613	621 (31.1%)
2016	2,032	2,336	304 (14.9%)
2017	1,978	2,024	46 (2.3%)
2018	1,718	2,007	289 (16.8%)
2019	1,498	2,010	521 (34.9%)
2020	1,234	1,874	640 (51.8%)
2021	1,376	1,774	398 (28.9%)
2022	1,165	1,642	477 (40.9%)
2023	1,285	1,612	327 (25.4%)
2024	1,666	1,727	61 (3.6%)
Total	15,944	19,601	

5.2. Estimation of RTFs

Using equation (5) and the *MLR* method, we obtain the mathematical expression as follows in (10).

$$\text{F}= e^{201.9}V^{-1.60}P^{-11.80} \qquad (10)$$

The values of $\tilde{F}$ represent the estimate of road traffic fatalities (*F*), which are evaluated by equation (10), and are presented in Table 3. From the simulation results, it is noted that in almost all years of the study period, the incidence of fatalities was lower than the predicted fatalities. The difference between the actual and predicted values in the case of the number of fatalities is not as high as in the case of the total number of accident cases. This may be related to the fact that despite the increase in the number of vehicles and the decrease in population projections, traffic management has been quite efficient by the relevant authorities. Furthermore, on average, the expected fatalities estimated by the Andreassen formula are 209.2 per year, a result which is close to the average of the actual fatalities.

Table 3.
Simulation results on estimated *RTFs* referred to the nonlinear regression model.

Year	No of fatalities (F)	Estimated $\tilde{F}$	Error (%)
2015	270	276	-6 (-2.2%)
2016	269	250	19 (7%)
2017	222	220	2 (0.9%)
2018	213	208	5 (2.3%)
2019	227	217	10 (4.4%)
2020	181	202	-21 (-11.6%)
2021	197	191	6 (3%)
2022	164	185	-21 (-12.8%)
2023	192	172	20 (10.4%)
2024	175	171	4 (2.2%)
Total	2,110	2,092	

5.3. Estimation of RTIs

Using equation (6) and the *MLR* method, we obtain the mathematical expression as follows in (11).

$$\text{I}= e^{296.4}V^{-1.95}P^{-17.69} \qquad (11)$$

The values of $\tilde{I}$ represent the estimate of road traffic injuries (*I*), which are evaluated by equation (11), and are presented in Table 4. From the simulation results, it is noted that in almost all years of the study period, the actual number of injuries was lower than the predicted number of injuries. The difference between actual and predicted values in the number of injury cases is similar to the case of fatalities cases. According to the same reason of the case of fatalities, this may be related to the fact that despite the increase in the number of vehicles and the decrease in population projections, traffic management has been quite efficient by the relevant authorities. Moreover, on average, the expected number of injured estimated by the Andreassen formula is 2101.6 per year, a result which is close to the average of the actual injured number.

Table 4.
Simulation results on estimated *RTIs* referred to the nonlinear regression model.

Year	No of Injures (I)	Estimated $\tilde{I}$	Error (%)
2015	2,422	2,839	417 (17.20%)
2016	2,509	2,511	2 (0.007%)
2017	2,389	2,151	-238 (-9.96%)
2018	2,078	2,022	-56 (-2.69%)
2019	1,817	2,149	332 (18.27%)
2020	1,417	2,006	589 (41.50%)
2021	1,663	1,913	250 (15.03%)
2022	1,435	1,896	461 (32.12%)
2023	1,539	1,760	221 (14.35%)
2024	2,080	1,769	-311 (-14.95%)
Total	19,349	21,016	

6. Validation of the Model

The nonlinear regression models presented in the equations above were estimated for the three variables *RTCs*, *RTFs*, and *RTIs*, respectively. The estimated coefficients and statistics are given in Table 5. From the simulation results included, the estimated coefficients (β_0, β_1, β_2), standard error, and t-test values for the *RTCs* and *RTIs* coefficients are almost equal. All parameters are very significant.

Table 5.
Regression results: coefficients (β_0, β_1, β_2).

	Coefficient β_0			Coefficient β_1			Coefficient β_2		
	Estimated	Standard Error	t-Test	Estimated	Standard Error	t-Test	Estimated	Standard Error	t-Test
RTCs	245.30	262.07	0.93	-1.73	1.21	-1.43	14.45	16.58	-0.87
RTFs	201.91	133.12	1.51	-1.60	0.61	-2.59	-11.80	8.42	-1.40
RTIs	296.42	284.39	1.04	-1.95	1.31	-1.48	-17.69	17.99	-0.98

From Table 6, it is found that *R*-Square coefficients are 0.67, 0.89, and 0.69, respectively. Data from the ANOVA table shows that the significance values of the models are lower than the significance level α=0.05. Moreover, since the calculated value of *F* is greater than F(0.05; 2,n-3)=4.74, this requires the rejection of H_0, accepting that the test is significant at the 5% accuracy level. It can be concluded that the developed models with two independent variables (*V*) and (*P*) that predict the number of road traffic accidents are good, recommending that the estimated nonlinear regression models properly fit the Albanian case data referring to the period 2015-2024.

Table 6.
Summary of Model Statistics.

Statistic	*R*-Square	Standard Error	F-Test	Sig F
RTCs	0.67	0.06	4.85	0.004
RTFs	0.89	0.08	14.16	0.001
RTIs	0.69	0.09	5.91	0.003

In addition, from the simulation results and analyses used in the study, it is noted that the linear relationship between the regressed *Υ* and independent variables X_1, X_2 is observed. The general Andreassen's two-variable prediction models of *RTAs* are suitable for predicting the actual number of accident cases, fatalities, and injuries in Albania. An important benefit of the developed models is that they can be used to estimate accidents for the future.

7. Conclusion

In many scientific types of research of recent years, the statistics of trend in road traffic accidents in a huge number of populations worldwide strongly highlight the fact of a dramatically increasing trend in the rate of *RTAs*, including Albania [14, 44-46]. This research aims to provide an overview of road traffic accident statistics in our country using data from 2015 to 2024 to analyze the current situation and future projections. It is observed that the number of road traffic accidents continues to be problematic, given the decreasing population in our country and the increasing level of motorization. Despite the measures taken and the progress achieved in the field of road infrastructure, there is still work to be done in this sector. Road safety remains a major issue for the public health sector in our country, as it is noted that the number of road traffic accidents with minor or serious injuries has increased significantly over the last decade.

Road traffic accidents depend on parameters such as the number of vehicles, their quality, traffic safety initiatives and regulations, and the intensity of enforcement by relevant authorities. The number of vehicles in a country directly affects the number of *RTAs*, given that an increase in the number of vehicles leads to higher average traffic volumes [37]. Therefore, there is a relationship between *RTA*s and the number of vehicle ownership and the population projections. In this study, this relation has been investigated and modeled in Albania by using the adapted Andreassen model forms.

According to the simulation executed referring to this model, where population projections and the number of registered vehicles are taken as independent variables, a highly estimated accident prediction model was developed. The dependent variable Y is related to road traffic accidents, while the independent variables X_i, i=1, 2 are related to population projections and motorization level. The relationship between these variables is given by the equations (9), (10), and (11).

To verify the relationship between the studied variables, the F-test is used, and a high statistical significance ($p < 0.001$) is observed for all developed models. Moreover, the results obtained in this paper are a starting point for future road safety prediction, finding that the increase in vehicle ownership leads to an increase in the number of accidents and injuries, as well as a decrease in the number of fatalities per vehicle.

In conclusion, according to the statistical evaluations conducted in the study, the Andeaseen regression model is valid for the assessment of road traffic accidents (RTA) in the country of Albania. This fact supports and suggests that the developed models can be used to assess and predict future road traffic accidents. The development models within the transport sector are a very useful tool to mitigate and minimize road traffic accidents to a certain extent.

8. Limitations of the Study

This study is based on road traffic accident data available on the website of the Albanian Institute of Statistics (INSTAT). Meanwhile, there is a lack of complete information on minor accidents and less important road traffic accidents. Sometimes different types of accidents are not counted in the surveillance system, but they exist in reality and have important effects on the overall modeling of road traffic accidents. The road traffic accident model, in terms of the total number of cases (C), fatalities (F), and injuries (I), developed in the study is based only on the data available from the INSTAT database.

9. Future Work

In the future, more variables of influence, such as economic income level and other social issues that impact road traffic accidents within the transportation system will be included. Furthermore, the use of advanced statistical methods and the integration of different methodologies, such as combining statistical methods with machine learning and/or optimization algorithms, which provide a more comprehensive framework for accident analysis and prevention, should be used too.

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References

[1] B. P. Loo and D. Banister, "Decoupling transport from economic growth: Extending the debate to include environmental and social externalities," *Journal of Transport Geography*, vol. 57, pp. 134-144, 2016. https://doi.org/10.1016/j.jtrangeo.2016.10.006.
[2] J. Wan, Q. Xie, and X. Fan, "The impact of transportation and information infrastructure on urban productivity: Evidence from 256 cities in China," *Structural Change and Economic Dynamics*, vol. 68, pp. 384-392, 2024. https://doi.org/10.1016/j.strueco.2023.11.008
[3] M. H. Abdelati, "Towards sustainable transportation in egypt: An analysis of current challenges and future opportunities," *Journal of International Society for Science and Engineering*, vol. 7, no. 1, pp. 16-28, 2025. https://dx.doi.org/10.21608/jisse.2024.305711.1090
[4] A. A. Zahidy, M. H. Sutanto, and S. Sorooshian, "Examining the relationship between road service quality and road traffic accidents: A case study on an expressway in Malaysia," *Traffic Safety Research*, vol. 8, pp. e000056-e000056, 2024. https://doi.org/10.55329/gzqy4926
[5] C. Liu, S. Zhang, H. Wu, and Q. Fu, "A dynamic spatiotemporal analysis model for traffic incident influence prediction on urban road networks," *ISPRS International Journal of Geo-Information*, vol. 6, no. 11, p. 362, 2017. https://doi.org/10.3390/ijgi6110362
[6] World Health Organization, *Global status report on road safety 2018*. Switzerland: World Health Organization, 2019.
[7] F. F. Mohamad, J. Mohamad, and A. S. Abdullah, "Do young Malaysian drivers involve in speeding behaviour: An investigation at selected accident hotspots in peninsular Malaysia," *J. Adv. Res. Soc. Behav. Sci. J. homepage*, vol. 9, no. 1, pp. 75-83, 2017.
[8] S. S. Tehrani, L. C. Falls, and D. Mesher, "Road users' perception of roughness and the corresponding IRI threshold values," *Canadian Journal of Civil Engineering*, vol. 42, no. 4, pp. 233-240, 2015. https://doi.org/10.1139/cjce-2014-0344
[9] D. Bishai, "National road casualties and economic development," Retrieved: https://pubmed.ncbi.nlm.nih.gov/16145717/, 2006.
[10] M. Beenstock and D. Gafni, "Globalization in road safety: explaining the downward trend in road accident rates in a single country (Israel)," *Accident Analysis & Prevention*, vol. 32, no. 1, pp. 71-84, 2000. https://doi.org/10.1016/s0001-4575(99)00053-6)
[11] World Health Organization, *Global status report on road safety*. Geneva, Switzerland: WHO, 2013.
[12] World Health Organization, *Global plan: Decade of action for road safety 2021-2030*. Geneva, Switzerland: WHO, 2021.
[13] Road safety performance review: Albania, "United nations publication issued by the economic commission for Europe," Retrieved: https://digitallibrary.un.org/record/3813635?ln=en, 2018.
[14] R. Dervishi, J. Kasharaj, and I. Kondi, "Estimating of road accidents during the covid-19 pandemic year in Albania," *International Journal of Ecosystems & Ecology Sciences*, vol. 11, no. 3, pp. 489-494, 2021. https://doi.org/10.31407/ijees11.318

[15] F. Wang, J. Wang, X. Zhang, D. Gu, Y. Yang, and H. Zhu, "Analysis of the causes of traffic accidents and identification of accident-prone points in long downhill tunnel of mountain expressways based on data mining," *Sustainability*, vol. 14, no. 14, p. 8460, 2022. https://doi.org/10.3390/su14148460

[16] S. Regev, J. J. Rolison, and S. Moutari, "Crash risk by driver age, gender, and time of day using a new exposure methodology," *Journal of safety research*, vol. 66, pp. 131-140, 2018. https://doi.org/10.1016/j.jsr.2018.07.002

[17] M. Alshannaq, R. Imam, and D. W. Alsarayreh, "Modelling of traffic accident severity in Jordan using machine learning," *International review of civil engineering*, vol. 14, no. 5, 2023. https://doi.org/10.15866/irece.v14i5.22730

[18] P. Pergantis, V. Bamicha, I. Chaidi, and A. Drigas, "Driving under cognitive control: the impact of executive functions in driving," *World Electric Vehicle Journal*, vol. 15, no. 10, p. 474, 2024. https://doi.org/10.3390/wevj15100474

[19] G. Tiwari, R. Goel, and K. Bhalla, "Road safety in India: Status report. New Delhi: Transportation Research & Injury Prevention Centre, Indian Institute of Technology Delhi," Retrieved: https://tripc.iitd.ac.in/assets/publication/RSI_2023_web.pdf, 2023.

[20] A. Boakye, G. K. Abledu, S. Kwofie, J. K. Gbang, S. A. Gyimah, and D. Mbima, "Comparative model analysis of road traffic accidents in Ghana," *International Journal of Statistics and Applications*, vol. 6, pp. 105-112, 2016.

[21] A. Bener, S. J. Hussain, M. Al-Malki, M. Shotar, M. Al-Said, and K. Jadaan, "Road traffic fatalities in Qatar, Jordan and the UAE: estimates using regression analysis and the relationship with economic growth," *Eastern Mediterranean Health Journal*, vol. 16, no. 3, pp. 318-323, 2010.

[22] E. Cenaj and R. Dervishi, "Road accident fatalities forecasting models using smeed's regression analysis: A case study," *European Journal of Engineering and Technology Research*, vol. 9, no. 6, pp. 20-24, 2024.

[23] World Health Organization, "Global status report on road safety," Retrieved: https://www.who.int/teams/social-determinants-of-health/safety-and-mobility/global-status-report-on-road-safety-2023, 2023.

[24] L. Malka, R. Dervishi, P. Malkaj, I. Konomi, R. Ormeni, and E. Cenaj, "Modelling and assessing environmental impact in transport to meet the sector's climate goals in 2050," *Weseas Trans Environ Dev*, vol. 20, pp. 350-64, 2024. https://doi.org/10.37394/232015.2024.20.34

[25] C. Oprea, E. Rosca, I. Preda, A. Ilie, M. Rosca, and F. Rusca, "Forecasting methods for road accidents in the case of Bucharest city," *Engineering Proceedings*, vol. 68, no. 1, p. 3, 2024. https://doi.org/10.3390/engproc2024068003

[26] D. Andreassen, "Population and registered vehicle data vs. road deaths," *Accident Analysis & Prevention*, vol. 23, no. 5, pp. 343-351, 1991. https://doi.org/10.1016/0001-4575(91)90055-A

[27] P. P. Valli, "Road accident models for large metropolitan cities of India," *IATSS research*, vol. 29, no. 1, pp. 57-65, 2005. https://doi.org/10.1016/S0386-1112(14)60119-9

[28] T. Tsuboi, "Quantitative Traffic Safety Analysis for India by Japanese Experience," *Sociology*, vol. 10, no. 1, pp. 1-14, 2020.

[29] T. K. Ray and S. Bhaduri, "Application of Road Traffic Accident Modelling for Future Prediction: A Case Study of Kolkata," *Int J Cur Res Rev | Vol*, vol. 9, no. 5, p. 1, 2017.

[30] D. Lord and B. N. Persaud, "Estimating the safety performance of urban road transportation networks," *Accident Analysis & Prevention*, vol. 36, no. 4, pp. 609-620, 2004. https://doi.org/10.1016/S0001-4575(03)00069-1

[31] A. C. Mbakwe, A. A. Saka, K. Choi, and Y.-J. Lee, "Alternative method of highway traffic safety analysis for developing countries using delphi technique and Bayesian network," *Accident Analysis & Prevention*, vol. 93, pp. 135-146, 2016. https://doi.org/10.1016/j.aap.2016.04.020

[32] Transporti, "Accidents and characteristics of road vehicles," Retrieved: https://www.instat.gov.al/, 2024.

[33] European Commission, "European road safety observatory, directorate general for transport," Retrieved: https://roadsafety.transport.ec.europa.eu/system/files/2021-07/asr2020.pdf, 2021.

[34] A. Borsos, C. Koren, J. N. Ivan, and N. Ravishanker, "Long-term safety trends as a function of vehicle ownership in 26 countries," *Transportation research record*, vol. 2280, no. 1, pp. 154-161, 2012. https://doi.org/10.3141/2280-17

[35] F. Archer, *Indicators for traffic safety assessment and prediction and their application in micro-simulation modelling: A study of urban and suburban intersections*. Sweden: Royal Institute of Technology Stockholm, 2005.

[36] A. Bhattarai and S. Shafir, "Analyzing road infrastructure and safety in urban nepal: A synthesis of existing research," *Preprints*, 2024. https://doi.org/10.20944/preprints202409.2058.v1

[37] G. Yannis, C. Antoniou, and E. Papadimitriou, "Autoregressive nonlinear time-series modeling of traffic fatalities in Europe," *European transport research review*, vol. 3, pp. 113-127, 2011. https://doi.org/10.1007/s12544-011-0055-4

[38] L. Malka and F. Bidaj, "Opacity evaluation for passenger diesel vehicle cars in Tirana," *J. Environ. Sci. Eng. A*, vol. 4, no. 7, pp. 352-358, 2015. https://doi.org/10.17265/2162 5298/2015.07.003

[39] General Directorate of Road Transport Services, "Positive statistics on consequences and road accidents for the year 2023," Retrieved: https://www.dpshtrr.al/te-reja/lajme/statistika-pozitive-pasojat-nga-aksidentet-rrugore-vitin-2023, 2023.

[40] World Population, "World population," Retrieved: https://www.worldometers.info/world-population/albania-population/, 2024.

[41] General Directorate of Road Transport Services, "Open data: Statistics and reports," Retrieved: https://www.dpshtrr.al/sherbime-online/open-data-statistika-raporte, 2024.

[42] H. Fu, W. Chen, and J. Fu, "Chapter 9 - Landslide and rockfall prediction technology," *In Woodhead Publishing Series in Civil and Structural Engineering, Rock Mechanics and Engineering, Elsevier*, pp. 245-307, 2021. https://doi.org/10.1016/B978-0-12-822424-3.00009-8

[43] A. C. Rencher and W. F. Christensen, "Méthods of multivariate analysis. a john wiley & sons," *Inc. Publication*, vol. 727, pp. 2218-0230, 2002. https://doi.org/10.1002/9781118391686.scard

[44] R. H. Latief, R. I. K. Zaki, and A. H. Albayati, "Analysis of road traffic accidents among Iraqi Governorates," *Civil and Environmental Engineering*, vol. 19, no. 1, pp. 134-48, 2023. https://doi.org/10.2478/cee-2023-0012

[45] M. Islam, "An Exploratory Analysis on Fatalities of Roadway Departure Crashes," *Transportation Research Circular*, no. E-C220, 2017.

[46] O. I. Inah, M. I. Ofem, F. I. Abam, S. O. Effiom, and O. O. Jimmy, "Trend and causative factors of road traffic crashes in nigeria: A six sigma (dmaic) approach," *Journal of Road Safety*, vol. 36, no. 1, pp. 53-65, 2025. https://doi.org/10.33492/JRS-D-25-1-2460893