Journal of Infrastructure, Policy and Development 2025, 9(2), 11464.
https://doi.org/10.24294/jipd11464

Article

Fuel price dynamics and its impact on road safety in Europe

Vilém Kovač*, **Tomáš Řezníček**

Institute of Technology and Business, School of Expertness and Valuation, Okružní 517/10, 37001 České Budějovice, Czech Republic
*** Corresponding author:** Vilém Kovač, kovac@znalcivste.cz

CITATION

Kovač V, Řezníček T. (2025). Fuel price dynamics and its impact on road safety in Europe. Journal of Infrastructure, Policy and Development. 9(2): 11464. https://doi.org/10.24294/jipd11464

ARTICLE INFO

Received: 4 February 2025
Accepted: 10 March 2025
Available online: 15 May 2025

Abstract: Rising fuel prices can affect driver behavior and thus the number of accidents, which is a key road safety issue. The aim of this paper was to assess and quantify the relationship between fuel prices (FP) and the number of road accidents in Europe. Content analysis of statistics from the countries was used to collect data, which were examined using Ramsey resets and Poisson distributions and then processed using negative binomial regression (NB), cluster analysis and visualization using contour plots. The results show that in Germany and Poland there is a statistically significant low negative correlation between fuel price and the number of traffic accidents, while in the Czech Republic and Denmark the relationship is weaker and statistically insignificant. In Iceland, no significant correlation was found. The contribution of this paper is to provide important insights that can be used in the development of transport policies and regulations to improve road safety. The main limitations include the difficulty of data collection, as many countries do not publish detailed statistics, and the low number of accidents in Iceland, which makes it impossible to perform a robust analysis for this country and may cause generalization of the results.

Keywords: cost of fuel; traffic accidents; negative binomial regression; content analysis; traffic safety

1. Introduction

Traffic accidents and the price of fuel are two important aspects affecting the lives of citizens in developed countries. Meanwhile, fuel prices have a direct impact on households' and companies' economies and budgets, as decreasing or increasing fuel prices significantly affect the transport spending of economic operators. When fuel prices increase, it creates negative sentiments among citizens that may culminate in protests (von Uexkull et al., 2024).

However, a positive effect of increasing fuel prices is the reduction of greenhouse gas emissions, due to more economical driving or reduced driving activity (Kamruzzaman et al., 2020), where a portion of car users will start to apply fuel-efficient driving behavior when fuel prices increase Knittel et al. (2021) and another portion of drivers will start to use alternative means of transport as a less fuel-intensive option (Zhang et al., 2021). A good analogy is the lockdown during the Covid-19 pandemic, when driving activities of all economic agents were significantly reduced. As a result, the total number of traffic accidents in the year the lockdown was implemented was significantly lower than in previous years (Qureshi et al., 2020).

While traffic accidents as an anomaly in road transport have a direct impact on the physical and psychological health of the population (Alshardan et al., 2020), their safety also has a significant economic impact (Tan et al., 2020), causing both medical and recovery costs as well as disabling the economic agent from engaging in economic activities. Fuel prices are influenced by the impact of various economic and geopolitical factors (Kpodar el al., 2021). When the price of oil from which fuel is produced has a very significant impact on the price of fuel. The final price of fuel is also governed by the taxes of a given country and the last factor is competition, which tends to be distorted in the fuel market in some countries (Berezvai et al., 2024).

2. Aim of the study

The aim of this paper is to evaluate and quantify the relationship between fuel prices and the number of traffic accidents in Europe.

To meet the stated objective, two research questions were set:

Tracking the evolution of the number of traffic accidents in these countries provides a basic overview of trends in traffic safety. This information is necessary to understand whether there have been significant changes that could affect the interpretation of the relationship between fuel prices and accident rates.

VO:1 How has the number of traffic accidents evolved between 2018 and 2024 in the Czech Republic, Germany, Poland, Denmark and Iceland?

Examining the evolution of fuel prices is essential to quantify their impact on the number of traffic accidents. Tracking these changes will identify periods when fluctuating prices may have influenced traffic behavior.

VO2: How have fuel (petrol/diesel) prices evolved over the years studied in the countries studied?

Identifying the relationship between fuel prices and the number of accidents is a key step towards achieving the objective of the thesis. This question directly examines the main hypothesis that changes in fuel prices can affect the frequency of traffic accidents.

VO3: What is the relationship between average fuel prices and the number of traffic accidents in the countries studied?

3. Literary research

According to Knittel and Tanaka (2021), drivers respond to rising fuel prices by reducing consumption and switching to fuel-efficient driving. This study used econometric analysis and refueling microdata to explore the relationship between fuel prices and consumer behavior, applying regression analysis to identify changes in driver behavior. Conversely, Alberini et al. (2022) found that gasoline cars experience a decrease in miles driven when prices increase, while this effect is not significant for diesel vehicles and no changes were observed in average fuel consumption when prices increased. This difference suggests that fuel economy behavior may depend on fuel type and vehicle characteristics.

Akinyemi (2023) examined the effect of higher gasoline prices on accident rates and found that higher prices may lead to an increase in accident rates due to more aggressive driving behavior. Supporting this view, Navarro-Moreno et al. (2023) found that rising fuel prices negatively affect driver behavior and impair road safety. Their study used quantitative analysis and regression models. On the contrary, Naqvi et al. (2023) found that a 10% increase in fuel prices leads to a 2.4% reduction in traffic fatalities. This result is supported by earlier results of Naqvi et al. (2020) who found that even a small price increase (1%) reduces total fatalities by 0.4%. These conflicting results suggest that the effect of fuel prices on road safety is complex and influenced by many factors. Research by Kovac et al. (2023) examined the relationship between vehicle price and vehicle safety, finding that vehicle price does not always have a positive impact on vehicle safety.

Ahmed et al. (2023) found that higher fuel prices can improve road clearance, with large commercial vehicles showing the greatest elasticity to price changes. (Byaruhanga, 2024) showed that investments in road safety infrastructure can improve traffic flow and reduce fuel consumption. Sun et al. (2020) found that higher fuel prices increase the use of public transport, leading to lower fuel consumption and improved air quality.

Gang et al. (2022) found that higher fuel prices can have a negative impact on households' economic performance. The Ramsey RESET test and other visualization techniques were used to analyze them.

They showed that higher fuel prices can contribute to more efficient design of transportation networks and reduced GHG emissions (Zhang et al., 2022). Their research used a hidden Markov model and optimization algorithms. Kovac et al. (2023) also found that higher fuel prices lead to lower death rates for car drivers but increase death rates for motorcyclists, likely due to higher motorcycle registration as a more fuel-efficient alternative. Mortality itself may also be linked to car safety, which was examined by Banzhaf and Kasim (2017), who found that the safety level of newly purchased cars was higher in 2022 than in 2020. According to Ren et al. (2023), who investigated the probability of an accident occurring when using autonomous vehicles, it was found that well-adjusted steering parameters can reduce the number of accidents. When according to Akapov and Beklaryan (2022), autonomous transportation brings new challenges and opportunities for road safety. Mićić et al. (2022) dealt with the prediction of traffic accidents on rural roads in Serbia. When according to the authors it was found that negative binomial model with random effects and without random effects showed the highest variability. This is also confirmed by Almajyul et al. (2022) who analyzed the number and causes of traffic accidents at intersections using NB. When the NB model according to the authors fits well to the data related to traffic accidents.

According to Zhang and Burke (2021), higher gasoline prices lead drivers who drive more miles to buy less fuel-efficient cars. Empirical hypothesis testing and Gaussian normal distribution of the data were used to analyze them. Research by Řezníček and Sloup (2024) analyzed the relationship between the number of traffic accidents and the light factor.

To better understand the effect of fuel prices on accident rates, Hall and Tarko (2019) and Kumar and Toshniwal (2015) recommend the use of negative binomial regression and cluster analysis. Almajyul and Al-Ghreimil (2022) used negative binomial regression to analyze the accident rate on rural roads and used classification and clustering to identify patterns and factors contributing to accidents.

Cluster analysis and negative binomial regression will be used for this work as recommended by Hall and Tarko (2019) and Kumar and Toshniwal (2015). These methods will be key to understanding the relationship between fuel prices and accident rates in the selected countries.

4. Methodology

Data on traffic accidents will be collected from the official websites of five European countries: for the Czech Republic, data will be obtained from Centrum dopravního výzkumu (2024); for Germany, from Statistisches Bundesamt (2024); for Poland, from Obserwatorium Bezpieczeństwa Ruchu Drogowego (2024). Since data from official Polish sources were only available until 2019, they were supplemented with data from Knoema (2024). For Denmark data will be collected from Statistics Denmark (2024) and for Iceland, from Island.is (2024). From these sources, monthly statistics will be obtained that contain information on the number of traffic accidents recorded in each country.

The basic data on fuel prices (FP) come from the Czech Republic, where the Czech Statistical Office regularly monitors and publishes fuel prices monthly. Once archival data on fuel prices in the Czech Republic are available, it will be necessary to obtain similar data from the other four countries. This will be done by searching the Waze app for twenty petrol stations from each country. This application allows real-time monitoring of fuel prices, which will provide up-to-date data. An important condition for the selection of petrol stations will be that they are located outside major cities and motorways, ensuring that the data obtained is comparable.

A representative average will then be calculated for each country using the trimmed average method. Based on this representative average from the Czech Republic, the data can then be multiplied by a coefficient that will be calculated for each country. This coefficient will reflect the price differences between the Czech Republic and other countries, thus allowing an estimate of the typical fuel price in each country. The resulting averages (FP) will be used for further analyses.

The trimmed average can be calculated as (Konşuk et al., 2020):

$$\text{Trimmed average} = \frac{1}{n-2k}\sum_{i=k+1}^{n-k} x_{(i)} \quad (1)$$

where:

- n—Total number of observations (sample size);
- k—Number of extreme values removed from both ends of the data set;
- $x(i)$—The ordered value in the sorted data set;
- ∑—Summation symbol, indicating the sum of values from $k + 1$to $n - k$;
- $1/(n - 2k)$—Normalization factor that ensures the trimmed mean is correctly scaled.

Lastly, FP prices (diesel and petrol) will need to be unified into a single value that represents a single average value. In the Czech Republic, approximately 55% of vehicles are diesel and 45% petrol, reflecting their popularity. In Germany, diesel engines dominate with a share of 60%, as a result of a long tradition and tax incentives for diesel vehicles. In Poland, the ratio is more balanced, with 50% diesel and 50% petrol cars, partly due to imports of used vehicles. In Denmark, petrol engines are more popular with a 60% to 40% diesel ratio, which may be influenced by the higher cost of diesel and environmental regulations. In Iceland, petrol engines are more prevalent with a 70% petrol to 30% diesel ratio, due to shorter distances and lower petrol costs.

Due to data distortion, the period from 3/2020 to 3/2021 will be removed from the database, given that there was a reduction in movement due to the Covid-19 pandemic and thus a reduction in traffic and FP prices due to low demand.

The obtained database will be processed by cluster analysis using a Gaussian distribution of data. This approach will effectively identify similarities and differences in the distribution of fuel prices across countries. Based on the results of this cluster analysis, a contour plot will be created to provide a visual representation of the density and distribution of the data within the countries.

This will use a Gaussian normal distribution, which can be expressed in terms of (Maina, 2022):

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right) \quad (2)$$

where:
- $f(x)$—Probability density function at point x;
- σ—Standard deviation;
- μ—Mean (average fuel price).

Subsequently, a contour plot will be created using bilinear interpolation, which can be expressed as (Mastyło and Silva, 2020):

$$f\,(x,y) \approx f\,(x_1, y_y) \times \left(1 - \frac{x - x_1}{x_2 - x_1}\right)\left(1 - \frac{y - y_1}{y_2 - y_1}\right) + \cdots \quad (3)$$

where:
- $f(x, y)$—Interpolated function value at point (x, y);
- $(x1, y1)$—Coordinates of a known point in the grid;
- $(x2, y2)$—Coordinates of another point used for interpolation.

When choosing a regression analysis, we will need to consider several aspects, the first being to confirm or refute the linearity of the data. When the Ramsey RESET test is chosen, it will use the F-statistic to determine the linearity or non-linearity of the data. The formula can be expressed as (Gang et al., 2022):

$$F = \frac{(RSS_{restricted} - RSS_{unrestricted})/m}{RSS_{unrestricted}/(n-k-m)} \quad (4)$$

where:
- F—Test statistic for the F-test;
- $RSS_{restricted}$—Residual sum of squares for the restricted model;
- $RSS_{unrestricted}$—Residual sum of squares for the unrestricted model;
- m—Number of constraints in the model;
- n—Number of observations;
- k—Number of parameters in the unrestricted model.

Subsequently, a test will be performed to confirm or refute the Poisson distribution, which will determine the final model of the regression analysis. This formula can be expressed as (Konşuk et al., 2020):

$$P(X = k) = \frac{\lambda^k e^{-\lambda}}{k!} \quad (5)$$

where:

- $P(X = k)$—Probability that the random variable X takes the value k;
- λ—Mean (expected number of occurrences);
- k—Number of events.

Negative Binomial Regression (NB) will be used to investigate the relationship between fuel prices and the number of accidents. This method will be chosen based on preliminary tests of the data distribution. The standard approach to modeling count data is Poisson regression, which assumes that the mean (λ) and the variance are equal. However, in this case, the boxplots show that the variance of the data is significantly greater than the mean, leading to the need to choose an alternative model.

To test this assumption, an overdispersion test will be performed to determine whether the Poisson model is appropriate. It is assumed that the results of the test will confirm the presence of overdispersion, indicating the need to use a different model.

For this reason, a negative binomial model will be used which, unlike the Poisson regression, allows for variable variance by introducing an additional variance parameter.

Negative binomial regression can be expressed by the formula (Hall and Tarko, 2019):

$$Y_1 = \beta_0 + \beta_1 X_1 + \epsilon_1 \tag{6}$$

where:

- $Y1$—Dependent variable (e.g., number of accidents);
- $\beta 0$, $\beta 1$, …, βk—Regression coefficients, that estimate the relationship between the price of fuel and the number of accidents;
- $X1$—Independent variables (average fuel price (diesel/petrol) in the country);
- $\epsilon 1$—Error term.

In this analysis, we focused exclusively on the relationship between fuel prices and traffic accidents. However, it is important to note that accident rates are influenced by a number of other factors such as transport infrastructure, climatic conditions, traffic density, legislative measures (e.g., changes in speed limits), technological advances in vehicles or the behavior of drivers themselves.

5. Results

In the first part of the results section, the contour fences of each country will be presented first. These plots visualize the distribution and density of the data obtained from the fuel price analysis in the different regions of each country.

An overall assessment of the comparison of **Figures 1** and **2** from the contour plots shows that while in Denmark there is a relatively stable relationship between fuel prices and accident rates, where higher prices may lead to lower accident rates, in the Czech Republic this relationship is more complex. In the Czech Republic, a high number with a lower dependence on FP price is evident, suggesting that other factors (e.g., traffic density, infrastructure quality or driving behavior) further influence the number of accidents.

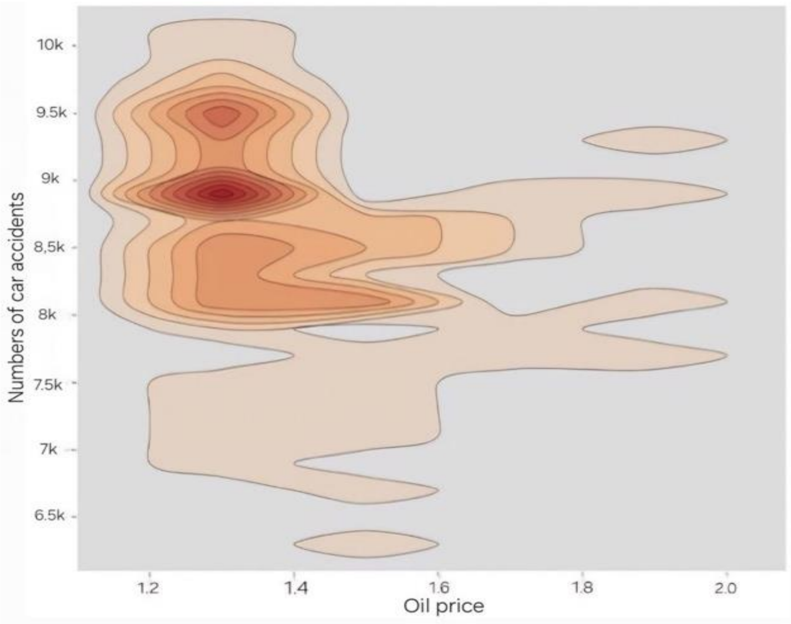

Figure 1. Contour plot CZ.

Source: Authors' elaborations.

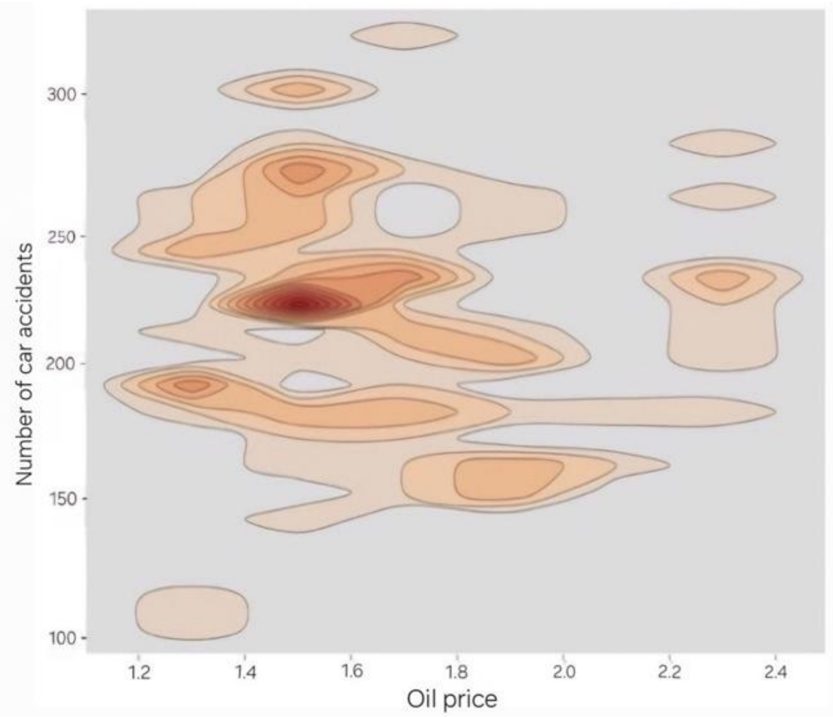

Figure 2. Contour plot DK.

Source: Authors' elaborations.

An overall assessment When comparing Germany (**Figure 3**) and Poland (**Figure 4**), fuel prices in Poland do not show a significant effect of FP prices on the number of accidents according to the graphical representation, but in Germany the association is partially observable. On the contrary, for Iceland, where the number of accidents is very low, the contour plot method is not effective because the low incidence of accidents makes it difficult to detect any effect of fuel prices on road safety.

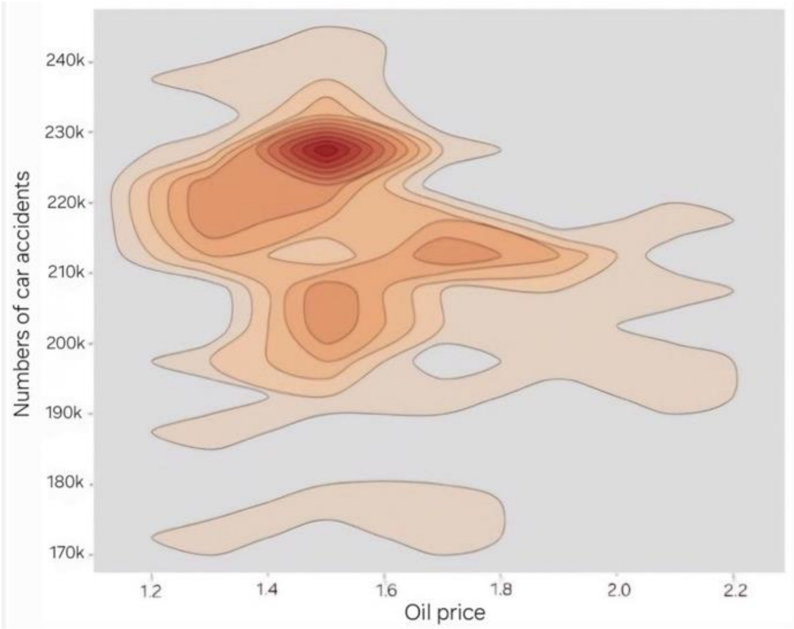

Figure 3. Contour plot DE.

Source: Authors' elaborations.

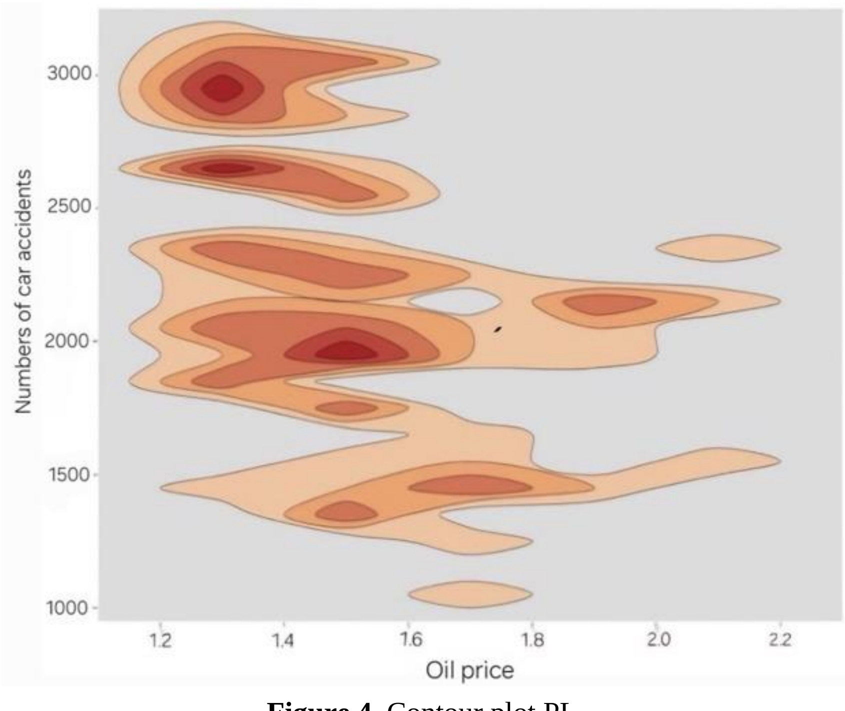

Figure 4. Contour plot PL.

Source: Authors' elaborations.

Table 1 below shows the results of the Ramsey RESET and overdispersion tests. The Ramsey RESET test is used to check the linearity or nonlinearity of the model, while the overdispersion test determines whether the data fit a Poisson distribution.

Table 1. Results of the Ramsey RESET test and the overload test.

Model	RESET Value	df1	df2	*p*-value (RESET)	*z* value Overdispersion	*p*-value Overdispersion	Dispersion Estimate
Czechia	3.2172	2	55	0.4771	5.5262	1.636×10^{-8}	76.636
Poland	8.0683	2	55	0.0008	7.3192	1.247×10^{-13}	105.43
Iceland	0.8083	2	43	0.4523		6.273×10^{-7}	13.455
Germany	0.3095	2	55	0.735	2,396,449	6.297×10^{-7}	1136.6
Denmark	5.0524	2	55	0.009674	633,453	4.082×10^{-8}	7.3945

Source: Authors' elaborations.

According to the results shown in **Table 1**, the linearity of the data was rejected as the values for models 1, 2 and 5 did not fit linearity. Ramsey RESET tests for these models had *p*-values below the 0.05 significance level (for model 1: $p = 0.04771$, for model 2: $p = 0.0008461$, for model5: $p = 0.009674$), indicating that the relationship between the variables is not linear. At the same time, the Poisson distribution for all models was also rejected. Overdispersion tests for models 1 to 5 showed very low *p*-values, indicating that the dispersion of the data is greater than would be consistent with a Poisson distribution.

The following **Table 2** presents the results of a negative binomial regression that was used to analyze the relationship between average fuel price and the number of accidents in five European countries. A separate regression model was constructed for each country and the results include coefficient estimates, standard errors, *z*-values and *p*-values for each variable.

Table 2. Negative binomial regression results.

Country		Estimate	Std. Error	*z*-value	Pr (>|*z*|)
Czechia	(Intercept)	9.18402	0.09623	95.443	$< 2 \times 10^{-16}$
	Average FP	−0.09888	0.06809	−1.452	0.146
Poland	(Intercept)	8.4595	0.2287	36.994	$< 2 \times 10^{-16}$
	Average FP	−0.5142	0.1477	−3.482	0.000498
Iceland	(Intercept)	6.28698	0.15877	39.597	$< 2 \times 10^{-16}$
	Average FP	0.04088	0.08209	0.498	0.618
Germany	(Intercept)	12.41156	0.07382	168.144	$< 2 \times 10^{-16}$
	Average FP	−0.09568	0.04671	−2.049	0.0405
Denmark	(Intercept)	5.63301	0.16699	33.734	$< 2 \times 10^{-16}$
	Average FP	−0.12698	0.09371	−1.355	0.175

Source: Authors' elaborations.

The results of the negative binomial regression presented in **Table 2** show the relationship between the average fuel price and the number of accidents in five European countries. The regression coefficient ($\beta 1$) expresses the change in the logarithmic number of accidents when the fuel price increases by one euro. A negative coefficient value indicates that higher fuel prices are correlated with lower accident rates.

The most significant correlation was found in Poland ($\beta 1 = -0.5142$, $p = 0.000498$), where a statistically significant decrease in accidents corresponds to approximately 51.4% when the fuel price increases by one euro. A statistically significant negative relationship was also found in Germany ($\beta 1 = -0.09568$, $p = 0.0405$), but the effect is weaker when a one euro increases in fuel price leads to a 9.6% decrease in accidents.

In the Czech Republic ($\beta 1 = -0.09888$, $p = 0.146$), Denmark ($\beta 1 = -0.12698$, $p = 0.175$) and Iceland ($\beta 1 = 0.04088$, $p = 0.618$)

In addition to the regression coefficients, **Table 2** shows the intercepts of the models, which represent the expected logarithmic number of accidents at zero fuel price (hypothetical situation). The highest intercept was in Germany (12.41), corresponding to a high baseline accident rate. The intercept was 8.46 in Poland, 9.18 in the Czech Republic, 5.63 in Denmark and 6.29 in Iceland, reflecting differences in traffic size and density between countries.

The relationship between fuel prices and accident rates was not found to be statistically significant, which may mean that fuel price changes in these countries do not have a direct impact on accident rates.

6. Discussion

Authors VO:1 How did the number of traffic accidents evolve between 2018 and 2024 in the Czech Republic, Germany, Poland, Denmark and Iceland?

The evolution of the number of road accidents in each country between 2018 and 2024 shows different trends and fluctuations that can be interpreted in the context of economic, social and infrastructural changes in these countries. This is pointed out by Sun et al. (2020). In the Czech Republic and Poland, a fluctuating trend can be observed, where the number of accidents changes not only seasonally, but also depending on long-term factors such as changes in infrastructure or according to the season. In Germany and Denmark, the trend in the number of accidents appears to be relatively stable, although there are also seasonal fluctuations. Germany, as a country with a highly developed transport infrastructure, shows some consistency in the number of accidents, although a slight decrease can be observed in recent years. This could be the result of improving transport infrastructure, increasing vehicle safety and more effective enforcement of traffic regulations. In Iceland, where the number of accidents is generally lower due to a smaller population and lower traffic density, the trends are less pronounced, but seasonal variation can also be observed, with the winter months possibly bringing more accidents due to more difficult road conditions.

A significant spike in the number of accidents occurred between March 2020 and March 2021, when the COVID-19 pandemic and measures to counter its spread had a major impact on mobility and traffic. During this period, there was a significant decrease in the number of accidents, which was mainly due to reduced traffic, closures and travel restrictions.

VO2: How have fuel prices (gasoline/diesel) evolved over the years studied in the countries studied?

Between 2018 and 2024, fuel prices showed different trends and fluctuations, influenced by both global economic factors and local conditions. In the Czech Republic and Poland, prices rose gradually in 2018 and 2019, but the COVID-19 pandemic in 2020 led to a significant price decline. This decline was followed by a period of price increases in 2021 and 2022, when prices rose again to higher levels than before the pandemic.

Denmark and Germany, where fuel prices are traditionally higher due to high taxes and regulations, also experienced price increases, albeit with slightly different levels. This increase reflects the impact of the tax burden and regulatory measures, which are reflected in the final prices for consumers. In Iceland, where fuel prices are generally higher due to high transport costs and a small market, there have also been significant increases. This confirms the argument of Zhang and Burke (2021) who point out that higher fuel prices lead to changes in consumer behavior, which translates into different trends in fuel consumption and prices across countries.

VO3: What is the relationship between the average fuel price and the number of traffic accidents in the countries studied?

The relationship between the average fuel price and the number of road accidents in the countries studied shows different influences that may be cultural, economic or infrastructural in nature. The results of the negative binomial regression analysis suggest that in most countries there is some relationship between fuel prices and the number of accidents, although the strength and direction of this relationship varies. This finding is supported by the counterfactual research conducted, such as Naqvi et al. (2023), whose results indicate a reduction in accident rates when fuel prices increase. The opposing studies are Akinyemi (2023) who on the other hand argue that when the price of petrol increases, the number of accidents increases. These claims may be contradictory based on the states in which the research was conducted.

In the Czech Republic and Germany, the analysis showed a weak negative correlation, suggesting that the number of traffic accidents tends to decrease slightly as the price of fuel increases. This relationship may be explained by the fact that higher prices may lead to a reduction in the frequency of travel, especially over longer distances, which would in turn lead to fewer accidents. Alberini et al. (2022) agree with this. However, this relationship is not statistically significant in the Czech Republic. In Poland, a stronger negative correlation between fuel price and number of accidents was found to be statistically significant. This suggests that here higher fuel prices may have a stronger influence on driver behavior, possibly due to economic factors, where more expensive fuels may be more restrictive to movement and lead to a reduction in traffic volume, and hence the number of accidents. However, no significant correlation was found in Iceland, which may be due to the specific conditions of this country, such as lower population density and lower traffic volume. Although a negative relationship was found in Denmark, it was not statistically significant, as in the Czech Republic. This result may suggest that there are other, stronger factors that influence the number of accidents in Denmark, such as the quality of infrastructure or transport policy.

It is also important to note that the effect of fuel prices on accident rates is not always straightforward. Higher petrol prices can lead some drivers to fill up with cheaper, lower quality fuel, which can negatively affect the roadworthiness of vehicles, especially older models with more sensitive engines. In the long term, this factor may contribute to an increased risk of mechanical failure and consequently to higher accident rates, which should be taken into account in future research.

7. Conclusion

The aim of the study was to evaluate and quantify the relationship between fuel prices and the number of traffic accidents in Europe, and by using binomial regression analysis the aim was achieved.

The evolution of traffic accidents and fuel prices between 2018 and 2024 shows different trends reflecting country-specific conditions. In the Czech Republic and Poland, a fluctuating number of accidents was observed, influenced by seasonal changes but also by long-term factors. In Germany and Denmark, the situation was more stable, with Germany showing a slight decrease in accidents, probably due to effective enforcement of traffic regulations. Iceland, with a lower population density and fewer accidents, showed less fluctuation, but the winter months brought increased risk. All countries studied experienced similar FP price trends, with an initial increase in 2018 and 2019 followed by a drop in prices during the COVID-19 pandemic in 2020, followed by price increases again in 2021 and 2022.

The results of the analysis showed that while in Poland and Germany there is a statistically significant negative relationship between fuel price and the number of traffic accidents, in the Czech Republic, Denmark and Iceland the relationship was not as strong or statistically significant. This differential effect of fuel prices between countries can be attributed to the specific socio-economic and infrastructural conditions of each country.

The main finding is that higher fuel prices may lead to a decrease in the number of accidents, but this effect is not universal and is strongly influenced by local conditions. These results were particularly relevant for Poland, which may have important implications for transport policy making and fuel price regulation in that country.

The contributions of this paper are important for foreign transport and economic policymaking. The findings that fuel prices can affect the number of traffic accidents provide a valuable tool for policymakers who can use these findings to design legislation and regulations aimed at improving road safety. For example, in countries such as Poland, where a strong negative correlation between fuel prices and accident rates has been demonstrated, governments may consider adjusting fuel tax policies. This research also provides a methodological framework that can be applied in other regions, contributing to a wider use of the results and improving road safety through economic instruments.

The limitations that affected the depth and scope of the analysis were mainly data collection, as many countries do not regularly publish detailed statistics on traffic accidents, making comparisons and analysis difficult. In addition, for Iceland, where statistics are available, the number of accidents is so low that this makes it impossible to conduct a statistically robust analysis and draw reliable conclusions. This factor, together with possible inaccuracies in fuel prices due to differences in data collection methods between countries, limits the possibilities of generalizing the results.

Author contributions: Conceptualization, VK; methodology, VK; software, VK; validation, TŘ; formal analysis, TŘ; data curation, TŘ; writing—original draft

preparation, VK; writing—review and editing, VK; supervision, VK. All authors have read and agreed to the published version of the manuscript.

Conflict of interest: The authors declare no conflict of interest.

References

Ahmed, K., Kamihigashi, T., & Matsuo, M. (2023). Positive fuel price elasticities of expressway traffic flows: Insights for policymakers and management strategists. Transport Policy, 142, 99–114. https://doi.org/10.1016/j.tranpol.2023.08.012

Akinyemi Y. C. (2023). Short- and long-run impacts of gasoline price and macroeconomic factors on road traffic safety in Nigeria. *African Development Review*, 35(3), 308–319. https://doi.org/10.1111/1467-8268.12710

Akopov, A., & Beklaryan, L. (2022). Simulation of rates of traffic accidents involving unmanned ground vehicles within a transportation system for the 'smart city.' Business Informatics, 16(4), 19–35. https://doi.org/10.17323/2587-814x.2022.4.19.35

Alberini, A., Horvath, M., & Vance, C. (2022). Drive less, drive better, or both? Behavioral adjustments to fuel price changes in Germany. Resource and Energy Economics, 68, 101292. https://doi.org/10.1016/j.reseneeco.2022.101292

Almajyul, A., Al-Ghreimil, N. (2022). Traffic Accident Analyzer: A Visual Analytics Tool for Traffic Accidents Dataset. In: Proceedings of Sixth International Congress on Information and Communication Technology.

Alshardan, A. M., AlShuqaybi, H. M., Agha, S., et al. (2020). Assessment of sleep quality, post-traumatic stress disorder, and locus of control in motor vehicle accident survivors. Australasian Medical Journal, 13(3). https://doi.org/10.35841/1836-1935.13.3.78-85

Banzhaf, H. S., & Kasim, M. T. (2019). Fuel consumption and gasoline prices: The role of assortative matching between households and automobiles. Journal of Environmental Economics and Management, 95, 1–25. https://doi.org/10.1016/j.jeem.2018.11.010

Berezvai, Z., & Helfrich, D. (2024). The impact of a short-term fuel price cap on market prices after its removal: Evidence from Hungary. Energy Strategy Reviews, 54, 101472. https://doi.org/10.1016/j.esr.2024.101472

Byaruhanga, C. B., & Evdorides, H. (2024). The impact of indirect benefits (reduced travel time, fuel use and emissions) in cost benefit analysis of road safety countermeasures. Traffic Injury Prevention, 25(3), 434–439. https://doi.org/10.1080/15389588.2024.2322665

Centrum dopravního výzkumu. (2024). Traffic accidents in the Czech Republic—Statistics (Czech). Centrum dopravního výzkumu. https://nehody.cdv.cz/statistics.php

Gang, C., Sha, H., Farooq, M. U., et al. (2022). The helix of CO2, household income, and oil pricing under the assumption of Keynesian consumption function: A policy-mix scenario of oil-importing South Asia for SDGs-2030. PLOS ONE, 17(4), e0265515. https://doi.org/10.1371/journal.pone.0265515

Hall, T., & Tarko, A. P. (2019). Adequacy of negative binomial models for managing safety on rural local roads. Accident Analysis & Prevention, 128, 148–158. https://doi.org/10.1016/j.aap.2019.03.001

Island.is. (2024). Accident map. Available online: https://island.is/en/accident-map (accessed on 2 January 2025).

Kamruzzaman, M. H., & Mizunoya, T. (2020). Quantitative analysis of optimum corrective fuel tax for road vehicles in Bangladesh: achieving the greenhouse gas reduction goal. Asia-Pacific Journal of Regional Science, 5(1), 91–124. https://doi.org/10.1007/s41685-020-00173-5

Knittel, C. R., & Tanaka, S. (2021). Fuel economy and the price of gasoline: Evidence from fueling-level micro data. Journal of Public Economics, 202, 104496. https://doi.org/10.1016/j.jpubeco.2021.104496

Knoema. (2024). Knoema data platform. Available online: https://knoema.com (accessed on 2 January 2025).

Konşuk Ünlü, H., Young, D. S., Yiğiter, A., et al. (2020). A mixture model with Poisson and zero-truncated Poisson components to analyze road traffic accidents in Turkey. Journal of Applied Statistics, 49(4), 1003–1017. https://doi.org/10.1080/02664763.2020.1843610

Kovač, V., Alexandros, S., Panagoiota, P., (2024). Relationship Between Vehicle Price and its Safety Ratings. LOGI—Scientific Journal on Transport and Logistics, 15(1), 37–48. https://doi.org/10.2478/logi-2024-0004

Kovac, V., Kováciková, N., Turinska, L. (2022). Development of passenger car safety. AD ALTA - Journal of Interdisciplinary Research, 13(2), 361–367. https://doi.org/10.33543/1302

Kpodar, K., & Imam, P. A. (2021). To pass (or not to pass) through international fuel price changes to domestic fuel prices in developing countries: What are the drivers? Energy Policy, 149, 111999. https://doi.org/10.1016/j.enpol.2020.111999

Kumar, S., & Toshniwal, D. (2015). A data mining framework to analyze road accident data. Journal of Big Data, 2(1). https://doi.org/10.1186/s40537-015-0035-y

Maina, C. B. (2022). Em-algorithm for a normal-weighted inverse gaussian distribution: normal-reciprocal inverse gaussian distribution. Advances and Applications in Statistics, 72(1), 1–24. https://doi.org/10.17654/0972361722001

Mastyło, M., & Silva, E. B. (2020). Interpolation of compact bilinear operators. Bulletin of Mathematical Sciences, 10(02), 2050002. https://doi.org/10.1142/s1664360720500022

Mićić, S., Vujadinović, R., Amidžić, G., et al. (2022). Accident Frequency Prediction Model for Flat Rural Roads in Serbia. Sustainability, 14(13), 7704. https://doi.org/10.3390/su14137704

Naqvi, N. K., Quddus, M. A., & Enoch, M. P. (2020). Do higher fuel prices help reduce road traffic accidents? Accident Analysis & Prevention, 135, 105353. https://doi.org/10.1016/j.aap.2019.105353

Naqvi, N. K., Quddus, M., & Enoch, M. (2023). Modelling the effects of fuel price changes on road traffic collisions in the European Union using panel data. Accident Analysis & Prevention, 191, 107196. https://doi.org/10.1016/j.aap.2023.107196

Navarro-Moreno, J., de Oña, J., & Calvo-Poyo, F. (2023). How do road infrastructure investments affect Powered Two-Wheelers crash risk? Transport Policy, 138, 60–73. https://doi.org/10.1016/j.tranpol.2023.04.016

Obserwatorium Bezpieczeństwa Ruchu Drogowego. (2024). Accidents in Poland 2019-2024. Available online: https://obserwatoriumbrd.pl/wp-content/uploads/2025/01/Accidents_Poland_2019-2024_EN_01_2025.pdf (accessed on 2 January 2025).

Özen, M. (2020). Investigation of the Factors Affecting the Crash Frequency at Four-Legged Signalized Urban Intersections (Turkish). Teknik Dergi, 31(3), 10033–10053. https://doi.org/10.18400/tekderg.509128

Qureshi, A. I., Huang, W., Khan, S., et al. (2020). Mandated societal lockdown and road traffic accidents. Accident Analysis & Prevention, 146, 105747. https://doi.org/10.1016/j.aap.2020.105747

Ren, R., Li, H., Han, T., et al. (2023). Vehicle crash simulations for safety: Introduction of connected and automated vehicles on the roadways. Accident Analysis & Prevention, 186, 107021. https://doi.org/10.1016/j.aap.2023.107021

Řezníček, T., & Sloup, V. (2024). Car accidents in the czech republic and light as a contributory factor. ad alta: Journal of Interdisciplinary Research, 14(1), 348–354. Internet Archive. https://doi.org/10.33543/j.1401.348354

Statistics Denmark. (2024). Available online: https://www.dst.dk/da/Statistik/nyheder-analyser-publ/bagtal/2024 (accessed on 2 January 2025).

Statistisches Bundesamt (Destatis). (2024). Road traffic fatalities in Europe. Available online: https://www.destatis.de/Europa/EN/Topic/Transport/road_traffic_fatalities.html (accessed on 2 January 2025).

Sun, L., Zhang, J., Chen, M., et al. (2020). Research on Problems and Countermeasures of Road Safety Development under the Trend of Population Change. In: Proceedings of the 2020 5th International Conference on Information Science, Computer Technology and Transportation (ISCTT).

Tan, H., Zhao, F., Hao, H., et al. (2020). Cost analysis of road traffic crashes in China. International Journal of Injury Control and Safety Promotion, 27(3), 385–391. https://doi.org/10.1080/17457300.2020.1785507

von Uexkull, N., Rød, E. G., & Svensson, I. (2024). Fueling protest? Climate change mitigation, fuel prices and protest onset. World Development, 177, 106536. https://doi.org/10.1016/j.worlddev.2024.106536

Zhang, T., & Burke, P. J. (2021). Fuel prices and road deaths: Motorcyclists are different. Accident Analysis & Prevention, 162, 106396. https://doi.org/10.1016/j.aap.2021.106396

Zhang, Y., Xue, W., Wei, W., et al. (2022). A public transport network design using a hidden Markov model and an optimization algorithm. Research in Transportation Economics, 92, 101095. https://doi.org/10.1016/j.retrec.2021.101095