Exploring the impact of fuel price on driver harsh behaviour in Greece

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Abstract

Rising fuel prices have long been linked to shifts in driving behaviour, but their influence on driver aggression and harsh manoeuvres remains under investigation. This study explored the impact of fuel price changes on harsh driving behaviour in Greece from 2019 to 2022. Using statistical data and multiple linear regression models, researchers assessed correlations between fuel price trends and driving performance. Results revealed that as fuel prices increased, harsh events such as harsh acceleration or braking decreased. Interestingly, when fuel prices exceeded 1.65€/lt, harsh events dropped by 15% and the average speed declined by 8%, from 74 km/h to 68 km/h. It was revealed that higher fuel costs prompt drivers to adopt smoother, more cautious driving styles. The study also considered factors like economic pressure and environmental conditions. Policymakers might use fuel pricing and eco-driving incentives to encourage safer driving and reduce environmental impact.

Keywords: fuel price, driver behaviour, road safety, harsh events, linear regression.

1. Introduction

The movement of cars for transportation relies on fuel, the purchase of which is essential for their operation. Fuel prices are influenced by various factors, including global supply and demand, geopolitical developments, rising taxes and tariffs and the effects of climate change. In Greece, government taxation plays a significant role in determining fuel prices, often causing noticeable fluctuations over time. The energy crisis, marked by growing energy demand and limited resources, has prompted efforts to develop alternative energy sources and enhance vehicle energy efficiency. In response, car manufacturers are increasingly investing in more sustainable propulsion systems, such as hybrid and electric technologies.

Rising fuel prices have long been associated with changes in driving behaviour, yet the extent to which they influence driver aggression and harsh manoeuvres remains an area of ongoing research (Baysak, 2023). As costs increased, many individuals turned to alternative modes of transportation, including public transit, bicycles and electric scooters. Others have adjusted their driving styles to conserve fuel and reduce expenses (Michelaraki et al. 2020).

Gasoline prices may impact traffic safety through three key intermediary mechanisms: travel frequency and distance, choice of transport mode and individual driving behaviour (Anas & Hiramatsu, 2012). Firstly, as fuel prices rise, individuals may respond by reducing the number and length of their trips or by combining multiple errands into a single journey rather than taking separate trips. Secondly, higher fuel costs can prompt a shift away from private car use toward alternative modes of transport, such as public transit, carpooling, cycling or walking. Thirdly, drivers may adopt more fuel-efficient driving styles in response to elevated fuel prices, such as maintaining lower speeds and avoiding abrupt acceleration or braking, which can subsequently reduce the likelihood of collisions. Altogether, these behavioural and modal adjustments contribute to improved road safety, suggesting that an increase in fuel prices is generally associated with a decline in traffic crash rates.

The aim of this research was to investigate the impact of fuel price on driver harsh behaviour in Greece. The study also examined potential causes of harsh behaviour, such as economic pressure or environmental conditions. For the purpose of this research, statistical data on fuel prices and driver behaviour were collected and analysed between 2019 and 2022.

2. Literature Review

Numerous studies have examined the relationship between fuel prices and driver behaviour, highlighting significant behavioural shifts in response to fuel cost fluctuations. Existing literature predominantly focuses on reduced vehicle usage, changes in travel mode and driving patterns, while fewer studies have investigated the impact of fuel price on driver aggression and harsh manoeuvres.

To begin with, Knittel & Tanaka (2019) analysed fueling-level microdata to investigate how gasoline prices affect individual driving behaviour. Their findings indicated that increases in fuel prices led to reductions in fuel volume purchased, lower driving speeds and decreased acceleration levels—implying a tendency toward more economical driving styles. Similarly, Safaei et al. (2021) used panel data from 2007 to 2016 in the United States to explore the relationship between gasoline prices and traffic fatalities. Their analysis revealed that \$1 increase in gasoline prices is linked with a 24.2% increase in motorcycle fatal crashes.

Interestingly, Chi et al. (2010) conducted a related study in Mississippi, investigating the effect of gasoline prices on traffic safety by age, gender and race. It was demonstrated that gasoline prices had both short-term and intermediate-term effects on reducing total traffic crashes and crashes of females, whites and blacks. Using both Poisson-gamma and Prais-Winsten regression models, the study found that a 1% increase in inflation-adjusted gasoline prices led to a 0.25% reduction in the total number of crashes in the short term and a 0.47% decrease after a one-year lag. However, these price fluctuations were found to have no significant long-term effect on overall crash frequency, indicating that the influence of fuel prices on traffic safety may be temporarily impactful but not sustained over extended periods.

Naqvi et al. (2020) conducted a study aimed at quantifying the impact of fuel prices on the frequency of road traffic crashes by examining changes in travel behaviour. To achieve this, they analysed weekly fuel price data spanning from 2005 to 2015, employing both autoregressive and Seasonal Autoregressive Integrated Moving Average (SARIMA) approach. Their findings indicated that a 1% increase in fuel prices corresponded to a 0.4% decrease in the number of fatal road traffic crashes, highlighting the moderating effect of fuel costs on travel behaviour and road safety outcomes.

At the same time, Grabowski & Morrisey (2004) found that a 10% rise in gasoline prices led to a 3.4% reduction in traffic fatalities over a two-year span, with the effect being more than twice as strong among younger drivers. They also suggested that persistently low gasoline prices during the 1990s played a major role in keeping traffic fatality rates relatively unchanged during that decade. According to their estimates, if gasoline prices had consistently remained at the higher level of \$2.13 (adjusted to 2002 dollars) from 1985 to 2000, over 92,000 traffic deaths might have been prevented. In a subsequent study, Grabowski & Morrisey (2006) treated gasoline prices as an external factor and found that a 10% increase in state gasoline taxes was associated with a 0.6% reduction in fatalities, whether measured per capita or per vehicle mile traveled.

Other research has expanded the scope to include modal shifts. Lane et al. (2010) examined the relationship between gasoline prices and public transit ridership by analyzing data from January 2002 to April 2008 across nine major U.S. cities. Using regression analysis, it was assessed how variations in gasoline costs and their fluctuations affect ridership levels for both rail and bus systems, while accounting for factors such as service changes, seasonal variation and underlying trends. The findings revealed that changes in gasoline prices account for a small but statistically significant portion of the variation in transit ridership, suggesting that rising fuel costs do influence commuters' transportation choices to some extent. This aligns with broader findings in the literature that rising fuel prices incentivize the use of alternative transport modes such as bicycles and public transport (Soto et al., 2018).

Regarding consumer purchasing behaviour, Klier & Linn (2013) investigated the influence of fuel prices on new car fuel economy choices in the U.S. Their analysis showed a positive association between fuel price increases and the purchase of vehicles with higher fuel efficiency, especially smaller and hybrid vehicles. Notably, income level and education influenced the extent of this behavioural shift, with lower-income individuals being less responsive to fuel price changes.

3. *Data Overview*

Due to the daily variability of fuel prices across different supply areas, data collection on fuel pricing was conducted using the Fuel Price Observatory of the Ministry of Development. This official source provides the average daily retail price of petrol for each regional unit in Greece. For the purpose of this study, daily petrol price data were gathered for the years 2019, 2020, 2021 and 2022, allowing for a longitudinal analysis of fuel cost fluctuations.

In parallel, data from a naturalistic driving experiment were exploited over the same four-year period (2019-2022). A large dataset consisting of thousands of real-world driving trips was collected and analysed. Driving behaviour was recorded in real-time through smartphone sensors, leveraging a custom data collection system developed by OSeven Telematics. This system integrates advanced telematics capabilities, powered by machine learning algorithms and robust behavioural metrics. The OSeven mobile application identifies driving patterns through a suite of sophisticated tools. It is capable of detecting harsh driving events, speeding, transport mode and distinguishing between driver and passenger roles. The application not only collects behavioural data but also provides feedback to users, encouraging safer and more fuel-efficient driving habits.

Figure 1 illustrates the standard data handling process employed by the OSeven platform for each recorded trip.

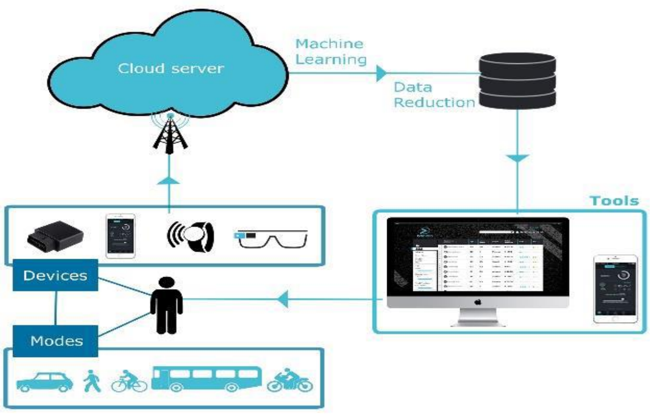

***Figure 1**: OSeven telematics data handling workflow*

For each trip, a considerable volume of data is recorded and transmitted through Wi-Fi or mobile networks. The system then processes the information to generate performance metrics, behavioural indicators and a composite driving score. The collected data capture both exposure and behavioural dimensions of driving. Exposure indicators include the duration of the trip (in seconds), total distance travelled and the type of road network (i.e. urban, rural or highway) based on GPS coordinates and integration with mapping services such as Google Maps or OpenStreetMap. Additional contextual factors include the time of day (such as rush hour or night-time driving) and prevailing weather conditions. Behavioural indicators assess the risk profile of the driver and include the extent and frequency of speeding (measured by both time and distance over the speed limit), driver distraction (notably mobile phone use during driving), the number and severity of harsh events, instances of aggressive driving (e.g., harsh braking or acceleration) and eco-driving efficiency, which evaluates smooth usage of acceleration, braking, steering and gear shifting.

It is important to emphasize that all data were collected in strict adherence to privacy and data protection regulations. OSeven Telematics operates under a clear and transparent privacy policy, compliant with the General Data Protection Regulation (GDPR). This includes informing users about the nature and purpose of data collection, the duration of data storage and the safeguards in place to ensure security, such as encryption of data both in transit and at rest. For the purposes of this study, all driving data were provided in anonymised format, thereby ensuring full confidentiality and ethical compliance. Table 1 presents a detailed overview of the independent variables included in the statistical models used in this study.

***Table 1**: Description of the independent variables used in the models*

Independent Variable	**Unit of Measurement**	**Description**
Fuel price	euro (€)/ litre	Gasoline price per litre according to the Fuel Price Observatory
Driving Duration	min	Total driving duration, represents the net driving time
Total distance	km	Total distance travelled in each trip per driver
ha/100kmh	-	Number of harsh accelerations per distance (100 km)
hb/100kmh	-	Number of harsh brakings per distance (100 km)
Speeding	km/h	Exceedance of speed limit
Mobile phone use	sec	Duration in which each driver used their mobile phone during trips

4. Methodology

The analysis incorporated data derived from three primary sources: driving behaviour data collected via the OSeven Telematics backend system and Fuel Price Observatory database. The dataset was initially processed and cleaned using Microsoft Excel, followed by statistical analysis performed in IBM SPSS Statistics. To explore the relationships between fuel price fluctuations and changes in driving performance, a combination of multiple linear regression and multiple lognormal regression models was applied. Both quantitative and qualitative methods were integrated to ensure a comprehensive understanding of the behavioural trends under investigation.

The regression analysis was designed to evaluate whether key driving characteristics, such as fuel price, average speed, mobile phone usage while driving (including calling, texting and browsing), duration and distance could be considered predictive factors for harsh acceleration and harsh braking events. The general form of the multiple lognormal regression model used in this study is presented in Equation (1):

$$y_i^* = \log(y_i) = b_0 + b_1{*}x_{1i} + b_2{*}x_{2i} + \ldots + b_v{*}x_{vi} + e_i \qquad (1)$$

In total, four regression models were developed: two aimed at predicting harsh acceleration events and two at forecasting harsh braking events. For each model, the robustness and explanatory power were evaluated by testing whether the numerical results met accepted standards of statistical validity. A core objective of this analysis was to identify which independent variables were significantly correlated with the dependent variables and, conversely, which variables may exhibit multicollinearity or redundancy. The coefficient of determination (R^2) was employed to assess the model's fit, representing the proportion of variance in the dependent variable explained by the independent variables. An R^2 value closer to 1 was interpreted as a stronger explanatory relationship.

In addition, the regression coefficients (β_i) were carefully interpreted in terms of their magnitude and sign, with an emphasis on logical consistency and theoretical alignment. For each coefficient, both the t-statistic and p-value were examined to assess statistical significance at conventional confidence levels (typically 95%). The intercept term (β_0), which accounts for the effect of omitted variables, was also evaluated to ensure it remained within acceptable limits. Furthermore, special attention was given to elasticity (e_i) and *relative influence elasticity (e_i)*, which quantify the responsiveness of the dependent variable to changes in individual independent variables.

5. Results

In order to analyze the relationship between driver behaviour and fuel price, this study utilized detailed driving data collected over a four-year period (2019-2022). The analysis served as an initial step toward understanding how fluctuations in fuel prices may influence driving patterns. This descriptive analysis, illustrating the correlation between fuel price and specific driving behaviours, provided visual evidence of how driver responses may shift in relation to fuel cost changes.

Figure 2 presents the relationship between fuel price (in euros per litre) and the frequency of harsh acceleration events per distance. A general decline in the frequency of harsh acceleration events as fuel prices increase was observed. This pattern supports the hypothesis that rising fuel costs encourage more cautious and fuel-efficient driving behaviours. Although there is some variability, the overall trajectory indicated a negative association between fuel price and aggressive acceleration, consistent with previous findings in the literature on eco-driving and economic incentives.

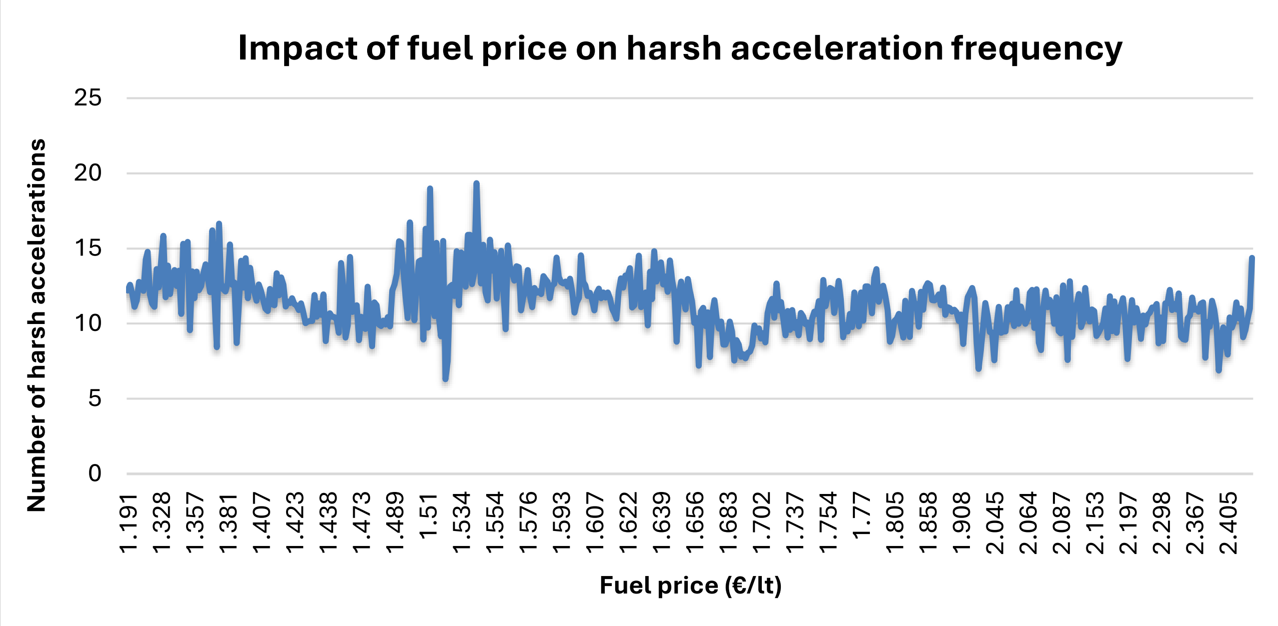

***Figure 2**: Impact of fuel price on harsh acceleration frequency*

Figure 3 depicts the relationship between fuel price (in euros per litre) and the frequency of harsh braking events per distance. A general downward trend in harsh braking frequency was observed as fuel prices increased, suggesting that higher fuel costs led drivers to adopt less aggressive braking patterns. While some variability was present throughout the data, the overall trend indicated a negative correlation between fuel price and harsh braking behaviour.

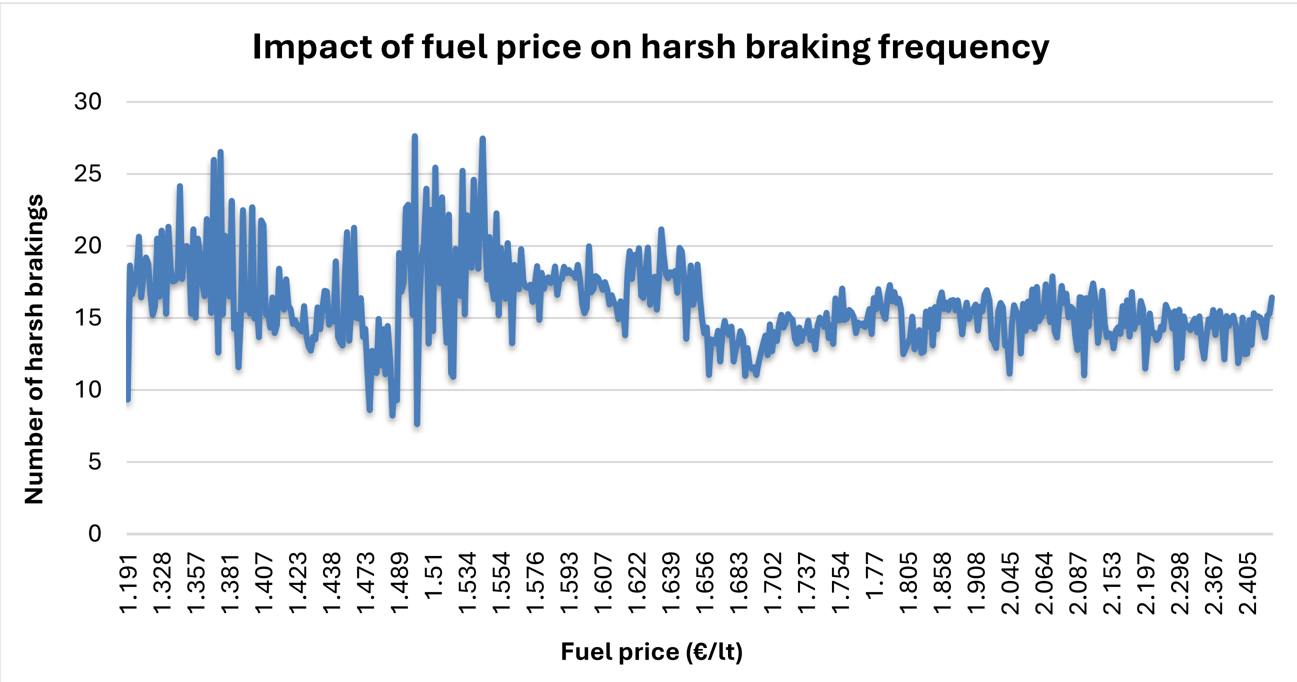

***Figure 3**: Impact of fuel price on harsh braking frequency*

As per average driving speed, data showed a slight decrease in average speed as fuel prices increased, suggesting that drivers may have adjusted their driving behaviour in response to higher fuel costs by reducing speed to conserve fuel. Although the dataset contained outliers and occasional spikes, the overall pattern reflected a tendency toward more moderate driving speeds during periods of elevated fuel prices. Figure 4 illustrates the relationship between fuel price (in euros per litre) and the average driving speed recorded.

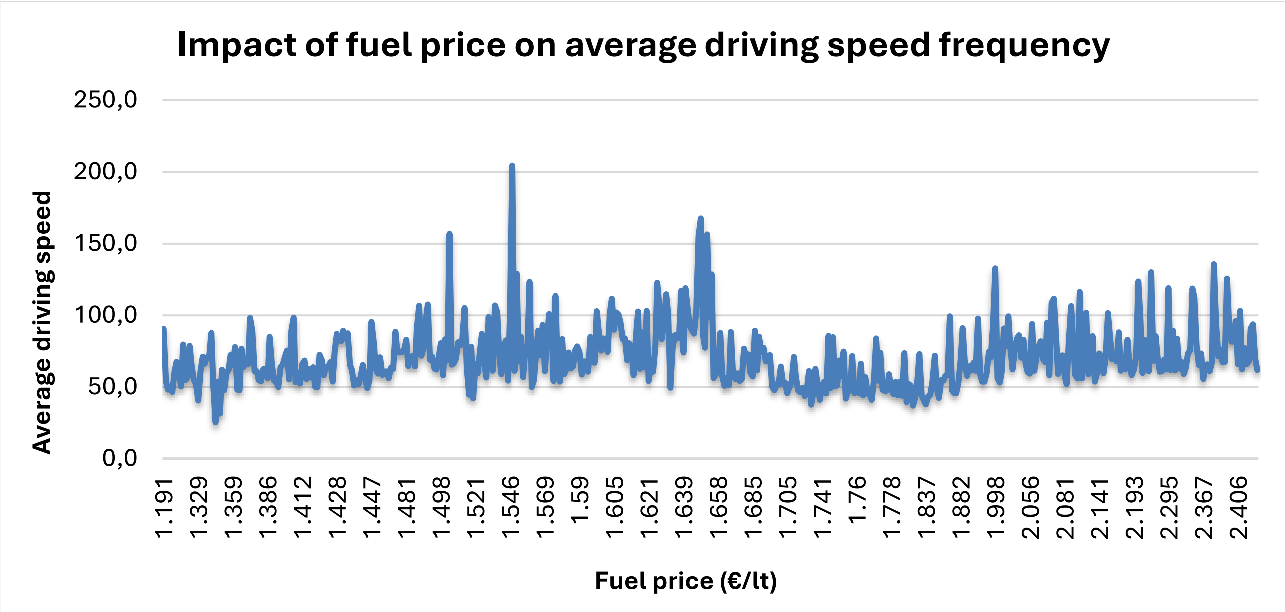

***Figure 4**: Impact of fuel price on average driving speed frequency*

Figure 5 compared the average number of harsh driving events per 100 kilometers for two fuel price ranges: below and above €1.65 per litre. The data showed that when fuel prices was below €1.65, the frequency of harsh accelerations and harsh brakings was 12.3 and 17.2 events respectively. In contrast, when fuel prices exceeded €1.65, these values declined to 10.5 for harsh accelerations and 14.6 for harsh brakings. This comparison indicated that higher fuel prices were associated with smoother, less aggressive driving behaviour, reinforcing the hypothesis that rising fuel costs can incentivize more cautious and economical driving styles.

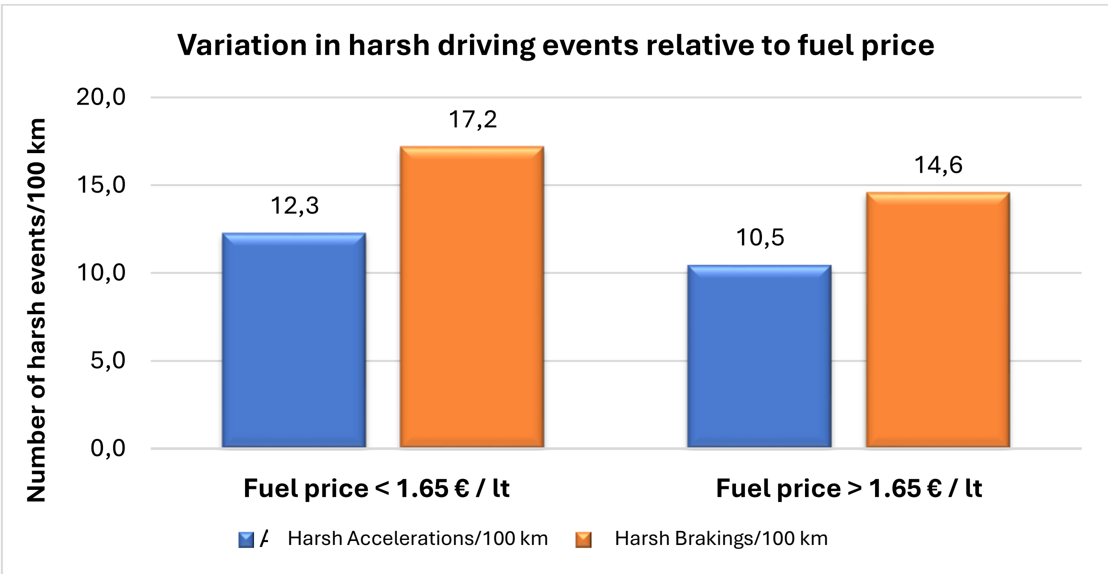

***Figure 5**: Variation in harsh driving events relative to fuel price*

When fuel prices were under €1.65, the average driving speed was recorded at 74 km/h. In contrast, when prices rose above this threshold, the average speed decreased to 68 km/h. This observed decline in speed suggested that higher fuel prices prompted drivers to adopt a more moderate and fuel-efficient driving style. Figure 6 displays the change in average driving speed in relation to fuel price.

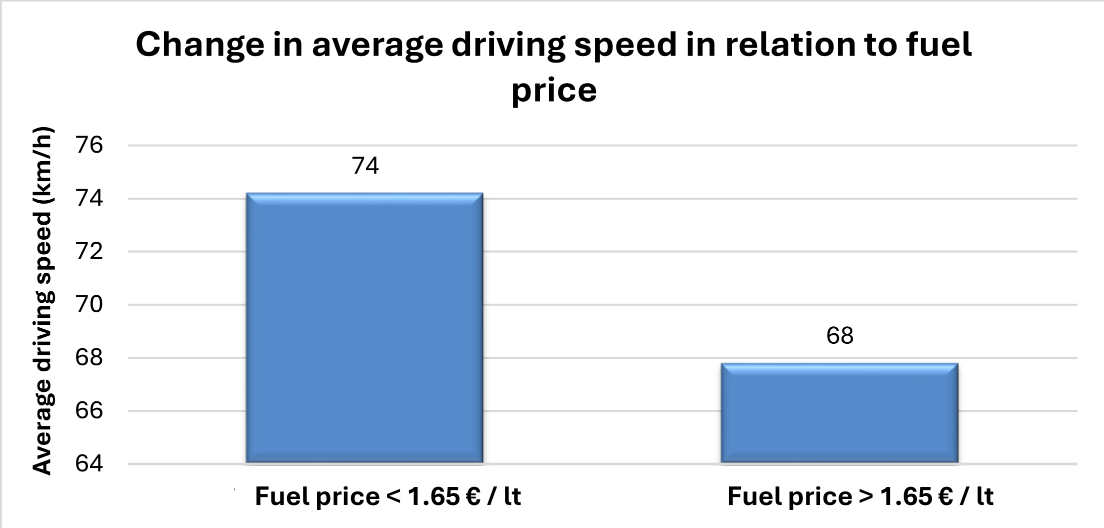

***Figure 6**: Change in average driving speed in relation to fuel price*

Table 2 presents the results of four regression models developed to examine the influence of selected independent variables on harsh driving behaviour. Models 1 and 2 used harsh acceleration events as the dependent variable, while Models 3 and 4 predicted on harsh braking events. For each independent variable included in the models, the Table reports the regression coefficient (bi), t-statistic (t), elasticity (ei) and relative influence elasticity (ei*), where applicable. The coefficient of determination (R^2) for each model was also provided as a measure of explanatory power.

To begin with, in the first model applied, fuel price had a significant negative effect on harsh accelerations, with a coefficient of -0.30 and a strong t-value of -17.20. This suggests that as fuel prices increased, the number of harsh accelerations decreased. The elasticity value (-0.61) indicates that a 1% increase in fuel price corresponded to an approximate 0.61% decrease in harsh acceleration frequency. Driving duration was also a significant positive predictor, with a high elasticity of 1.20, indicating a strong association with increased harsh acceleration events. Mobile phone use and average speed had smaller but statistically significant positive effects.

In the second model, speeding and total distance were positively associated with harsh acceleration events. Fuel price showed a negative effect, confirming the inverse relationship. One possible explanation for these findings is that drivers who travel longer distances and exceed speed limits are more likely to engage in aggressive driving behaviours, such as harsh acceleration, due to time pressure or habitual risk-taking. In contrast, higher fuel prices may act as a deterrent, encouraging drivers to adopt more economical and cautious driving styles to reduce fuel consumption, thereby lowering the frequency of harsh accelerations.

Moving to the third model, which targeted harsh braking events, fuel price continued to demonstrate a negative association, with an elasticity of -0.34. Driving duration emerged as the most influential factor, with an elasticity of 8.35, suggesting that longer trips are strongly associated with more frequent harsh braking. Average speed and mobile phone use were also positively related to harsh braking events, although with more modest influence.

The fourth model, also focused on harsh braking, showed similar trends. Fuel price remained a negative predictor, while speeding and total distance were both positively associated with harsh braking, suggesting that drivers who exceed speed limits and travel longer distances tend to brake more aggressively.

***Table 2**: Summary table of the mathematical models developed for harsh events*

Independent Variables	Model 1				Model 2				Model 3				Model 4			
	bi	t	ei	ei*	bi	t	ei	ei*	bi	t	ei	ei*	bi	t	ei	ei*
Fuel price	-0.30	-17.20	-0.61	-6.90	-0.19	-13.13	-0.39	1.00	-0.24	-10.45	-0.34	-5.02	-0.15	-6.90	-0.21	-1.45
Average speed	0.00	6.92	0.09	1.00	-	-	-	-	0.00	7.72	0.12	1.81	-	-	-	-
Mobile phone use	0.00	4.40	0.10	1.10	-	-	-	-	0.00	2.75	0.07	1.00	-	-	-	-
Driving duration	0.00	10.72	1.20	13.42	-	-	-	-	0.01	7.97	8.35	21.48	-	-	-	-
Speeding	-	-	-	-	0.13	28.29	0.68	-1.73	-	-	-	-	0.15	22.49	0.56	3.82
Total distance	-	-	-	-	0.01	4.65	14.04	-35.78	-	-	-	-	0.02	6.84	0.15	1.00
R^2	**0.448**				**0.536**				**0.338**				**0.434**			

6. *Discussion*

Results demonstrated that the increase in fuel prices led to a reduction in harsh events (acceleration or braking). It was observed that during periods of increased fuel prices, drivers improved their driving style and were more attentive to the task of driving, performing fewer abrupt events and fewer speeding violations. Interestingly, the results revealed that when the fuel price exceeded 1.65€/lt, there was a 15% reduction in harsh events, indicating less abrupt driving behaviour. Additionally, the average speed decreased by 8% (from 74 km/h to 68 km/h) during periods of higher fuel prices. Policymakers may consider fuel pricing strategies as a potential tool to promote safer driving behaviours.

Overall, the models consistently showed that fuel price had a significant and negative effect on both harsh acceleration and braking events, supporting the hypothesis that higher fuel costs promote more moderate and efficient driving behaviour. Variables such as driving duration, speeding and total distance also played key roles in influencing harsh events, with varying degrees of impact depending on the driving behaviour examined.

The R^2 values for the four regression models indicated the proportion of variance in the dependent variables explained by the independent variables included in each model. In the first model predicting harsh accelerations, the R^2 was 0.448, meaning that approximately 44.8% of the variability in harsh acceleration frequency was accounted for by factors such as fuel price, driving duration, average speed and mobile phone use. The second model, which included variables like speeding and total distance, showed a slightly higher R^2 of 0.536, indicating a better model fit and suggesting that these variables provided stronger explanatory power for predicting harsh accelerations. For harsh braking, the third model had an R^2 of 0.338, while the fourth model showed an improved fit with an R^2 of 0.434.

Based on the relative elasticity values, it is evident that driving duration had the strongest influence on harsh accelerations, particularly in Model 1, where it recorded a value of 13.42, indicating a substantial contribution to aggressive driving behaviour. This suggests that the longer the driving time, the more likely drivers are to exhibit harsh acceleration events, possibly due to fatigue, loss of attention or impatience during extended trips. In Model 2, total distance had the highest relative influence, reinforcing its role as a key deterrent to aggressive acceleration behaviour.

Regarding harsh braking (Models 3 and 4), driving duration emerged as the dominant factor in Model 3, with an exceptionally high value of 21.48, implying a very strong association with increased harsh braking frequency. This may reflect cumulative driver fatigue or increased exposure to dynamic traffic conditions over longer trips. In Model 4, speeding was the most influential variable (elasticity value equal to 3.82). These findings highlight how speed-related behaviours and travel length are major contributors to aggressive braking, while fuel price remains an important moderating factor across both types of harsh events.

Despite its strengths, the study is subject to several limitations. First, the analysis was restricted to data collected within Greece, which may limit the generalisability of the findings to other geographical or socio-economic contexts. Second, while fuel price was treated as a major influencing factor, other variables such as traffic density, weather conditions and road type were not fully integrated into the regression models, although they may significantly affect driving behaviour. Third, the study relies on telemetry data from a single app-based platform, which may introduce sample bias depending on user demographics or driving contexts. Additionally, behavioural changes observed in response to fuel price fluctuations may also be short-term adjustments, which do not necessarily reflect sustained behavioural transformation.

Future studies should aim to overcome these limitations by incorporating a broader set of contextual variables, including real-time traffic conditions, vehicle type and environmental factors. Moreover, longitudinal research is needed to assess whether the behavioural adaptations observed during high fuel price periods are temporary or sustained over time. Expanding the analysis across different countries or regions would also allow for cross-cultural comparisons and deeper insights into the generalisability of the results. Finally, the integration of qualitative data, such as driver interviews or surveys, could provide a more nuanced understanding of the motivations and perceptions underlying behavioural change in response to economic pressures.

7. Conclusions

While much of the literature explores general behavioural adaptation, the present study specifically focused on harsh driving behaviour, a less-examined but critical aspect of road safety and fuel economy. Using detailed telematics data collected in Greece between 2019 and 2022, this research employed multiple linear regression models to investigate the relationship between fuel prices and key driving behaviour indicators. The results clearly demonstrated that as fuel prices increased, drivers exhibited fewer harsh acceleration and braking events, along with a reduction in average driving speed. Notably, when fuel prices exceeded €1.65 per litre, harsh events dropped by 15% and average speed declined by 8%, reflecting a behavioural shift toward more cautious and fuel-efficient driving. These findings are consistent with existing literature suggesting that financial constraints, such as rising fuel costs, can influence driver decision-making and reduce aggressive driving tendencies.

Further descriptive and regression analyses revealed that driving duration, mobile phone use and total distance were also positively associated with harsh driving events. Drivers tended to accelerate and brake more aggressively on longer trips or when distracted by mobile phone use, likely due to fatigue, impatience or reduced attention. Moreover, speeding emerged as a strong predictor of harsh events, particularly for harsh braking, further reinforcing the role of driving style in overall traffic safety outcomes.

From a practical perspective, the findings suggested several implications for policy and behaviour change. Awareness campaigns, enforcement of speed limits and driver training programs can help mitigate risky behaviours and promote smoother, more economical driving. Moreover, encouraging public transport usage and expanding eco-driving education could indirectly reduce road congestion, crash risk and fuel consumption.

8. Acknowledgements

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