Evaluating driver preferences between punitive and non-punitive speeding penalties: Results from a stated choice experiment

Athanasios Theofilatos [a,*], Apostolos Ziakopoulos [b], Evangelia Stratigi [a], Pantelis Kopelias [a], Dimitris Potoglou [c]

[a] Department of Civil Engineering, University of Thessaly, Pedion Areos, Volos 38334, Volos, Greece
[b] National Technical University of Athens (NTUA), Department of Transportation Planning and Engineering, 5 Heroon Polytechniou St., Athens, GR 15773, Greece
[c] School of Geography and Planning, Cardiff University, CF10 3WA Cardiff, UK

ABSTRACT

Introduction: Speeding remains a major contributory factor to traffic crashes, making the design of effective penalty schemes a critical policy concern. Hence, the aim of this study is to investigate driver preferences regarding penalties for speeding violations in Greece: (Option A) immediate fines with off-road short detention (administrative process); (Option B) attendance of compulsory road safety seminars; and (Option C) judicial processes with possible dispute of fines in court. *Method:* Data were collected via a Stated Choice (SC) survey conducted during June and July 2023 in Greece, involving 161 participants resulting in 805 choice situations, and were analyzed by utilizing a random parameter multinomial logit model to capture unobserved heterogeneity among drivers. *Results:* Results showed that only 4.6% of respondents preferred the judicial process, indicating a strong deterrent effect of potential trial and associated costs. For Option A, statistically significant results included the monetary fine and penalty points, as well as the compulsory detention time off-road. For Option B, time and cost of road safety awareness seminars were significant. For the administrative process (monetary fine), the value that respondents were willing to pay to save 1 h of waiting off-road, was significantly higher (from 81.46 to 82.69 euros per hour) when compared to the driving education and awareness seminars (from 0.356 to 1.18 euros per hour), suggesting that drivers show a preference for higher monetary fines rather than being subjected to an off-road delay imposed by the police officer. *Conclusion:* The findings point towards more effective enforcement strategies while balancing penalty costs and duration of compulsory off-road detention and promoting educational-related non-punitive measures. *Practical applications:* The study could inform policymakers in designing and integrating a more diverse range of speeding penalties that align with driver preferences, potentially improving compliance, acceptability and better road safety outcomes.

1. Introduction

The World Health Organization (WHO) identifies Road Traffic Injuries (RTIs) and subsequent fatalities (collectively referred to as RTIs in the following) as a significant global health issue (World Health Organization, 2023). Beyond enhancing vehicle technology and infrastructure, considerable research and policy efforts have focused on enforcement and awareness-raising through road safety campaigns (Phillips et al., 2011). Additionally, strong emphasis has been placed on alternative road safety measures, such as penalty points on driving licenses, instantaneous speed enforcement using fixed point cameras, and average speed enforcement, implemented through point-to-point cameras or radar systems. Some of these initiatives (like speed section control) have shown positive results in various instances in past studies, as indicated by Soole et al. (2013). Specifically, section control was shown to reduce offense rates even by 11 times during operation in one naturalistic experiment in the UK, and average speed enforcement was

found to considerably reduce speeding instances in another observational study. Overall, average speed enforcement was estimated to contribute to reductions ranging between 33% and 85% of killed or serious injury crashes after implementation.

Nonetheless, RTIs remain a persistent and impactful problem, keeping road safety as a top priority on state policy agendas of highly motorized countries. For example, the European Union (EU) has set a very ambitious aim to reduce road fatalities to nearly zero by the year 2050, to be in line with the Vision Zero strategy, although the achievement of which has been disputed (Jamroz et al., 2019). To further suppress the occurrence of RTIs and to mitigate their consequences, traffic law enforcement measures are key instruments (Castillo-Manzano et al., 2019). Traffic penalties are critical towards implementing the Safe System Approach (U.S. DOT, 2024), as they greatly influence driver behavior and deter traffic violations (such as speeding), which can affect both offenders and nearby road users that may have been regulation-abiding.

Using the Classical Deterrence Theory as a foundation, two types of deterrence are proposed by criminology: general deterrence (targeting the broader population) and specific deterrence (targeting individual offenders; Stafford & Warr, 1993; Paternoster & Bachman, 2012). To support deterrence and enforcement, these concepts have been translated within the road safety context. General deterrence refers to how road users and their behaviors are affected by the fear of being caught and subsequently punished. On the other hand, specific deterrence pertains to how the actual legal consequences influence individuals who have been caught and punished (ERSO, 2018). In that sense, issuing a penalty for traffic offenses such as speeding is one of the main components to modify drivers' behavior mainly because of deterrence, suggesting that individuals make behavioral choices on the basis of the perceptions about the threat of a penalty.

Overall, there are two methods for administering penalties, namely: (a) the *Judicial Process*, where penalties are determined in court, and their application and severity depend on a conviction; and (b) the *Administrative Process*, where penalties are issued without direct court involvement, through a penalty notice process, although the accused individual can choose to contest them in court. The choice of penalty may be determined based on the objectives, the advantages and disadvantages of each type of penalty, as well as evidence relating to each penalty type (Sakashita et al., 2021). An earlier study by Yannis et al. (2004) defined the hierarchy of road safety enforcement and emphasized the crucial role played by the legal and organizational framework in facilitating police enforcement operations. By increasing the perceived risk of detection and subsequently reducing violation rates, such initiatives aim to induce changes in road user behavior, in order to decrease traffic crashes, injuries as well as associated social costs.

The effects of police enforcement can be modeled by means of game theory, including payoffs for drivers, that is, monetary valuation of travel time plus traffic ticket if caught speeding as well as the police cost such as cost of enforcement plus societal cost of prevented crashes (Bjørnskau & Elvik, 1992). Also, Elvik (2015a) reported that drivers responded to increased enforcement by complying better with speed limits. Elvik (2024) also found that a large increase in law enforcement is associated with a greater change in the number of crashes or injured road users (rather than a small increase in enforcement). However, traffic rule strictness may have more unclear effects in the case of riders, as it has been found to reduce instances of rider speeding but increase instances of riding while under the influence of alcohol (Ziakopoulos et al., 2021). Furthermore, drivers who commit severe offenses are less discouraged by fixed penalties compared to those who do not commit such offenses (Elvik, 2016).

Even though the impacts of traffic law enforcement and traditional penalties have been widely examined in the literature, one of the major topics to be further investigated in this field is the drivers' acceptance of non-punitive measures, such as advanced road safety training and crash prevention seminars instead of penalties. To the best of the authors' knowledge, the perception of drivers toward innovative penalties that are non-punitive, such as driver detention off-road for a brief period, typically around 20 min, as an alternative to issuing a speeding ticket at the time of the speed violation, has yet to be investigated in road safety literature. Similarly, there is untapped potential for alternative penalties for traffic violations that are more constructive and positive in essence. These alternative types of penalties aim to create a change in safety culture and driving skills rather than simply punishing the driver for committing a speeding offense. Thus, a better understanding of drivers' choices and the factors driving these choices and their importance is necessary in designing, evaluating, and implementing policies that aim to address and prevent driver speeding behaviors.

This study aims to add to current knowledge in the field by investigating driver choices toward three traffic penalty types relating to speeding offenses: (a) the administrative process, which involves immediate issue of a ticket and short detention off-road; (b) compulsory speeding and crash prevention seminars; and (c) the judicial process, which involves no speed ticket at the time of the violation, but appearance in court to contest the penalty. Based on the objectives of this study and the reviewed literature, the following hypotheses are proposed. First, drivers are expected to exhibit a stronger preference for non-punitive speeding penalties over punitive ones, reflecting support for measures that promote learning and behavioral improvement rather than punishment exclusively. Secondly, preferences between punitive and non-punitive speeding penalties may vary across respondents.

After this section, the paper is organized as follows. Section 2 presents prior evidence as reported in the literature including an overview of the data sources and processing. Section 3 describes the steps followed to design and implement the stated choice experiment and an overview of the analytical approach employed in this study. Section 4 presents and discusses the key findings obtained from the analysis of respondents' choices and their policy implications. Finally, Section 5 concludes the paper and presents directions for future research.

2. Literature review

There is a vast body of literature regarding the effectiveness of law enforcement measures and penalties. This review section will touch upon the overall effectiveness of penalties and law enforcement through an array of measures, intending to analyze and discuss the relationship that is developed through policy enforcement between stakeholders and road users. Moreover, available evidence determining whether the overall punishment preferences of the public have any impact on road safety behavior and regulation compliance will be examined.

2.1. Speed and speeding enforcement nuances

Given that the role of speeding is a key crash contributor (World Health Organization, 2023), speeding behaviors have been the target of intense road safety, traffic psychology, and wider related transport research. Higher levels of risk perception have been linked to more cautious driving and reluctance to engage in speeding behavior, while this response can be taught and/or trained, termed as conditioned aversive response by Harbeck and Glendon (2013). Conversely, individuals who perceive the risks of speeding as low are more likely to engage in speeding (Warner & Åberg, 2008). It has been established that speeding behavior is highly determined by driving habits, as supported by self-reported speeding behavior within a framework of the extended theory of planned behavior (TPB), developed by Ding et al. (2023). Naturally, the surrounding transport environment plays a considerable role, as drivers choose to speed in specific regions, such as in areas with more open spaces, fewer obstacles, better road visibility, better road quality, and lower precipitation due to a desire to avoid hazardous outcomes (Abdel-Aty et al., 2024; Masello et al., 2023). Other non-psychological conditions, such as being considerably late, lead to more speeding instances as well (Fitzpatrick et al., 2017).

Regulating traffic speed and speeding behaviors has been one of the oldest and most intuitive road safety measures (e.g., Albalate & Bel, 2012), and thus a good starting point for investigations of policy effects and behaviors related to enforcement. It is undeniable that speed-related enforcement has been effective in reducing crash occurrence and injury severity when implemented initially, or when implemented more frequently and even across enforcement types, such as fixed or mobile speed cameras, or speeding enforcement with radar or laser systems (Goldenbeld & van Schagen, 2005; Elvik et al., 2009; Elvik, 2015a; Elvik, 2015b). Speeding enforcement is notably a more important deterrent to drivers compared to actual safety concerns when they choose to speed (Schechtman et al., 2016).

Meanwhile, it has long been established that road safety rules such as speed limits must be believable in order to be effective and more seamlessly adopted. Setting speed limits as a political decision is a frequent occurrence, and road users question their rationality as a result (Mannering, 2009). There are common instances of speed limits being

too strict compared to road design in terms of altimetric and planimetric layout (Bellini et al., 2020). While the results by Li et al. (2017) support the effectiveness of more speed enforcement sites and higher numbers of related issued tickets in reducing road crashes, the authors also note that the average length of speeding enforcement checks leads to a larger number of observed speed-related crashes.

Different individuals have expressed wildly varying speed choices given fixed road locations, and even nearby locations have displayed high heterogeneity in past research (Ahie et al., 2015). This finding is echoed for speed limit perceptions as well (Schechtman et al., 2016), with the added note that these perceptions are often erroneous. It can also be argued that law enforcement patterns are optimizable, and thus strategies that do not promote the highest penalties or strictest speed limits that can possibly be applied to a given road layout can yield the highest road safety levels for a region. The cost of overly thorough speed enforcement on traffic efficiency can be perceived by the users: (i) microscopically (for instance, "how long will it now take me to go from X to Y?") and (ii) macroscopically (for instance, "traffic in route Z has become worse nowadays"). Therefore, it is important to take public opinion into account and implement frameworks that improve road safety without compromising traffic efficiency in too large degrees, which has been shown to be possible (Lu et al., 2023).

2.2. Changing penalty severity: The case of license suspensions and revocations

License suspension or, in the more severe or repeat offenses, revocation by law enforcement authorities have been mostly found to be an effective road safety measure. Both measures have been found to significantly reduce the number of crashes and violations in dedicated *meta*-analyses (Masten & Peck, 2004; Elvik et al., 2009). Considering the length of the license suspension period, Fell and Scherer (2017) note that the effects of short suspension periods (1–30 days) are similar to those of modest suspension periods (31–90 days), and that to see statistically significant benefits the period must be increased to long suspension (91–180 days or longer). However, it is worth noting that longer periods of license suspension have also demonstrated contradictory results, with higher probabilities of driver recidivism (Moffatt & Poynton, 2007).

On a similar note, favoring license suspension with possible future revocation instead of outright revocation from the start has been shown to reduce traffic violations in South Korean drivers (Kim et al., 2011). In a study by Ma et al. (2015), the effectiveness of license suspension for alcohol-related violations is noted as considerable when paired with remedial alcohol training programs. These programs have two main benefits, the first of which is enabling drivers to have improved self-discipline and not require constant oversight when circulating on the road. The second benefit is that increased punishment can be assigned for cases of non-completion of the remedial program, serving as a secondary safeguard of the regulation system, and thus as a form of social contract between violator and stakeholder.

2.3. Perceiving fines and penalties

Following the previous patterns of perceptions and effectiveness, several policies can be based on traffic fine adjustments. Based on the findings reported by Elvik (2016), it can be argued that this relationship is non-linear, as low fine increases (up to + 50%) do not affect violations, modest fine increases (between + 50% and + 100%) reduce violations, but large fine increases (over + 100%) tend to increase violations, making them counterproductive.

Furthermore, first-time offenders are only part of the sample. For repeat offenders, the manner by which recidivism is measured is not straightforward: Out of the four recidivism measures examined by Watson et al. (2015) for increased speeding penalties, only two were found to meaningfully express recidivism, namely the proportion of offenders who re-offended in the follow-up period and the overall

frequency of re-offending in the follow-up period. Moreover, the drivers are required to be aware of the adjustments in penalties and certain that they will be affected if they do not comply with the new regulations (Fleiter et al., 2013). To complicate matters, the stability of offending deterrence factors has been reported to fluctuate across time periods, as the perceptions of drivers change.

Among observed deterrence factors, certainty of apprehension appears to have the most pronounced fluctuations (Truelove et al., 2020). Therefore, relapses might emerge from repeat offenders based on their perception fluctuation, and as a reaction to these relapses, the non-offending general public will demand effective policies. After all, there are known differences between perceptions of punishment between offenders and non-offenders, as the former consider specific punishments as too severe, while the latter consider them too mild (Auksė et al., 2022); such perception differences provide impetus for demands of heightened punishment of violators. However, an interesting contradiction has also been noted through the findings of Khojastehpour et al. (2022), as the authors report that the general public is more concerned about privacy issues when the detection and reporting of speeding and parking violations to the police is aided by public reports, compared to the private sector.

3. Data and methods

The required data for this study were collected from a Stated Choice (SC) survey carried out in Greece during June and July 2023. The SC design was carried out through the Ngene software (Choicemetrics, 2021), while all the required statistical analyses were performed by utilizing the Apollo package which was developed by Hess and Palma (2024) in the R-studio software (R Core Team, 2020). The following subsections provide more details about designing and implementing the SC survey to collect data on respondent choices, as well as the theoretical background of the analysis methods.

3.1. Questionnaire survey

The present study employs a stated choice experiment designed to explore traffic penalties for speeding violations. In particular, the questionnaire survey is composed of three parts as outlined in the following. The first part comprised questions about drivers' attitudes and perceptions regarding road safety and awareness, interacting with other drivers, mobile phone use while driving, seatbelt and helmet use, as well as reactions towards implementation of enforcement measures such as cameras and speed monitoring devices.

The second part of the questionnaire focused on the stated choice experiment, which was designed to unveil driver preferences towards three penalty types for speeding violations. Specifically, the first choice of preferred imposed penalties are mainly traditional penalties, however, they also include a non-monetary or non-punitive action; the police officers detain the driver for a specific amount of time off-road at the point of speed check (20 min, indicatively) so that there is a significant delay in the trip duration of the driver. The second type of alternative concerns attending a series of compulsory driving and awareness seminars, while the last alternative involves no speed-ticket on the spot but a subsequent appearance in court where the speeding offender can appear and contest the fine. More details about the scenarios and the options/alternatives are presented in Section 3.2 of the paper below.

Finally, the third part of the questionnaire collected demographic characteristics of the respondents, such as age, gender, education, income, and car ownership.

3.2. Stated choice (SC) design

Firstly, the overall concept upon which the Stated Choice (SC) part of the questionnaire was based focuses on law enforcement and speeding penalties based on a specific scenario setup:

"*You are driving at 65 km/h on a city road where the speed limit is 50 km/h. Your violation is captured by a traffic camera and within the next few minutes you are being stopped by a police officer. Below are the three possible penalties (alternatives), which are imposed due to this speed violation:*

- *Option A (Fine) – includes a fine imposed immediately and a possible delay due to detention off-road by police, for a brief time period, as well as the accumulation of penalty points according to the Traffic Code in Greece. Note that accumulating 25 penalty points results in license suspension. Also note that the term "delay" denotes the time that the offender spends by the road until informed by the police authorities that they may leave.*
- *Option B (Awareness Seminar) – entails attending a mandatory speed awareness seminar, where you have the choice to attend predetermined duration driving lessons and pay the associated costs. More specifically, Option B consists of speed awareness courses after the violation, where the driver is required to undergo retraining by attending driving courses for a specific number of hours, which will be determined by the relevant traffic authorities. After reviewing the current practices research in Greece, it was defined that the cost of 1 h of training costs approximately 15 euros. Finally, it should also be noted that the fine is suspended for 3 years, meaning if someone violates the speed limit for a second time within 3 years, the option of attending the course is no longer available, and only immediate penalty or court can remain as possible options.*
- *Option C (Court) – leads to a court summons, meaning there is no immediate exemption, and the fine will be determined by the court during the trial. Court expenses are included in this option. License suspension does not occur until the trial. This option can also be used if the driver disputes the excessive speeding occurrence. Another difference from Option A, is that in this case, the violation is also recorded in the Tax Office, not just by the Police.*[1]"

Table 1 illustrates the attributes and their corresponding levels in the choice tasks for each alternative (fine, education, court). The next step was to construct the utility function for each alternative and apply the D-efficient design (with zero priors). A D-efficient design minimizes the determinant of the covariance matrix of parameter estimates, yielding more precise estimates while maximizing the information gained from each choice task and is suggested for discrete choice studies as suggested by Kuhfeld et al. (1994).

Finally, the blocks (the groups in which respondents were divided), as well as the number of scenarios were determined, resulting in a design

Table 1
Attributes and their corresponding levels in the choice tasks.

Attribute	Levels
Option A − Fine	
Monetary Fine (euros)	40, 100, 150, 200, 250
Delay/detention off-road (minutes)	0, 15, 30, 45, 60
Penalty Points	0, 1, 2, 3
Option B − Awareness seminar	
Required Hours (hours)	3, 4, 5,6
Cost (euros)	45, 60, 80, 100
Option C − Court	
Cost of Trial (euros)	400, 450, 500, 550, 600
Monetary Fine + Tax (euros)	40, 100, 150, 200, 250
Waiting Time for Trial (months)	6, 12, 24, 36, 48

---

[1] There are wider concerns regarding the enforcement of fines, particularly those issued by traffic law enforcement agencies in Greece. For instance, there is a common perception that fines administered by the police may be susceptible to evasion or manipulation, while penalties processed through the tax office are subject to more rigorous oversight and enforcement, reducing the possibility of non-payment.

consisting of 40 rows, which are categorized into 8 blocks each containing 5 tasks. Table 1 below presents the list of attributes for each alternative as well as their corresponding levels utilized in the current SP design.

The present SC survey followed a D-efficient design with zero priors, which was developed by using the software Ngene (Choicemetrics, 2021), as it offers flexibility for any experiment type regarding the number of alternatives, choice tasks, and attributes. In SC surveys, prior knowledge about the parameters that are expected in the model can be specified as these priors might guide the design of the experiment. However, for this survey, there is no prior information, and consequently model priors are assigned to have zero values. In other words, no particular values for the model parameters are *a priori* assumed. Instead, the experiment is designed to be the most efficient regardless of the true parameter values. D-efficient designs with zero priors are flexible and focus on maximizing the information gain about the parameters of interest, leading to more precise estimates from the data.

3.3. Survey implementation

The survey was carried out during June and July 2023, in Greece, by using both in-person and web survey tools such as Google Forms, via random sampling. Initially, respondents were made aware of the anonymity of the survey, as well as the legal framework for data protection in Greece according to relevant national laws. The inclusion criteria for the study required that respondents be adults with a valid driving license and consequently only those who met this criterion were eligible to participate in the survey. The in-person surveys endeavored to provide a sufficient representation of all age and gender groups within the sample, by targeting respondents belonging to less represented groups.

Before proceeding to complete the survey, it was confirmed that the respondents were informed about the study's purpose and duration of the survey (approximately 15 min) and then provided their consent – otherwise the survey would be terminated. It was also stated that participant data was anonymized and handled confidentially. No incentives were given for participation (e.g., monetary rewards, gift cards). Respondents were then provided with a detailed briefing regarding the experiment. This briefing included explanations of the attributes and how they would be presented during the choice task. It is noted that an ethical approval was secured by the relevant Ethics Committee at hosting Institute, before the launch of the survey.

3.4. Analytical approach: Random parameters multinomial logit model

In this study, two modeling approaches were utilized. To analyze respondents' preferences for the three alternatives namely, fine/detention off-road, awareness seminar, and court appearance and in order to account for unobserved heterogeneity, a random parameters multinomial logit model was applied, in which it is assumed that the estimated parameters may vary across the sample of respondents and thus, follow a distribution, such as normal, uniform and lognormal. Following Washington et al. (2010), a random-parameter model has for observation n, outcome probabilities defined as $P_n^m(i)$:

$$P_n^m(i) = \int_x P_n(i) f(\beta|\varphi) d\beta \quad (1)$$

Where $P_n(i)$ is the probability of observation n having discrete outcome i, $f(\beta|\varphi)$ is the density function of β with φ referring to a vector of parameters of that density function (mean and variance). Thus:

$$P_n^m(i) = \int_x \frac{\exp[\beta_i X_{in}]}{\Sigma_I \exp[\beta_i X_{in}]} f(\beta|\varphi) d\beta \quad (2)$$

Where I denotes all possible outcomes for observation n, while $i \in I$. The log-likelihood is:

$$LL = \sum_{n=1}^{N} \sum_{i=1}^{I} \delta_{in} LN[P_n^m(i)] \qquad (3)$$

Where N is the total number of observations, I denotes the total number of outcomes, δ_{in} is defined as being equal to 1 if the observed discrete outcome for observation n is i and zero otherwise.

In cases where the dependent variable takes only two values (0 or 1), a binary logistic regression model can be used to model the variable of interest. The goodness-of-fit of the models can be assessed with the McFadden R^2, which is based on the likelihood ratios of the full model (L_f) and the empty model (L_0). Values higher than 0.2–0.3 indicate a reasonable model fit, as suggested by McFadden (1979).

Lastly, Halton draws were utilized in this study, which are derived from a well-known technique developed by Halton (1960) to produce a systematic non-random series of numbers. Halton draws (samples) are significantly more efficient than purely random draws, achieving accurate probability approximations with considerably fewer draws (Washington et al., 2010). Since there is no closed-form solution to the underlying integrals, more Halton draws are always preferable, since they theoretically improve the approximation. Conversely, more complex models demand more Halton draws, since using low number of draws might lead to poor model likelihood approximation (Hess & Palma, 2024). On the other hand, although more Halton draws enhance estimation accuracy, they also increase computational time and cost as well. Therefore, in the present model, 2,000 draws were selected to strike a balance between estimation precision and computational feasibility.

4. Results and discussion

4.1. Sample characteristics and preliminary analysis

The survey sample included 161 respondents that were separated in eight (8) blocks, and each one of them participated in 5 choice situations, subsequently leading to 161*5 = 805 observations (choice situations) in the dataset for the SC analysis. It is noted that only respondents with a valid driving license were considered for the analysis. In total, 47 participants were excluded because either they did not provide consent to participate in the survey or did not hold a valid driving license.

All preliminary analyses presented in this section refer to the 161 observations, as they concern parts 1 and 3 of the questionnaire and not the SC experiment. Tables 2 and 3 show the characteristics of the sample and descriptive characteristics of responses to other questions in the survey questionnaire.

4.2. Model estimation results

This section presents the estimated parameters of the random parameter models. Two choice models were estimated on the basis of the conducted SC experiment of the study. The models' results are presented in this section, while the next section discusses what these results imply for preferred penalty choice behavior. For the parameter estimation of the two models, the number of Halton draws for estimating the panel effect coefficients is set to 2,000. In the present models, all the independent variables were tested for producing statistically significant random parameters. The variables that were not found to have a statistically significant random parameter were subsequently changed to fixed parameters. Furthermore, previous empirical studies in the field of road safety (Alnawmasi et al., 2025; Behnood & Al-Bdairi, 2020; Milton et al., 2008) have reported that the normal distribution provides better fit than other distributions (such as uniform and lognormal) in random parameter logit models and consequently was utilized in this study. This is also confirmed by our findings, which provided better estimation results during the modeling exploratory stage, compared to other distributions.

Firstly, the distribution of the alternative choices in the dataset is

Table 2
Distribution of variables related to attitudes and behavior.

Variable	Count	%
Attitudes and declared behavior-related variables		
Do you consider yourself a good driver?		
Yes	136	84.5%
No	25	15.5%
Are you satisfied with the level of road safety in Greece?		
Not at all	38	23.6%
Slightly	97	60.2%
Quite	23	14.3%
Very much	3	1.9%
How satisfied are you with the driving behavior of other drivers?		
Not at all	45	28.0%
A little	89	55.3%
Quite	24	14.9%
Very much	3	1.9%
Do you wear a seatbelt/helmet while driving?		
Always	127	78.9%
Often	25	15.5%
Sometimes	5	3.1%
Rarely	4	2.5%
Never	0	0.0%
Do you use a mobile phone while driving?		
Always/Very often	3	1.9%
Often	8	5.0%
Sometimes	33	20.5%
Rarely	81	50.3%
Never	36	22.4%
Have you been involved in a crash in the last 3 years?		
Yes	43	26.7%
No	118	73.3%
Do you think Greece needs more strict law enforcement (stricter measures)?		
Yes	133	82.6%
No	28	17.4%
Do you support the use of cameras on roads and at traffic lights?		
Yes	134	83.2%
No	27	16.8%
Would you adhere to the speed limit if you knew there were speed cameras		
Yes	148	91.9%
No	13	8.1%

explored. It is observed that Option A (fine) was selected in 334 (41.4%) choice situations, Option B (education and awareness) was selected in 434 (53.91%) choice situations, while only 37 (4.6%) choice situations were relevant for Option C (court process). It is highly likely that the lower representation of option C is due to the potentially very high waiting period and unknown territory of legal and judicial processes for most citizens. More discussion on the potential reasons behind this distribution is presented in section 4.2.

Starting from the Mixed Multinomial Logit (MMNL) model estimation, Table 4 shows the parameter estimates as well as the respective standard errors and p-values for the analysis of the best-fitting model (all three alternatives considered). The value of the Log-Likelihood at zero (LL_0) was found to be −884.38, while the value of the Log-Likelihood of the converged model (LL_f) was estimated to be −581.58. The respective McFadden R-squared value was 0.342, while the AIC and BIC values were found to be 1187.17 and 1243.46, respectively.

Table 4 shows that the signs for most of the beta coefficients of the attributes in the experiment were significant and in line with prior expectations. However, in the utility function of Option C (court) only the alternative specific constant was negative and statistically significant, showing evidence that respondents – all else being equal – were less likely to choose 'court' out of the three options; in fact, 'court' was the least preferred option followed by awareness seminars and fine, which was the reference alternative. Noting also that all the attributes of Option C were not statistically significant points to evidence of non-trading against this alternative, that is, under none of the attribute level

Table 3
Distribution of demographic characteristics variables.

Variable	Count	%
Demographic variables		
Gender		
Male	73	45.3%
Female	88	54.7%
Other/Prefer not to answer	0	0.0%
Age		
<25 years	63	39.1%
25–40 years	35	21.7%
40–55 years	35	21.7%
> 55 years	28	17.4%
Monthly Income (in euros)		
<1000	72	44.7%
1000–3000	46	28.6%
3000–5000	19	11.8%
>5000	3	1.9%
Prefer not to answer	21	13.0%
Education level		
Primary	3	1.9%
Secondary	21	13.0%
Undergraduate	84	52.2%
Postgraduate/PhD	53	32.9%
How many times do you drive per day by car?		
0	32	19.9%
1	32	19.9%
2	55	34.2%
>2	42	26.1%
What is your main purpose of driving?		
Work	76	47.2%
Education	27	16.8%
Medical care	5	3.1%
Leisure	37	23.0%
Other	16	9.9%

Table 4
Summary of model estimates, standard errors and significance (three alternatives).

Related Option	Variable	Estimate	Std. err.	t-test	p-value
Option A	Alternative Specific Constant: Fine	NA	NA	NA	Reference category
Option B	Alternative Specific Constant: Seminar	−0.940	0.310	−3.032	0.001 ***
Option C	Alternative Specific Constant: Court	−4.070	0.400	−10.175	<0.001 ***
Option A	Mean of monetary fine	−5.480	0.780	−7.026	<0.001 ***
Option A	Standard deviation of fine	−2.680	0.700	−3.829	<0.001 ***
Option A	Mean of off-road delay (detention time)	−7.440	2.060	−3.612	<0.001 ***
Option A	Standard deviation of off-road delay	5.220	2.110	2.474	0.007 ***
Option B	Mean of awareness lessons hours	−4.390	1.120	−3.920	<0.001 ***
Option B	Standard deviation of awareness lessons hours	2.420	0.580	4.172	<0.001 ***
Option B	Mean of cost of awareness lessons	−12.330	5.070	−2.432	0.007 ***
Option B	Standard deviation of cost of awareness lessons	−4.770	2.520	−1.893	0.030 **

Note: *** significant at 99%, ** at 95% and * at 90% level.

combinations, which formulated Option C would respondents choose to have a speeding violation resolved in a court.

Regarding Option A (fine), two of the three alternative specific variables were found to be significant at the 95% level of confidence, both having negative signs. More specifically, this finding indicates that an increase in the monetary fine and the longer that a driver must remain off-road after a road check, seem to decrease the probability of selecting this type of penalty. Moreover, all these variables have a significant corresponding standard deviation term meaning that they indeed are meaningful to be treated as random parameters, which follow the normal distribution. On the other hand, the number of points deducted from the point system does not seem to have an influence on selecting this alternative, meaning that respondents mainly choose according to the trade-off between time detained off-road and monetary fine.

To put that into perspective, if the means of the beta coefficients of detention time are divided by the cost of the imposed fine, a generalized estimate of Value of Time (VOT) can be provided across the sample, taking into account the distribution of preferences. Hence:

$VOT(OptionA) = \frac{-7.440}{-5.480} = 1.358$ euros per minute of delay (or 81.46 euros per hour of delay).

As for the utility function of Option B (education awareness seminars), both alternative specific variables (cost and duration of lessons) were found to significantly affect the choice of this alternative and have negative signs of the beta coefficients as expected. Similarly, if the mean of the beta coefficient of the total awareness lesson hours is divided by the cost of the driving lessons, a generalized estimate of VOT is provided. In the present case, a much lower VOT is recorded than before which is also interesting, namely:

$VOT(OptionB) = \frac{-4.390}{-12.330} = 0.356$ euros per hour of awareness lesson

The overall VOT, as estimated by statistical modeling, provides a useful aggregate measure but does not illustrate the full range of potential VOT values of the population, as it represents an average individual's trade-off between time and money. However, although the

results are reported at an aggregate level, time and cost variables were specified as random parameters in the models, thus allowing for individual-level heterogeneity in preferences. This approach ensures that potential variation in drivers' VOT is captured in the overall estimates, and thus in any policy actions that are designed based on them. Authorities who are interested in the distribution of VOT across their specific subset of individuals need to compute the VOT for each individual using their specific (normal) distribution of these individual VOTs as calculated in our study. Hence, by considering both the overall VOT and the distribution of individual VOTs, a comprehensive understanding of how the value of time varies within the sample studied is gained.

Regarding the non-alternative specific variables, such as socio-demographic characteristics and attitudes and perceptions toward road safety and enforcement, initially they were also examined, however their effects were not found to be statistically significant and were subsequently removed from the MMNL model. All the variables related to Option C (court) were not found to be statistically significant (either as fixed or random parameters), except for the alternative specific constant. Therefore, VOT for Option C is not calculable.

For that reason, it was also meaningful to test a binary model (Mixed Logit Model) with only Options A and B. Moreover, given the relatively low share of Option C (court), which was selected in about 4.6% of choice situations, a second statistical model was decided to be developed; including only Options A (fine) and B (education awareness lessons). In this case, there were 334 cases selecting Option A and 434 selecting Option B, resulting in a total of 768 choice situations.

Table 5 shows the parameter estimates, as well as the respective standard errors and p-values for the second analysis with the 2 alternatives (the model with the best statistical fit). The value of the LogLikelihood at zero (LL$_0$) was found to be −532.34, while the value of the

Table 5

Summary of model estimates, standard errors and significance (two alternatives).

Related Option	Variable	Estimate	Std. err.	t-test	p-value
Option B	Alternative Specific Constant: Seminar	NA	NA	NA	Reference category
Option A	Alternative Specific Constant: Fine	1.101	0.290	3.800	<0.001 ***
Option A	Mean of monetary fine	−5.654	0.946	−6.000	<0.001 ***
Option A	Standard deviation of monetary fine	−3.747	0.937	−4.000	<0.001 ***
Option A	Mean of penalty points	−0.305	0.086	−3.500	<0.001 ***
Option A	Mean of off-road delay	−7.792	4.605	−1.700	0.045 **
Option A	Standard deviation of off-road delay (detention time)	−4.791	3.066	−1.600	0.059 *
Option B	Mean of lesson hours	−19.789	5.872	−3.400	<0.001 ***
Option B	Standard deviation of awareness lesson hours	−17.422	4.834	−3.600	<0.001 ***
Option B	Mean of cost of awareness lessons	−16.812	6.296	−2.700	0.004 ***
Option B	Standard deviation of cost of awareness lessons	−5.682	2.268	−2.500	0.006 ***

Note: *** is significant at 99%, ** at 95% and * at 90% level.

LogLikelihood of the converged model (LL_f) was estimated to be −420.33. The respective McFadden R-square value was 0.2104, while the AIC and BIC values were found to be 860.66 and 907.1 respectively.

As for the impact of the independent variables on penalty choice in the mixed binary logit model, the findings were highly consistent with the previous model. One difference with the previous model is the magnitude of the beta coefficient of the duration of lessons for Option B. Furthermore, in this model, the mean and the standard deviation of the penalty points were found to be statistically significant, in contrast with the previous model when all three alternatives were considered. Thus, given the newly introduced "penalty" of detaining the driver off-road for a given amount of time, the effects of penalty points need further investigation.

When calculating a general estimate of the VOT for Option A, the value in this model is now 1.37 euros per minute of delay (off-road) or 82.69 euros per hour of trip delay. This is an approximate 18% increase in VOT for Option A. On the other hand, the re-estimated VOT for Option B is now 1.18 euros per hour of lesson, which is much higher than the VOT it was estimated in the previous model (0.356). In any case, in both statistical models, the VOT for Option A is much higher than Option B, indicating that drivers are more willing to pay more to avoid delays during their trips caused by police off-road detention rather than spending a number of hours on education and awareness lessons and paying the associated costs.

4.3. Discussion and policy implications

The present study findings yield several findings on penalty choice behavior and overall penalty perception, regarding the importance of the factors considered. These findings and relevant policy implications are discussed here.

The majority of respondents (53.91%) selected the education alternative (Option B), supporting the first hypothesis of the paper that drivers are more open to non-punitive measures. A first interesting observation is that only a small proportion of respondent choices involved selected the court alternative (Option C – Judicial process/court), specifically 4.6% of choice situations. As stated earlier in the paper, this option does not involve an immediate fine as in Option A, as it will be decided at a later date during the trial. However, the trial costs and the fine costs possibly deterred respondents from selecting this alternative. Another major difference is that this violation (and the respective penalty) is recorded by both Tax Office and Police. This is an important finding in the understanding of Greek driver preferences towards penalties, suggesting that receiving a direct fine and subsequently disputing it with the Police Administration may be more convenient and practical than awaiting trial and bearing the full costs of both legal proceedings and the traffic penalty. A common sentiment also is that the involvement of tax authorities makes the whole procedure more complicated for respondents. This is a usual issue with traffic enforcement in Greece, as it is common practice by many drivers to unofficially dispute the fines and finally achieve their erasure through complaints. The same is the case with driving plates removal for instance for illegal overtaking or parking, since in many cases the authorities themselves return the driving plates to the offending drivers especially during Christmas or Easter periods if the violation was not very severe (e.g., illegal parking in a disabled ramp). From the various logit-based models that were tested to describe drivers' speed penalty preferences, the best-fitting models are the mixed models (multinomial and binary), where panel effects in the stated choice data are accounted for by applying random parameters with normal distributions, thus confirming the second hypothesis of the paper that there is heterogeneity in driver preferences. However, demographic and other attitudinal factors were not found to be statistically significant, hence, there is no evidence that preferences vary across driver characteristics, attitudes, or past crash involvement (e.g., between risky and non-risky drivers).

Regarding the impact of the independent variables on each alternative utility function, the two models showed mostly consistent effects on penalty choices in terms of signs and magnitude of the beta coefficients, except for the impact of penalty point reduction, which was found significant only in the second model where the court alternative was not considered. Hence, from the results, authorities aiming at promoting a preferred method for penalizing speeding offenses should balance between costs and time to make them preferable and effective. For instance, to raise public awareness toward alternative penalties such as education lessons, authorities might reduce lesson costs per hour to ensure that drivers are treated more positively, and their penalties are made more constructive rather than purely punitive.

On a similar note, it was interesting how the Value of Time (VOT) for Option A (fine and delay off-road) and VOT for Option B (awareness lessons) differ in those two cases. The results showed relatively low generalized VOT estimates for driving awareness lessons (0.356 to 1.18 euros per hour). Consequently, authorities could raise the cost or increase the required hours of these seminars to maximize their effectiveness to promote better road safety culture and driving behavior.

On the other hand, due to the high values of Time for Option A in the two models, namely 81.46 and 82.69 euros per hour, respectively, the drivers seem to be more willing to pay a higher price instead of being retained by the police officers off-road and sustain significant delays in their trips. Consequently, this alternative penalty type might be a better way to enforce speeding in Greek roads. An important factor behind the effectiveness of this road safety measure might be the trip purpose during the speeding offense, since it is reasonable to expect that a modest delay (such as 20 min, indicatively) would be perceived differently during a recreational trip than during a commute to work, particularly for professional drivers. Moreover, it is critical to note that

the above estimate only accounts for the driver and does not include potential passengers. Therefore, when passengers are considered, the above estimates increase further delay affects multiple people simultaneously, not because each person is willing to pay more individually. For instance, an average indicative vehicle occupancy factor for Greece is 1.2 for passenger cars, which would hint at a direct 20% increase in VOT for Option A when accounting for passengers, assuming that offenders are evenly distributed across all vehicle types and occupancies.

Indeed, a study by Flügel et al. (2020) provides interesting remarks that can be considered largely in line with the present findings. More specifically, in Norway, the average value of an hour is about NOK 120 (with 1 NOK equaling 8.8 Euro cents in the early summer of 2024). However, the authors state that this value varies significantly depending on the length and purpose of the trips, for example, the official values for 2019 prices used in appraisals are NOK 77 per hour for leisure trips, NOK 512 per hour for business trips, and NOK 93 per hour for commuting trips, all for short trips (under 70 km). The overall average across different trip purposes is NOK 99.4 per hour, which is lower than the present finding. Moreover, higher VOT levels were reported by related research as well (Tveter, 2023) when analyzed under the effects of exogenous monetary changes.

It is undeniable that the Option A policy approach (mandatory off-road detention by the police officer) should be treated with care as it could result in excessive speeding after the end of the detention period, as drivers are likely to drive faster than before to compensate for the delay. On the other hand, given that individuals with a high VOT are willing to pay more money to save a given amount of time in their trips, potential policy changes might also be directed toward increasing the fines for excessive speeding if the offender wishes to eliminate the time lost. In this case, a high VOT suggests that time is highly valuable to these offending individuals, as their time is considered particularly productive or they do have a high income, simply meaning the cost of losing time is significant in terms of lost earnings or productivity. Arguably, the impact of this proposed alternative measure must be further investigated and evaluated in future studies. Further studies should also investigate in more detail the combined effects of trip purpose and total travel time on the VOT when drivers are retained off-road.

Income was not found to be statistically significant in our models, indicating some level of uncertainty regarding its effect. As such, this conclusion should be interpreted with caution and be further validated in future surveys with income data and trip purpose. Another implication of the individual income levels, which is not explicitly apparent in the final models, is that the estimated trade-offs between time and cost could not be directly related to each driver's annual earnings. Nevertheless, by extracting the mean net income of Greek citizens, which was estimated to be 12,391 euros per year or around 1,032 euros per month (Eurostat, 2024), each produced VOT of this study can be put into perspective and calculate the corresponding percentage share for an 'average' respondent. Admittedly, there should be perhaps a distinction between high- and low-income travelers in terms of the amount of fine paid to avoid mandatory off-road detention by future studies in the field. In addition, future studies could examine how trade-offs between time and income vary across income groups, providing deeper insight into heterogeneity in driver preferences.

Another potential limitation of this study is the relatively modest sample size of 161 respondents. While this number is close to recommended sample size (Johnson & Orme, 2010) and resulted in 805 choice observations, a larger sample could have provided greater precision in parameter estimates. Future studies should aim to recruit a broader respondent base to enhance statistical power and strengthen the generalizability of the findings. Moreover, an increased sample size would further enhance current findings as, for example, this resulted in not having many responses selecting the court option. However, the explanation for this low percentage was demonstrated previously in this section. Secondly, in order to gain further insights on the direct fine and off-road detention approach (Option A), the trip purpose and the specific

socio-demographics (income, parenting) could be incorporated into the scenario design so as to have different scenarios that would result into a more complex SP experiment producing a higher number of choice situations per respondent.

This study did not directly assess whether the proposed alternative penalties would indeed reduce speeding. Future research should test these measures in practice to verify whether greater acceptability of non-punitive measures leads to higher driver compliance and thus improved safety outcomes. However, the derived VOTs offer a useful basis for understanding potential behavioral responses to different enforcement approaches. It would also be of particular interest to examine the effectiveness of these alternative measures, especially in regard with re-offenders, to gain a good understanding of deterrence (Watson et al., 2015). In that context, future research could incorporate self-reported speeding behavior and past speeding penalties to examine whether preferences differ between drivers who frequently exceed speed limits and those who do not.

Overall, the current research provides an examination of alternative and perhaps radical measures toward speeding offenses. However, this paper does not advocate uniform re-examination, or much less, relaxation, of all traffic laws and regulations across countries and violation types. Rather, the present research aim is to underline the value of co-operation with the public and gauging of acceptance of new or changed measures, while advocating for an open mind to the possibility that less severe punishments can lead to higher compliance of road users. Hence, as per the aforementioned, there is potential for alternative penalties for traffic violations that are more constructive and positive.

5. Concluding remarks

Despite the efforts of researchers and practitioners, road traffic casualties remain high worldwide. In that context, speeding, which is a major cause of crashes and fatalities, should be better enforced. Alternative countermeasures in regard to traffic penalties for speeding are demonstrated to have great potential to reshape drivers' culture and behavior and not being exclusively punitive. Moreover, the ability to explain and anticipate the decisions of drivers regarding their respective penalties for exceeding the speed limit is essential when developing speeding-related policies, evaluating the potential of new alternative measures.

The current study aims to add to current knowledge by investigating driver choices towards three traffic penalty types relating to speeding offenses: Administrative process (immediate issue of ticket and short detention off-road), compulsory seminars, and judicial process (no issue of speed ticket on the spot along with subsequent appearance in court to contest the penalty). The required data for this study were collected from a Stated Choice (SC) survey carried out in Greece during June and July 2023.

Our results cast a new light on the understanding of drivers' penalty choice factors and their importance, which are needed when designing, evaluating, and implementing policies that aim to modify driver speeding behavior. In both employed statistical models, the VOT for Option A (mandatory off-road detention and direct fine) is much higher than Option B (education and awareness lessons), indicating that drivers are more willing to pay higher fines to avoid delays during their trips rather than paying to avoid dedicating a number of hours to education and awareness lessons. Another interesting remark is that Option C (court appearance and attempt to dispute the fine) is by far the least popular penalty chosen, most likely due to the potentially immense time and associated costs involved and the obscure nature of the legal processes.

In summary, this paper argues that authorities have the opportunity to explore a variety of alternative measures and penalties, moving away from a purely punitive approach and incorporating a diverse range of penalties. Our overall results provide a basis for further investigation in

this field. Ideally, these findings should be replicated in a study with a larger sample size, preferably in other European countries, to investigate whether certain Greek characteristics are applicable to drivers across Europe with varying traffic cultures.

6. Declaration of generative AI in scientific writing

The authors declare that no AI was used in this work except for syntax and grammatical error correction. Therefore, the authors take full responsibility for the content of the publication.

CRediT authorship contribution statement

Athanasios Theofilatos: Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis, Conceptualization. **Apostolos Ziakopoulos:** Writing – review & editing, Writing – original draft, Methodology, Data curation. **Evangelia Stratigi:** Software, Investigation, Formal analysis, Data curation. **Pantelis Kopelias:** Writing – original draft, Methodology, Conceptualization. **Dimitris Potoglou:** Writing – review & editing, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Abdel-Aty, M., Ugan, J., & Islam, Z. (2024). Exploring the influence of drivers' visual surroundings on speeding behavior. *Accident; analysis and prevention, 198,* Article 107479.

Ahie, L. M., Charlton, S. G., & Starkey, N. J. (2015). The role of preference in speed choice. *Transportation Research Part F: Traffic Psychology and Behaviour, 30,* 66–73.

Albalate, D., & Bel, G. (2012). Speed limit laws in America: The role of geography, mobility and ideology. *Transportation research part A: Policy and practice, 46*(2), 337–347.

Alnawmasi, N., Ziakopoulos, A., Theofilatos, A., & Ali, Y. (2025). Understanding the effects of underreporting on injury severity estimation of single-vehicle motorcycle crashes: A hybrid approach incorporating majority class oversampling and random parameters with heterogeneity-in-means. *Analytic Methods in Accident Research, 45,* Article 100372.

Aukśē, E., Slavinskienė, J., Šeibokaitė, L., Markšaitytė, R., & Sullman, M. (2022). Differences in the perceived justice of penalties for road traffic offenses between Lithuanian offenders and non-offenders. *PLoS One1, 17*(6), Article e0269239.

Bellini, D., Iaconis, M. C., & Traettino, E. (2020). Speed limits and road warning signs as aid for driving behavior. *Transportation research procedia, 45,* 135–142.

Behnood, A., & Al-Bdairi, N. S. S. (2020). Determinant of injury severities in large truck crashes: A weekly instability analysis. *Safety Science, 131,* Article 104911.

Bjørnskau, T., & Elvik, R. (1992). Can road traffic law enforcement permanently reduce the number of accidents? *Accident Analysis and Prevention, 24,* 507–520.

Castillo-Manzano, J. I., Castro-Nuño, M., López-Valpuesta, L., & Pedregal, D. J. (2019). From legislation to compliance: The power of traffic law enforcement for the case study of Spain. *Transport policy, 75,* 1–9.

Choicemetrics. (2021). *Ngene 1.3 User Manual & Reference Guide.* Sydney (Australia): ChoiceMetrics.

Ding, Y., Zhao, X., Wu, Y., Zhang, X., He, C., & Liu, S. (2023). How psychological factors affect speeding behavior: Analysis based on an extended theory of planned behavior in a chinese sample. *Transportation research part F: Traffic psychology and behaviour, 93,* 143–158.

Elvik, R., Høye, A., Vaa, T., & Sørensen, M. (2009). *The handbook of road safety measures.* Emerald Group Publishing Limited.

Elvik, R. (2015a). Speed enforcement in Norway: Testing a game-theoretic model of the interaction between drivers and the police. *Accident Analysis & Prevention, 84,* 128–133.

Elvik, R. (2015b). Methodological guidelines for developing accident modification functions. *Accident Analysis & Prevention, 80,* 26–36.

Elvik, R. (2016). Association between increase in fixed penalties and road safety outcomes: A meta-analysis. *Accident Analysis & Prevention, 92,* 202–210.

Elvik, R. (2024). A comparative analysis of accident modification functions for traffic law enforcement. *Accident Analysis & Prevention, 195,* Article 107415.

ERSO, 2018. Speed Enforcement 2018. https://road-safety.transport.ec.europa.eu/system/files/2021-07/ersosynthesis2018-speedenforcement.pdf. Accessed:10 April 2024.

Eurostat (2024). Mean and median income by age and sex . European Commission. Available at: https://ec.europa.eu/eurostat/databrowser/view/ilc_di03_custom_18330713/default/table. Doi: 10.2908/ilc_di03. Accessed 8 October 2025.

Fell, J. C., & Scherer, M. (2017). Administrative license suspension: Does length of suspension matter? *Traffic Injury Prevention, 18*(6), 577–584.

Fitzpatrick, C. D., Samuel, S., & Knodler, M. A., Jr (2017). The use of a driving simulator to determine how time pressures impact driver aggressiveness. *Accident Analysis & Prevention, 108,* 131–138.

Fleiter, J., Watson, B., & Lennon, A. (2013). *Effective punishment experiences: The need for a more comprehensive approach to conceptualising behavioural punishers and reinforcers in a road safety context* (pp. 1–30). Psychology of punishment: New research.

Flügel, S., Halse, A.H., Hulleberg, N., Jordbakke, G.N., Veisten, K., Sundfør, H.B., & Kouwenhoven, M. (2020). Value of travel time and related factors. Technical report, the Norwegian valuation study 2018–2019. (English summary). Institute of Transport Economics. Report no. 1762/2020.

Goldenbeld, C., & van Schagen, I. (2005). The effects of speed enforcement with mobile radar on speed and accidents: An evaluation study on rural roads in the dutch province Friesland. *Accident Analysis & Prevention, 37*(6), 1135–1144.

Halton, J. H. (1960). On the Efficiency of Certain Quasi-random Sequences of Points in evaluating Multi-dimensional Integrals. *Numerishe Mathematik, 2,* 84–90.

Harbeck, E. L., & Glendon, A. I. (2013). How reinforcement sensitivity and perceived risk influence young drivers' reported engagement in risky driving behaviors. *Accident Analysis & Prevention, 54,* 73–80.

Hess, S., & Palma, D. (2024). Apollo: A flexible, powerful and customisable freeware package for choice model estimation and application. *Package version*, (3), 2. http://www.ApolloChoiceModelling.com.

Jamroz, K., Budzyński, M., Romanowska, A., Żukowska, J., Oskarbski, J., & Kustra, W. (2019). Experiences and challenges in fatality reduction on polish roads. *Sustainability, 11*(4), 959.

Johnson, R., & Orme, B. (2010). Sample size issues for conjoint analysis. In B. Orme (Ed.), *Getting started with conjoint analysis: strategies for product design and pricing research* (pp. 57–66). Madison: Research Publishers.

Khojastehpour, M., Sahebi, S., & Samimi, A. (2022). Public acceptance of a crowdsourcing platform for traffic enforcement. *Case studies on transport policy, 10* (4), 2012–2024.

Kim, K. S., Myeong, M. H., & Kweon, Y. J. (2011). Differences in traffic violations and at-fault crashes between license suspension and revocation. *Accident Analysis & Prevention, 43*(3), 755–761.

Kuhfeld, W. F., Tobias, R. D., & Garratt, M. (1994). Efficient Experimental Design with Marketing Research applications. *Journal of Marketing Research, 31,* 545–557.

Li, R., El-Basyouny, K., Kim, A., & Gargoum, S. (2017). Relationship between road safety and mobile photo enforcement performance indicators: A case study of the city of Edmonton. *Journal of Transportation Safety & Security, 9*(2), 195–215.

Lu, Q. L., Qurashi, M., & Antoniou, C. (2023). Simulation-based policy analysis: The case of urban speed limits. *Transportation research part A: Policy and practice, 175,* Article 103754.

Ma, T., Byrne, P. A., Haya, M., & Elzohairy, Y. (2015). Working in tandem: The contribution of remedial programs and roadside licence suspensions to drinking and driving deterrence in Ontario. *Accident Analysis & Prevention, 85,* 248–256.

Mannering, F. (2009). An empirical analysis of driver perceptions of the relationship between speed limits and safety. *Transportation Research Part F: Traffic Psychology and Behaviour, 12*(2), 99–106.

Masello, L., Castignani, G., Sheehan, B., Guillen, M., & Murphy, F. (2023). Using contextual data to predict risky driving events: A novel methodology from explainable artificial intelligence. *Accident Analysis & Prevention, 184,* Article 106997.

Masten, S. V., & Peck, R. C. (2004). Problem driver remediation: A meta-analysis of the driver improvement literature. *Journal of Safety Research, 35*(4), 403–425.

McFadden, D. (1979). Quantitative methods for analyzing travel behaviour of individuals: Some recent developments. In D. A. Henser, & P. R. Stopher (Eds.), *Behavioural travel modeling* (pp. 279–318). London: Croom Helm.

Milton, J. C., Shankar, V. N., & Mannering, F. L. (2008). Highway accident severities and the mixed logit model: An exploratory empirical analysis. *Accident Analysis & Prevention, 40*(1), 260–266.

Moffatt, S., & Poynton, S. (2007). The deterrent effect of higher fines on recidivism: Driving offenses. *Crime and Justice Bulletin, 106,* 1–16.

Paternoster, R., & Bachman, R. (2012). Perceptual deterrence theory. In F. T. Cullen, & P. Wilcox (Eds.), *The Oxford handbook of criminological theory* (pp. 649–670). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199747238.013.0033.

Phillips, R. O., Ulleberg, P., & Vaa, T. (2011). Meta-analysis of the effect of road safety campaigns on accidents. *Accident Analysis & Prevention, 43,* 1204–1218.

R Core Team. (2020). *RStudio: Integrated Development for R.* PBC, Boston, MA: RStudio. http://www.rstudio.com/.

Sakashita, C., Fleiter, J. J., Cliff, D., Flieger, M., Harman, B., & Lilley, M. (2021). *A Guide to the use of Penalties to Improve Road Safety*. Geneva, Switzerland: Global Road Safety Partnership. https://www.grsproadsafety.org/wp-content/uploads/2023/05/Guide_to_the_Use_of_Penalties_to_Improve_Road_Safety.pdf.

Schechtman, E., Bar-Gera, H., & Musicant, O. (2016). Driver views on speed and enforcement. *Accident Analysis & Prevention, 89,* 9–21.

Soole, D. W., Watson, B. C., & Fleiter, J. J. (2013). Effects of average speed enforcement on speed compliance and crashes: A review of the literature. *Accident Analysis & Prevention, 54,* 46–56.

Stafford, M., & Warr, M. (1993). A Reconceptualization of General and specific Deterrence. *Journal of Research in Crime and Delinquency, 30,* 123–135.

Truelove, V., Freeman, J., Watson, B., Kaye, S. A., & Davey, J. (2020). Are perceptions of penalties stable across time? the problem of causal ordering in deterrence applied to road safety. *Accident Analysis & Prevention, 146,* Article 105746.

Tveter, E. (2023). The value of travel time: A revealed preferences approach using exogenous variation in travel costs and automatic traffic count data. *Transportation, 50*, 2273–2297.

U.S. DOT (2024). What is a Safe System Approach? U.S. Department of Transportation. https://www.transportation.gov/NRSS/SafeSystem. Accessed 21 October 2024.

Warner, H. W., & Åberg, L. (2008). Drivers' beliefs about exceeding the speed limits. *Transportation research part F: traffic psychology and behaviour, 11*(5), 376–389.

Washington, S. P., Karlaftis, M. G., & Mannering, F. (2010). *Statistical and econometric methods for transportation data analysis*. Chapman & Hall/CRC.

Watson, B., Siskind, V., Fleiter, J. J., Watson, A., & Soole, D. (2015). Assessing specific deterrence effects of increased speeding penalties using four measures of recidivism. *Accident Analysis & Prevention, 84*, 27–37.

World Health Organization. (2023). *Global status report on road safety 2023. World Health Organization. Available.* https://www.who.int/teams/social-determinants-of-health/safety-and-mobility/global-status-report-on-road-safety-2023.

Yannis, G., Louca, G., Vardaki, S., & Kanellaidis, G. (2004). Development of traffic enforcement programmes for the improvement of road safety. In *In the Proceedings of the 2nd International Conference on Transport Research in Greece, Hellenic Institute of Transportation Engineers, Hellenic Institute of Transport* (pp. 259–268).

Ziakopoulos, A., Nikolaou, D., & Yannis, G. (2021). Correlations of multiple rider behaviors with self-reported attitudes, perspectives on traffic rule strictness and social desirability. *Transportation research part F: traffic psychology and behaviour, 80*, 313–327.