Date: 21-02-2013

An Analysis of Mobile Phone Use by Car Drivers in Greece

G.Yannis[a*], A.Laiou[b], S.Vardaki[c], E.Papadimitriou[d], A.Dragomanovits[e], G.Kanellaidis[f]

[a] Associate Professor, tel. +30-210-7721326, e-mail: geyannis@central.ntua.gr
[b] Researcher, tel. +30-210-7722585, e-mail: alaiou@central.ntua.gr
[c] Ph.D., Senior Researcher, tel. +30-210-7721282, e-mail: sophiav@central.ntua.gr
[d] Ph.D., Research Associate, tel. +30-210-7721380, e-mail: nopapadi@central.ntua.gr
[e] Researcher, tel. +30-210-7722585, e-mail: dragoman@central.ntua.gr
[f] Professor, tel. +30-210-7721283, e-mail:g-kanel@central.ntua.gr

[a,b,c,d,e,f,] Department of Transportation Planning and Engineering, School of Civil Engineering, National Technical University of Athens, 5, Iroon Polytechniou str, 15773, Zografou Campus, Greece, fax +30-210-7721327

No. of words (main text)**:** 5,175

No. of tables: 7

No. of figures: 1

[*] Corresponding author

Abstract

The objective of this study is to investigate the rate of mobile phone use among car drivers in Greece and its association with driver's characteristics and other parameters. Data collected through an observation survey were used in a binary logistic regression model which highlighted the explanatory factors of using a mobile phone while driving. Pseudo-elasticities quantified the impact of each variable on mobile use. The observation survey showed that 9% of car drivers in Greece use a hand-held mobile phone. The dependent variable with the greatest impact is driver's age being between 16 and 24 years old. The results will assist the development of targeted intervention strategies to decrease mobile phone use while driving and will act as a baseline against which the effect of these interventions can be measured. Education and information campaigns have a key role in increasing public awareness regarding the risks involved in using a mobile phone in traffic.

Keywords: Public health; Safety & hazards; Traffic engineering ; mobile phone, observation survey; binary logistic regression; elasticity

Notations:

E : error

K : constant corresponding to a 95% interval (U distribution)

p : percentage of observations with specific characteristics

q : 1- p

n : number of observations (n>30)

U : logit (use of mobile phone while driving)

x_1 : working day

x_2 : observation session (14.00-18.00)

x_3 : urban road

x_4 : national road

x_5 : gender (male)

x_6 : age (16-24)

x_7 : age (25-54)

$E_{x_{nk}}^{P_{ni}}$ direct pseudo-elasticity of the k-th variable from the vector x_n, denoted x_{nk}, with respect to the probability, P_{ni}, of person n experiencing outcome i

i : number of possible outcomes

$\Delta(\beta'_i \chi_n)$: value of the function determining the outcome, s_{ni}, after x_{nk} has been changed from 0 to 1

$\beta'_i \chi_n$: the value when $x_{nk} = 0$

x_n : vector of K explanatory variables shared by all outcomes

β_i : vector of estimated coefficients on the K variables for outcome i

β_{ik} : the coefficient on x_{nk} in outcome i

e_i : pseudo-elasticity of variable i

e_i^* : relevant pseudo-elasticity of variable i

Introduction

It is widely accepted that mobile phones offer various advantages such as safety during emergencies, personal convenience and business communication. Nevertheless, the use of mobile phones while driving is becoming an increasing public health concern. The magnitude of the potential public health problem is moderated by the amount of exposure to this risk; that is, how frequently mobile phones are used by drivers (Eby & Vivoda, 2003).

A number of studies have investigated the proportion of drivers who use a mobile phone while driving (Gras et al, 2007). 81% of a representative sample of licensed Finnish drivers has admitted using the mobile phone while driving (Pöysti, Rajalin & Summala, 2005). Sullman and Baas (2004) found that more than half of New Zealand drivers used a mobile phone at least occasionally while driving. In Spain, about 60% of licensed drivers with recent driving activity reported using a mobile phone while driving (Gras et al, 2007). 48% of Dutch drivers with a driving license, phone from their cars at least once a week and approximately 30% of them indicate that they use a hand-held phone occasionally (SWOV, 2010). In the UK, the 2009 survey on mobile phone use by drivers showed that the proportion of drivers observed using hand-held mobile phones whilst driving was 1.4% for car drivers and 2.6% for van and lorry drivers (Walter, 2010). In the USA, the observed hand-held mobile phone use by drivers, during daytime, was 5% in 2009 (NHTSA, 2010). In Australia, observational studies reveal that approximately 2% of drivers use a hand-held mobile phone while driving (Walsh et al, 2008).

However, it should be noted that in several cases the available results are compromised by features of the experimental design, as regards both the data collection and analysis method (Yannis et al, 2010). The great differences in mobile phone use rates are due to the differences in the methods used for data collection and of the sample. For example, recording drivers' stated preference or including in the sample only drivers who also own a mobile phone might lead to overestimation of the true prevalence of using a mobile phone and driving.

Using a mobile phone while driving has negative effects on driving behaviour and increases the crash rate (Backer-Grøndahl & Sagberg, 2011), (SWOV, 2010), (Gras et al 2007), (Sullman & Baas, 2004). Experimental research shows that using mobile phones while driving leads to impaired driving, and this driving impairment, to a large extent, is a result of cognitive, rather than physical, visual and auditory distractions (Backer-Grøndahl & Sagberg, 2011). The decrement in the performance of drivers can be identified in a number of areas. For example, it has been reported that drivers spent less time checking instruments and mirrors while driving and using the phone (Gras et al, 2007). Furthermore, the use of mobile phones while driving was found to reduce vehicle headspaces (Yannis et al, 2010). Increased drivers' reaction time, impairment of drivers' ability to deal with visual information and to detect critical events, decreased vehicle control, increased mental workload and deterioration in driving performance in terms of lane control have also been associated with mobile phone use while driving (Backer-Grøndahl & Sagberg, 2011), (Brusque & Alauzet, 2008), (Pöysti et al, 2005), (Sullman & Baas, 2004).

Simulators and close course studies raise the possibility that drivers might adopt compensation strategies to cope with the reduction of cognitive resources due to talking on the mobile phone while driving (Rosenbloom, 2006). Such a strategy could be the reduction of travel speed while phoning which has actually been reported in several studies. Nevertheless, it is not possible to conclude that drivers increase their safety margins sufficiently to compensate for their impaired performance. Epidemiological studies have also been conducted in order to evaluate whether phone use while driving increases accident risk. These showed that mobile phone activity while driving is associated with a fourfold increased likelihood of crashing (NHTSA, 2011; Brusque & Alauzet, 2008; McEvoy et al, 2005). Police reports indicate that significantly higher rates of accidents related to driver inattention (unsafe speed, driving on the wrong side of the road) are found among drivers using mobile phones (Taylor et al, 2003).

An issue that has been under considerable debate is the importance of telephone mode for the effects of telephoning while driving. Since the physical distraction may be less for hands-free phones than for hand-held phones, most international legislation against the use of a mobile phone while driving concerns hand-held phones only (Törnros & Bolling, 2005). However, research has concluded that mobile phone use has a negative impact on driving behaviour, no matter if a hand-held or a hands-free phone is used (Backer-Grøndahl & Sagberg, 2011; NHTSA, 2011; SWOV, 2010; Brusque & Alauzet, 2008; Walsh et al, 2008). Yet, to date, there is no scientific unison that hand-held phones are riskier than hands-free phones (Backer-Grøndahl & Sagberg, 2011).The negative effects on the driving task are similar for hand-held and hands-free phoning and the crash rate is also similar. A number of studies show that drivers using hand-held phones compensate for the negative effects of phoning more readily than drivers using hands-free phones (SWOV, 2010).

Driver's gender and age, area type, day and time are some of the parameters that have been examined regarding their impact on the use of mobile phone while driving. It must be noted that the results of such studies may vary depending on the examined type of mobile use (talking, phoning or texting), on the method used for this purpose (observation surveys, questionnaires/interviews, simulator studies) and on the telephone mode (hand-held or hands-free). Specifically it has been found that young drivers and males use their phones more often than older drivers or females (SWOV, 2010), (Walsh et al, 2008), (Pöysti et al, 2005), (Sullman & Baas, 2004). For males, age is the main explanatory factor of phoning while driving, followed by phone use for work-related reasons and extensive mobile phone use in everyday life. For females, high mileage and intensive use of mobile phone are two explanatory factors (Brusque & Alauzet, 2008). The youngest, novice drivers have the highest level of phone usage of all age categories (Lamble et al, 2002) while the rate for older drivers is significantly lower than the rates for other age groups (Taylor et al, 2003). Mean age is higher for females who speak on a mobile phone on urban roads than on other road types while males are more likely to use a mobile phone to talk on the highway (Gras et al, 2007). Hand-held mobile phone use is higher in urban than rural areas (Walter, 2010), (Gras et al, 2007), (Taylor et al, 2003).

Results regarding the time of the day when mobile phones are more used are unclear. Walter (2010) found that the use of mobile phones by drivers increases during the morning to a peak at lunchtime, and decreases again in the afternoon period. On the other hand, Taylor et al (2003) found similar rates of mobile phone use during the morning and afternoon periods; however, a significantly higher rate was reported in the evening than in the other periods. The use of mobile phones by drivers is higher during the week than on weekends (Walter, 2010).

A higher annual mileage, a later model car with a larger engine, the preference of a higher driving speed, and little driving experience (in years) are some other parameters that seem to enhance the use of mobile phones while driving (Pöysti et al, 2005), (Sullman & Baas, 2004). On the contrary, the more skilled the drivers think themselves to be, the more likely they have a phone in their car while law-abiding and safety oriented drivers use their phones less frequently (Pöysti et al, 2005).

In Greece, the use of mobile phones while driving has been identified as a critical factor for road accidents (NTUA, 2011). Moreover, Greek drivers have been found to be less compliant to traffic rules, overall and as regards mobile phone use in particular, and more likely to exhibit risky or inappropriate driving behaviour (SARTRE4, 2012). This low compliance and poor behaviour may be partly attributed to the lack of systematic enforcement. The objective of the present study is to investigate the rate of mobile phone use among car drivers in Greece and its association with driver's characteristics and other parameters that have been recorded during an observation survey. Binary logistic regression has been developed to highlight the explanatory factors of using a mobile phone while driving. The results will assist the development of targeted intervention strategies to decrease mobile phone use while driving and will act as a baseline against which the effect of these interventions can be measured.

Observation survey

In order to effectively target interventions towards those drivers who use mobile phones while driving, the characteristics of these drivers must be identified (Sullman & Baas, 2004). Mobile phone use derived from police crash records may not accurately reflect exposure since use is often self-reported by the driver involved in the crash. Drivers may be reluctant to report this potential distraction because of liability issues. A less biased way to obtain frequency of mobile phone use is through direct observation on the roadway, where observers stand at intersections and record use of hand-held mobile phones as vehicles pass by (Eby & Vivoda, 2003).

Data collection for this study involved direct observation of mobile phone use by car drivers. For the purposes of the survey, a hand-held mobile phone is defined as a device that is being held at the time of observation. Mobile phone use was recorded only if the observer had a clear view of the mobile phone itself. This study did not address the use of hands-free mobile phones. Although this might be considered a limitation of the survey which can lead to under-recording of mobile use, it is estimated that the results are not dramatically affected by this due to the large sample of the survey. Observers did not interview drivers, so that their untainted behaviour is captured. Registration numbers or other means of vehicle or driver identification were not recorded.

The survey data was collected by trained data collectors at intersections controlled by stop signs or traffic lights and at toll stations. Only stopped vehicles were observed to allow time to collect a variety of information required by the survey, including subjective assessment of drivers' age. The survey took place on all days except Sundays. Data was collected throughout the day from 10:00 to 22:00 and during three observation sessions per day at each site (10:00–14:00, 14:00–18:00 and 18:00–22:00). A total of 8,048 car drivers were observed. Of those, 747 car drivers were using mobile phones.

Data recorded during the observation survey are: day, observation session and specific location, vehicle's cubic capacity (large or small car), driver's gender, driver's estimated age (young: 16-24, middle aged: 25-54, older: 55+) and mobile phone use. As far as driver's age is concerned, it could only be estimated, since any interaction between observers and drivers was not allowed. The difficulty in making correct age estimations was eliminated by using only three different age categories and by paying a lot of attention to the training and previous experience of the observers, in similar surveys. The relevant questionnaire was inserted in portable computers using specialised software (Computer Aided Personal Interviewing - C.A.P.I.).

Fourteen observation sites representing the traffic distribution across Greece were selected. Within urban areas, observation sites were along several different types of roads in order to record drivers' behaviour in various road and traffic conditions (different speeds and flow levels). On the national road network the survey took place along the two main highways that lead to the capital (Athens) and the second largest city of Greece (Thessaloniki). Observations on rural road network were made around the city of Larissa, in central Greece. Larissa is one of the main cities of Greece and agriculture is one of the main professional activities in the area. Therefore, traffic volumes on the rural network present the necessary variation. Random sampling was achieved using the following routine: at each location, observers chose and recorded the characteristics of the first vehicle on the right lane. Then, the second vehicle on the second lane was chosen etc. The map of Greece showing the three main areas where the survey took place and the number and type of survey sites can be found in Figure 1. Depiction of the exact location of the survey sites in each city would require maps of scale that is not suitable for the journal format. Details on survey sites are presented in the final report of the relevant research project (NTUA, 2009) and can be asked from the authors, if needed.

(Figure 1)

In order to eliminate inaccurately recorded data, special attention was given to the selection and training of the observers. Most observers had previous experience in field studies and all observers attended an intense informational/educational training. During data collection, a superintendent supervised each observer's work to a percentage up to 90%.

Basic characteristics of the sample of the survey are presented in Table 1. These characteristics concern the car type, the gender and the estimated age of the driver, and the area type of each recorded case. The survey sample (8.048 drivers) is considered adequate for the purpose of the specific survey. The calculated error of each different category of each recorded characteristic, shown in Table 1, also ensures that the sample is adequate and that all different characteristics are satisfactorily included in it.

(Table 1)

Data analysis provided an overall rate of mobile phone use and specific rates for each gender and age subgroup, car type and area type which are shown in Tables 2, 3 and 4. In each case, the reliability was tested by calculating the error for a 95% interval, using the following formula:

$$E = K\sqrt{\frac{p \cdot q}{n}} \qquad (1)$$

where: E: error
K = 1.96: constant corresponding to a 95% interval (U distribution)
p: percentage of observations with specific characteristics
q = 1- p
n: number of observations (n>30)

In total, 9% (±0.63%) of the observed car drivers did use a mobile phone while driving. Generally, female drivers use their mobile phones while driving more (12 ±1.39%) than male drivers do (8 ±0.70%). The same result was found for drivers aged 25 to 54 years old (use percentage is 12 ±1.56% for females and 9 ±0.81% for males). However, the results regarding the use of mobile phones by female drivers of different age groups should be treated cautiously due to the small sample.

(Table 2)

The examination of mobile use by drivers of large or small cars, did not lead to clear results given that the respective percentages are 9 ±0.89% and 10 ±0.90%.

(Table 3)

In urban areas 11% (±0.80%) of car drivers used their mobile phones while driving. In rural areas, the usage rates are lower, at 6% (±0.98%).

(Table 4)

Car drivers in Greece use their mobile phones while driving on working days (11% ±0.78%) more than on Saturdays (5% ±0.99%). Furthermore mobile phone use is increased between 14.00 and 18.00 on working days and between 10.00 and 14.00 on Saturdays.

(Table 5)

Model development

Binary logistic regression was selected for the development of a statistical model that can describe the use of mobile phones while driving by car drivers in Greece, using all the data collected in the above described observation survey. Logistic regression was found to have been used in various research works examined during the literature review such as in the work of Pöysti et al (2005), Sullman and Baas (2004) and Brusque and Alauzet (2008). The exploration of more characteristics of the drivers, the vehicle and the road environment or the exploration of the effect of specific factors to the use of mobile phones could also be interesting and useful in the development of a model for mobile use but it was not possible, in this case, due to lack of data. However, the effect of some factors was eliminated by the selection of observation sites (intersections controlled by stop signs or traffic lights and toll stations). Consequently, mobile phone use (no or yes) was used as the dependent variable of the binary logistic regression model while the independent variables and the respective categories for each one of them were:

- day of the week (working day or Saturday),
- observation session (10.00-14.00, 14.00-18.00 or 18.00-22.00),
- type of car (large or small),
- road type (urban, national or rural),
- driver's gender (male, female)
- driver's estimated age (16-24, 25-54 and 55+)

All independent variables are categorical. For each independent variable with k categories, k-1 dummy variables were used to investigate the differences among categories with respect to the dependent variable. One category of each variable was used as the reference category. Reference categories are not included in the model. The results of the binary logistic regression are shown in Table 6.

(Table 6)

Variables with a p-value higher than 0.05, were excluded from the model as non-significant. Moreover, the variables included in the model are found to be statistically significant by means of the Wald test and the results are shown in Table 6.The following model was formulated:

$$U = 0.512*x_1 + 0.261*x_2 - 0.318*x_3 - 1.328*x_4 - 0.261*x_5 + 1.398*x_6 + 0.905*x_7 - 3.134 \qquad (2)$$

where U : logit (use of mobile phone while driving)
x_1 : working day
x_2 : session (14.00-18.00)
x_3 : urban road
x_4 : national road
x_5 : gender (male)
x_6 : age (16-24)
x_7 : age (25-54)

The Likelihood Ratio Test criterion is met since LRT = -2*(L(0)-L(b)) = 4,973.822 – 4,767.207 = 206.615 > 16.92 = x^2 for 9 degrees of freedom and for a 95% interval, where L(b) is the likelihood of the proposed model and L(0) is the likelihood of the restricted ("empty") model. This indicates that the model is statistically preferred comparing to the one without the used variables.

It must be noted that the selection of the specific model was the result of a long process during which various models and cross-impacts among the different factors were tested. However, the examination of such models did not lead to the identification of improved prediction of mobile use in comparison to the used model.

Estimating the responsiveness and sensitivity of the dependent variable with respect to changes in each independent variable was also needed in order to allow the comparison of the impact of different variables on using a mobile phone while driving. This was achieved by calculating the elasticity of each independent variable (Washington, Karlaftis & Mannering, 2003). The elasticity value of a continuous variable is defined as the percentage change in the dependent variable resulting from small, incremental changes in an independent variable.

Elasticity can be particularly useful because it is dimensionless, unlike any estimated coefficient of regression parameter, which depends on the units of measurement of each parameter.

However, elasticity of discrete variables cannot be defined in the standard way, and therefore pseudo-elasticity is used instead. This describes the change in choice probability when the discrete variable changes from one value to another (Chang & Mannering, 1999), (Shankar & Mannering, 1996). The direct pseudo-elasticity of the k-th variable from the vector x_n, denoted x_{nk}, with respect to the probability, P_{ni}, of person n experiencing outcome i, is computed as (Ulfarsson & Mannering, 2004):

$$E_{x_{nk}}^{P_{ni}} = e^{\beta_{ik}} \frac{\sum_{i=1}^{I} e^{\beta'_i x_n}}{\sum_{i=1}^{I} e^{\Delta(\beta'_i x_n)}} - 1 \qquad (3)$$

where I is the number of possible outcomes, $\Delta(\beta'_i x_n)$ is the value of the function determining the outcome after x_{nk} has been changed from zero to one whereas $\beta'_i x_n$ is the value when $x_{nk} = 0$, x_n is a vector of K explanatory variables shared by all outcomes, β_i is a vector of estimated coefficients on the K variables for outcome i, and β_{ik} is the coefficient on x_{nk} in outcome i. According to Ulfarsson and Mannering (2004) the equation is valid for pseudo-elasticities of observation-specific binary indicator variables meaning that it is suitable in the examined case. Since equation (3) refers to each individual (n) in the sample, the calculated pseudo-elasticity refers to the sensitivity of the specific case towards the change of the value of the variable and thus is a disaggregate elasticity. In order to calculate the aggregate elasticity which expresses the sensitivity of the whole sample towards the examined change, to the corresponding total change of the probability of an outcome is calculated using the formula (Ben-Akiva & Lerman, 1985):

$$E_{x_{ik}}^{P(i)} = \frac{\sum_{n=1}^{N} P_n(i) E_{x_{ink}}^{P_n(i)}}{\sum_{n=1}^{N} P_n(i)} \qquad (4)$$

Consequently, the aggregate elasticity of the sample towards the examined change in a variable is the weighted mean of the individual elasticity based on the corresponding choice probabilities.

The relevant pseudo-elasticity (e_i^*) of each variable was also calculated by dividing the pseudo-elasticity of the specific variable by the pseudo-elasticity of the variable with the lowest impact on the dependent variable. This allows for the classification of variables with respect to the magnitude of their effect on the dependent variable in a straightforward way. The pseudo-elasticity and the relevant pseudo-elasticity value for each independent variable used in the model are also shown in Table 6.

Modeling results

The positive or negative impact that each independent variable has on the dependent is indicated by the sign (±) of the coefficient of the independent variable in the regression model. Variables with a positive coefficient have a positive impact on the probability of using a mobile phone while driving. On the contrary, variables with a negative coefficient have a negative impact on it. According to this and the binary logistic regression results, it can be concluded that driving on a working day, in the afternoon (between 14.00h and 18.00h) and being between 16 and 55 years old are parameters that enhance the use of mobile phones while driving a car in Greece. In contrast, driving on the urban or on the national road network and being a male are parameters that reduce the use of mobile phone by car drivers in Greece.

Odds ratios, defined as the exponentials of parameter estimates exp(B), are also presented in Table 6 and can be used to compare the different probabilities of using a mobile phone while driving that correspond to the various categories of each dependent variable. Based on such comparisons, it was found that car drivers are 66.9% more likely to use their mobile phone while driving on a working day compared to Saturday, having allowed for time, road type and driver's gender and age.

When time is examined more precisely, it is found that the odds ratio for the period 14.00h-18.00h, which contrasts with the period 18.00h-22.00h, is 1.298. Consequently, people driving their cars between 14.00h and 18.00h are 29.8% more likely to use their mobile phone while driving than those who drive between 18.00h and 22.00h, taking into account all the other examined parameters.

For the examination of the effect of road type on mobile phone use while driving a car in Greece, urban and national roads were contrasted to rural roads. The corresponding odds ratios are 0.728 and 0.265 respectively. These results indicate that car drivers travelling on urban roads are 27% less likely to use their mobile phone compared to those travelling on rural roads. Similarly, car drivers travelling on national roads are 74% less likely to use their mobile phone compared to those travelling on rural roads. Again, these results apply when the day of the week, time and driver's gender and age are also taken into account.

The results regarding driver's gender show that male car drivers are 23% less likely to use their mobile phone while driving compared to female car drivers. Furthermore, the probability of young car drivers (16-24 years old) to use a mobile phone while driving is approximately 4 times higher than that of older drivers (55+ years old). The respective probability of middle-aged car drivers (25-54 years old) is almost 2.5 times higher than that of older drivers allowing for the day of the week, time, road type and driver's gender.

Additional insight was obtained through the estimation of variable elasticities and normalized elasticities. The calculated pseudo-elasticity values, shown in Table 6, were used for the exploration of the impact that each dependent variable has on the independent. The dependent variable with the highest pseudo-elasticity value is driver's age from 16 to 24 years old. Thus, this is the one with the greatest impact on using a mobile phone while driving, compared to the rest of the examined variables. Furthermore, driving on a working day has a 2.86 times greater impact on using a mobile phone while driving than being a male driver. Driving on a national road has a 2.91 times greater impact on using a mobile phone than riding on an urban road. Regarding driver's age, it was found that being between 16 and 24 years old has a 1.74 times greater impact on using a mobile phone while driving than being between 25 and 54 years old.

Discussion

Worldwide, the use of mobile phones while driving is a common practice that has been analysed in detail, but research results are not always conclusive. During the last years, more and more studies focus on the identification of profiles of people who tend to use mobile phones while driving and the risk caused of this driving behaviour (Brusque & Alauzet, 2008). The objective of this study was to investigate the rate of mobile phone use among car drivers in Greece and its association with driver's characteristics and other parameters that have been recorded during an observation survey. Data used in this study was obtained through a national observation survey on mobile phone use.

The results of the observation survey showed that 9% of car drivers in Greece use a hand-held mobile phone while driving. Even though observational studies produce objective data regarding mobile phone use, there are always limitations on what the observers are able to see. This means that exposure rates based on the results of observation surveys might be underestimated which is of great importance as research has shown that hands-free phones may still expose drivers to risk (Gras et al, 2007).

Female drivers were found to use their mobile phones more than male drivers in total and for ages 25 to 54 years old. In urban areas drivers use their mobile phones while driving more than in rural areas. These results match with the results of previous studies (e.g. Taylor et al, 2003) and might be attributed to lower driving speeds in urban areas and consequently lower perceived risk of distracted driving.

As it was also found, car drivers in Greece use their mobile phones more while driving on working days than on Saturdays. These results may be partially explained by the continuously increasing use of mobile phones for work-related reasons and in everyday life. Furthermore, mobile phone use is increased between 14.00 and 18.00 on working days and between 10.00 and 14.00 on Saturdays. These might be related with peak traffic density and with common activities such as transition from work to home on working days and recreation activities on Saturdays.

The exploration of the impact that each independent variable has on the dependent showed that driving on a working day, in the afternoon, and being a young or middle-aged driver are parameters with a positive impact on the use of mobile phones while driving a car in Greece. On the other hand, the impact of driving on the urban or on the national road network and of being a male driver on the use of mobile phone is negative.

Based on the pseudo-elasticity values, the dependent variable with the greatest impact on using a mobile phone while driving, compared to the rest of the examined variables, is driver's age being from 16 to 24 years old.

The present study has contributed to the exploration of mobile phone use among car drivers in Greece and to the identification of parameters with an impact on this practice. The results of such studies can be exploited by public authorities and road safety policy decision makers to improve the targeting of driver awareness on the risk of phone use while driving.

Using a mobile phone while driving is regarded a factor contributing to road accidents.

However, a total prohibition of mobile phones is not realistic. On this direction, only hand-held use is forbidden in many countries (SWOV, 2010). People are generally positive towards such restrictions which may indicate that hand-held phones are perceived as more dangerous than hands-free phones (Backer-Grøndahl & Sagberg, 2011). In the Netherlands, self-reported data shows that the use of hand-held phones has been increasing, rather than decreasing during the last few years. However, there has been an improvement compared to the situation prior to the legal prohibition. Yet, legislation on driving behaviour is not always effective, especially in the case of young people (SWOV, 2010). In the UK, the proportion of drivers of cars, vans and lorries observed using hand-held phones reduced after the introduction of the legislation in 2003, and after an increase in the corresponding penalty in 2007. After these immediate drops, the proportion using a hand-held mobile phone increased again (Walter, 2010). Regulations of mobile phone use while driving in European countries and related penalties are presented in Table 7. Evaluations in the USA and other countries consistently show that mobile phone laws reduce hand-held phone use by about 50% shortly after the laws take effect and such reductions are maintained three to seven years later. However, it is unknown whether these laws lead to increased use of hands-free devices (NHTSA, 2011).

(Table 7)

In order to increase the effectiveness of legal measures, consideration should be given to increased surveillance of drivers and law enforcement. A positive public opinion is also critical for the success of legal measures taken regarding mobile phone use by drivers. Education and information campaigns can contribute to making the public more aware of the risks of the use of a mobile phone in traffic. Research is also required to determine why many drivers continue this practice despite fines and demerit points (SWOV, 2010), (Taylor et al, 2003).

While legal measures might lead to the reduction of mobile use while driving, technology related measures can eliminate the distraction caused by the use of a mobile phone while driving. Such measures are the use of systems which rely on voice activation for input; the use of tactile marks on the phone key pad buttons to give each button a distinct feel, reducing the need for drivers to look away from the road; use of technology that blocks phone calls while driving; the development of more ergonomic design of devices to minimize distraction e.g. avoiding the current trend of miniaturisation of mobile phones etc. (Yannis, 2011)

Using a mobile phone, as well as other distractions, is considered by many drivers an important and common activity that they are unwilling to give up (NHTSA, 2011). Nevertheless, there is research to suggest that many drivers underestimate the decrement in their performance caused by mobile phones (Gras et al, 2007). Research has also shown that people who are aware of the risks do not always adjust their behaviour accordingly; in many cases because they do not think the increased risk applies to them. This is an issue with young road users in particular (SWOV, 2010), (Gras et al, 2007). There are also drivers who are unaware that using a mobile phone while driving is illegal (Taylor et al, 2003). Each of these possibilities should be addressed in future research aimed at more clearly defining driver knowledge and attitudes toward this practice. Furthermore, collection of data regarding the different types of mobile phone use (e.g. texting, talking, dialing, using hands-free devices or not) and estimation of the corresponding relative risk, should be further pursued in future research. The results of this research can be useful for providing better insight of the parameters affecting the use of mobile phones by car drivers and for supporting future steps of research on the topic. Actually, the exploitation of these results has already begun with the investigation of specific safety parameters (Yannis et al, 2013). However, it would be also useful to explore the relationship of mobile use while driving in combination to other contributing factors to target specific road safety problems. Other issues that could be addressed in future research is the examination of the relationship between road accidents and the use of mobile phones while driving plus the exploration of drivers' risk perception regarding the use of mobile phones while driving.

Acknowledgment

This paper is based on the work carried out within the framework of a research project financed by the Hellenic Ministry of Infrastructure, Transport and Networks.

References

Backer-Grøndahl, A. & Sagberg, F. (2011). Driving and telephoning: Relative accident risk when using hand-held and hands-free mobile phones. *Safety Science* 49, 324–330.

Ben-Akiva, M. & Lerman, S.R. Discrete Choice Analysis: Theory and Application to Travel Demand. The MIT Press, Massachusetts, 1985.

Brusque, C. & Alauzet, A. (2008). Analysis of the individual factors affecting mobile phone use while driving in France: Socio-demographic characteristics, car and phone use in professional and private contexts. *Accident Analysis and Prevention* 40, 35-44.

Chang, L.Y., & Mannering, F. (1999). Analysis of injury severity and vehicle occupancy in truck - and non - truck - involved accidents. *Accident Analysis and Prevention Vol.31*, 579-592.

Eby, D.W. & Vivoda J.M. (2003). Driver hand-held mobile phone use and safety belt use *Accident Analysis and Prevention* 35, 893-895.

Gras, M.E., Cunill, M., Sullman, M.J.M., Planes, M., Aymerich, M., Font-Mayolas, S. (2007). Mobile phone use while driving in a sample of Spanish university workers. *Accident Analysis and Prevention* 39, 347-355.

Lamble, D., Rajalin, S. & Summala, H. (2002). Mobile phone use while driving: public opinions on restrictions. *Transportation* 29, 223-236.

McEvoy, S.P., Stevenson, M.R., McCartt, A.T., Woodward, M., Haworth, C., Palamara, P., Cercarelli, R. (2005). Role of mobile phones in motor vehicle crashes resulting in hospital attendance: a case-crossover study. *British Medical Journal* 331, 428-430.

National Highway Traffic Safety Administration (NHTSA). *Countermeasures That Work: A Highway Safety Countermeasure Guide for State Highway Safety Offices*. 6th edn. US Department of Transportation, Washington, DC, 2011, Report DOT HS 811 444. See http://www.nhtsa.gov/staticfiles/nti/pdf/811444.pdf . Accessed 19/09/2011.

National Highway Traffic Safety Administration (NHTSA). *Driver Electronic Device Use in 2009.* Traffic Safety Facts. Research Note. US Department of Transportation, Washington, DC, 2010, Report DOT HS 811 372. See http://www-nrd.nhtsa.dot.gov/Pubs/811372.pdf. Accessed 14/09/2011.

National Technical University of Athens (NTUA). *Development of a strategic plan for the improvement of road safety in Greece, 2011-2020*. Department of Transportation Planning and Engineering, School of Civil Engineering, Athens, Greece, 2011, Final Report.

National Technical University of Athens (NTUA). *Road safety data collection in Greece*. Department of Transportation Planning and Engineering, School of Civil Engineering, Athens, Greece, 2009, Final Report.

Pöysti, L., Rajalin, S. & Summala, H. (2005). Factors influencing the use of mobileular (mobile) phone during driving and hazards while using it. *Accident Analysis and Prevention* 37, 47-51.

Rosenbloom, T. (2006). Driving performance while using mobile phones: An observational study. *Journal of Safety Research* 37, 207-212.

SARTRE4 (2012). Social Attitudes towards Road Traffic Risk in Europe. http://www.attitudes-roadsafety.eu/.

Shankar, V.N. & Mannering, F.L. (1996). An exploratory multinomial logit analysis of single-vehicle motorcycle accident severity. *Journal of Safety Research, Vol.27*, 183-194.

Sullman, M.J.M. & Baas, P.H. (2004). Mobile phone use amongst New Zealand drivers. *Transportation Research Part F* 7 (2004) 95-105.

SWOV Institute for Road Safety Research (2010). Use of mobile phone while driving. *Fact Sheet*. See http://www.swov.nl/rapport/Factsheets/UK/FS_Mobile_phones.pdf Accessed 15/09/2011.

Taylor, D.McD., Bennett, D.M., Carter, M., Garewal, D. (2003). Mobile telephone use among Melbourne drivers: a preventable exposure to injury risk. *The Medical Journal of Australia* 179,140-142.

Törnros J.E.B. & Bolling, A.K. (2005). Mobile phone use - Effects of handheld and hands-free phones on driving performance. *Accident Analysis and Prevention* 37, 902-909.

Ulfarsson, G.F. & Mannering, F.L. (2004). Differences in male and female injury severities in sport-utility vehicle, minivan, pickup and passenger car accidents. *Accident Analysis and Prevention* 36, 135-147.

Walsh, S.P., White, K.M., Hyde, M.K., Watson, B. (2008). Dialing and driving: Factors influencing intentions to use a mobile phone while driving. *Accident Analysis and Prevention* 40, 1893-1900.

Walter, L. *Seatbelt and mobile phone usage surveys: England and Scotland 2009*. Department for Transport, London, 2010.

Washington, S.P., Karlaftis, M.G. & Mannering, F.L. Statistical and Econometric Methods for Transportation Data Analysis. Chapman & Hall / CRC Press, Boca Raton, FL, 2003.

Yannis, G. Distracted Driving, *13th European Transport Safety Lecture* organised by the European Transport Safety Council (ETSC), Athens, Greece, 2011.

Yannis, G., Papadimitriou, E., Papantoniou, P., Petrellis, N. Cell phone use and traffic characteristics. *Proceedings of the 12th World Conference on Transport Research,* Lisbon, Portugal, 2010.

Yannis, G., Papadimitriou, E., Papantoniou, P., Voulgari, Ch. (2013) Driver Distraction and Road Safety in Greece and Internationally. *Journal of Transport and Shipping*, 5, 57-74.

List of captions