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Investigating the acceptance of environmental parking charging and congestion charging in urban centers in Greece

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Abstract

Transport charging policies consist a basic tool for sustainable mobility while they increasingly applied in urban centers. The objective of the paper is to investigate drivers' acceptance of an environmental parking charging policy and an environmental congestion charging policy in Greek urban centers. For this purpose, data collected through a questionnaire survey while two ordinal logistic regression models developed to determine the public acceptance of the environmental transport charging policies under consideration; 370 responses were collected and analyzed. Results indicated that Greek drivers who are more environmentally conscious, accept other similar environmental charging policies and with high annual income have increased probability to accept the examined policies. Furthermore, several other parameters such as the driver's satisfaction level considering travel cost and Public Transport accessibility, the weekly trips for work and age affect policies acceptance and should be taken into account by policymakers when developing and implementing similar environmental mobility strategies.

Keywords: *environmental parking charging policy, environmental congestion charging policy, sustainable mobility, public acceptance, questionnaire survey, ordinal logistic regression*

1. Introduction

One of the greatest environmental and social challenges world faces today, lies in the mobility of people and goods. Considering that the vast majority of European citizens live in an urban environment, with over 60% living in urban areas of over 10,000 inhabitants, the quality of the environment in urban areas is of vital importance (Eurostat, 2016). People need a seemingly infinite network of vehicles and transportation systems to uphold societies and economies.

The sustainable mobility has attracted considerable interest by the scientific community and the public policymakers since in addition to economic importance, mobility activities have environmental and social impacts especially in urban centers (Guimarães et al., 2018; Litman and Burwell, 2006; Santos and Ribeiro, 2013). All the main definitions of sustainable mobility stress that it is not enough to refer to environmental aspects, although they are of primary importance, but also social and economic impacts should be taken into account (Gallo and Marinelli, 2020).

Based on the above, a key international target is to find effective mobility strategies to reduce urban problems. Several cities apply vehicles access regulations into urban areas such as Congestion Charging Zones (CC), Low Emission Zones (LEZs) or a combination of both. To date, CC and LEZ systems have been implemented in several cities internationally (Singapore, London, Stockholm, Milan, Gothenburg, Paris, Barcelona). The objective of congestion charging policy is the pricing of vehicles for the burden they cause on traffic and consequently on the environment and public health. The LEZ operates to encourage the most polluting heavy diesel vehicles driving in London to become cleaner.

Parking policies have significant environmental and economic implications, which often left unconsidered. Cruising for parking, implies significant time costs, aggravates congestion and pollution, and increases greenhouse gas emissions (Shoup, 2005; Russo et al., 2019). To date, numerous parking policies has been implemented in urban centers like command-and-control regulatory policies and market-based policies considering on-street parking, residential parking, employer parking, and parking in malls and downtown commercial areas (Russo et al., 2019).

However, there is an important precondition for the successful implementation of such policies; that is public acceptability (Shatanawi et al., 2020; Jakobsson et al., 2000; Schade and Schlag et al., 2003). Significant progresses have been made on understanding public acceptance of such schemes from different perspectives while several researchers studied the acceptability of transport charging schemes within the societies using different approaches.

Considering demographic factors, females are more receptive to the application of a proposed congestion charging policy than males (Liu and Zheng, 2013). However, the income level of does not affect the acceptability of congestion charging significantly (Hao et al., 2013). The acceptability of a pricing scheme implementing for the urban access restriction also depends on personal-outcome expectations. Drivers will more possibly accept the scheme if they expect a positive impact of the reduction in traffic and environment quality (Schuitema et al, 2010; Eliasson & Jonsson, 2011). Finally, more complex a charging policy is, the more difficulty the public will have in understanding it, which has led to public disapproval (Hensher & Li et al., 2013).

In that context, the objective of this study is to investigate and analyze drivers' acceptance toward environmental transport charging policies with emphasis on environmental parking charging as well as charging for vehicles access in Greek urban centers. For this purpose, a questionnaire was conducted which lead to the development of two statistical models, presented in the following chapters.

2. Data and Methodology

2.1 Survey

Within the framework of the present research, a personal interview, questionnaire-based survey was undertaken, aiming at collecting information on the level of understanding and accepting

environmental charging policies and measures in Greece. The questionnaire survey included questions on travel characteristics of respondents, environmental awareness and sensitivity, stated preference on alternative annual card cost and demographics. Questionnaire filling time was estimated on average 10 minutes.

The first part of the questionnaire focused on the drivers' travel profile and on the characteristics of their cars. Respondent's travel profile included information on the main transport mode used for accessing workplace/ education or leisure, the number of weekly trips, the travel cost, if they travel through the Athens center and the drivers' satisfaction on their typical daily trip. Concerning the car's characteristics, there were questions about the cubic capacity, the year of first registration and the fuel type.

The second section investigated respondents' environmental awareness and sensitivity. In particular, it included a series of questions related to perceptions of key environmental issues of road transport as well as some general environmental questions. Also, respondents were asked to state their opinion on environmental charging policies, such as environmental vehicle registration fees, environmental incentives for old-technology vehicles withdrawal, environmental incentives to purchase new-technology and environmental friendly vehicles, environmental parking charging, environmental charging for vehicles access (congestion charging) in Greek urban centers, environmental tolls. In this paper, the focus is to investigate drivers' acceptance toward environmental parking charging policy as well as environmental congestion charging in Greek urban centers.

The third section referred to the stated preference analysis and consisted of a hypothetical scenario of replacing the current car access mobility restrictions (Athens Ring) in the center of Athens with an environmental charging system for private cars (annual card). It targeted at identifying the public acceptance of the annual card, considering the charging depending on the year of the vehicle's first registration and the time saving of a typical trip. Finally, the fourth part collected information on demographics characteristics of respondents (gender, age, annual income and education level).

2.2 Study Area

Athens is the capital and largest city of Greece, and among the most important economic centers in Southeastern Europe. The city of Athens (Municipality of Athens) has a population of 664.046 inhabitants (ELSTAT, 2011) of which 315.210 are men and 348.836 are women, and a land area of 38,96 km^2. Residencies correspond to a 35% of the metropolitan area's total land uses, while 7% of that land corresponds to industrial activities, 6% to administration, 5 % to recreation and 26% to commerce and other activities (Mnistry of Environment, Energy and Climate Change, 2014).

Passenger cars constitute 69% of the total vehicle fleet in the Region of Attica, followed by motorcycles (motorcycles and mopeds) with 24%, trucks with 6,7% and buses with 0,3% (ELSTAT, 2018). Considering passenger vehicles there is a steady annual increase (1,2% on average) after the year 2013. The continuous increase of the vehicle fleet in combination with the decrease of the new registrations from 2007 onwards (ELSTAT, 2011), indicates that old technology cars are not withdrawn which leads to an aging vehicle fleet.

The Municipality of Athens have demarcated about 10.000 car parking spaces of which 3.463 are intended for visitors, 5.177 are for residents and 1.000 special parking places. Also, there are yellow lined parking places, intended for use by public services, embassies and banks fleet of vehicles. Finally, 1.604 two-wheeler parking places have been implemented in the city of Athens.

Considering environmental quality, noise and air pollution are two fundamental problems facing the Region of Attica nowadays. According to the latest Strategic Noise Map published by the Ministry of Environment and Energy in 2013, the majority of the citizens of Athens (53%) living or traveling in the city center, experience daily noise values of 65-70 dB. During 2018, the highest NO_2 air pollution emissions of the last five years were identified (Minstry of Environment, Energy and Climate Change, 2018).

2.3 Sample Characteristics

Data collected through a questionnaire that completed in the form of interviews in areas of the northern, southern, central and western suburbs of Athens. Quality and validity check performed leading to 370 questionnaires. The sample size considered sufficient for the purposes of the study.

The collected data were interpreted using descriptive statistics. As targeted, the percentage of men (49%) who answered the questionnaire is approximately equal to the percentage of women (51%). Also, almost equal percentages are observed in the age categories 18-30 and 31-55. The age group >55, constitutes the smallest percentage (16%) of the sample. The results confirm that the sample follows a properly balance stratification with respect to these parameters (Fig. 1).

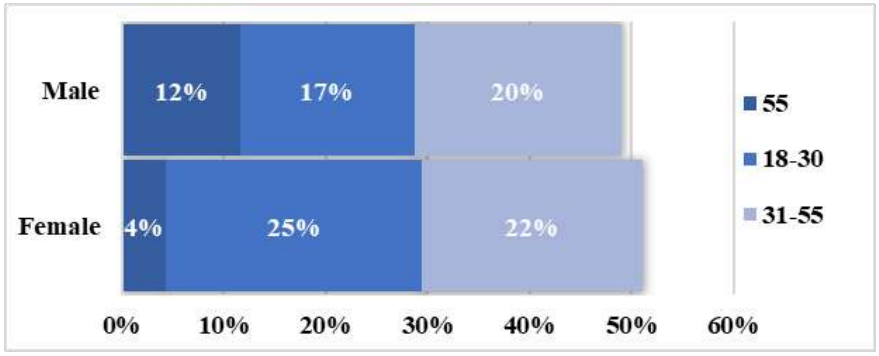

Figure 1: *Age distribution per gender of participant drivers*

2.4 Theoretical Background

The questionnaires have brought out an adequate number of variables. Following the data collection and the developed database, it was determined that statistical ordinal logistic regression model would be appropriate for the statistical analysis of the environmental parking

charging and congestion charging acceptance. Specifically, two ordinal logistic regression models was developed to model how demographic parameters, respondents' travel characteristics, respondents' environmental awareness and the level of acceptance of other environmental charging policies influence the public acceptance of the two proposed environmental charging policies in Greek cites.

Following Washington et al. (2010), a brief description is provided as follows. Based on the proportional odds assumption (the assumption that the logarithms of odds follow an arithmetic series), the ordinal logistic regression for the occurrence probability of an event p can be expressed as the link of the logarithm of the odds with a linear utility function:

$$y_i^* = logit(p) = LN\left(\frac{p}{1-p}\right) = \beta_0 + \sum b_i x_i \quad \textbf{(1)}$$

In this case, the actual dependent variable yi^* is unobserved and therefore standard regression techniques cannot be performed. Instead, the observed variable y_i is included in the data, as the ordered variable described previously. The typical relationship between the observed and the actual dependent variable is formalized as follows:

$$y = \begin{Bmatrix} 0, \ if \ y^* \leq \ \beta_{01} \\ 1, \ if \ \beta_{01} \leq \ y^* \leq \beta_{02} \\ \dots \\ n, \ if \ \beta_{0n} \leq y^* \end{Bmatrix} \quad \textbf{(2)}$$

In the analysis under consideration, the dependent variables are ordinal variables taking into account that the values include five categories "Definitely Not", "Probably Not", "Possibly", "Probably", "Definitely". This scale corresponds to the level of acceptance of the two environmental transport charging policies under consideration. The final models were evaluated considering the common statistical tests (pseudo R^2, t- test etc.) but also based on the logical explanation of the results. Also, the correlation of variables was examined to select the best-fitting mathematical model. In practice, what is expected is the best possible correlation between dependent and independent variables and the zero correlation between independent variables.

3. Results

3.1 Descriptive Analysis

A preliminary part of the analysis focused on interpreting collected data using descriptive statistics. According to Fig. 2, half the sample accepts the proposed environmental parking

charging policy while the majority of the respondents do not accept or hesitate to accept the proposed environmental congestion charging policy in Greek urban areas.

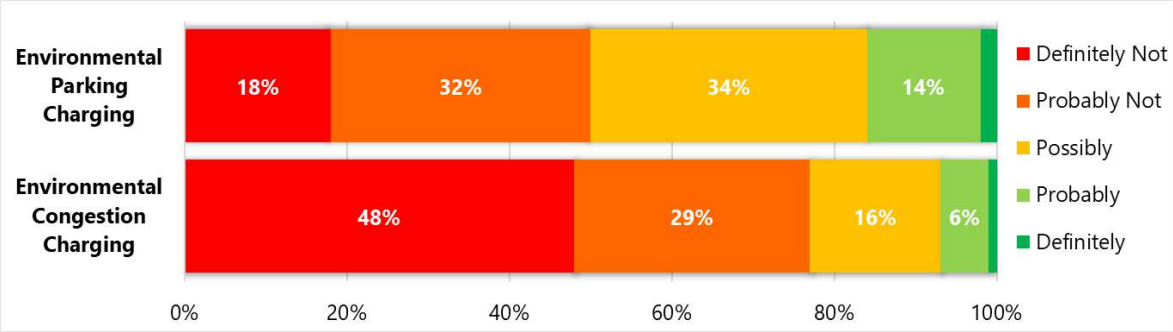

Figure 2: *Environmental transport charging policies public acceptance in Greek urban centers*

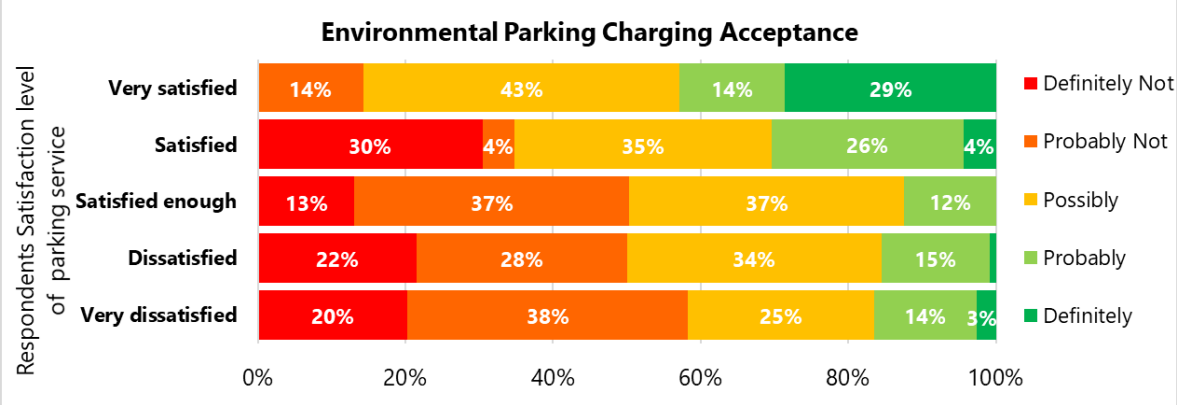

Figure 3: *Environmental parking charging acceptance considering the satisfaction level of existing parking service*

In fact, the respondents who are contended with the existing parking service in the city center of Athens seem to accept the environmental parking policy to a greater extent compared to those who are displeased (Fig. 3). Specifically, the sample that feels that it is not satisfied by the parking service seems to be divided into whether it accepts or does not accept the proposed parking policy. Moreover, according to Fig. 4, the majority of respondents who claim to be satisfied with the daily travel time accept the implementation of the environmental congestion charging policy in urban centers in Greece. Although, those who are satisfied and quite satisfied with the travel time do not seem to support the transport policy under consideration.

Finally, considering Fig. 5, the less disturbed the respondent is by the exhaust gases in the center of Athens, the more difficult it is to accept the proposed environmental charging measures.

Specifically, only the 4% of respondents who believe that exhaust fumes on road are little annoying accepts the environmental parking charging and congestion charging policies in Greece.

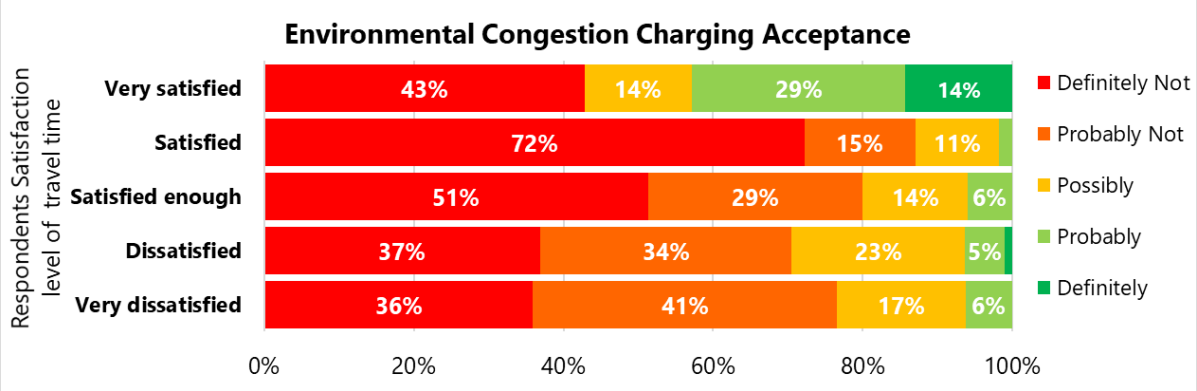

Figure 4: *Environmental congestion charging acceptance considering the satisfaction level of travel time*

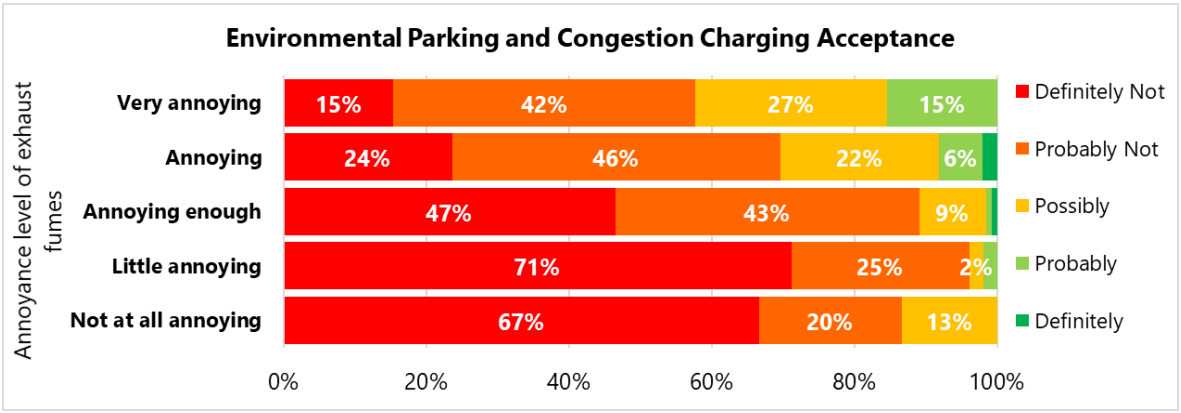

Figure 5: *Environmental parking and congestion charging acceptance considering the annoyance level of exhaust fumes*

3.3 Modelling Results

Questionnaire data were initially analyzed and two ordinal logistic regression models were developed. For the first model, the dependent variable was defined as

- "At what level do you accept the implementation of environmental parking charging in Greek urban centers?"

while for the second model, the dependent variable was defined as

- "At what level do you accept the implementation of environmental congestion charging in Greek urban centers?"

These are essentially the two core questions that are employed in the current study in order to capture the public acceptance of the two environmental transport charging policies under consideration.

Accordingly, the final independent variables included in the parking charging acceptance model were the level of public acceptance of the environmental congestion charging in Greek urban centers (1= Definitely Not, ..,5= Definitely), the answer to the question "To what extent do you believe transport sector is responsible for environmental pollution?" (1= not at all, ..,5= highly), the number of weekly trips the respondent makes for work and education (0-4, 5-10, >10), the level of satisfaction in terms of personal travel costs (1=very dissatisfied, …, 5=very satisfied), the respondent's age group (18-30, 31-55, 55+) and annual income (<10.000€, 10.001-25000€, >25.000€).

Results appear on Table 1. The final model had a McFadden R^2 of 0,14, which is considered adequate for logistic regression models.

Table 1: *Ordinal logistic regression model results – environmental parking charging policy*

Parameter	Coefficient	Std. Error	t value	p value	Odds Ratio
Environmental Parking Charging Policy Acceptance					
Env_CongestionCharging_Acceptance	0,876	0,114	7,698	0,000	2,402
TrQ_Transport_ environmental_pollution	0,988	0,136	7,248	0,000	2,687
WeeklyTrips_EducationWork	0,519	0,173	3,005	0,003	1,681
PersonalSatisfaction_TravelCost	0,318	0,101	3,165	0,002	1,374
Age	-0,589	0,167	-3,519	0,000	0,555
Annual_Income	0,402	0,198	2,030	0,042	1,495
Definitely Not|Propably Not (Constant $P_{1\text{-}2}$)	4,585	0,774	5,928	0,000	-
Propably Not|Possibly (Constant $P_{2\text{-}3}$)	6,533	0,803	8,137	0,000	-
Possibly|Probably (Constant $P_{3\text{-}4}$)	8,670	0,859	10,094	0,000	-
Probably|Definitely (Constant $P_{4\text{-}5}$)	11,570	1,008	11,479	0,000	-

Based on these results, a series of deductions can be made. Drivers who accept the implementation of an environmental congestion charging policy in Greek urban centers are more likely to accept the environmental parking charging policy. For each additional unit of acceptance level of congestion charging, the odds that the respondent acceptance level of environmental parking charging policy will be "Definitely" instead of "Probably" increase by

about 2,4 times. Also, an environmentally conscious respondent is more possible to accept the environmental charging policy under consideration. More specifically, respondents who believe strongly that the transportation sector is responsible for environmental pollution, have 13,5 times the probability to accept the environmental parking charging "Definitely" instead of "Probably" compared to those who don't agree with that statement.

It also turned out that the drivers who make many trips during the week for the purpose of work or education accept in a greater extent the implementation of the proposed environmental parking charging policy. Drivers who make more than 10 trips per week to work or educated have almost 70% increased probability to accept the parking charging policy definitely "Definitely" instead of "Probably", compared to drivers who make 5-10 trips per week. The level of satisfaction considering the travel cost affects also positively the level of acceptance of the parking policy under consideration. For each additional unit of satisfaction level, the odds that the respondent's acceptance level of environmental parking charging policy will be "Definitely" instead of "Probably" increase by about 37% (odds ratio=1,374).

Regarding respondents demographic characteristics, it was found that younger people and people with high annual income are more likely to accept the environmental charging policy under consideration, than older people and people with average annual income respectively. Specifically, respondents who belong to the age group "31-55" have 0,55 times the probability (or an equivalent 45% reduced probability) to accept the proposed parking policy "Definitely" instead of "Probably", compared to age group "18-30". The odds ratio of 1,495 for annual income shows that as annual income increases, respondents are more likely to accept the policy. For each additional annual income group a respondent belongs, the odds that the driver responds with "Definitely" instead of "Probably" increase by about 50%.

Consequently, the final independent variables included in the congestion charging acceptance model were, the level of public acceptance of the proposed environmental circulation tax in Greek urban centers (1= Definitely Not, .., 5= Definitely), the annoyance level from road traffic noise (1= not at all annoying, .., 5= very annoying), the importance level of choosing a car to buy taking into account the environmental burden it is going to cause (1= unimportant, …, 5= very important), the level of personal satisfaction in terms of Public Transport accessibility (1= very dissatisfied, …, 5= very satisfied), the respondent's annual income (<10.000€, 10.001-25000€, >25.000€). Results appear on Table 2. The final model had a McFadden R^2 of 0,27, which is considered adequate for logistic regression models.

Based on the model results, drivers who accept the implementation of an environmental circulation tax in Greek urban centers are more likely to accept the environmental congestion charging policy. For each additional unit of acceptance level of congestion charging, the odds that the respondent acceptance level of environmental congestion charging policy will be "Definitely" instead of "Probably" increase by about 4,2 times. In addition, a respondent who is bothered by the traffic noise on urban road network is more possible to accept the environmental charging policy under consideration. More specifically, respondents who believe that traffic noise is very annoying in urban centers, there is almost a 65% increase in the likelihood to accept the environmental congestion charging policy "Definitely" instead of "Probably", compared to those who feel that vehicles noise is simple annoying.

Table 2: *Ordinal logistic regression model results - environmental congestion charging policy*

Parameter	Coefficient	Std. Error	t value	p value	Odds Ratio
Environmental Congestion Charging Policy Acceptance					
Env_Circulation_Tax_ Acceptance	1,437	0,158	9,122	0,000	4,207
TrQ_Annoyance_from_traffic_noise	0,500	0,146	3,413	0,001	1,648
VehicleChoiceFactor_EnvironmentPollution	0,640	0,156	4,092	0,000	1,896
PersonalSatisfaction_PublicTransportAccess	-0,249	0,132	-1,892	0,058	0,780
Annual_Income	0,566	0,191	2,957	0,003	1,762
Definitely Not|Propably Not (Constant P_{1-2})	7,063	0,919	7,686	0,000	-
Propably Not|Possibly (Constant P_{2-3})	9,198	0,977	9,412	0,000	-
Possibly|Probably (Constant P_{3-4})	11,185	1,034	10,812	0,000	-
Probably|Definitely (Constant P_{4-5})	14,042	1,269	11,068	0,000	-

Those who believe that environmental burden is a crucial factor to choose a car, have 9,5 times the probability to accept the proposed environmental congestion charging policy compared to those who think that the environmental burden is an insignificant parameter. The level of satisfaction considering the Public Transport accessibility affects also positively the level of acceptance of the policy under consideration. For each additional unit of satisfaction level, the odds that the respondent's acceptance level of environmental charging policy will be "Definitely" instead of "Probably" decrease by about 22% (odds ratio= 0,780). Regarding respondents demographic characteristics, it was found that people with high annual income are more likely to accept the environmental charging policy under consideration, than people with average annual income. Specifically, the odds ratio of 1,762 for annual income shows that as annual income increases, respondents are more likely to accept the policy. For each additional annual income group, the odds that the driver responds with "Definitely" instead of "Probably" increase by about 76%.

The above results also apply to the utility functions U_{1-2}, U_{2-3} and U_{3-4} with the only difference that it is a comparison between the levels "Definitely Not" and "Propably Not" (for the function U_{1-2}), "Propably Not" and "Possibly" (for the function U_{2-3}) and "Possibly" and "Probably" (for the function U_{3-4}). The influence of variables are interpreted in the same way, since the coefficients of the ordinal logistic regression models are common between the categories of the dependent variable.

4. Conclusion

The present research aimed to explore the factors affecting the drivers' acceptance toward environmental transport charging policies with emphasis on environmental parking and congestion charging policies in Greek urban centers. For this purpose, data collected through a questionnaire survey aiming at collecting information on the level of understanding and accepting environmental charging policies under consideration. The questionnaire survey included questions on travel characteristics of respondents, environmental awareness and sensitivity of the respondents, stated preference on alternative annual card cost and demographics.

After data collection, a dataset was produced consisting of 370 drivers' responds in Athens. Based on that dataset, two ordinal logistic regression models were developed providing valuable insights as a number of affecting factors was determined for the level of acceptance of the two proposed environmental charging policies.

Regarding the public acceptance of the environmental charging policies under consideration, it is shown that Athenian drivers who accept the implementation of an environmental congestion charging policy in Greek cities, are more likely to accept the proposed environmental parking charging policy. Similarly, drivers who accept to pay an environmental circulation tax are more likely to accept the environmental congestion charging policy under study.

An environmentally conscious and sensitive driver is more possible to accept the environmental charging policies under consideration. Specifically, respondents who believe strongly that the transportation sector is responsible for the environmental pollution, have increased probability to accept the environmental parking charging policy compared to those who don't agree with that statement. Also, a respondent who is bothered by the traffic noise on urban road network is more possible to accept the environmental congestion charging policy under consideration. Possibly, the respondents who are bothered by the traffic noise perceive the implementation of the proposed environmental policy as a way to limit the noise, through the reduction of traffic.

Furthermore, the drivers who make many trips during the week for the purpose of work or education accept in a greater extent the implementation of parking charging policy probably because they believe that the parking management will be improved decreasing the time searching for parking. The level of satisfaction considering the travel cost affects also positively the level of acceptance of the parking policy under consideration. Respondents who are dissatisfied with the Public Transport accessibility have increased probability to accept the environmental congestion charging in urban centers, possibly because they believe that by restricting passenger car entrance in urban centers, Public Transport will be promoted.

Regarding respondents demographic characteristics, analysis has shown that younger people and people with high annual income are more likely to accept the environmental charging policies under consideration, than older people and people with average annual income respectively. This is probably due to the fact that young people are more flexible and open to new situations, while older people are attached to their habits. Also, this may be explained by the fact that young people may be characterized by a greater environmental consciousness compared to the elderly.

Considering that the environmental factor will be of high priority for all policymakers, respective stakeholders and cities will be planning and implementing sustainable urban mobility strategies and policies for the next decades in order to transform the cities, the present

study deals with two environmental transport charging policies. Future research should focus on the comparison of these environmental transport charging policies in different countries/cities in order to identify regional characteristics that affect the public acceptance. Moreover, apart from the examined policies, several other policies should be deeply investigated in order to provide to policymakers the most appropriate policies for each city.

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