

Article

Public Acceptability of Environmentally Linked Congestion and Parking Charging Policies in Greek Urban Centers

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Abstract: Nowadays, urban centers face the challenge to upgrade life quality by reducing traffic congestion, air pollution emissions and road casualties. Transport charging policies applied in cities at a quick pace are a key tool for sustainable mobility. However, public acceptability is an important precondition to be adopted for such policies. In this context, the scope of this paper is the investigation of the public acceptability of environmentally linked urban charging policies in Greek urban centers. Specifically, the paper's objective is the investigation of Greek drivers' acceptability of the implementation of a congestion charging policy and a parking charging policy with the charging being adjusted according to the Euro class and technology of the vehicle in favor of less polluting cars. A structural equation model (SEM) was developed using data from a questionnaire survey which provided a sample encompassing 733 respondent drivers from three main urban centers of Greece: Athens, Thessaloniki and Volos. Several statistical relationships were detected and quantified correlating the two examined urban environmental charging policies with five latent unobserved variables. Based on the results, public acceptability of environmental congestion charging policies and the public acceptability of environmental parking charging policies were found to be positively correlated with each other, meaning that a driver who supports one environmentally linked transport charging policy is more likely to support the other one as well. The environmental sensitivity and high commuting profiles of drivers are influential factors that positively affect the acceptability of the two examined transport charging policies' implementation in Greek urban centers. Analysis has also shown that younger, higher-educated respondents and females are more likely to accept the environmental charging policies under consideration.

Keywords: transport charging policy; environmentally linked; urban sustainability; public acceptability; structural equation model



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1. Introduction

One of the greatest environmental and social challenges the world faces today lies in the mobility of people and goods. Among the various mobility concepts that have appeared in recent decades, one of the most important is sustainable mobility [1], which is attracting considerable interest by the scientific community and public policymakers, since in addition to economic significance, mobility activities have environmental and social impacts especially in urban centers [2–4]. Therefore, sustainable urban mobility seems to create a new ethos in the transportation sector [5], enhancing social justice, economic efficiency, environmental protection [6] and contributing positively to urban centers and in their built environments [7].

Following fast moving daily life, because of the increase in private car fleets and the rapid incense of car ownership respecting the change of population and income levels [8,9], many cities are suffering from high levels of traffic congestion, traffic noise and environmental impacts, imbalance between parking supply and demand, increase in road accidents

and other socioeconomic problems. Traffic congestion is a common problem existing in urban areas that creates huge economic loss to society and a diminished life quality of citizens and visitors. Numerous cities suffer from long-term traffic congestion, which is estimated to cost EUR 270 billion annually in Europe [10].

Moreover, searching for street parking implies significant travel time costs, and increases traffic congestion and air pollution [11]. The literature reveals that about 30% of traffic congestion is caused by vehicles that are cruising for parking space [12,13]. Within this scope, several attempts have been made to recalculate the impact on traffic congestion from cruising [14,15], but the 30% rate is still widely used in academic settings and policies. Seeing that these socioeconomic costs are not taken into account for the parking prices setting, they contribute to social prosperity losses [11].

Focusing on Greece, the problem of traffic congestion has already come to an acute stage for Athens and many other cities and is still growing fast. Regarding the city centers of Athens and Thessaloniki, the traffic congestion levels appear quite high whereas the level of service of commuters is not equivalent to that of other similar European cities. In particular, travel times in Athens were 43% longer than during the baseline non-congested conditions in 2019, 34% in 2020 mainly due to the pandemic COVID-19 and mobility restrictions, whereas there was an increase to 37% in 2021 [16]. Athens is the 18th while Thessaloniki is the 86th out of 240 in the ranking of European cities with the highest levels of traffic congestion [16]. Additionally, 53% of the residents of Athens experience daily noise values of 65–70 Db [17]. Considering the parking spaces in Athens, the Municipality has demarcated about 10,000 car parking spaces of which 3463 are intended for visitors, 5177 are for residents and 1000 special parking places. Athens has the 3rd lowest index of visitors' parking spaces per 1000 inhabitants compared to other Greek cities.

Accordingly, the fundamental aim of all public and private authorities is to find effective strategies to reduce these issues in urban centers. Many cities worldwide have implemented various policies to promote sustainable urban mobility by managing travel and traffic demand. Congestion Charging Zones (CC) and Low Emission Zones (LEZs) are typical examples of car access regulations into urban areas. CC was first implemented in the 1950s in Singapore and since then only a few other applications have been reported (London, Stockholm, Milan, Gothenburg), despite the significant socio-economic benefits that may arise. CC policy aims to charge the vehicles for the burden they cause on traffic and consequently on the environment and public health. London, Oslo, Milan and Bergen are some of the cities that apply the CC policy with the charging depending on the technology and the Euro Class of the vehicle entering the charging zone [18]. LEZs are urban areas with restrictions on the commuting of more polluting and older technology vehicles, encouraging the most polluting vehicles to become cleaner. Compared to CC zones, LEZs in most cities cover a larger area of the city.

Parking policies in urban areas consist prominent measures which contribute significantly to social welfare through the improvement of air quality, vehicular congestion levels and economic costs on urban residents [11,19]. To date, numerous command-and-control and market-based parking policies have been implemented in urban centers considering residential, retail, workplace, and integrating parking [11], which are mainly focused on social and environmental values [20]. More specifically, some European cities charge parking based on car emission level, such as London, which has implemented the CO₂-based residential parking permit [20].

In that context, the purpose of this paper is to identify a thorough structure of relationships correlating the drivers acceptability of the implementation of environmentally linked congestion and parking charging policies in Greek urban centers with several parameters regarding drivers sociodemographic and travel characteristics as well as environmental perspectives. A structural equation model (SEM) was developed using data from a questionnaire survey which provided a broad sample encompassing 733 respondent drivers from three main urban centers of Greece: Athens, Thessaloniki and Volos. Within the framework of the analysis, several statistical relationships were detected and quantified

correlating the two urban environmental charging policies under investigation with five latent unobserved variables.

The main research questions formulated to achieve the purpose of the present research and to fill gaps which are not covered by other studies are as follows:

- [1] Which factors define Greek drivers' acceptability of the implementation of environmentally linked transportation charging schemes in Greek urban areas?
- [2] Can the self-reported inputs of Greek drivers be converted to meaningfully represent unobserved theoretical constructs expressing (i) sociodemographic profiles, (ii) travel profiles, (iii) environmental awareness and (iv) travel satisfaction?
- [3] Are the two examined environmentally linked transportation charging policies influenced by each other?

The paper is organized as follows: Initially, a thorough literature review is presented considering the parameters that internationally affect the public support of transportation charging schemes in urban centers and the methodologies that are used. Section 3 describes the structure of the questionnaire-based survey which was undertaken for the purposes of the current paper as well as the three study areas. Afterwards, descriptive statistics and relevant figures outlining the sample are provided, followed by an overview of the SEM mathematical background. Results from the fitted SEM model and their comparison with the results extracted from previous similar studies are then presented. To conclude, a summary of the current research results is included in the last section.

2. Literature Review

To create appropriate urban mobility policies, it is crucial to investigate how residents and visitors to the city are expected to react to these new regulations considering that public acceptability is an important precondition to integrate them successfully into society [21–23]. Transport charging policies are not easily endorsed by commuters [23–25], whereas much has been achieved to understand public acceptability of such policies from different point of views. It is pointed out that parking restrictions and pricing are the policies with the largest public acceptability [20,26]. Several researchers have investigated the acceptability of transport charging schemes within the societies through various methodologies.

According to the literature, the parameters that affect public acceptability of transportation charging policies could be categorized in the following three categories: policy structure and characteristics, attitudinal factors and sociodemographic characteristics [27].

Regarding the first category, a complex design of the structure of a congestion charging system is found to be related negatively with its public acceptability [28,29]. More specifically, the acceptability of a scheme with a charging based on time or on traffic delays is lower than a charging policy with fixed charges [29]. This finding may be justified by the potential difficulty of people to understand the mechanism of the policy, which may lead to public disapproval [30,31]. In addition, the equity in pricing considering pricing mechanisms is an important factor in establishing strong public acceptability [31].

Regarding the second category, public support for a transportation charging policy also depends on personal outcome presumptions and perceived outcomes. Drivers could more likely accept a proposed charging policy if they expect a positive outcome on the traffic congestion levels and air pollution in their city [32,33]. The uncertainty about a proposed congestion charging scheme effectiveness and concrete use of its revenues [24,34] also determines the support of the policy.

Researchers conclude that environmental concern is one of the most influential attitudinal factors that affect transport charging policy acceptability [35]. High awareness and sensitivity about current traffic congestion and environmental problems are related positively with the public acceptability of charging policies [23,27,36]. However, the relationship between environmental concerns and policy support may not be so significant, if in the city that it is to be implemented the citizens pay attention to economic development without concern about environmental protection [37].

Considering sociodemographic characteristics, parameters such as age, gender, education level and travel characteristics affect public acceptability of transportation charging schemes whereas annual income does not influence public acceptability of congestion charging significantly [38]. However, other studies show that drivers with high incomes continued commuting with their cars into the charging area [39,40]. Furthermore, females are more receptive to the implementation of the congestion charging schemes in urban areas [39]. Finally, the drivers who travel during weekdays are more willing to pay twice as much as those who travel during weekends [41,42].

Most studies aiming to investigate the public acceptability of a proposed transport charging policy in a city conducted questionnaire-based surveys and developed statistical regression models to describe the influence of several factors on public acceptability. Specifically, Ma and He [35] developed an ordinal regression model using questionnaire survey data to analyze the explanatory variables of acceptability of congestion charges in Beijing. Another similar study developed a multivariate probit model to investigate the factors that influence public perception regarding the effectiveness of six traffic-management measures [40]. Liu and Zheng [39] present a linear regression model to investigate the acceptance of congestion charging on the city of Brisbane, whereas Jansson and Rezvani [21] conducted a multiple regression analysis to investigate the dependence of public acceptability of an environmental transport policy in Sweden and environmental beliefs, experience with alternative fuel vehicles and socio-demographics. In addition, Likert scales and exploratory factor analysis are used to determine public acceptability of a urban transportation policy [43]. Finally, Liu et al. [44] manage through a structural equation model to analyze relationships that exist among the different aspects of public acceptability of congestion charging in the Chinese context.

3. Method and Materials

Within the framework of the present research as a first step, a personal interview and questionnaire-based survey was undertaken, aiming at collecting information on the level of understanding and accepting congestion and parking charging policies in Greek urban centers. In the second step of the overall methodology, a SEM was developed to detect and investigate numerous statistical relationships correlating the two examined urban environmental charging policies with latent unobserved variables.

3.1. The Survey

The questionnaire survey included questions on travel characteristics of respondents, environmental awareness and sensitivity and stated preferences of alternative scenarios of a proposed environmental congestion charging policy and demographic characteristics.

The first part of the questionnaire focused on the drivers' travel profile and on the characteristics of their cars. Respondents' travel profile included information on the main transport mode used for commuting for the purpose of work/education or leisure, the number of weekly trips, the travel cost per week and the drivers' satisfaction on a typical daily trip concerning several factors. Regarding the car's characteristics, questions about the engine capacity, the year of 1st registration and the type of fuel are included.

The second section investigated respondents' environmental awareness and sensitivity as well as respondents' level of acceptability of the two examined environmentally linked transport charging policies. In particular, it includes a series of questions related to perceptions of key environmental issues of road transport as well as some general environmental questions. Furthermore, respondents were asked to state their opinion on environmentally linked charging policies, such as congestion charging, parking charging and tolls on highways with the charging being adjusted according to the age and technology of the vehicle, in favor of less polluting cars.

The third part examined a hypothetical scenario of implementing in the city center of Athens an environmental congestion charging system for private cars, with the charging adjusted according to the Euro class of the car. In the framework of this study, the

stated preference part is not examined. Finally, the fourth part collected information on demographics characteristics of respondents (gender, age, income, education level and so on).

3.2. Study Area

The questionnaire survey took place in three main city centers of Greece: Athens, Thessaloniki and Volos. The places where the questionnaire survey-interview took place were near parking spaces and metro stations in the urban centers and all the suburbs of the cities, aiming to capture all different characteristics of the residents.

Athens is the capital and largest city in 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 of which 47% are men [45]. Residencies correspond to 35% of the metropolitan area's total land uses, whereas 7% of that land corresponds to industrial activities, 6% to administration, 5% to recreation and 26% to commerce and other activities [46]. Passenger cars constitute 69% of the total vehicle fleet in Attica, followed by motorcycles (motorcycles and mopeds) with 24%, trucks with 6.7% and buses with 0.3% [47].

Thessaloniki is the second largest city in Greece, with over 1 million (2011) inhabitants in its metropolitan area and 824,676 (2011) in the urban area, of which 46% are men [45]. Volos is a coastal port city in Thessaly situated about 330 km north of Athens and 220 km south of Thessaloniki. It is the sixth most populous city in Greece with a population of 144,449 (2011), of which 49% are men [45].

4. Descriptive Statistics

Before the core of the analysis, a preliminary section focused on interpreting collected data using descriptive statistics. In the beginning, a quality check was performed leading to a total of 733 responses. Most responses are from the city of Athens (74%), whereas all of the respondents own and use a car for commuting as they stated in the survey. A table with the description of each variable of the questionnaire survey is presented.

Focusing on demographics, men and women represent 53.1% and 46.9% of the sample, respectively. Almost equal percentages are observed in the age categories 18–30 and 31–55, whereas the oldest age group constitutes the smallest percentage (17.7%) of the sample. The results confirm that the sample follows a properly balance stratification with respect to these parameters.

Considering travel characteristics, as expected, most respondents use a private car for commuting with the purpose of work and/or education (57%) and for the purpose of leisure (80%). Additionally, approximately 62% of the sample make 5–10 trips per week with the purpose of work and/or education in the wider area of the city center whereas 16% make more than 10 trips per week.

Based on Figure 1, most respondents are aware and sensitive about the environmental problems caused by road transportation and consequently what society faces. Specifically, the majority of the respondents claim that they are bothered by traffic noise and fumes and believe that the average age of the Greek car fleet should be lower.

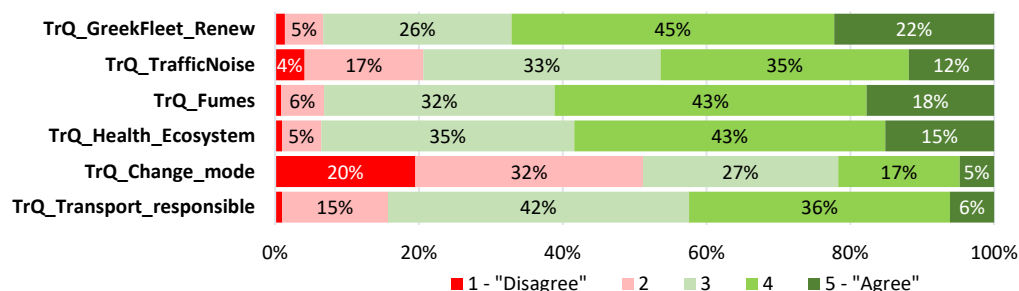


Figure 1. Respondents' environmental awareness and sensitivity.

According to the following figure (Figure 2), only 26% of the sample supports the implementation of a congestion charging policy in Greek urban areas, whereas the public acceptability level of an environmental parking charging policy is higher (46%) but still low. Probably, the low observed level of acceptability of such policies is because respondents are unaware of the positive social impacts of such policies combined with the additional charge they will incur through commuting.

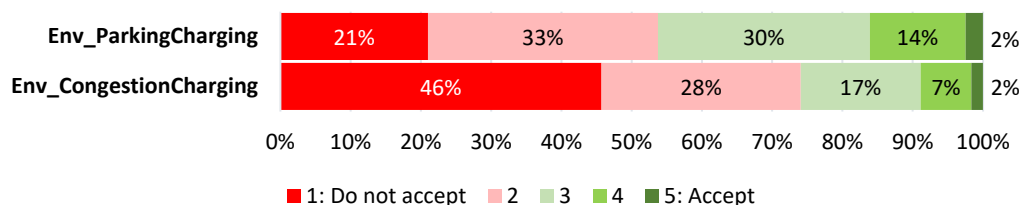


Figure 2. Environmentally linked transport charging policies public acceptability in Greek urban centers.

In fact, the respondents who are content with the existing parking service in their city seem to accept the environmental parking policy to a greater extent compared to those who are dissatisfied (Figure 3). Specifically, the sample that feels that it is very dissatisfied by the parking service seems mainly to not support (63%) the proposed parking policy.

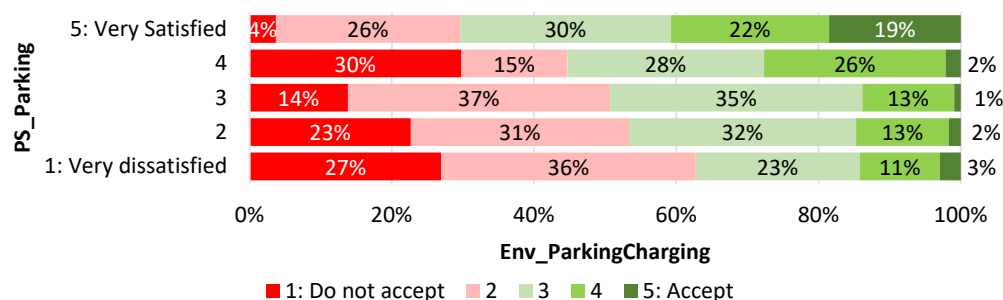


Figure 3. Environmental parking charging acceptability considering the satisfaction level of existing parking service.

Moreover, according to Figure 4, the 53% of respondents who claim to be very 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, it is pointed out that the majority of surveyed Athenian participants (57%) prefer the examined congestion charging policy instead of the existing management traffic system in the center of Athens, which is an odd/even system (Athens Ring).

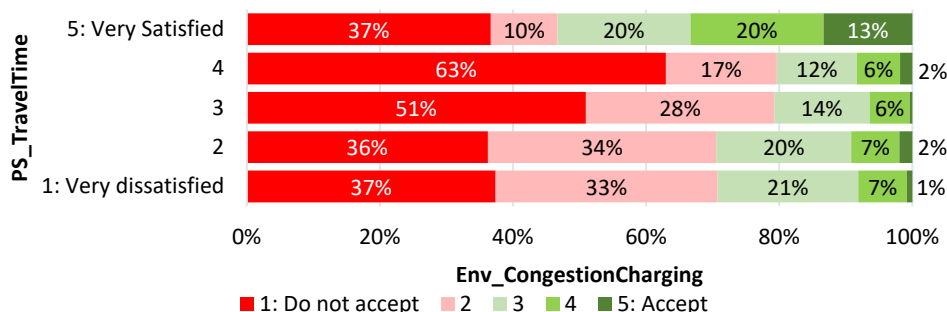


Figure 4. Environmental congestion charging acceptability considering the satisfaction level of travel time.

5. Structural Equation Modeling Background

The target of the Structural Equation Modelling (SEM) approach is to create causal models in order to interpret the dependencies of the acceptability of the two environmen-

tally linked transport charging policies in Greek urban areas. SEM belongs to the model family of latent variable analysis and comprises a widely used array of techniques used to capture effects of parameters that are unavailable or otherwise unable to be observed.

In transportation applications, latent constructs include characteristics such as attitudes in favor or against a policy or program, educational background, level of satisfaction with a program or service, and socioeconomic status, to name a few [48]. SEM techniques serve to illustrate the form of the structure of the examined data and reduce overall model error by incorporating measurement errors into the modeling framework; in addition, they handle endogeneity among variables well [48].

The underlying mathematical structure of SEMs can be defined as follows [48]:

$$\eta = \beta\eta + \gamma\zeta + \varepsilon \quad (1)$$

where η is a vector expressing the dependent variables; ζ is a vector expressing the independent variables; ε is a vector expressing the regression error term; β is a vector expressing the regression coefficients for the dependent variables; γ is a vector expressing the regression coefficients for the independent variables.

The exogenous factor covariance matrix is expressed as $\Phi = \text{COV}[\varepsilon, \varepsilon^T]$ and the error covariance matrix is expressed as $\Psi = \text{COV}[\varepsilon, \varepsilon^T]$. If the parameter vector θ is considered, which will create the model-based variance–covariance matrix, $\Sigma(\theta)$, the variance–covariance matrix for the model in Equation (1) is:

$$\Sigma(\theta) = G(1 - \beta)^{-1}\gamma\Phi\gamma^T(I - \beta)^{-1T}G^T \quad (2)$$

where G is a selection matrix containing either 0 or 1 to select the observed variables from all the dependent variables in η . Further details in the particulars of SEMs can be provided in relevant textbooks [49,50].

Finally, assessment of an SEM should take into account many criteria including theoretical appeal of the model specification, overall χ^2 goodness of fit between observed and implied variance–covariance matrices, individual variable coefficients and their standard errors and GOF indices [48]. One of the most common goodness-of-fit measures is standardized root average square residual (SRMR), which is an index of the average of standardized residuals between the observed and the hypothesized covariance matrices. Values of the SRMR range between zero and one, with well-fitting models having values < 0.08 [51].

A very useful tool for the interpretation of the results is path analysis. Specifically, the model structure and all modelled coefficients and interrelationships can be visualized in a path diagram. Regarding the interpretation of results, SEMs and their respective path diagrams can be typically considered as a multi-stage regression process. The way the paths are drawn determines whether the explanatory variables are correlated causes, mediated causes, or independent causes.

6. SEM Results and Discussion

Following the data collection and the scope of this paper, it was decided that a SEM statistical model would be appropriate for the statistical analysis of environmentally linked congestion and parking charging policies acceptability from Greek drivers. To develop SEM statistical models accurately, a meaningful and informative structure of latent variables was required. The proposed SEM model retained five latent unobserved variables, which were formulated considering the categorization of variables in Table 1 by grouping replies from relevant questions: (i) demographic characteristics, (ii) travel characteristics, (iii) travel personal satisfaction, (iv) car choice and (v) environmental perspectives. The statistical analysis was conducted in R-studio (R Core Team, 2013) and utilized the lavaan R package [52].

Table 1. Exported variables from the questionnaire survey.

Variable	Description	Scale
Demographics		
Region	The city in which the survey took place [1: Volos, 2: Thessaloniki, 3: Athens]	1–3
Gender	Gender [0: male, 1: female]	0–1
Age	Age [1: 18–30, 2: 31–55, 3: >55]	1–3
Annual_Income	Annual income [1: <10,000 €, 2: 10,001–25,000 €, 3: >25,000 €]	1–3
Education	Education level [1: Basic, 2: Intermediate, 3: Advanced (Bachelor), 4: Advanced (Master or Doctorate)]	1–4
Travel_Characteristics		
Mode_Work	Which travel mode do you use mainly for trips with the purpose of work or education? [1: Private Car, 2: Motorcycle, 3: Public Transport, 4: Taxi, 5: Bicycle, 6: Walking]	1–6
Mode_Leisure	Which travel mode do you use mainly for trips with the purpose of leisure? [1: Private Car, 2: Motorcycle, 3: Public Transport, 4: Taxi, 5: Bicycle, 6: Walking]	1–6
WeeklyTrips_Work	How many trips do you make per week with the purpose of work or education in the wider area of the city center? [1: 0–4, 2: 5–10, 3: >10]	1–3
WeeklyTrips_Leisure	How many trips do you make per week with the purpose of leisure in the wider area of the city center? [1: 0–4, 2: 5–10, 3: >10]	1–3
WeeklyCost	How much money do you spend weekly for commuting [1: <20 €, 2: 21–40 €, 3: 41–60 €, 4: >60 €]	1–4
Travel_Personal_Satisfaction—In terms of your typical daily commute, how satisfied are you with:		
PS_TravelTime	the travel time	1–5
PS_TravelCost	the travel cost	1–5
PS_Mode	the travel mode	1–5
PS_CarEmissions	the emissions from vehicles	1–5
PS_Parking	the parking	1–5
PS_PT_Access	the accessibility to Public Transport	1–5
PS_RoadSafety	the road safety	1–5
PS_AltChoices	the alternative choices of commuting	1–5
Car_Charcteristics—About the vehicle you use for commuting:		
EngineCapacity	What is the engine capacity (cc)? [1: <1000, 2: 1001–1200, 3: 1201–1400, 4: 1401–1600, 5: 1601–1800, 6: >1800]	1–6
FuelType	What is the fuel type? [1: Gasoline, 2: Diesel, 3: CNG, 4: LPG, 5: BEV, 6: Hybrid]	1–6
First_Registration	What is the year of first registration? [1: < 2000, 2: 2011–2005, 3: 2006–2010, 4: 2011–2015, 5: >2016]	1–5
Car_Choice—Which of the following do you consider important to choose a vehicle?		
CC_Cost	cost	1–5
CC_Type	vehicle type (e.g., sedan, SUV etc)	1–5
CC_Consumption	fuel consumption	1–5
CC_Fuel	type of fuel	1–5
CC_EngineCapac.	engine capacity (cc)	1–5
CC_HP	Horsepower	1–5
CC_Age	year of first registration	1–5
CC_Emissions	gr of pollutants/km	1–5

Table 1. Cont.

Variable	Description	Scale
EnvQ_Perspectives—To what extent do you . . .		
EnvQ_Critical_issue	think environmental protection is a critical issue?	1–5
EnvQ_Recycling	recycle or reuse materials?	1–5
EnvQ_Organizations	are you involved in environmental organizations (eg WWF, Arcturos)?	1–5
EnvQ_Personal_choices	feel you can protect the environment with your choices?	1–5
EnvQ_Make_others_aware	try to make others aware of the environment?	1–5
EnvQ_Polluter_pays	agree with the logic “the polluter pays” and therefore with the imposition of charges/ fines on those who pollute the most?	1–5
TrQ_Perspectives—To what extent . . .		
TrQ_Transport	do you think road transport is responsible for environmental pollution?	1–5
TrQ_Change_mode	would you change the mode that you use for your everyday commuting to protect the environment?	1–5
TrQ_Health_Eco	are you concerned about the effects of air pollution on health and the ecosystem?	1–5
TrQ_Fumes	do the vehicles engines exhaust fumes bother you?	1–5
TrQ_TrafficNoise	does the traffic noise bother you?	1–5
TrQ_Fleet_Renew	Do you think the Greek vehicle fleet needs to be renewed?	1–5
Env_Transportation_Charging_Policies—To what extent do you accept the implementation of the following environmentally linked transportation charging policies in Greek cities (lower prices for environmentally friendly vehicles)?		
Env_CongestionCharging	Environmental Congestion Charging	1–5
Env_ParkingCharging	Environmental Parking Charging	1–5
Env_HighwaysTolls	Environmental Tolls on Highways	1–5
Other		
DrivingExperience	How many years have you been driving? [1: <5, 2: 5–10, 3: >10]	1–3

Following SEM calibration, the produced model results are presented on the following table (Table 2). Statistically significant p -values (<0.05) are shown in bold. Overall, the model appears to fit the data well. All of the three examined goodness of fit measure values and the signs of the parameter estimated coefficients suggest good model fit.

The path diagram of the developed SEM model is presented in Figure 5 with green arrows denoting positive correlations, whereas red arrows denote negative correlations. It should be noted that covariances between latent variables are not depicted in the path diagram for readability reasons.

When looking closer at the results, many informative relationships are revealed by variable correlations. Respondents’ gender and education level are positively correlated with sociodemographic characteristics, whereas age is negatively correlated with that latent variable. Demographic characteristics of Greek drivers were, in turn, identified as positively contributing to the level of acceptability of the two examined environmentally linked urban charging policies. Specifically, females are more receptive to the implementation of environmentally linked congestion and parking charging schemes in Greek urban areas than males overall. An increase in age leads to reduction of the latent variable of demographic characteristics and thus lower acceptability, indicating that young drivers are more positive about new sustainable strategies that may change their everyday travel routine. Finally, the annual income of Greek drivers does not affect public acceptability of the examined policies significantly. These results are reasonable and in line with the past literature [38,39] and serve as a sanity check of SEM model results.

Table 2. SEM model for drivers acceptability of environmentally linked urban charging policies in Greek urban centers.

SEM Components		Parameters	Estimate	S.E.	z	p (> z)
Latent Variables	Demographics	Gender	1.000			
		Age	−1.829	0.285	−6.407	0.000
		Education	1.574	0.261	6.036	0.000
	Travel_Characteristics	WeeklyTrips_Work	1.000			
		WeeklyCost	4.886	1.047	4.666	0.000
		Mode_Work_Car	1.744	0.341	5.111	0.000
	Travel_Personal_Satisfaction	PS_Mode	1.000			
		PS_RoadSafety	1.142	0.164	6.945	0.000
		PS_Parking	1.156	0.167	6.912	0.000
	Car_Choice	CC_Consumption	1.000			
		CC_Fuel	1.302	0.132	9.841	0.000
		CC_Emissions	1.262	0.126	10.000	0.000
	Env_Perspectives	EnvQ_Critical_issue	1.000			
		EnvQ_Personal_choice	0.752	0.066	11.374	0.000
		EnvQ_Polluter_pays	0.941	0.078	12.055	0.000
		TrQ_Change_mode	1.310	0.091	14.400	0.000
		TrQ_Fumes	1.287	0.074	17.462	0.000
		TrQ_TrafficNoise	1.315	0.085	15.475	0.000
Regressions	Env_CongestionCharging	TrQ_Health_Ecosystem	1.197	0.071	16.867	0.000
		Demographics	0.671	0.301	2.227	0.026
		Travel_Characteristics	1.517	0.440	3.445	0.001
		Travel_Personal_Satisf.	−0.159	0.102	−1.561	0.119
	Env_ParkingCharging	Env_Perspectives	0.321	0.087	3.671	0.000
		CC_Emissions	0.214	0.036	5.894	0.000
		Demographics	1.439	0.371	3.879	0.000
		Travel_Characteristics	1.701	0.537	3.170	0.002
		Car_Choice	−0.425	0.218	−1.953	0.051
	Env_Perspectives	Env_Perspectives	0.718	0.156	4.600	0.000
		CC_Fuel	−0.136	0.047	−2.912	0.004
Covariances	Env_CongestionCharging	Env_ParkingCharging	0.479	0.040	12.094	0.000
		TrQ_TrafficNoise	0.109	0.023	4.801	0.000
	TrQ_Change_mode	Env_CongCharging	0.223	0.026	8.453	0.000
		CC_Fuel	−0.130	0.026	−5.065	0.000
	CC_Emissions	EnvQ_Personal_choice	0.231	0.031	7.398	0.000
		TrQ_Change_mode	0.231	0.031	7.398	0.000
	Demographics	Travel_Characteristics	−0.013	0.004	−3.668	0.000
		Travel_Personal_Satisf.	0.030	0.008	3.579	0.000
	Travel_Characteristics	Car_Choice	0.018	0.008	2.401	0.016
		Env_Perspectives	0.030	0.007	3.960	0.000
		Travel_Personal_Satisf.	−0.016	0.005	−3.181	0.001
		Car_Choice	0.003	0.004	0.779	0.436
	Travel_Personal_Satisfaction	Env_Perspectives	−0.015	0.005	−3.302	0.001
		Car_Choice	−0.069	0.016	−4.206	0.000
		Env_Perspectives	−0.003	0.013	−0.226	0.821
Goodness-of-fit measures	CFI		0.803			
	TLI		0.75			
	SRMR		0.067			

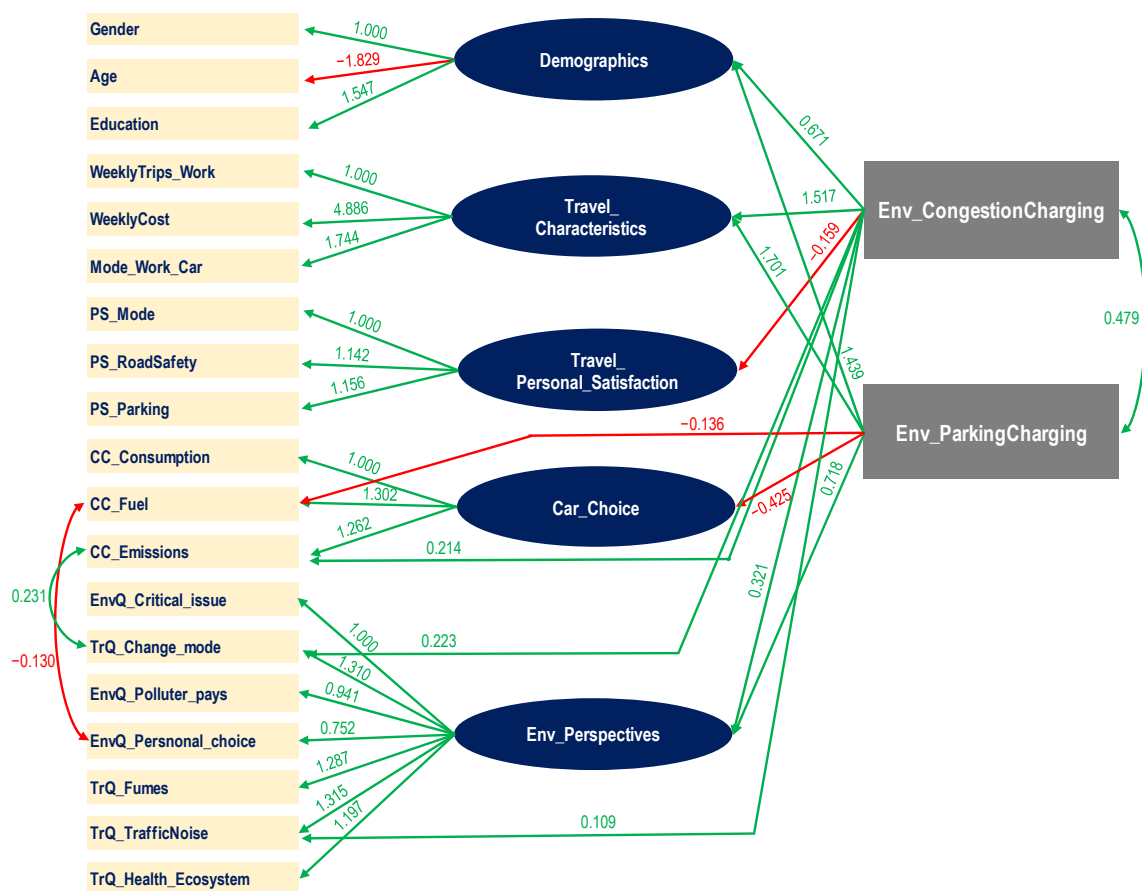


Figure 5. Path diagram of the SEM model for drivers' acceptability of environmentally linked urban charging policies in Greek urban centers.

The second latent variable expresses the travel profile of the respondents. All contributing independent variables are positively correlated with travel characteristics, which were identified as positively contributing to the two examined policies acceptability. In turn, a driver who use her/his car more times weekly for commuting with the purpose of work or education, and therefore spends more money per week for travelling, accepts to a greater extent the implementation of the examined charging policies. This can be explained by the fact that users that spent more time in their daily routine in their cars are more supportive of new charging policies in order to improve the mobility status in the city center.

Travel personal satisfaction is a latent construct based on a participant self-reporting about her/his level of satisfaction considering everyday commuting. All contributing independent variables denote the level of satisfaction considering the travel mode that is used for everyday trips, road safety and the parking service, whereas reasonable positive correlations are obtained with the environmental congestion charging policy. In turn, more dissatisfaction with daily typical commuting is positively correlated with higher public acceptability of the examined environmentally linked congestion charging policy. It is pointed out that the travel personal satisfaction does not affect public acceptability of the parking charging policy significantly.

Car choice is a latent construct based on the importance of the parameters that influence the respondent's choice of a vehicle. The emissions that the vehicle emits (gr of pollutant/km) presents a positive correlation with the environmental congestion charging policy, which is reasonable since it indicates an environmentally conscious respondent. It is noteworthy that all contributing independent variables of car choice are latent variables, and are positively correlated with the latent, which is identified as negatively contributing

to environmental parking charging policy acceptability. This is a key difference between the two examined policies highlighting that for each user, the approach for parking is not totally equal with the overall approach for traffic congestion.

Finally, environmental perspectives' latent variables express attitudes towards environmental issues related or not with the transportation sector. As stated in the literature review, environmental concern is one of the most influential attitudinal factors that positively affect transport charging policy acceptability [23,27,35,36]. As such, environmental perspectives' latent variables are reasonably formulated with positive correlations with the examined dependent variables. This result indicates that an environmentally conscious driver is more likely to accept environmentally linked charging policies under consideration.

7. Conclusions

The paper's objective is the investigation of Greek drivers' acceptability of congestion charging policies and parking charging policies with charging being adjusted according to the Euro class and technology of the vehicle in favor of less polluting cars. Specifically, the current research aims to present a thorough structure of relationships correlating environmentally linked congestion and parking charging policies' acceptability by Greek drivers with several parameters regarding drivers sociodemographic characteristics, travel profiles as well as environmental perspectives. A SEM model was developed using data from a questionnaire survey which provided a broad sample encompassing 733 respondent drivers from 3 main urban areas of Greece: Athens, Thessaloniki and Volos.

The contribution of this research is the examination of a multitude of characteristics and attitudes and their correlation with public acceptability of the implementation of the two examined environmentally linked transport charging policies in Greek urban areas. Several statistical relationships were detected and quantified correlating the acceptability of the two examined policies with five latent unobserved variables: (i) demographic characteristics, (ii) travel characteristics, (iii) travel personal satisfaction, (iv) car choice and (v) environmental perspectives.

Based on the above key findings and the overall research results, the following practical recommendations can be extracted, which are crucial both for stakeholders as well as for policy makers. The public acceptability of environmental congestion charging policy and the public acceptability of environmental parking charging policy were found to be positively correlated with each other, meaning that a driver who supports the one environmentally linked charging policy is more likely to support the other one as well. Additionally, environmental sensitivity is one of the most influential factors that positively affect the acceptability of the two examined transport charging policies.

It must be noted that a travel profile presenting a more intensive commuting is positively correlated with higher acceptability levels, probably because it is believed that traffic congestion levels and parking management will be improved with the implementation of such policies by decreasing travel time, which includes the time searching for parking. Analysis has also shown that younger people, high-educated respondents and females are more likely to accept the environmental charging policies under consideration.

It is clear that cities will be planning and implementing sustainable urban mobility strategies and policies in the future in order to transform their congested centers; however, this transition does not have a successful manual. Travel and traffic charging measures have been taken into account as key strategies for managing travel demand, traffic congestion and air pollution from road transportation. Each city should adopt policies that fit to the socio-economic characteristics of the country and more specifically of the city. Both public and political acceptability are considered essential to guarantee the success of transport charging policies. If not, the respective policies will not be accepted by users and will lead to opposite results for policy makers.

Based on the above, a key contribution of the present analysis refers to stakeholders and especially policy makers that aim at successful and acceptable sustainable policies by understanding the factors that affect public acceptability of environmentally linked trans-

portation charging policies, especially in Greek urban areas. More specifically, based on the present analysis, special focus should be given on dissemination actions and incentives targeted to specific user profiles that are not positive on accepting these charging policies. These profiles are based both on demographic characteristics as stated above but also on travel and environmental ones.

It must be noted that the present research is not without limitations. The questionnaire yields self-reported data on characteristics and attitudes on various travel and environmental aspects. Self-reported data from questionnaire replies have known deficiencies in terms of accuracy and lack of direct observation capabilities [53] and response bias [54]. Nonetheless, in the context of this study, the two main questions about environmentally linked transport charging policies acceptability provide a clear acceptability criterion and the answers are drawn from a recent time period. Furthermore, the inclusion of additional Greek cities with different characteristics in the same statistical model could be considered one more limitation of this research. In this study, the cities under consideration were grouped together without investigating any differences and variations between them through the aggregate level SEM of the present study.

These limitations can provide an impetus for future research efforts. Specifically, 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 public acceptability. Moreover, apart from the examined transport charging policies, several other policies should be deeply investigated in order to provide to policymakers the most appropriate policies for the city.

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