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Transportation Research Procedia 00 (2022) 000–000

Transportation Research Procedia

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Transport Research Arena (TRA) Conference

A socioeconomic analysis for a green traffic restrictions scheme in Athens

Virginia Petraki[a]*, Panagiotis Papantoniou[b], George Yannis[a]

[a] Department of Transportation Planning and Engineering, National Technical University of Athens, Athens, Greece.

[b] Department of Surveying and Geoinformatics Engineering, University of West Attica, Athens, Greece

Abstract

The objective of this paper is the appraise of the socioeconomic impacts within 15 years of a proposed annual charging policy called Green Car Access Card (GCAC) for the daily access of a passenger car in the city center of Athens, Greece with the charging being adjusted according to the Euro class. A questionnaire survey was conducted, using stated preference while a binary logistic model was developed to determine the acceptance of GCAC. A socioeconomic analysis is developed to quantify the impact on traffic, road safety, air pollution and climate change until 2035 due to the implementation of the policy. Specifically, for the business-as-usual "BAU" Scenario and the "GCAC" Scenario the casualties on road accidents, the travel time, the fuel consumption and the emissions from motorized transport are estimated and expressed in monetary units. Results indicate a high IRR index (22%) and a positive NPV which prove that the proposed investment provides a significant benefit to society and commuters.

Peer-review under responsibility of the scientific committee of the Transport Research Arena (TRA) Conference
Keywords: socioeconomic analysis; stated preference; congestion charging; passenger cars

1. Introduction

While one of the greatest environmental and social challenges world faces today, lies in the mobility of people and goods, urban traffic problems are a key challenge in modern cities in terms of congestion, road safety, and environment. 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 (Eurostat, 2016), the quality of the environment in urban areas is of vital importance. As a consequence, people need a seemingly infinite network of vehicles and transportation systems to uphold societies and economies.

* *E-mail address:* vpetraki@mail.ntua.gr

2352-1465
Peer-review under responsibility of the scientific committee of the Transport Research Arena (TRA) Conference

The need for sustainable transport is increasingly recognized and receives more and more attention. Cities face the challenge to enhance the quality of urban environment reducing traffic congestion, environmental pollution and road accidents. Moreover, transport charging policies for the control access of vehicles in urban centres consist a key tool for sustainable mobility and internalisation of external transport costs while they increasingly applied in urban centres. Within this framework, several cities apply vehicles access regulations into urban areas such as Congestion Charging Zones, Low Emission Zones or a combination of both (Ye, 2012; Holman et al., 2015). To date, those systems have been implemented in several cities internationally like Singapore, London, Stockholm, Milan, Gothenburg, Paris and Barcelona. The aim of congestion charging and low emission zones is the pricing and the traffic restriction of vehicles for the burden they cause on traffic and consequently on the environment and public health.

In that context, the objective of this paper is the estimation and quantification of the socioeconomic impact of a proposed environmental transport charging policy for private car's access in the city center of Athens, the capital of Greece. The proposed annual charging policy called Green Car Access Card (GCAC) is investigated for the daily access of a passenger car in the center of Athens with the charging being adjusted according to the Euro class of the vehicle. To achieve this objective, a socioeconomic analysis is carried out with a time horizon of 15 years. The examined policy is based in the principle "the polluter pays".

2. Literature Review

2.1. Congestion Charging Impacts

Urban traffic access regulations are implemented by cities to improve the traffic conditions and in general the urban environment and quality of life of citizens and tourists. In most cases these policies proved to be effective in reducing environmental pollution, the level of traffic congestion and, consequently travel times, improving road safety, etc.

Several impact assessments shows that the vehicle entry in a congestion charging zone was significantly reduced. Regarding the central London charging zone, annualised results for 2007 compared with pre charging conditions in 2002 reveal reductions of 16% in total vehicles, 21% in vehicles with four or more wheels and 29% in potentially-chargeable vehicles (TfL, 2008). In Stockholm the number of vehicles entries decreased by 23.8% in the period of the pilot operation of the charging scheme, January-May 2006 (Rotaris et al., 2009). In Singapore, the entry due to the ALS system by 44% (Menon et al., 1993) and due to ERP by 10-15% per day compared to ALS (Chin, 2009). In Milan the introduction of Ecopass led to a decrease of 14.2% (AMMA, 2008) while the Area C system implementation reduced vehicle entry by 56% in comparison with Ecopass.

2.2 Socioeconomic Analysis

According to European Investment Bank, 2013 and as set out in Article 101 of Regulation (EU) No 1303/2013, an economic or socioeconomic analysis must be carried out to appraise the project's contribution to welfare of society at large. As such the analysis is made on behalf of the whole society and not just the project promoter (EIB, 2013). The key concept is the use of shadow prices to reflect the social opportunity cost of goods and services, instead of prices observed in the market, which may be distorted (Sartori et al., 2020).

The method generally used to convert the market prices to shadow prices is to apply a set of conversion factors (CFs) to the project financial costs. In principle, CFs should be made available at the national level by a planning office and not calculated on a project-by project basis. In practice, however, distortions in investment projects in Europe are not so substantial; therefore, for most elements, it can be assumed that their shadow pricing corresponds to market prices (European Commission, 2021).

After market prices adjustment and non-market impacts estimation, costs and benefits occurring at different times must be discounted. The discount rate in the economic analysis of investment projects, the Social Discount Rate (SDR), reflects the social view on how future benefits and costs should be valued against present ones (Sartori et al., 2020). The SDR would currently range from a maximum of 8.13 % for Estonia to 0.80 % for Italy (calculated following the SRTP method), with an EU average of 3.6 % and a median value of 2.8 % (European Commission, 2021).

3. Data

3.1. The Survey

Data were collected through a properly designed questionnaire that was completed in the form of interviews in areas of the northern, southern, central and western suburbs of Athens, aiming at collecting information on the level of understanding and accepting congestion charging policies for private cars access in Athens.A quality and validity check was performed leading to a total of 370 questionnaires. The sample size was considered sufficient for the purposes of the study. The questionnaire survey included 4 parts and the filling time was on average 10 minutes.

The first part focused on the drivers' travel profile and the characteristics of their cars. Respondent's travel profile included information on the main transport mode for everyday commuting, the number of weekly trips, the travel cost, etc. Concerning the car's characteristics, there were questions about the cubic capacity, the year of 1st registration and fuel type are included. The second section investigated respondents' environmental awareness and sensitivity as well as respondent's level of acceptance of environmental transport charging policies. In particular, it includes a series of questions related to perceptions of key environmental issues. Also, respondents were asked to state their opinion considering environmental pricing measures.

The third part examined a hypothetical scenario of replacing the current car access mobility restrictions (Small Ring) in the center of Athens with an environmental congestion charging system for private cars. It targeted at identifying the public acceptance of the examined congestion charging policy, with the charging being adjusted according to the Euro class of the private car. Specifically, depending on the age of the 1st registration (Euro class), three possible GCAC annual costs (low, medium, high) have been set. The driver is asked to answer if she/he is willing to pay the three possible GCAC fees to reduce by 5, 10 or 15 minutes her/his daily typical trip.

Finally, the fourth part collected information on demographics characteristics of respondents. As expected, 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 largest age group (>55) constitutes the smallest percentage (16%) of the sample.

Table 1. GCAC annual costs in the context of the stated preference analysis

Vehicle age (years) (1st Registration)	**Low Cost (€)**	**Medium Cost (€)**	**High Cost (€)**
1-5	40	80	160
6-10	60	120	240
11-15	100	200	400
16-20	120	240	480
<20	140	280	560

3.2. GCAC Public Acceptance

Based on the third part of the survey a mixed binary logistic regression model was developed to capture how parameters of the GCAC annual cost, travel time saving, date of private car's 1st registration, affect the public acceptance of the GCAC policy for private cars access in the center of Athens.

In the case of repeated observations, such as the case of stated preference surveys with multiple responses, one often needs to capture the correlation across observations from the same individual. Mixed effects logistic regression is used to model binary outcome variables, in which the log odds of the outcomes are modeled as a linear combination of the predictor variables when data are clustered or there are both fixed and random effects.

Based on the above, the mixed binary logistic regression specification is shown in the following table. All variables are considered statistically significant at the typical 95 % level, and they are reported when they are within to up to the 90 % level. In the analysis under consideration, the dependent variable was considered to be discrete taking into account the fact that it corresponded to values 0 (I do not accept the GCAC) and 1 (I accept the GCAC).

Table 2. Mixed binary logistic regression specification

	Parameter	Coefficient	Std. Error	t-test	Sig.
	Intercept	10.337	1.042	9,924	0
	GCAC annual cost	-0.032	0.005	-6.235	0
	Travel Time	-0.408	0.026	-15.774	0
Car's 1st Registration	**>= 2016**	-1.906	0.824	-2.313	0.021
	2011 – 2015	-2.041	0.781	-2.613	0.009
	2006 – 2010	-1.300	0.849	-1.532*	0.126*
	2001 – 2005	-1.756	0.869	-2.021	0.043
	=< 2000	0	-	-	-

The "Travel time" variable represents the time in minutes of a typical everyday trip in case of the implementation of the GCAC policy and corresponds to three values (25 min., 20 min., 15 min.) considering that a typical trip in Athens without the implementation of the GCAC is considered to be 30 minutes. The "GCAC annual cost" variable represents the cost of the GCAC per year for a passenger car for its access in the center of Athens and corresponds to the prices values that presented in the Table 1 depending on the year of 1st registration of the respondent's car.

Both variables have been determined negatively correlated with public acceptance of the GCAC, meaning that an increase in cost or travel time lowers the public acceptance of the environmental transport charging policy under consideration for private car's access in the center of Athens. Finally, the variable "Private car's 1st registration" represents the year of the first registration of the respondent's private car and corresponds to five age groups. The age group "<2000" corresponds to the oldest passenger cars under consideration (Euros Class I, II) and the reference group. To determine the public acceptance of the GCAC policy, , it is necessary to estimate the utility functions for each age group of passenger cars. Based on Table 1, the estimated utility functions are presented in the following table.

Table 3. Utility functions

$U_{>2016}$ =	8.43		
$U_{2011-2015}$=	8.30		
$U_{2006-2010}$=	9.04	-0.408* Travel_Time	-0.032* GCAC_AnnualCost
$U_{2001-2005}$=	8.58		
$U_{<2000}$ =	10.34		

Consequently through the equation $Pi = \frac{e^{Ui}}{1+e^{Ui}}$, the public acceptance (%) of the examined transport environmental policy is calculated, giving the "GCAC_AnnualCost" variable for each age group the low annual costs presented in the TableX and assuming that the time of a typical daily trip in the center of Athens is reduced to 10 minutes due to the implementation of the GCAC policy.

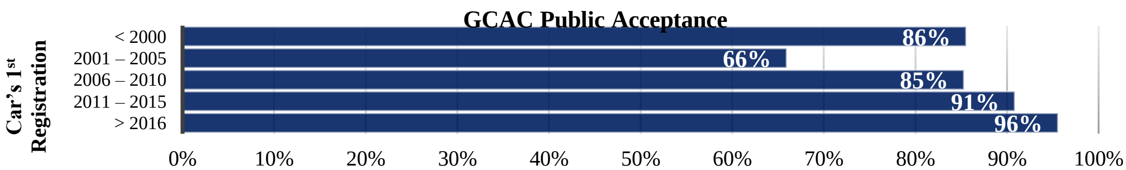

Fig. 1. GCAC public acceptance.

3.3. Traffic Data in Athens

The average speed in the center of Athens was calculated for the year 2020 through a traffic simulation model developed by the Traffic Engineering Laboratory of National Technical University of Athens. The investigated network created in Aimsun Next mobility software is the city center of Athens. Therefore, through the model it emerged that in the "Do nothing" Scenario the average speed on the small Ring of central Athens in 2020 is 15.3 km/h. Considering the GCAC policy acceptance from the questionnaire as a simulation input, it emerged that in the "GCAC" Scenario the average speed on the small Ring of central Athens in 2020 will be 21 km/h.

For the estimation of the average speed in the next 15 years, it is assumed that in the "Do nothing" Scenario it remains equal to 15.3 km/h. Also, in the "GCAC" Scenario the first year of the policy's implementation the average speed is 21 km/h, the second year decreases to 16.5 km/h and after the second year, 15 km/h. It is assumed that the traffic return to the conditions before the policy's implementation.

To estimate the distribution of the passenger car fleet in the Region of Attica in 2019 by the 1st registration, the new registrations of passenger cars per year were collected for the years 1985 to 2019 from the ELSTAT and grouped into the following five age categories. The withdrawal of passenger cars was then calculated as the difference between all passenger cars in Attica in 2019 and all new registrations of new and used passenger cars from 1985 to 2019. In particular, it was considered that the withdrawn passenger cars with 1st registration > 2016, 2011 – 2015, 2006 – 2010, 2001 – 2005 and < 2000 were 5%, 15%, 20%, 20% and 40% of the total withdrawal, respectively. Therefore, the distribution of the passenger car fleet in Attica in the year 2019 to the five age groups was calculated as shown in the following table.

In the "GCAC" Scenario, the total annual growth of the Athens passenger car fleet was considered to be 1% according to the estimate for the increase of the vehicle fleet in Greece the following 10 years as mentioned in the National Energy and Climate Plan. Subsequently, for the change of the passenger car fleet per year, an overall annual withdrawal of 2.3% was considered, with 1.5% being removed from the oldest age group (< 2000) and 0.8% from the 2001 – 2005 age group. At the same time, 80% of the withdrawal was allocated to the newest technology cars under consideration while 20% were allocated to the next category of new technology passenger cars (2011 – 2015).

Similarly, in the "Do nothing" Scenario, a lower rate of annual withdrawal of 1.5% was taken into account, with 1% being removed annually from the oldest age group (< 2000) and 0.5% from the 2001 – 2005 age group. Then 60% of the withdrawal was allocated to the newest technology passenger cars under consideration while 40% to the next newest ones. Thus, in the "Do nothing" Scenario there was an annual decrease in average age of the fleet by 0.4 years while in the "GCAC" Scenario there was a greater annual decrease by 0.6 years on average.

4. The Socioeconomic Analysis

In this section, a socioeconomic analysis is performed for the implementation of the proposed annual charging policy called Green Car Access Card (GCAC) in the city center of Athens, for a time horizon of 15 years (2020-2035). The analysis is performed following European Commission guidelines for Cost Benefit Analysis (CBA) of investment projects (Sartori et al., 2020) and the Economic Appraisal of Investment Projects at the EIB (EIB, 2013). For "GCAC" Scenario, the investment and operational costs as well as the following direct socio-economic benefits are considered and measured.

4.1 Travel Time

Travel time impact refer to the monetized time gains or losses because of the implementation of GCAC in the center of Athens. Vehicle hours travelled in the center of Athens are calculated from data on average traffic speed and vehicle kilometres travelled. Person hours travelled are calculated considering vehicle hours travelled and a private vehicle occupancy equal to 1.2 (IBI & NAMA, 2009). Regarding Greece, the value of travel time (VOT) for passengers commuting with private car for the purpose of work is 9 €/ hour while for other purpose is 4.1 €/ hour (Schroten et al., 2019). Taking into account that the distribution of distance travelled for work, education and for other purpose in Greece is 58% and 42%, respectively (Eurostat, 2021), it is estimated that the weighted average of the VOT for passengers is 6.74 €/ hour.

4.2 Fuel Consumption

Fuel consumption is expressed as the fuel in liters required for a vehicle to travel a distance unit (liters/100 km). The annual fuel cost consumed by the vehicles in each scenario is estimated considering the average fuel consumption of a passenger car by car's age group, the shadow price of gasoline cost, as well as the vehicle kilometres travelled in the center of Athens in each Scenario.

For the calculation of fuel consumption by the Greek passenger car fleet, the following figure was taken into account which shows the average fuel consumption (gasoline equivalence) per new passenger car and per year (Yang and Bandivadekar, 2017). In order to calculate the annual cost of fuel consumption in Athens by private cars, in each scenario, it is necessary to collect the gasoline prices in Athens the first year of the implementation. Since fuel prices are influenced by various technical, political and economic factors, the price escalation over time is difficult to assess.

However, according to Sartori et al. (2020), by taking into account the evolution of the efficiency on the vehicles' consumption, no price escalation is suggested. For the purposes of the analysis, an average price of 95 octane gasoline of 1.6 €/l (plus VAT) is taken into account, considering the year 2020. The final retail price (shadow price) of gasoline is derived by imposing the fuel taxes (oil refinery cost, State's petroleum fee, Regulatory Authority for Energy fee, VAT etc.) (ACEA, 2021) and is estimated equal to 0.8 €/l.

4.3 Road Safety

For the road safety assessment considering the implementation of GCAC in the center of Athens, the number of road fatalities and injuries in the "Do nothing" Scenario and in the "GCAC" Scenario as well as the social cost per fatality and injury are taken into account. For the road safety estimation in the next 15 years taking into account the implementation of the GCAC policy, the technological renewal of passenger cars as well as the change of the average speed in the center of Athens are considered. Based on several studies, reducing traffic speed as well as the new technology of the vehicle are two parameters that affect positively road safety (Elvik et al.2019, NHTSA, 2013; SICIŃSKA, 2019; HØYE, 2019).

Also, the number of fatalities, seriously and slightly injured in a road accident involving a passenger car, in the Region of Attica in 2019 were collected through the Hellenic Statistical Authority (ELSTAT, 2019). Specifically, the casualties are classified according to the severity and the year of the 1st registration of the involved passenger car in the specified age groups under consideration.

To estimate the fatalities and injuries taking into account the change of the average speed during the first 2 years, the Nilsson's equation that relate changes in the number of injury accidents to changes in the mean speed of traffic is taken into account. Considering that in the "Do nothing" Scenario, the average speed of passenger cars in the center of Athens remains stable for the next 15 years, the road safety estimation is based mainly on the renewal of the passenger car fleet. Finally the social cost per fatality, serious injury, light injury is estimated for Greece equal to 2,148,034 €; 273,574 €; 51,373 € respectively (ITF, 2020).

4.4 Environment

Transport investments can considerably affect air quality and climate change either by reducing or increasing the level of air pollutant and GHG emissions. With respect to transport, the main GHG emissions are carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) while the main air pollutants are particles, acidifying pollutants (NOx, SO_2) and ammonia (NH_3) (Sartori et al., 2020). The air pollutant and GHG emissions investigated in this study are NOx, NH3, PM2.5 and N_2O, CO_2, respectively. To estimate the total volume of emissions additional generated or avoided from the GCAC implementation in Athens, the following parameters are taken into account: annual veh-km, emission factors expressed in gr/ km and unit costs per pollutant expressed in €/ ton.

The exhaust emission factors expressed in gr/km. The NOx (given as NO_2 equivalent), NH_3, $PM_{2.5}$ and N_2O factors forecast for the next decade takes into account that the vehicles technology is renewed every five years through the introduction of new European emission Standards (Euro Class). The CO_2 factors forecast takes into account the fleet-wide targets for 2025 and 2030 for the CO_2 performance of new passenger cars in Europe, namely a 15% reduction from 2021 emission levels by 2025 and a 37.5% reduction by 2030 (EU Regulation, 2019).

Regarding the cost of CO_2 per ton according to the European Commission, the year 2020 amounts to 40 € / ton CO_2, while the year 2035 is estimated to increase by € 15 (European Commission, 2016). The unit costs for pollutants NOx, N_2O, NH_3,and $PM_{2.5}$ are taken into account equal to 5,100 €; 21,400 €; 4,800 €; 86,000 € as reported for urban centers in Greece (Schroten et al., 2019). Considering that no projection was found for the unit costs of these pollutants and since according to Sartori et al. (2020), by taking into account the evolution of the efficiency on the vehicles' consumption, no price escalation is suggested, no escalation of the unit costs is taken into account.

4.5 Investment and Operational costs

Regarding the investment and operational costs for the implementation of the proposed environmental transport charging policy (GCAC) for private car's access in the city center of Athens, the following assumptions were made:

- Cost of 50 GCAC road signs with a unit cost of 1,000 euros including purchase, installation and maintenance costs.
- 0.2 euros for printing an annual card for the daily access of a passenger car in the city for 1,000,000 cars.
- 5 employees for the collection, management of violations, etc., with an employee salary of 2,000 euros per month.
- 5 traffic policeman, with a salary of 1,500 euros per month.
- Conversion factor for shadow wage for Athens equal to 0.8 (Sartori et al., 2020).
- Digital control costs including the cost of developing the camera management system (300,000 euros), the cost of providing the 60-camera system (3,000€/ camera) and the cost of hosting and technical support of cameras (10,000€/ month).

Table 7. Investment and operational costs

	Per year
Road signs	€ 50,000
Information and advertising campaigns	€ 20,000
GCAC Stickers	€ 200,000
Operating staff	€ 96,000
Traffic police	€ 72,000
Digital control	€ 630,000

4.6 Summary

Then a socioeconomic analysis is conducted to quantify the impact on traffic, road safety, air pollution and climate change until 2035 due to the implementation of the proposed environmental transport charging policy for a private car's access in Athens. Taking into account the investment and operational costs and the socioeconomic benefits, the Internal Rate of Return (IRR) as well as the Net Present Value (NPV) are estimated to evaluate the economic feasibility of the proposed policy, as presented in the following table.

Table 8. The socioeconomic analysis

Costs & Benefits		NPV (3%)	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035
				Operation											
C1 Investment Cost	mil.€	**-0.51**	**-0.53**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
C1.1 Road Signs	mil.€	-0.05	-0.05	0	0	0	0	0	0	0	0	0	0	0	0
C1.2 Cameras Cost	mil.€	-0.17	-0.18	0	0	0	0	0	0	0	0	0	0	0	0
C2.5.1 System Development	mil.€	-0.29	-0.30	0	0	0	0	0	0	0	0	0	0	0	0
C2 Operational Costs	mil.€	**-6.25**	**-0.02**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**
C2.1 Media, advertising	mil.€	-0.25	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
C2.2 Stickers	mil.€	-2.32	0.00	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20
C2.3 Staff	mil.€	-1.11	0.00	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10
C2.4 Traffic policemen	mil.€	-0.83	0.00	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07
C2.5 Digital Control System	mil.€	-1.39	0.00	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12
C2.6 Cameras maintenance	mil.€	-0.35	0.00	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
Total Costs	mil.€	**-6.77**	**-0.55**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**	**-0.54**
B1 Driver Surplus	mil.€	**69.13**	**0.00**	**78.82**	**30.96**	**-3.56**	**-3.54**	**-3.51**	**-3.48**	**-3.45**	**-3.42**	**-3.39**	**-3.35**	**-3.52**	**-3.16**
B1.1 Travel Time	mil.€	60.58	0.00	77.15	29.96	-3.88	-3.90	-3.92	-3.94	-3.96	-3.98	-4.00	-4.02	-4.04	-4.14
B1.2 Fuel Consumption	mil.€	8.66	0.00	1.67	1.00	0.32	0.36	0.40	0.46	0.50	0.55	0.61	0.66	0.52	0.98
Externalities	mil.€	**24.88**	**0.00**	**-118.96**	**-18.92**	**9.31**	**10.53**	**11.71**	**12.89**	**14.08**	**15.26**	**16.43**	**17.59**	**18.65**	**24.22**
B2 Road Safety	mil.€	20.15	0.00	-119.72	-19.46	9.04	10.24	11.42	12.59	13.75	14.90	16.04	17.17	18.28	23.70
B3 Environment	mil.€	4.74	0.00	0.76	0.55	0.26	0.29	0.29	0.30	0.33	0.36	0.39	0.42	0.37	0.52
Total Benefits	mil.€	**94.02**	**0.00**	**-40.13**	**12.04**	**5.74**	**6.99**	**8.19**	**9.41**	**10.63**	**11.84**	**13.04**	**14.24**	**15.13**	**21.05**
ENVP	mil.€	**87.25**	**-0.55**	**-40.67**	**11.50**	**5.21**	**6.46**	**7.66**	**8.87**	**10.09**	**11.30**	**12.51**	**13.70**	**14.59**	**20.52**
ERR		**22%**													

Table 9. Sensitivity Analysis

Social Discount Rate	1%	2%	3%	4%	5%	6%
Net Present Value	**114.4**	**99.9**	**87.3**	**76.1**	**66.4**	**57.8**

It is important to note that from the year 2022 onwards there is a cost in terms of travel time within the center of Athens as it is considered that the total vehicle kilometers after the third operation year are balanced while the average speed decreases from 15.3 km/ h to 15 km/ h . However, there is significant time savings in the first two years of operation, due to the significantly fewer vehicle kilometers traveled in case of the proposed policy implementation. Regarding road safety, it is observed that the first two operation year there will be a loss, possibly due to the increased average speed that prevails in the years 2020 and 2021 compared to the current situation. From the year 2022 onwards, there is a road safety benefit, due to the lower average speed and the technology fleet renewal.

5. Discussion

It is concluded that in case of the introduction and implementation of Green Car Access Card (GCAC) in the city center of Athens by the year 2035, there is a significant reduction in injuries and fatalities related with road accidents and a significant environmental benefit. The positive NPV (87.25 mil.€) as well as the high IRR (22%) presented in all the Scenario under consideration, indicates the socio-economic feasibility of the pubic investment over time. Specifically, in case the examined police is implemented in the center of Athens, it is estimated that the casualties will be reduced by 337, the transport pollutants will be reduced with CO_2 being reduced by 81,764 tons. Finally, Even in extreme price changes over a 15-years period, the NPV remains positive, ensuring the feasibility of the investment.

At a time when air pollution and traffic congestion are two of the major problems of modern cities and environmental pricing policies are emerging in more and more cities internationally, it is imperative that cities take action aiming at improving the standard of living of residents and visitors. It is clear that cities will be planning and implementing sustainable urban mobility strategies and policies for the next decades in order to transform their congested centers however this transition has not a successful manual. Each city should adopt policies that fit to the socio-economic characteristics of the country and more specifically of the city.

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