Drivers' stated preferences towards road pricing: the case of Athens

Christina Milioti
Department of Transportation Planning and Engineering
National Technical University of Athens
5 Iroon Polytechniou Street, 15773, Zografou, Athens
GREECE

Ioanna Spyropoulou
Department of Transportation Planning and Engineering
National Technical University of Athens
5 Iroon Polytechniou Street, 15773, Zografou, Athens
GREECE

Matthew Karlaftis
Department of Transportation Planning and Engineering
National Technical University of Athens
5 Iroon Polytechniou Street, 15773, Zografou, Athens
GREECE

Abstract: - Traffic congestion is a phenomenon which threatens the sustainable development of urban areas, and measures to tackle the problem are being sought. A quite effective way targeting traffic congestion is road pricing. The principle of road pricing is to charge for the "burden" that road users produce mainly on traffic and subsequently on environmental conditions. Within this study a road pricing scheme has been designed for the city of Athens, to investigate driver attitudes towards the scheme, through a questionnaire survey which was conducted to travellers in the city of Athens. Participants of the survey were asked to answer several questions to elicit their preferences in respect to road pricing, their acceptability and their willingness-to-pay for the implementation of such a scheme. Results indicate that the majority of travellers is aware of the advantages of a road pricing scheme and is not against (about 10% in favor and about 53% conditionally agree) the design of such a measure to reduce urban congestion and that there are specific parameters that influence scheme acceptability.

Key-Words: Congestion,Congestion charging, Acceptability, Stated preference

1 Introduction

Congestion is a common phenomenon in urban centres which threatens the sustainability of the cities and a key political issue in many European countries [1]. Congestion is a consequence of the increase in the demand for travel and of the increase in car ownership, and effective measures for managing the demand and urban congestions are sought.

The impacts of congestion are not restricted to traffic conditions (increased travel time, queue lengths, delays) but also include traffic accidents, traffic noise, environmental pollution (air pollutants), parking problems, impact on health etc [2]. Hence, the European Commission has issued the Green Bible to raise awareness and organise specific policy and actions towards a new culture for urban mobility mainly targeting at reducing urban congestion, improving environmental conditions, increasing public transport patronage, walking and cycling [3].

Road pricing has emerged as an effective measure for tackling urban congestion (and the consequent

environmental pollution) and has been implemented in several cities including London, Rome, Milan, Stockholm, Bergen, Oslo and Trodheim [4]. The effectiveness of a road pricing scheme depends largely on public acceptability which denotes an evaluation of the expected impacts of the scheme by the users (residents, car drivers, public transport passengers, businesses etc.) [5].

The purpose of this study is to investigate drivers' preferences towards congestion pricing under a hypothetical such scheme for the city of Athens.

2 Methodology

2.1 The questionnaire

The main tool of this study was a stated preference questionnaire, which was organised in four sections. The first section involved information related to elements of respondents travel behaviour in respect to their trip characteristics. In particular, the frequency, purpose and duration of the most commonly followed route to the center of Athens were obtained. In addition, respondents also provided information on their origin and destination locations. The necessity of obtaining such information is based on the assumption that traveller acceptability and willingness-to-pay for a congestion charging scheme is dependent on trip characteristics.

The objective of the second section of the questionnaire was twofold. First, as respondents had not experienced the operation of a congestion charging scheme before, this section aimed at increasing their awareness on such as scheme and on its potential impact both positive and negative. Second, as driver perceptions on traffic congestion and road pricing may also affect their acceptability and willingness-to-pay the aim of this section was to induce such dependencies. Hence, this section contained questions related to the impact that congestion has on respondents' activities, possible measures to improve traffic conditions, advantages and disadvantages of a congestion pricing scheme, potential use of the scheme revenues. The last question of this section asked whether respondents would be in favor of or against to the implementation of a congestion pricing scheme.

The stated preference experiment comprised the third part of the questionnaire, and its objective was to generate data for a discrete choice analysis to investigate drivers' willingness-to-pay. In this section, respondents were presented with two different routes defined by three different variables/characteristics – namely, toll price, travel time reduction and travel time deviation as illustrated in Figure1. Nine different such scenarios were presented and respondents asked to note the route they would choose in each scenario considering a typical trip to the centre of Athens by car on a weekday between 7.00am and 9.00pm of 45 minute duration.

*** Please Insert Figure 1 here***

Finally, within the fourth section of the questionnaire data on the demographic and socio-economic characteristics of the drivers including gender, age, household income, occupation and level of education was obtained.

2.2 The stated preference experiment

The first property of a stated preference experiment to be determined involves the variables to be considered that describe the presented choices, and in the examined case the route characteristics. The variables should be chosen under the assumption that they affect driver choice. Next the number and value of the variable attribute levels needs to be defined. The attribute levels need to be realistic and cover a substantial part of the whole spectrum of possible values. Increasing the number of variables and attribute levels results to a more detailed experiment but at the same time to a complex and time consuming experiment. In the presented study, it was decided to employ three variables each of which was described by three attribute levels.

A pilot survey was conducted to identify the most crucial parameters that determined driver willingness-to-pay. The two primary variables to determine drivers' preferences, which were an obvious choice, were toll price and travel time reduction. Two other variables that were considered were use of revenues the three different attribute levels of which being public transport improvement, social causes and tax reduction, and travel time deviation. The analysis of the pilot questionnaire data indicated that the use of revenues for public transport improvement was the obvious choice for most respondents and therefore this variable did not provide any additional effect on drivers' preferences and was excluded from the discrete choice experiment. The three variables finally selected for the experiment were: toll price, travel time reduction and travel time deviation. Each of these variables had three different attribute levels which are illustrated in Table1.

*** Please Insert Table 1 here***

Hence, there are 3^3 =27 combinations of all possible values and 351 possible pairs of these combinations that result for use in a binary choice

experiment Therefore the following fractional factorial design experiment was derived. The 27 combinations were partitioned in three blocks A, B, C, each of which consisted of nine profiles. A constraint was applied for the allocation of the different profiles into the three blocks, which was to ensure a balanced design in each block. A design is balanced when for each variable each attribute level appears in all blocks the same numbers of times, and is usually considered to be a prerequisite for efficient designs.

The binary choice experiment was achieved by matching the profiles of two blocks (A-B, A-C and B-C) under two constraints. Obtaining an orthogonal design and minimising the number of dominant choices. Orthogonality ensures that the variables used are varied independently from one another [6], and comprises a characteristic of an efficient design. Still, orthogonality properties may not be retained in the estimation process especially when there are non-competed choices within the stated preference section of a questionnaire [7].

Each one of the three matching A-B, B-C, A-C obtained this way appeared as a set of nine binary choices in the stated preference section of the questionnaire. The pairing of the profiles was achieved by modeling the problem as a 0-1 integer programming problem, which in fact is an assignment problem having as side constrains the conditions for orthogonality and, as objective function to be minimised, the sum of the assignment variables corresponding to the obvious choices. Only a very limited, 3 in the worst case scenario, dominant choices appeared in the matching. Thus the information loss was not significant compared to the advantage of the elimination of cross-effects that orthogonality claims. The three different choice sets A-B, B-C and A-C appear in Table 2.

*** Please Insert Table 2 here***

3 Field Survey

The questionnaire was completed by direct interviews made in person. The only quota applied to the sample was that the respondents were passenger-car drivers entering the center of Athens. The field survey was conducted on working days, at different working hours of the day in an attempt to capture different driver and trip characteristics. Most interviews were carried out in the center of Athens mainly in offices and in organised parking stations, so that the respondents could devote all the required time for answering the questions. During the interview and completion of the questionnaire detailed explanations were provided to make sure that respondents had comprehended all the issues concerning congestion pricing. The interviewers gave detailed explanations to all respondents' questions, so as to prevent any ambiguity on the provided answers.

262 questionnaires were completed and after a detailed study of the answers given, 22 of them were found to contain either mistakes or inconsistent answers and were not included in the analysis. Hence, the final sample consisted of 240 questionnaires; and Table 3 summarises the socio-economic and demographic characteristics of the sample.

*** Please Insert Table 3 here***

Driver trip characteristics were also analysed and results are presented in Table 4.

*** Please Insert Table 4 here***

The majority of drivers driving to the centre of Athens makes work related trips (68%), 75.4% of which are made on a daily basis comprising commuting trips. This indicates that the majority of trips made to the centre of Athens by car involve non-elastic trips, i.e. trips the characteristics of which including frequency, destination and time of arrival at destination cannot be modified. 25.4% of trips involve leisure or shopping purposes and 60% of which are made rather occasionally (<2 times in a week). Hence, drivers making leisure/shopping trips might be able to adapt their trip characteristics under new conditions, e.g. implementation of a road pricing scheme. A small proportion of drivers made trips related to studying locations (e.g. university, college etc). The reason for this category being introduced rather than being incorporated within the work related trips is that the characteristics of such trips are different to work related trips in that their frequency and time of arrival at destination point can be adaptable to new conditions. More than half of the respondent trips were commuting trips (54.6%), and the rest were almost evenly distributed between frequent and occasional trips.

4 Driver attitudes

4.1 Driver preferences on road pricing

Statistical analysis of data extracted from the second section of the questionnaire elicited driver preferences in relation to the measure of road pricing. What needs to be considered together with the identified trends is that the survey participants have not experienced the implementation and effects of such a measure. Respondents experience congested traffic conditions, as the road network in

Athens suffers from heavy congestion during the peak hours. Increased travel time was considered to be the most important effect of traffic congestion by the participants being followed by environmental pollution and deterioration of psychological calm.

The advantages and disadvantages of an urban congestion scheme as perceived by the road users, provide an indication of user acceptability factors. Tables 5 and 6 illustrate drivers perceptions on the advantages and disadvantages of a congestion pricing scheme (participants were asked to rank their answers in order of preference).

*** Please Insert Table 5 here***

The perceived advantages of a road pricing scheme mainly involved the mitigation of traffic congestion (about 35% selected it as the most or second most important advantage) and the improvement of environmental conditions (about 30% selected it as the most or second most important advantage). The reduction of traffic congestion and, in fewer cases, the reduction of environmental pollution comprises the primary objective of the majority of the implemented urban congestion schemes [1]. This comes in accordance with driver perceptions. In certain cases, in Norwegian cities (Oslo, Trodheim and Bergen), the primary aim of such a scheme was the collection of revenue to be invested first on improving road infrastructure and secondly on public transport services [8]. Revenue utilisation scored rather low in drivers' perceptions on the advantages of a road pricing scheme as about 10% of the drivers selected it as the most or second most important advantage. In addition, about 10% of the drivers did not consider revenue utilisation as an advantage. About 16% considered that the most or second most important advantage of a congestion pricing scheme is the quality of life improvement which is a qualitative effect that may include the aforementioned ones. A small proportion of drivers considered attributing cost to those who create it as a significant advantage. Last, 2.5% of the drivers are of the view that a congestion pricing scheme does not present any advantages.

*** Please Insert Table 6 here***

As anticipated, the vast majority of drivers considered the user cost – as expressed through the toll cost – of a road pricing scheme as the most crucial disadvantage (43% ranked it as 1st or 2nd choice). The value of the toll determines several elements of the scheme including its acceptability, the resulting reduction of car-use and the amount of collected revenue. Second most important disadvantage was perceived to be the loss of privacy that users perceive to be a result of them being monitored when entering or exiting the scheme area, being followed by the scheme implementation costs. There is a small, yet existent, proportion of participants (about 6%) who were of the view that the implementation of a road pricing scheme does not have any adverse effects.

Findings in similar studies indicated that the use of the collected revenues of a congestion pricing scheme is a crucial factor which affects scheme acceptability [9]. Table 7 illustrates respondent preferences on the use of revenues of a congestion pricing scheme.

*** Please Insert Table 7 here***

The great majority of respondents prefer the use of revenues in sectors that will result in an improvement of travel conditions, as about 53% answered that the revenues should be used towards public transport and road network improvements (as 1st or 2nd choice). The most popular sector for revenue use proved to be public transport improvement (about 34%). This can be explained as the desire of drivers to be provided with alternative transport modes if car-usage is charged, which also involves a well-defined, effective and retributive use of revenues. More general uses of revenues such as tax reduction and social causes show low priorities in the respondents' preferences.

4.2 Driver acceptability on road pricing

Driver acceptability of a road pricing scheme is a prerequisite for its successful implementation. It has been observed however, that the acceptability increases following scheme implementation. For the city of Athens, 10.8% of the respondents were in favor of congestion pricing, 32.1% were against it while 53.3% conditionally agreed. The latter category expressed the approval of road pricing with the prerequisite of additional actions to support the measures; for example improving the services of alternatives to car-use, or using the revenues to improve public transport.

To interpret the factors that affect acceptability statistical analysis was performed. In particular a binary logistic model was developed having acceptance as a dependent variable and variables related to driver characteristics, trip characteristics and driver perceptions as independent ones. The results indicated that driver acceptance depended on the factors demonstrated in Table 8.

*** Please Insert Table 8 here***

Trip frequency and trip duration are positively related to acceptability; hence, increase of these two variables increases acceptability. This is justified as increased trip duration and trip frequency results in the impact of improved travel conditions, which is

anticipated as a consequence of congestion pricing, being more evident to the driver. Trip purpose however did not affect driver acceptability significantly, although in principle the consequences of congestion should affect more people travelling to work than people travelling for leisure or shopping. Driver characteristics were also not found to affect driver acceptability. Acceptability of the system is influenced by use of revenues [10], [11], [12]. In several cases it has been established that acceptability is positively related to the use of revenues towards improving public transport services. This is because those who accept the pricing scheme consider the improvement of travel conditions of primary importance and hence a concrete use of revenues would more efficient. This comes in accordance with the findings from surveys in London, which demonstrate that acceptability of urban pricing increases from 43% to 63%, if the revenues are used for transport and environmental improvements [13].

4.3 Driver acceptability on road pricing

This analysis was performed using as input data the responses in the stated preference experiment, and investigate drivers' willingness-to-pay between a high and a low toll, corresponding to the two alternative routes presented to them in each examined scenario, in relation to specific route characteristics. To interpret drivers' decision to accept a high or low toll level as a function of the travel conditions, a binary logistic regression model was developed having as a dependant variable the choice between a high or a low toll level and independent variables travel time reduction, travel time deviation, and other driver characteristics. Table 9 illustrates the developed model.

*** Please Insert Table 9 here***

The resulting model produced an average fit (R^2=0,624) and the correct prediction percentages were 86,8% (71,15% for high and 86,8% for toll selection). The results of the model indicate that the most important factors related to the driver's willingness to pay decision are travel time reduction and travel time deviation. As it was expected value of time is a crucial factor which affects driver willingness to pay a high or low tariff level.

A positive correlation between high toll level and driver perception that traffic comprises the main advantage of a pricing scheme was found, indicating that drivers who consider road pricing as a solution towards congestion are prepared to pay a high toll. Also a positive correlation between high toll and road pricing acceptability shows that those who agree with the pricing scheme (even conditionally agree) are willing to pay a higher toll. Drivers who consider the using the scheme revenues to towards tax reduction usually prefer the lower toll scenario. Last, demographic characteristics such as respondent gender, age, marital status, education and income did not appear to influence driver choice regarding their willingness–to-pay. It should be noted that while filling-in the questionnaires respondents did not feel comfortable with declaring their household income, or were not fully aware of it.

5 Conclusion

Congestion is considered as a serious problem affecting the sustainability of urban centres and urban road pricing is considered as an effective way for traffic management. Although the toll cost is considered a serious disadvantage of the system in view of the high acceptability, one can infer that the trade off between cost and benefits arising from a pricing scheme turns in favor of the benefits. Under this light this study investigated traveller preferences for a road pricing scheme for the city of Athens, with the use of a questionnaire survey.

Participants indicated that they considered road pricing to be an effective means towards targeting both traffic congestion and environmental pollution. Only a small participant number (2,5%) noted that road pricing does not produce any advantages. In terms of disadvantages, user cost was considered to be the most crucial one, with loss of privacy and infrastructure cost being also considered as disadvantages. Concerning the use of the revenues, the great majority of the respondents prefer a specially purpose use aiming at improving public transport and environmental conditions and not a general purpose use such a tax reduction.

In general, acceptability of the road pricing scheme can be considered to be quite high as approximately 60% of the participants agreed or conditionally agree with road pricing; and acceptability usually increases following scheme implementation. Acceptability on the scheme also depended on the trip patterns and in particular on trip duration and trip frequency, but was not found to be influenced by the aim of the trip. Demographic characteristics were also not found to affect acceptability.

Travel time reduction resulting from the implementation of the scheme was found to be the most important factor influencing driver's choice of a higher toll instead of a lower one. Travel time

deviation is somewhat less important, but still an important factor towards willingness-to-pay a higher instead of a lower toll. Last, drivers who considered as the main advantage of a road pricing scheme being the reduction of traffic congestion were more willing to pay a high toll. Demographic characteristics did not seem to affect willingness-to-pay.

The results of this study highlighted several of the aspects that influence the acceptability of Athenians towards a road pricing scheme and

References:

[1] Jones, P., and Hervik, A., Restraining car traffic in European cities: an emerging role for road pricing, *Transportation Research Part A*, Vol.26, No.2, 1992, pp. 133-145.

[2] E.C.M.T., The European conference of Ministers of Transport, Transport Policy and the environment, Paris, 1990.

[3] Commission of the European Communities, Green Paper: Towards a new culture for urban mobility, Brussels, 2007.

[4] Langmyhr, T., Understanding innovation: the case of road pricing, *Transport Reviews*, Vol.19, No.3, 1999, pp. 255-271.

[5] Schuitema, G., and Steg, L., The role of revenue use in the acceptability of transport policies, *Transportation Research Part F*, Vol.11, No.3, 2008, pp. 221-231.

[6] Hensher, D.A., Stated preference analysis of travel choices: The state of practice, *Transportation*, Vol.21, No.2, 1994, pp. 107-133.

[7] Rose, J.M., and Bliemer, M.C.J., The design of stated choice experiments: The state of practice and future challenges, working paper, University of Sydney, 2004.

[8] PATS, Empirical studies on price acceptability, Deliverable D.3, 2000.

[9] Ieromonachou, P., Potter, S., and Warren J.P., A Strategic Niche analysis of urban road pricing in the UK and Norway, *European Journal of Transport and Infrastructure Research*, Vol.7, No.1, 2006, pp. 15-38.

[10] Schade, J., and Schlag, B., Public acceptability of traffic demand management in Europe, *Traffic Engineering and Control*, Vol.41, 2000, pp. 314-318.

[11] Schade, J., and Schlag, B., Acceptability of urban transport pricing strategies, *Transportation Research Part F*, Vol.6, No.1, 2003, pp. 45-61.

[12] Small, K.A., Using the revenues from congestion pricing, *Transportation*, Vol.19, No.4, 1992, pp. 359-381.

[13] Jones, P.M., Gaining public sypport for road pricing through a package approach, *Traffic Engineering and Control*, Vol.32, 1991, pp. 194-196.

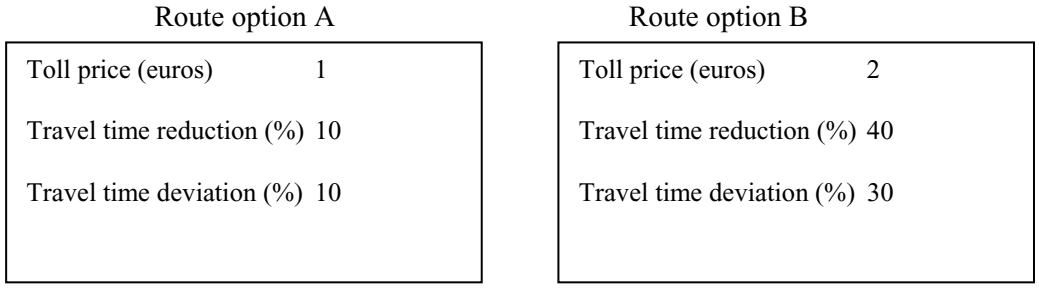

Figure 1. Choice situation presented to the respondent

Table 1. Variable attribute levels

Toll price	Travel time reduction	Travel time deviation
1€	10%	0%
2€	20%	10%
4€	40%	30%

Table2. Choice sets of the state preference experiment

Choice set A-B

	Block A			Block B		
Binary choices	Toll price	Time reduction	Time deviation	Toll price	Time reduction	Time deviation
1	4€	10%	30%	4€	10%	10%
2	4€	20%	30%	1€	10%	0%
3	4€	40%	10%	2€	10%	30%
4	2€	10%	10%	4€	20%	10%
5	2€	10%	0%	2€	40%	10%
6	2€	40%	0%	1€	40%	30%
7	1€	20%	0%	1€	40%	0%
8	1€	40%	10%	4€	20%	0%
9	1€	20%	30%	2€	20%	30%

Choice set B-C

	Block B			Block C		
Binary choices	Toll price	Time reduction	Time deviation	Toll price	Time reduction	Time deviation
1	4€	10%	10%	4€	40%	30%
2	4€	20%	10%	1€	10%	10%
3	4€	20%	0%	2€	20%	10%
4	2€	10%	30%	4€	10%	0%
5	2€	20%	30%	1€	10%	30%
6	2€	40%	10%	2€	20%	0%
7	1€	10%	0%	2€	40%	30%
8	1€	40%	30%	1€	20%	10%
9	1€	40%	0%	4€	40%	0%

Choice set A-C

	Block A			Block C		
Binary choices	Toll price	Time reduction	Time deviation	Toll price	Time reductio	Time deviation

						n
1	4€	10%	30%	4€	10%	0%
2	4€	20%	30%	4€	40%	30%
3	4€	40%	10%	1€	10%	10%
4	2€	10%	10%	2€	40%	30%
5	2€	10%	0%	1€	10%	30%
6	2€	40%	0%	1€	20%	10%
7	1€	20%	0%	4€	40%	0%
8	1€	40%	10%	2€	20%	0%
9	1€	20%	30%	2€	20%	10%

Table 3. Sample characteristics

Gender	No.	Age	No.	Employment	No.	Education	No.	Household Income	No.
Male	132	18 - 24	44	Employee	162		6	<800€	27
Female	108	25 - 34	91	Student	25	High-school	57	800-2000€	104
		35 - 45	50	Self-employee	45	University	177	2000-4000€	69
		>45	55	Unemployed	8			>4000€	40

Table 4. Characteristics of weekday trips to the centre of Athens

	Work	Leisure/ Shopping	Studies	Total
Every day	51.3%	2.5%	0.8%	54.6%
2-4 times a week	12.1%	7.5%	5.0%	24.6%
<2 times a week	4.6%	15.4%	0.8%	20.8%
Total	68.0%	25.4%	6.6%	100.0%

Table 5. Advantages of road pricing scheme

	1st option	2nd option	3rd option	4th-5th option	not selected
Improved quality of life	15,00%	18,75%	30,42%	25,83%	10,00%
Reduction of environmental pollution	22,50%	37,50%	20,83%	13,75%	5,42%
Revenue utilisation	8,75%	9,58%	14,58%	57,50%	9,58%
Congestion improvement	45,42%	23,75%	15,00%	11,25%	4,58%
Paying toll for creating cost	5,83%	6,67%	11,67%	61,67%	14,17%
No advantage	2,50%	-	-	-	-

Table 6. Disadvantages of road pricing scheme

	1st option	2nd option	3rd option	not selected
User cost	68,75%	17,92%	7,50%	5,83%
Loss of privacy	15,00%	41,67%	31,25%	12,08%
Infrastructure cost	10,42%	32,50%	46,25%	10,83%
No disadvantage	5,83%	-	-	-

Table 7. Use of revenues

	1st option	2nd option	3rd option	4th-5th option	not selected
Environment improvement	24,58%	22,92%	22,08%	28,33%	2,08%
Public transport improvement	32,50%	25,42%	16,25%	24,17%	1,67%
Social Causes	19,58%	11,67%	20,83%	42,50%	5,42%
Road network improvement	14,58%	32,92%	24,17%	26,25%	2,08%
Lower taxes	8,75%	7,08%	16,25%	63,33%	4,58%

Table 8. Driver acceptability factors

	Coefficient	t-stat	Significant at
Trip frequency	0,385	1,995	95,4%
Trip duration	0,330	27,500	95%
Driver Perception: Revenue use on public transport	0,810	2,596	99%
Driver Perception: Revenue use for lower taxes	-0.679	-1.656	90.3%
Driver Perception: No disadvantage of congestion pricing	1,936	1,825	93,2%
Constant	-2,231	-2,979	99,7%

Table 9. Driver willingness to pay factors

	Coefficient	t-stat	Significant at
Difference between travel time reduction of the chosen route and the non-chosen route	14,424	16,714	100,0%
Difference between travel time deviation of the chosen route and the non-chosen route	-10,907	-16,121	100,0%
Road pricing acceptability	,289	1,622	89,5%
Driver Perception: Revenue use for lower taxes	-,675	-2,857	99,6%
Driver Perception: Advantage of road pricing Reduction in congestion	,408	2,459	98,6%
Profession	-,324	-1,465	85,7%
Constant	-1,818	-9,562	100,0%