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MISTIC (UOC – UAB - URV)

Research Methodologies in Network and  
Information Technologies

**The user point of view in the deployment of congestion tolls**

J. Guasch, May 2014

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# The user point of view in the deployment of congestion tolls

Joint university master program in security of information and communication technologies (MISTIC) (UOC – UAB - URV)

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## ABSTRACT

One known problem for many urban areas is the traffic congestion during rush hours. This causes an increase of pollution levels and the lost of time and efficiency for commuters and transportation. Among other strategies, some cities [1,2] have implemented electronic congestion tolls to limit the traffic access, preserving the historical center or certain areas. These systems may show deficiencies regarding privacy, security and may lack of general public acceptance, opening a debate that might limit their applicability and determine governmental policies.

## INTRODUCTION

This survey is part of an academic assignment in the joint university master program in security of information and communication technologies by UOC, UAB and URV that I'm currently pursuing. As a research topic, I decided to study the congestion tolls deployment and the importance of some key issues as privacy and security. This topic has multiple sides and considerations that have to be deeply studied. The aim of this work has been putting in practice some research techniques while getting an initial sight on the subject.

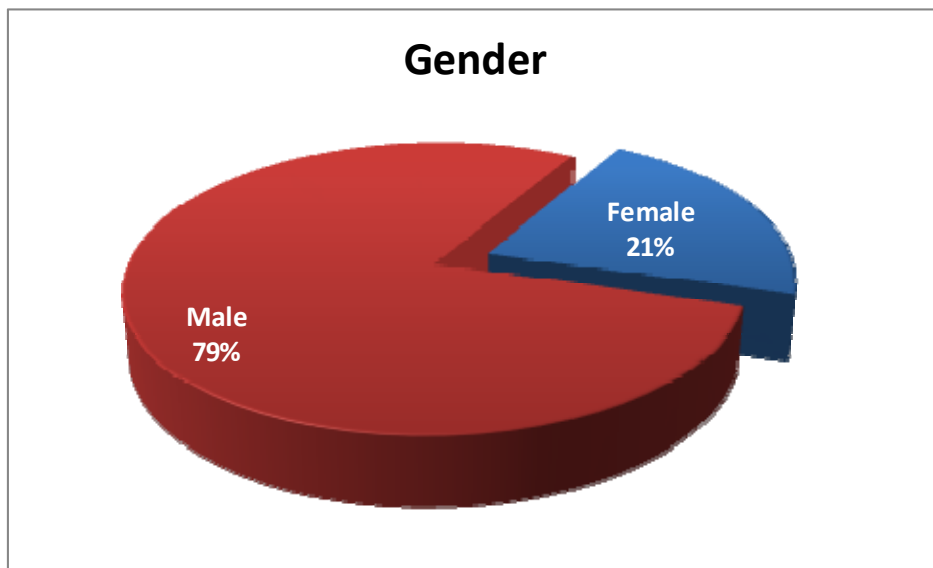
A questionnaire has been designed to gather information about the user point of view concerning congestion tolls. The questionnaire was aimed to obtain information about the ways people access to their jobs or studies and their perception on several aspects related to the congestion toll deployment over other strategies.

## RESULTS

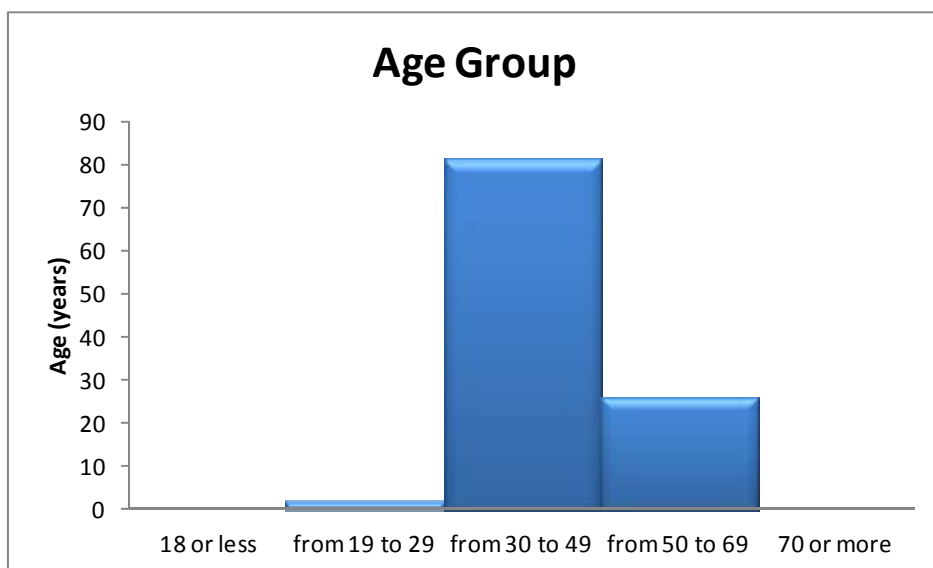
The survey has been answered by 109 respondents that gave their opinion and suggestions about various aspects regarding their transportation habits, the way they saw the congestion tolls deployment, among other alternatives, and the importance of some key aspects as privacy, security or available payment systems.

## 1. General Information

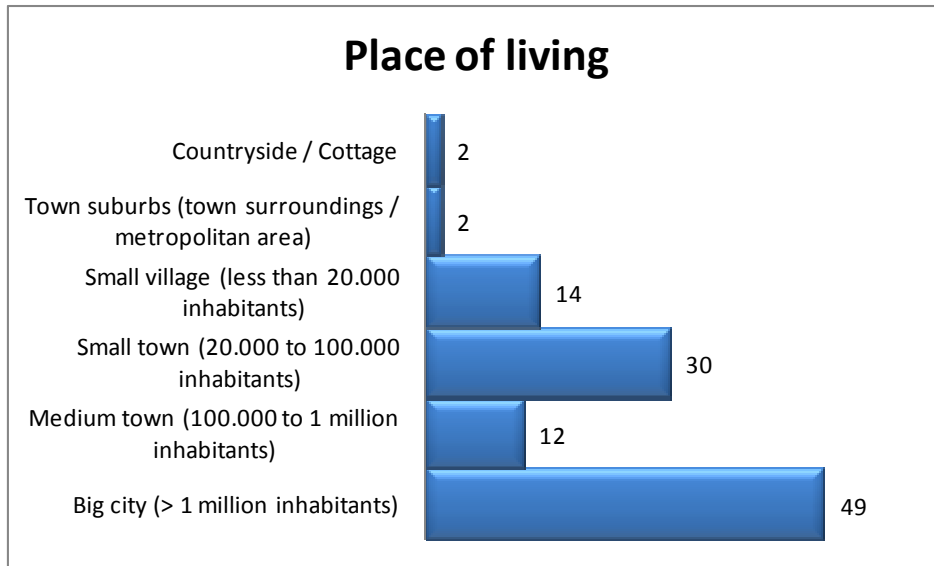
Survey users were asked with general questions regarding gender, age segment and place of living as basic population information. The results show that the respondents are mainly male (79%, see figure 1) from 30 to 49 years old (74%, see figure 2) and living in a big city (> 1 million inhabitants), (45%) followed by those living in a small town (20.000 to 100.000 inhabitants), (28%, see figure 3). This general information will be useful when analyzing the data coming from the mobility habits and congestion tolls acceptance sections.



**Figure 1:** Gender distribution of respondents



**Figure 2:** Age groups distribution



**Figure 3:** Place of living distribution

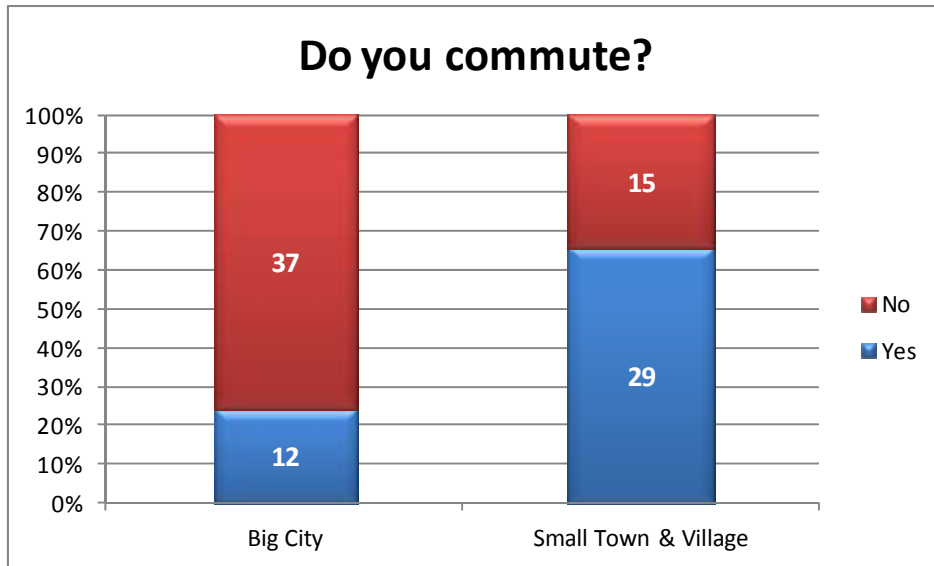
We might see from figure 3 that respondents form two distributions regarding the place of living, one is people living in a big city and the other is people living out of a big city, centered on those living in a small town. Both distributions show comparable sizes. Countryside and town suburbs inhabitants appear to be far less frequent.

## 2. Mobility habits

Probably because of this dual population in the distribution of places of residence, the respondents are also distributed regarding the way they access their job or studies. 47% claim to be commuters. Table 1 and figure 4 below show the distribution of commuters among big city inhabitants and the inhabitants from small village and small town.

Do you commute to a neighbor city or town to work or study?	Big City		Small Town & Small Village	
	Count	Percentage	Count	Percentage
Yes	12	24.49%	29	65.91%
No	37	75.51%	15	34.09%

**Table 1:** Commuters among two different distributions of respondents



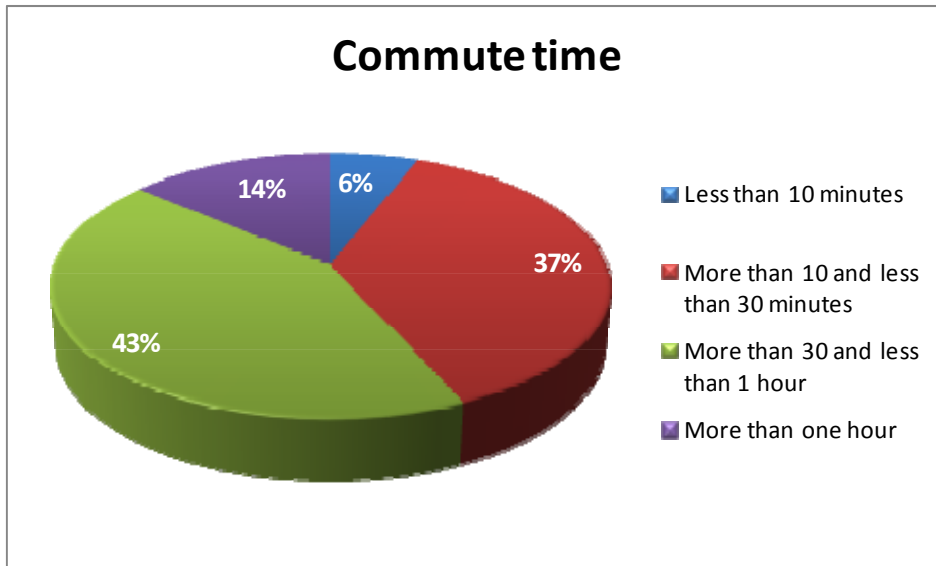
**Figure 4:** Commuters among two different distributions of respondents

From this information, we see that 70% of commuters are from outside the big city. Although some big city inhabitants declare to commute as well (24%), the proportion might suggest a clear imbalance between the flow to the big city and the flow from the big city. This appears to be consistent with the traffic conditions information of an average urban area during rush hours.

Commuters reported their average commute time considering one way only. The question allowed a single choice from 4 time segments. Table 2 and figure 5 summarize the results.

<b>What is your daily commute average time (one way)?</b>		
<b>Answer</b>	<b>Count</b>	<b>Percentage</b>
Less than 10 minutes	3	5.88%
More than 10 and less than 30 minutes	19	37.25%
More than 30 and less than 1 hour	22	43.14%
More than one hour	7	13.73%

**Table 2:** Average commute time



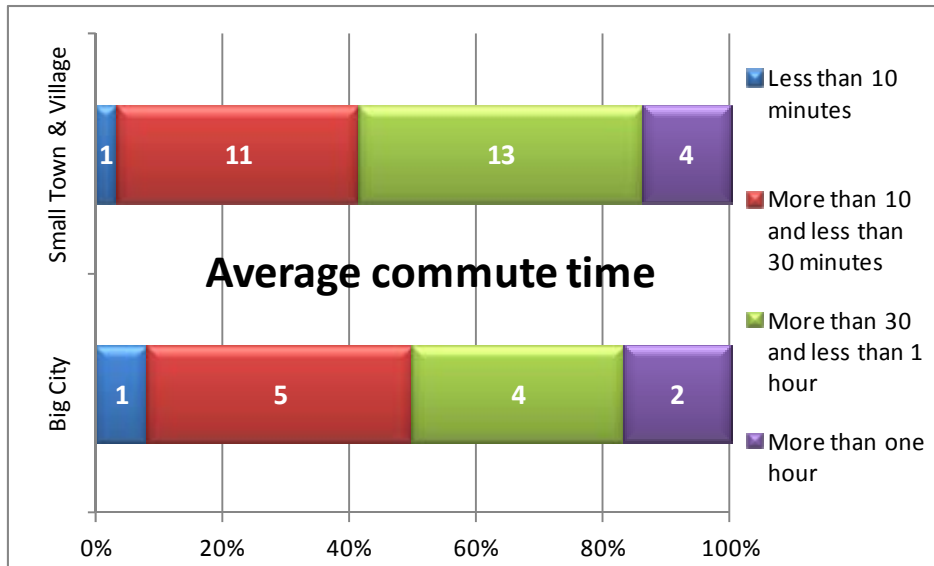
**Figure 5:** Average commute time

Segments from 10 minutes to 30 minutes and from 30 minutes to 1 hour add up the 80% of occurrences. Surprisingly, almost a 14% of respondents declare more than one hour commute time per way. This is more than twice the number of lucky ones asserting less than 10 minutes of commute time. From this information, we see that the time used on transportation generally represents a significant daily time proportion for commuters.

Segmenting those results into big city and small town/city commuters as shown in table 3 and figure 6, we might see some differences among those collectives and observe that times are slightly better (shorter) for big city inhabitants.

What is your daily commute average time (one way)?	Big City		Small Town & Small Village	
	Count	Percentage	Count	Percentage
Less than 10 minutes	1	8.33%	1	3.45%
More than 10 and less than 30 minutes	5	41.67%	11	37.93%
More than 30 and less than 1 hour	4	33.33%	13	44.83%
More than one hour	2	16.67%	4	13.79%

**Table 3:** Segmented commute time

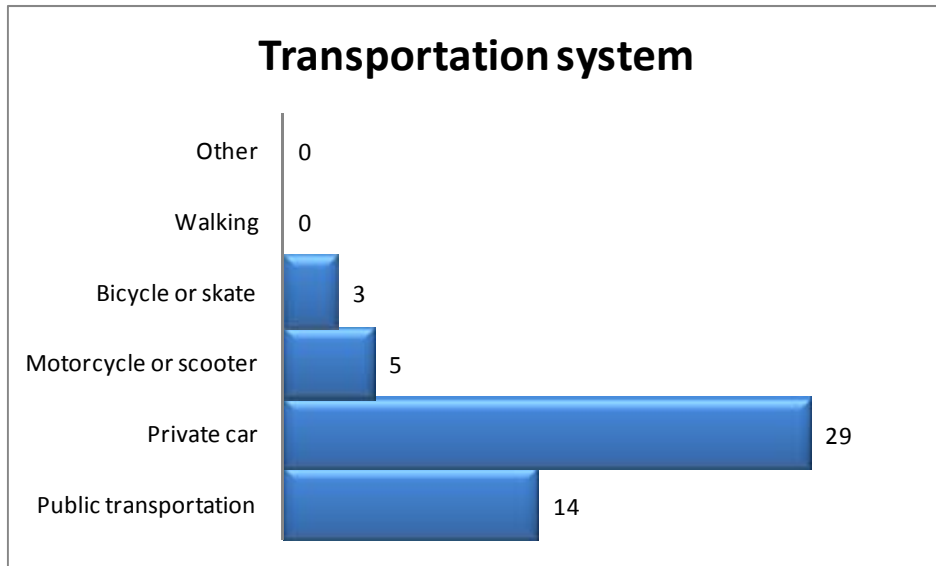


**Figure 6:** Average commute time segmented

Regarding the transportation system the commuters use, table 4 and figure 7 summarize the results and show a clear preference for private car over other alternatives.

<b>What transportation system do you use to commute?</b>		
<b>Answer</b>	<b>Count</b>	<b>Percentage</b>
Public transportation	14	27.45%
Private car	29	56.86%
Motorcycle or scooter	5	9.80%
Bicycle or skate	3	5.88%
Walking	0	0.00%
Other	0	0.00%

**Table 4:** Commuters transportation system

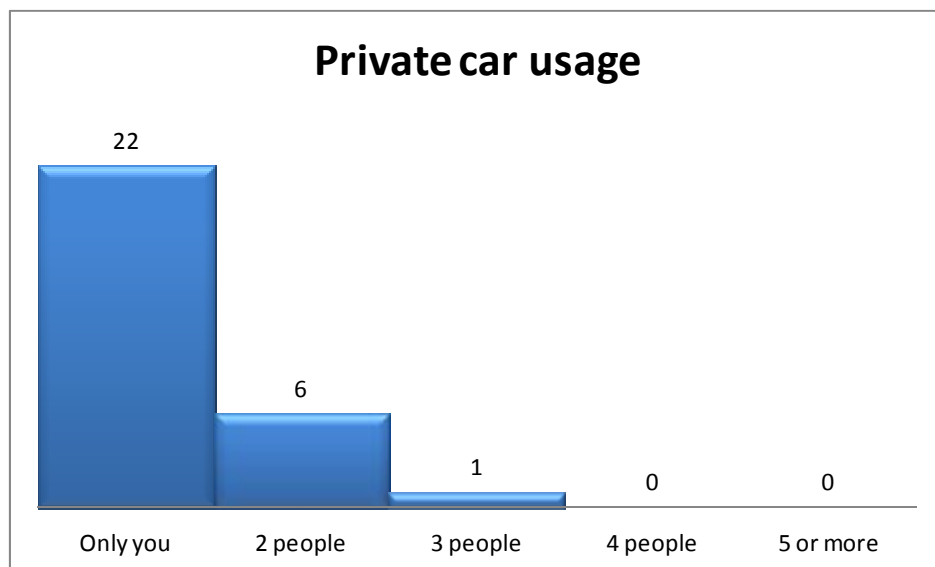


**Figure 7:** Commuters transportation system

Public transportation is far below private car usage while other systems as motorcycle, bicycle or walking are even much less significant. Due to the fact that this survey focuses on congestion tolls, this question was only asked to commuters; therefore no information was gathered regarding non-commuters preferred transportation systems.

Private car might be very convenient and flexible but is clearly the less efficient transportation system. It is the source of a high amount of pollution and congestion problems during peak hours. This is going to be more significant depending on how the car is used.

Figure 8 shows the distribution of people per car for those commuters that declared they use private car as main transportation system. It is remarkable to see the high proportion of cars with one single person. This gives sense to the previous remark about efficiency.



**Figure 8:** Private car usage



All survey users were asked about their opinion on some suggested strategies to reduce commute times. The question allowed multiple choices and included an open field to incorporate further suggestions or options.

Table 5 outlines the results for this question. The list of suggested options from the respondents is also listed hereafter.

<b>What strategies do you think might be effective to reduce commute times?</b>		
<b>Answer</b>	<b>Count</b>	<b>Percentage</b>
Improve public transportation	92	84.40%
Build new roads and highways	11	10.09%
Promote initiatives like 'car sharing'	26	23.85%
Deploy congestion toll rings to access the city	18	16.51%
Limit city access according to vehicle number plate	5	4.59%
Build car parks at the city entrance next to public transport	53	48.62%
Other	11	10.09%

**Table 5:** Suggested strategies to reduce commute times

It is quite relevant the high proportion achieved by the 'Improve public transportation' option, despite this is not the preferred transportation system as previously seen. Policy makers should consider whether public transportation improvement could mean a reduction in commute times and also a reduction in private car use.

The 'other' category collected the following suggestions and contributions (literally):

1. More flexibility to work in offices. Only when it's necessary
2. Promote ATM public *bycing* and public transportation
3. Avoid payment highways
4. Work at home
5. Home work
6. Promote use of bicycle
7. *Teleworking*, Telecommuting
8. Cheaper public transportation
9. Promote Children Public Transportation to school
10. Improve bike lanes
11. Improve speed in traffic paths through the city and avoid congestions

It is interesting to see that 4 out of 11 suggest some kind of work at home approach. This is an open debate well beyond the scope of this study. While supporters claim it could reduce traffic congestions and pollution, detractors argue it is convenient neither for the employer nor for the employee.

### 3. Congestion tolls acceptance

This section was designed to get more information about the user thoughts regarding congestion tolls deployment and some related issues.

At the beginning of this section, all respondents faced a direct question with a single choice answer including an open field for other opinions regarding the necessity of congestion tolls.

Table 6, below, summarizes the responses about congestion toll acceptance and comments on the open field 'other' are also listed.

<b>Do you think congestion tolls are necessary?</b>		
<b>Answer</b>	<b>Count</b>	<b>Percentage</b>
Yes, congestion is a major issue and has to be controlled	16	14.68%
Although I might agree, other alternatives should be previously studied	45	41.28%
No, we already pay taxes enough	45	41.28%
Other	3	2.75%

**Table 6:** Users opinion about congestion tolls necessity

The 'other' option answers indicated the following opinions (literally):

1. Blue and green car parks are really tools now
2. No, other alternatives should be previously studied
3. Creative solutions

Despite a 15% of unconditional affirmative responses, clearly negative or conditioned responses predominate. Even after the previous sections where the user took conscience about congestion problems and commute times, the introduction of these strategies is not easily accepted by users and is not straightforward for policy makers.

Responses according to gender vary from a 13% acceptance on females to 15% acceptance on males. No remarkable differences were detected according to the age group. However, due to the small population, results may not be significant enough.

A series of scale questions were also designed to know the user perception about several issues related to congestion tolls. They were centered on the following aspects:

- User privacy assurance
- Payment transaction security
- Type of available payment system
- Equity conditions among regions
- Investment destination of toll income

Tables 7 to 11 show how the respondents evaluated those issues from being not important to being considered as critical.

<b>Please, evaluate the importance of the following concepts from the congestion toll user point of view [User privacy assurance]</b>		
<i>Answer</i>	<i>Count</i>	<i>Percentage</i>
Not important	7	6.42%
Somehow important	25	22.94%
Important	33	30.28%
Very important	27	24.77%
Critical	17	15.60%

**Table 7:** User privacy assurance

<b>Please, evaluate the importance of the following concepts from the congestion toll user point of view [Payment transactions security]</b>		
<i>Answer</i>	<i>Count</i>	<i>Percentage</i>
Not important	1	0.92%
Somehow important	3	2.75%
Important	27	24.77%
Very important	35	32.11%
Critical	43	39.45%

**Table 8:** Payment transactions security

<b>Please, evaluate the importance of the following concepts from the congestion toll user point of view [Type of available payment system]</b>		
<i>Answer</i>	<i>Count</i>	<i>Percentage</i>
Not important	0	0.00%
Somehow important	7	6.42%
Important	43	39.45%
Very important	44	40.37%
Critical	15	13.76%

**Table 9:** Type of available payment system

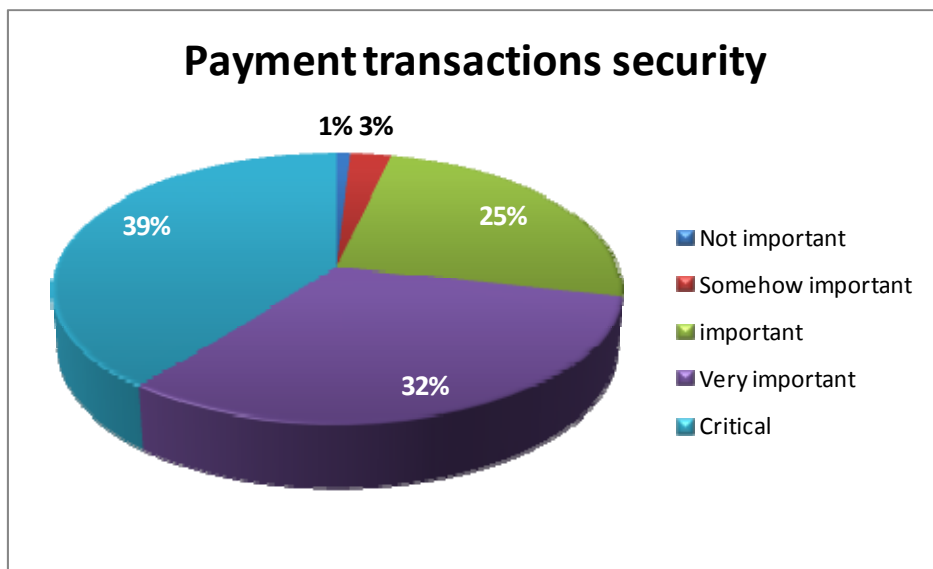
<b>Please, evaluate the importance of the following concepts from the congestion toll user point of view [Equity conditions among regions]</b>		
<i>Answer</i>	<i>Count</i>	<i>Percentage</i>
Not important	6	5.50%
Somehow important	8	7.34%
Important	35	32.11%
Very important	37	33.94%
Critical	23	21.10%

**Table 10:** Equity conditions among regions

<b>Please, evaluate the importance of the following concepts from the congestion toll user point of view [Investment destination of toll income]</b>		
<b>Answer</b>	<b>Count</b>	<b>Percentage</b>
Not important	2	1.83%
Somehow important	12	11.01%
Important	35	32.11%
Very important	36	33.03%
Critical	24	22.02%

**Table 11:** Investment destination of toll income

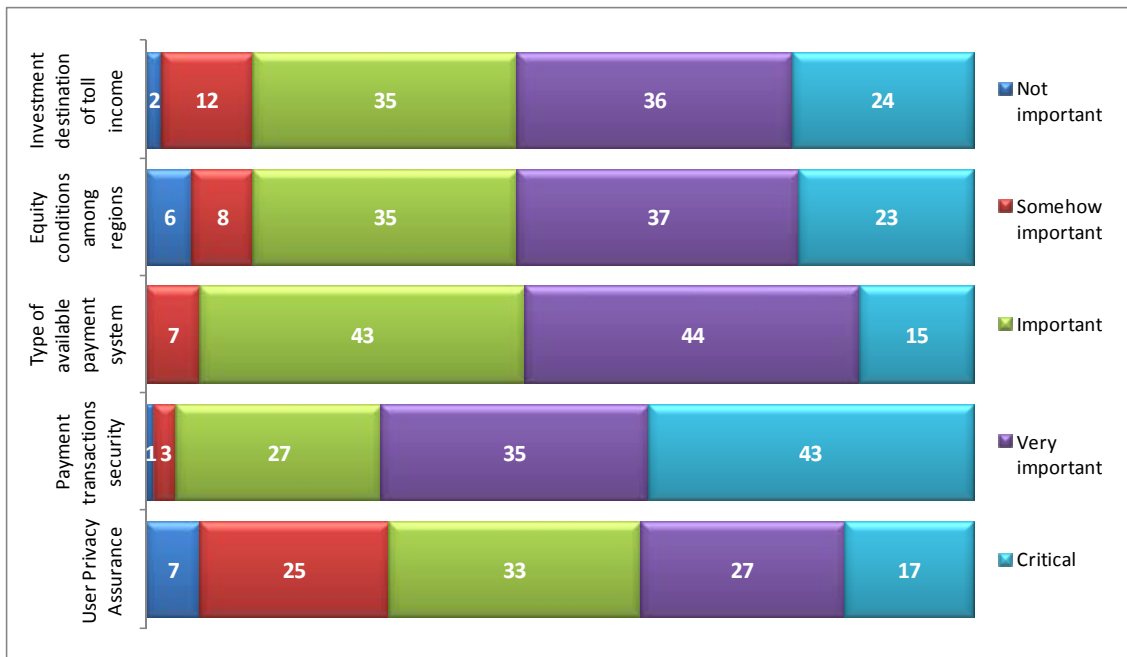
It is notable the relatively high number of respondents considering those issues as critical. Almost all users evaluate those concepts from important to critical. Surprisingly, the user privacy assurance accumulates a 29% of users considering privacy is either not important or somehow important. The aspect that appears to be more sensitive, after the values on the scale, is 'payments transaction security' where 39% of respondents consider it as critical concept. See figure 9:



**Figure 9:** Payment transactions security evaluation

Investment destination of toll income is also considered an important, very important or critical factor. Probably, a good visibility on the destiny of the toll benefits accordingly, could help users to accept the introduction of these governmental policies [3].

Next figure (figure 10) summarizes the user evaluation for all those aspects in one single image:



**Figure 10:** User evaluation on congestion toll aspects

Users that ranked as important, very important or critical ‘user privacy assurance’ were also asked to identify the main factors that might affect privacy. This was done from a multiple choices question with an open field for other suggestions. Table 12 collects the results.

<b>Please, identify what are the main factors that might affect privacy</b>		
<b>Answer</b>	<b>Count</b>	<b>Percentage</b>
The system may know your current position	53	48.62%
The system may know your daily routes	61	55.96%
The system may know your annual expenses	39	35.78%
The system may take pictures of you and/or your car	39	35.78%
The system may store your number plate	31	28.44%
Other	4	3.67%

**Table 12:** Users evaluation on main factors that might affect privacy

Users also indicated other possibilities (literally):

1. Privacy
2. Ethic Big data use. Right to oblivion mandatory
3. The system may know my schedule
4. All that can be known will be known

Similarly, users that graded as important, very important or critical ‘payment transactions security’ were asked to identify the main factors that might affect security. Again a multiple choices question with an open field for other contributions was presented.

Table 13 brings together the results and the additional suggestions are given below.

<b>Please, choose all the elements that would improve your security perception</b>		
<b>Answer</b>	<b>Count</b>	<b>Percentage</b>
Payment is kept anonymous	48	44.04%
User has a prepaid card to access	42	38.53%
Payment data is encrypted and send to the bank	58	53.21%
Location information and payment information are kept and managed separately	44	40.37%
Fare is calculated onboard. No location data is given	40	36.70%
User data is available upon request	16	14.68%
Other	3	2.75%

**Table 13:** User evaluation about security perception

Users also indicated other possibilities (literally):

1. Accept cash
2. Just need to be informed that transactions are safe
3. Any method is suspicious

Regarding payment systems, all users were asked about their opinion on the convenience of some of the most common payment systems that might be used in case of a congestion toll deployment. Table 14 and figure 11 outline the preferred systems highlighting credit/debit cards and on board tags.

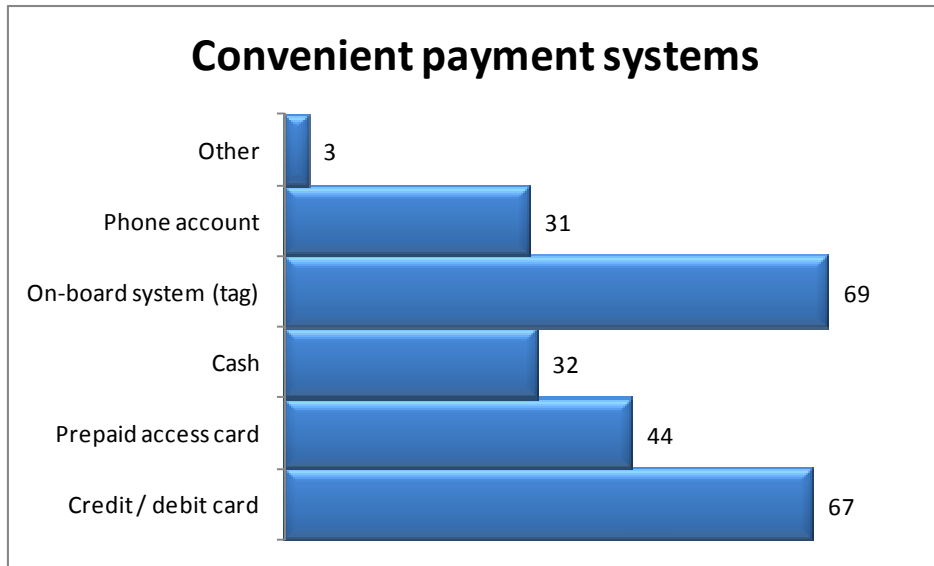
Some users also suggested other alternatives even though one is already included in the list and another one is more likely to be an opinion (literally):

1. NFC Smart Textiles
2. I don't agree with this system
3. Embedded into existing systems like *Teletag*

NFC Smart Textiles could be a promising idea that could open new possibilities into the rapidly evolving world of wearable's and smart fabrics.

<b>In case a congestion toll should be deployed, what payment systems would be convenient for you?</b>		
<b>Answer</b>	<b>Count</b>	<b>Percentage</b>
Credit / debit card	67	61.47%
Prepaid access card	44	40.37%
Cash	32	29.36%
On-board system (tag)	69	63.30%
Phone account	31	28.44%
Other	3	2.75%

**Table 14:** Preferred payment systems



**Figure 11:** Preferred payment systems

Last question requested respondents to put some propositions in order of preference. Those propositions, listed below as they emerged on the questionnaire, were related to congestion toll fare policies and aimed to get information about user preferences:

- Payment is flat rate per period (day, week, etc)
- Payment is responsive to day hour and traffic conditions
- Payment is dependent on vehicle type
- Payment is dependent on town area
- Payment is inversely proportional to the vehicle passengers number

Once counted, a weighed punctuation has been given to every proposition depending on the number of times users put it as first place, second place and so on. See table 15. The following simple formula has been used to evaluate the weight of every proposition:

$$\text{Total} = (\text{As \#1}) + (\text{As \#2}) * 2 + (\text{As \#3}) * 3 + (\text{As \#4}) * 4 + (\text{As \#5}) * 5$$

Please, order the following propositions regarding payment characteristics (1: most preferred, 5: least preferred)						Totals
Answer	As #1	As #2	As #3	As #4	As #5	
Payment is flat rate per period (day, week, etc)	27	22	13	12	35	333
Payment is responsive to day hour and traffic conditions	30	29	21	18	11	278
Payment is dependent on vehicle type	13	19	28	24	25	356
Payment is dependent on town area	14	18	30	25	22	350
Payment is inversely proportional to the vehicle passengers number	25	21	17	30	16	318

**Table 15:** Propositions counted and weighted

Despite there are no significant differences among the different proposition results, according to the calculated weight, the originally given propositions could be ordered as follows from most preferred to least preferred:

1. Payment is responsive to day hour and traffic conditions
2. Payment is inversely proportional to the vehicle passenger number
3. Payment is flat rate per period (day, week, etc)
4. Payment is dependent on town area
5. Payment is dependent on vehicle type

Some users (11) also wrote final comments regarding the subject at a final free text area. Those comments are listed below (literally):

- Please, improve public transportation
- I usually use Bike and Public transport in my town... parking congestions, and blue zones are enough "dissuasive"... (at least in Barcelona) or should I say "*impositives*". I think that the liberty of the citizens to go by car should be respected. Few people drive a car for amusement. 2,50€ /hour for parking is "dissuasive" enough.
- on Congestion Tolls payment process must be mandatory right to oblivion and ELIMINATION of Physical Barriers
- Toll rates are abusive and the government must free this kind of roads.
- I prefer other options (see the first answer)
- I believe congestion toll must be used only to reach environmental conditions goals but not to reduce traffic jams. That is, congestion toll must be used as a special measure in order to keep pollution within certain limits. Others mechanisms must be developed in order to reduce traffic jams and bottle-necks. The most important thing is to improve public transportation and develop the electric/hydrogen car it substitutes current ones emitting harmful gases and particles.
- On-board system (tag) should be more affordable for everyone to have access and thereby increase tolls reserved for this system.
- We need live near job. It is better rent a flat near job.
- It is necessary to improve the public transport and make it cheaper.
- It is unclear for me that congestion tolls are a proper solution. Arrived this point, shouldn't it be preferable to let the system auto regulate itself? Cities could plan and manage their infrastructures and citizens decide whether to live here or there... time to move is another kind of money.
- Before deploying congestion tolls, other options should be analyzed. Starting with public transportation improvement.

## CONCLUSIONS

Congestion is a common problem for urban areas during peak times. We've seen that many people commute to their job or place of studies everyday and spend a considerable amount of time on a daily basis.



Despite the cost and its inefficiency, many commuters prefer the private car to the public transportation. Car is used mainly by one single person that increases the overall inefficiency of the transportation. Many users are demanding improvements in public transportation as a way to reduce commute times.

The deployment of congestion tolls is not straightforward for policy makers and we've seen that the general opinion tends to prefer other options before accepting them blindly. Acceptance is conditioned to other improvements prior to the installation and deployment of tolls. Public transportation improvement is detected as an opportunity area to reduce commute time and private car usage.

Some important issues regarding the operation of congestion tolls have been evaluated by the respondents and we've seen that the users prioritized payment security over privacy. The most common payment systems appear to be preferred by users.

## **FURTHER WORK**

This was a very preliminary study conducted over a narrow and limited population. Some detected sights have to be explored more deeply to get more valid information and significant data in order to extract additional relevant conclusions.

The availability of more detailed data should also permit a better evaluation of some issues and how to deal with them when facing a toll project. The study of previous experiences and the state of the art of the technology [4,5,6] should help on that direction.

Further lines of research could seek to measure the convenient toll price according to the hour and to the actual traffic conditions. Also reviewing previous experiences and the different approaches to visualize how the toll income is invested on public transportation improvement or infrastructure construction.

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