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ORIGINAL PAPER

Predicting the results of a referendum on urban road pricing in France: "the cry of Cassandra"?

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Abstract
Introduction Abundant literature now exists on the acceptability of the new pricing measure represented by urban tolls. However, this literature contains few examples providing a "political" analysis of their introduction. Here, our aim is to study how the political behavior of individuals, identified on the basis of general attitudes regarding the principles of regulation and pricing, influences, or does not influence, attitudes with respect to urban tolls.
Method We study the *ex-ante* determinants of a vote on urban tolls. We use the results of a survey performed in France in the framework of the European Project ExpAcc (Explanatory Factors of Road User Charging Acceptability). We process the data using a Principal Components Analysis (PCA) then perform ordered logit estimation.
Result Regarding the specific question to the referendum, we show that it would be rejected by electors. We also show that there is a significant link between general attitudes to regulation by legislation, tax or pricing policies in transport on the one hand, and the vote in the referendum on tolls on the other. We confirm that individual self-interest matters a lot in political behaviour but that other types of motives also matter strongly
Conclusion As a consequence, a real-life political analysis cannot be limited to classical "economic" variables, even if they matter too obviously. Lastly, our results should be placed in relation with those concerning the more global issue of the acceptability of a new pricing measure through, for example, that of the compensation to be implemented.

Keywords Urban toll · Attitudes · Principal Component Analysis (PCA) · Ordered logit

JEL Classification R48 · R40 · C10

Cassandra is the daughter of King Priam. She made many predictions, in particular during the war of Troy. She predicted the fall of Troy and she warned the Trojans about the Greeks hiding inside the Trojan horse. However, except for one, all of her prophecies being disbelieved. She was unable to do anything to forestall these predictions since no one believed her. This part of the Greek tragedy is knowing through the myth of "the cry of Cassandra".

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1 Introduction

Predicting individual intention dealing with main transport projects is quite difficult. The implementation of an urban toll can be a good example: this measure was rejected in France at the end of the 90s [48] whereas it has met with success in European neighbors such as in Norway in the 90s and after through congestion charging in London (see [36, 53]), Stockholm (see [11]) and urban road pricing scheme in Milan [51].

The literature on the introduction of urban toll is relatively abundant. Different works have illustrated that before setting up a toll, adapted responses must be given to the following questions: what compensations can be

offered to the "loser" users, especially if they are low wage earners, whether they are located outside the toll perimeter and who, most often, are captives to cars [7, 14, 19, 22, 48, 58, 65]? What quality and availability can be provided for modal alternatives [1, 3, 13, 30, 35]? Consequently, to what should the revenues generated from the toll be assigned [8, 20, 50, 57, 59]?

More recent and less abundant in this transport literature are papers that provide a more "political analysis" of the introduction of urban toll. This literature seeks to analyze what determines the votes of electors [3, 6, 9, 17, 24–29, 39], but without an *ex-ante* analysis and without really putting the data to the test, with the exception of Jaensirisak et al. [28, 29], Gaunt et al. [17] and Harsman and Quigley [24] focusing only on the UK case study. A better understanding of intention change is a way of increasing transport policy effectiveness, as the cost of rejection can be important and sustained financially by society.

Our objective in this paper is to study how the political intention of individuals, identified on the basis of general attitudes to the principles of regulation and pricing, influences or does not influence their attitudes to urban tolls? Attitude is only one of the determinants of intention (with subjective norms and control perception and intention acts on behaviour [4]. To answer this previous question, we study the link between general attitudes to regulation and pricing and the vote of a referendum on urban tolls. We use the results of a survey performed in France in May 2011 ($N \sim 1\ 500$) in the framework of the ExpAcc project [61].[1] First, we use standard OLS estimation to obtain an overview of the relation between referendum and socio-economics variables. Providing new variables in a smaller number, a PCA (Principal Components Analysis) is then used to analyze general attitudes on regulation and pricing. Results from OLS estimation and PCA analysis are used to perform more in-depth relation between attitudes to pricing and intention to voting on the issue of urban tolls.

The results show that there is a significant link between general attitudes to regulation by legislation, tax or pricing policies in transport on the one hand, and the vote in the referendum on tolls on the other. Moreover, we confirm that individual self-interest matters a lot in political intention but that other types of attitudes also matter strongly.

The article is structured as follows. We first provide a review of the literature on urban tolls (Section 2), and then present the data and method of analysis (Section 3). We present our results and discuss them in the fourth part (Section 4).

[1] ExpAcc - Explanatory Factors of Road Users Charging of Acceptability – in the framework of ERA-NET SURPRICE. Stockholm (Sweden) and Helsinki (Finland) were the two others cities studied in this project (for more details see [23]).

2 Literature review on urban tolls and vote

The purpose of this review is to identify the issues that are now subject to relative consensus on the introduction of an urban toll but also to take stock of works that provide a more political analysis. We can notice that road tolls are not strictly the same as road pricing reform, since tolls are typically route specific. Road pricing reform is more generic and is perceived often very differently and less coercive from cordon based or distance-based charging.

We briefly present the theoretical determinants of individual votes then a typology of urban tolls and a comparison of the impacts of urban tolls in the lights of their various effects on the determinants of votes.

2.1 Theoretical determinants of individual votes

Theoretical determinants explaining individual voting are widely covered by seminal results coming from social choice and public choice theories [37, 42, 52]. The analysis of voting strategies distinguishes two decisional layers: should I vote (or not)? If I vote, what are (is) my choice motivation(s)?

2.1.1 The downs' Paradox: should I vote (or not)?

Downs [10] identifies the existence of an individual "sense of social responsibility" for the political system as a whole. People vote because they have been taught that voter participation is a necessary precondition for a well-functioning democracy. Hence, individuals develop a sense of responsibility and vote in order to sustain democracy. According to the "Downs' Paradox", the costs of voting can be higher than the benefits and this simple cost-benefit calculus leads to a poor electoral turnout. One of the explanation is the voter's cost–benefit calculus, which can represent a voter's concerns for the functioning of her polity, but also other intrinsic benefits provided by the act of voting itself, such as the warm glow of acting in a pro-social way. However, as compared to the probability of being "pivotal", the time resources I should engage could refrain myself from voting.

2.1.2 Expressive voting: ideological versus utilitarian principles

Expressive voting is not only able to explain why citizens vote, but also how they vote. If individuals decides to vote, literature shows that his choice will be based either on ideological (acting morally or against taxes) or utilitarian (self-interest) principles, or a mix of both [42, 56]. Concerning those determinants, a clear distinction should be made between sociotropic votes (welfare effects of a measure on the society to which I belong, via the impact on the environment

for instance) and egotropic votes (welfare effects of a measure that I will support directly, via money loses).

2.2 Typology of urban tolls

Due to the relative consensus on the introduction of an urban toll, we propose a typology of this measure focusing on its main issues. Literature identifies the following main issues: loss for captive users (depending income level, value of time, residential location, and modal alternative) and choice of revenues earmarking.

2.2.1 Captive users

Due to the time the issue has existed (1970s) and the growing number of successful toll projects, the issues linked to the introduction of urban toll are subject to several studies.[2] It penalizes some individuals who form a group of losers that require identifying and more or less compensating, in particular when they are captive users. They are considered as captive car users if they can't use modal alternative because of its unavailability or weak availability in particular in terms of schedules, accessibility (time to access to), and travel time. Captive users are more often localized on the outskirts. This need of compensation situates at the heart of the debate the question of how the revenues of the toll systems are assigned.

Following the works started by Richardson [49], many authors have established that the urban toll is a regressive pricing measure [7, 19, 22, 48, 58]. It is regressive because is penalized both the captive users previously described and the disadvantage individuals in terms of income. Sometimes, captive users are also disadvantage individuals. This effect of tolls on low income sections of the population has been the subject of empirical investigations in many cases. Applied to the Bay of San Francisco, Small [58] showed that without compensation, low income groups lost more than the middle income groups whereas high income groups were better off. Although incomes were redistributed on the basis of equality *per capita*, all the groups profited but the low income group profited the most. In the case of the East–west section of the urban boulevard of Lyon, France, Raux and Souche [48] showed how a specific measure to reduce parallel lanes led to the quasi-obligation to pay a toll for the new infrastructure. The improvement of the service rendered, through time savings on the new infrastructure and the transfer of part of the traffic from other links in the conurbation, was not enough to offset the quasi-absence of freedom of choice. Combined with a high toll price, it also had a negative effect on the most disadvantaged users (low income category).

[2] An efficient tariff measure (expressed in terms of time-saving) in the hypothesis that a congestion problem exists.

However, Karlström and Franklin [16] conclude that middle income groups suffer the most when low income class don't drive so much. This result is in line with van den Berg and Verhoef [65]. They underline the need to link the issue of time value to that of delays. In the case of a congestion toll, they show that although the drivers whose time is of the lowest value suffer a loss, this loss is even greater for car drivers who combine an intermediate value of schedule delays and the lowest time value for this schedule delays value.

In the case of Stockholm, Eliasson and Mattsson [14] showed that car drivers who lived outside the conurbation and those who lived in the center would be affected by the introduction of the toll. Emmerink et al. [15] had already demonstrated that urban tolls increase the cost of residences located outside and at the periphery of conurbation and, for certain categories of income, they limit this choice of location beyond the periphery. The impact of the toll is greater for both with low income and weak capacity to adapt. This capacity is further reduced if they travel for work.

This impact of tolling on captive users underlines the necessary discussion on the zones concerned. In particular, the performance of cordon scheme is critically dependent on the cordon location. However, showing that charging points selected by even a simple analytical procedure can achieve economic benefit from around 50 % higher than predefined cordons, May et al. [40] demonstrate the key role of the local transport system and urban planning.

2.2.2 Revenues earmarking

Thus many works underlined the importance of the issue of assigning the revenues of urban tolls that could be used to compensate certain categories of people. Reasoning in terms of partial or general equilibrium leads to differences of conclusion about whether the revenues should remain assigned to the transport sector [57, 59] or be allocated to improve certain types of social aid or reduce taxes [8, 20, 50]. Focusing on the optimal level for public decision making, King et al. [33], Proost and Sen [46] demonstrate that in the case of an urban toll, city should decide on the assignment of the revenues generated from it. Furthermore, city holds the optimal level of decision. The main reason for this, is that it is easier to reach consensus in a city than in a region where interests are less homogenous. Assigning toll revenues to public transport is the key factor of success for this measure. Armelius and Hultkrantz [3] pointed out that the number of winners increases considerably when the quality of public transport is improved at the same time as the toll is implemented. This improvement benefits both those that transfer from private car to public transport and those on the outskirts who already use public transport. Jansson [30] compared the methods and results obtained by different cost-benefit assessments performed on the tolls of London and

Stockholm and concluded that high quality public transport was vital to ensure the success of the toll. However, although the quality of public transport is essential to ensure that users opt for modal transfer, it does not reduce congestion alone [13]. Kottenhoff and Freij [35] observed that Stockholm's public transport system was already quite satisfactory before the toll was introduced. They showed that the installation of direct (faster) bus lines at the same time as the toll, attracted new public transport users coming from car. Furthermore, this additional capacity induces reduction of the in-bus congestion. Finally, Ahn [1] pointed out that the more an infrastructure is congested and the more measures are taken in favor of buses, the more individual well-being can be improved.

2.3 Determinants of votes in the case of urban tolls

As indicated, a first step of voting strategies is to know if individuals should vote (or not). In a second step, if individual decides to vote, his choice will be based either on ideological (against taxation in general) or utilitarian (self-interest) principles, or a mix of both. These determinants of voting are active in the case of urban tolls.

2.3.1 Voting or not?

According to Downs' Paradox a simple cost-benefit calculus leads to a poor electoral turnout. For the charging scheme of Edinburgh, Hencher and Li (2013) notice a turnout of nearly 62 % of Edinburgh residents who vote in a referendum on the implementation of a City centre cordon. The charging scheme was rejected by nearly 75 % of the voters [17]. A frequently observed phenomenon on urban toll is that just before a scheme is implemented, support drops to an all times low. This is a consistent pattern described for Stockholm by Winslott-Hiseliuset et al. (2009), for Norwegian cities by Odeck and Brathen [44] and Odeck and Kjerkreit [45], and for London by TfL [63]. In Manchester, a two-cordon congestion charging scheme was proposed and tested with a local referendum. The level of turnout is more than 50 % (53,2 %) and the scheme was rejected by 79 % of voters.

On the other side are cities in favour of urban toll. In September 2006, the city of Stockholm organised a referendum on its trial congestion charging. The voting percentage is quite important with 76,4 % but the referendum was coupled with the general election. Referendum results give a small majority in favour of keeping the charges: 51.3 % for (243, 055 voters) and 45.5 % against (215,731 voters), with 2 % blank ballots (9535 voters) and 1.2 % invalid ballots (5825) [13, 62]. In June 2011, a referendum was organised in Milan where 80 % of voters supporting a replacement of EcoPass with an extended congestion charging scheme. Even if it was coupled with 4 others referendums, only 49 % of the eligible voters casted their vote. As notice by Henscher and Li (2013) a major reason for Milan's success is that the new congestion charging (Area C) is much simpler compared to its predecessor (EcoPass). Both examples of Stockholm and Milan show that simplicity and effectiveness of the scheme system are a condition to reduce uncertainty and then increase of voters' support.

2.3.2 Ideological determinants of voting

Concerning ideological determinants of voting, literature identifies three main components: trust in government, political affiliation, and distributive concerns.

A reason to oppose congestion pricing is distrust in the stated reasons for its introduction or the use of the proceedings from it (for example see [32]). Even if one understands the economic rationale behind the policy, it is still possible to also disbelieve that the particular politicians in place to introduce and manage such a system will do it properly, and stick to the promises of revenue hypothecation made. And perhaps more importantly, even if one believes that politicians will do as promised, one may still be of the opinion that it is principally wrong for the government to get involved in a particular policy. One may call the former a pragmatic kind of libertarianism and the latter an ideological kind. Regardless of which, they are both associated with a low level of trust in government.

Political affiliation, political left and right, is one of the ideological determinants of voting and often depending of fairness ideology background. If even political organization is different between countries, in London or Stockholm, congestion pricing has been suggested by the political left, and opposed by the right. On the political left, vertical equity (concern for the underprivileged see [48]) is a cornerstone of the ideology. Left leaning politicians who suggest introducing congestion pricing can then perhaps be assumed to subscribe to the notion that, at least in Europe, the net effect of the policy is progressive. On the other end of the political spectrum there is a traditional orientation toward horizontal equity (concern for the principles of allocation of resources and responsibility - user pays principle- or - polluter pays principle-) stressing that costs should be born to a larger extent by the users. This would indicate that the political right should be supporting congestion pricing, as user fees ensure that each person pull a larger share of her own weight. It cannot be denied that the findings related to fairness fit the political landscape poorly. This pertaining to trust in the government, which also aligns well with the left-right scale, work well to explain attitude to congestion pricing. Moreover, as we explain further, the environment problematic have strong explanatory power, and with green parties often ending up left-of-centre, this too offers a

fitting explanation. Thus it appears that in the case of this particular policy, and the political debate in many European cities, it is the attitude to the role of government and to the environment, rather than the fairness of certain allocation principles, that has guided the political parties in their opinion forming.

2.3.3 Self-interest determinants of voting

Another part of the literature shows voting on urban toll can be determined by self-interest [3, 5, 54, 55]. However a clear distinction should be made between sociotropic (welfare effects of the toll on the society to which I belong, via the impact on the environment for instance) and egotropic votes (welfare effects of the toll that I will support directly, via time savings, money loses or benefit from revenue recycling). The amount of money to be paid has a negative influence on the attitude toward the system while urban toll green image has a positive one.

Eliasson and Jonsson [12] show the impact of the environmental concerns as a determinant of attitudes towards congestion pricing in Stockholm. The green self-image of the measure motivates a vote in favor of the scheme. Jaensirisak et al. [29] found also that an ability to achieve substantial environmental improvements was more important for acceptability than the scheme's perceived ability to deliver concerning congestion relief. Earmarking toll revenues to public transport is also an argument for the urban tolls [3, 39]. The number of electors against the measure fell considerably when the toll revenues were assigned to public transport [9].

Jones [31] and Allen et al. [2] have argued that uncertainty over its effectiveness is an important reason for the rejection of congestion charging. More recently on Edinburgh and Manchester cases studies, Hensher and Li [27] confirm that uncertainty associated with the effectiveness of congestion charging influence a vote against this pricing measure. Gaunt et al. [17] show a massive refusal coming from car-users and owners both because they have to pay and because they are not convinced by this measure in reducing congestion and improving public transport. This lack of effectiveness was itself linked to the difficulty for the respondents to clearly understand the toll scheme. This point is useful to understand that familiarity to congestion charging and its effectiveness breeds acceptability.

Jaensirisak et al. [28] examine both sociotropic and ergotic votes on Leeds and London case studies. Results show acceptability is influenced by selfish and social perspectives. They also identify factors influencing selfish and social perspectives. They showed that the toll was more acceptable to non-car users and younger persons, who perceive pollution and congestion as serious problems, consider that the present situation is unacceptable and judge tolls to be an efficient measure (time-saving). In contrast, bus users and those who perceive pollution problems as very serious in their city are more concerned with benefits to society as a whole than benefits to themselves. They also show a difference according to city as the inhabitants of London were more ready to pay than those of Leeds.

Gaunt et al. [17] and Harsman and Quigley [24] analyzed *ex-post* the results of a referendum on the urban toll in Edinburgh, where it was not introduced, and in Stockholm where it was. Harsman and Quigley [24] find that time-saving and increased costs were decisive factors influencing voting intention. In the calculation behind their voting, the respondent trade-off between the time saved by the toll and the additional cost linked to paying it. Furthermore, they show a strong link in voting orientations between political and self-interest motivations, for example between distributive concerns and political affiliation.

This literature review makes it possible to formulate some assumptions that will be tested empirically, in particular: to what extent is a referendum on urban toll reject or not? What are the self-determinants of vote (environmental concerns, toll road efficiency, socio-economics factors)?

3 Data and method of analysis

We first present the data used and then the analysis method.

3.1 The data

3.1.1 The survey

We performed a survey in Lyon during the second half of May 2011. At that date, Lyon Metropolitan Area (Great Lyon), France's second largest city with a city population of 481.000 of inhabitants and a metro area with 2.1 million of inhabitants. The share of population driving daily is 47 % and the share of population with access to at least one car is 77 % (official statistics[3]). Lyon is not a particular city in terms of transport pricing in France. Drivers have to pay excise taxes on oil (nationally fixed), on car purchase (depending on vehicle axle), for getting a driving license (the same for everyone) and to park their car in some dense areas (with a discount rate for handicapped). Each day, 570 000 cars enter through Lyon-Villeurbanne area and 322 000 cars circulate inside this area. Then because of the congestion, the following regulation principle "first come, first served" is used as a reference for private cars.

The sample chosen ($N \sim 1\,500$) was based on quotas controlled by telephone. It was designed to meet predetermined quotas for, among other things, age and gender, thereby

[3] Official statistics: modal share of trips, based on Household Travel Survey 2006 (one day of survey, only from Monday to Friday).

managing the response bias already at the collection stage. In order to ensure a sufficient share of respondents perceiving the survey as relevant, a deliberate bias was also introduced, by oversampling frequent car users and people living inside the hypothetical charging zone, to higher shares than would have been the case in a randomized sample of the population of Lyon. These quotas are representative of Greater Lyon (see Lyon Household Travel Survey, 2006), apart from the zone of residence (50 % lived in the toll zone – 41 % for the observed population - and 50 % outside but within a radius of 15 km from the city center - 59 % for the observed population) and the transport mode (2/3 were car drivers, i.e. 1 000 persons – 47.4 % for the observed population) (see map in Appendix 1). Specific quotas for the zone of residence and the transport mode are used to collect enough information on categories with a suspected high level of rejection (see Emmerink et al. [15], Eliasson and Mattson [17]).

The survey was carried out using a questionnaire administered in France by telephone by the company Enov Research. A total of 10,241 calls were initiated, out of which 53 % picked up to answer. Out of those answering, 37 % agreed to start answering questions after having been introduced to the purpose of the call. Then, as the interview went along, some calls were prematurely terminated, either on request by the respondent, or when the caller system detected that some answer placed the respondent outside one of the predetermine quotas. When 1500 calls had led to a complete survey being answered and all quotas met, the calling was completed.

3.1.2 The questionnaire[4]

The questionnaire was elaborated by all the partners of the Expacc project and carried out in all of the three cities, with some minor local variations. The questionnaire comprises a first part on general attitudes to the principle of regulation, taxation and pricing for transport. The general part included assertions on traffic, transport and pricing. The respondent had to indicate the extent to which they agreed with these assertions by answering according to a scale from 1 (absolutely disagree) to 7 (absolutely agree). They could also express the desire not to answer (NA: No Answer) (see Table 1).

Another part of the questionnaire was focused on attitudes to the introduction of an urban toll (see Table 2) and to a specific cordon charging experiment (see Table 3). For the part relating to the urban toll scenario, we test a cordon charging of 3 Euro a day to enter and circulate within the city center. The assertion was introduced as follows: "One of the ideas studied to reduce car traffic would be to introduce cordon charging around the city, which would entail charging all cars, vans and motorized two-wheeled vehicles that enter and circulate within the city. In Lyon, the zone applicable to the toll would include the central districts of Lyon and Villeurbanne (see the map attached). The principle would be that all car drivers entering or circulating inside this zone would pay a flat rate of 3 Euro a day, or 50 Euro a month, 24/7". Following the literature presented at the beginning of the present paper, questions test the effectiveness of the congestion charging scheme, the presence of a modal alternative, and the distinct impact linked to the level of captivity of the user.

Lastly, we asked the respondent to tell us how they could vote if a *referendum* was held on the introduction of this toll (If there was a referendum on the introduction on this urban toll, how do you vote? Certainly yes, probably yes, probably no, certainly no or No Answer).

The last part of the questionnaire collected socio-demographic data on the respondents (see Table 4).

Furthermore, we must point out some limitations, in our dataset. Firstly, and because it is both difficult to obtain and quite distinct between France, Sweden and Finland (for example conservative party in France is quite different from conservative party in Sweden), in our questionnaire we do not include question about individuals' political habits (do you vote in general? Do you agree with the current local/regional/national action?). Secondly, in particular because we didn't want both to increase time to answer the questionnaire and its complexity, we do not present modal alternatives with real-time information data (location, availability, and price).

3.2 The analysis method

After an overview on general attitudes on pricing based on a standard analysis, our analysis method comprises two steps which need further explanation: in the first step a Principal Components Analysis (PCA) and in the second steps, ordered logit estimation using results coming from the previous steps.

3.2.1 Principal Components Analysis (PCA)

In the case of a survey in which several questions are asked, the Principal Components Analysis (PCA) can be used to group the answers [43, 66]. It describes the structure of the correlations between the variables, in our case the 14 questions asked in the general part of the questionnaire, by providing a smaller number of independent linear combinations [18]. This makes it possible to create a new variable that can be substituted for each of the variables of the sub-groups identified without losing much information.

With 14 items, we haven't large data sets. However PCA method can produce interesting results in a first step. As Golob and Recker [18] write:"It is used to reduce the dimensionality of the data by accounting for redundancy among sets

[4] The full questionnaire can be obtained from the authors.

Table 1 Questions on general attitudes

	Numbers							
	NA (no answer)	1 absolutely disagree	2	3	4	5	6	7 absolutely agree
It is reasonable that flight tickets cost more for peak hours and days in comparison to other times - *flightph*-	30	406 (27.1 %)	183	172	169	225	139	176
It is reasonable that air traffic is subject to a special environmental tax - *flighttax*-	35	158	76	101	149	245	266	470 (31.7 %)
It is reasonable that Lyon Public Transport offers reduced fares outside peak hours - *ptoph*-	16	228	102	120	133	245	220	436 (29.1 %)
It is reasonable that the noisiest cars and two-wheeled vehicles are subject to a special tax on noise - *cartaxnoise*	5	280	95	131	145	215	210	419 (27.9 %)
It is reasonable to fund a new bridge or road by a road toll, levied from those who use it - *tollfinancing*-	24	383 (25.5 %)	153	186	215	245	118	176
If a bridge or road is subject to a toll, it is reasonable to offer a reduction to those travelling at off-peak hours -*tolloph* -	23	245	113	127	141	281	212	358 (23.9 %)
It is reasonable to travel freely on public transport (bus, subway, tram, regional train) to reduce bottlenecks on roads - *ptfree*-	6	201	110	141	169	197	169	507 (33.8 %)
It is reasonable to build new roads in Lyon to reduce bottlenecks on roads - *newroad* -	12	207	121	128	166	247	178	441 (29.4 %)
Bottlenecks on roads are one of the biggest problems in Lyon – *Congestion* -	15	74	77	183	229	342	231	349 (23.3 %)
Car and truck traffic is one of the biggest threats to the environment –*carenvir*-	11	77	71	144	224	354	255	364 (24.3 %)
Taxes are too high in France – *Tax* -	34	99	79	122	147	207	171	641 (42.7 %)
Automatic speed camera are a good way to save lives on the road – *camera* -	6	250	119	150	187	222	183	383 (25.5 %)
Many more means should be used to protect the environment - *moreenvir* -	5	16	18	31	107	223	273	848 (56.5 %)
The public authorities should give priority to reducing disparities between the poor and the rich – *dfisocial* -	30	77	47	95	164	188	211	688 (45.9 %)

of highly correlated traffic flow variables" (p. 55). In our case, the risk of highly correlated responses on general attitudes on regulation and pricing in transport can be anticipated and hence justify the choice of PCA method.

Let $X_{(n*p)}$ be the sample where n represents the observations and p the variables. The observations correspond to the respondents of the survey and the variables to the 14 questions asked on general attitudes to regulation and pricing. These variables are correlated and correspond to the variables to be studied.

The table of initial raw values takes the following form:

$$\begin{array}{cc} & \begin{array}{ccccc} 1 & \cdots & \text{Variables } j & \cdots & p \end{array} \\ \text{Individual} \begin{array}{c} 1 \\ \cdots \\ i \\ \cdots \\ n \end{array} & \begin{pmatrix} & & & & \\ & & & & \\ & \cdots & r_{ij} & & \\ & \cdots & & & \\ & & r_{nj} & & \end{pmatrix} \end{array}$$

r_{ij} is the value of variable j for observation i.

Table 2 Questions on the urban toll

	Numbers			
	NA (no answer)	Increase	Decrease	No change
The number of car trips in the toll zone to enter or leave it would …	23	74	972 (64.8 %)	431
The time spent in bottlenecks in Lyon would …	22	147	798 (53.2 %)	533
The number of users of Lyon public transport (bus, subway, tram, regional train) would …	10	1084 (72.3 %)	69	337
The commercial activity in the toll zone would …	36	149	766 (51.1 %)	549
The quality of life for those living in the toll zone would …	35	737 (49.1 %)	236	492

Table 3 Questions on the urban toll scenario

	Numbers			
	NA (no answer)	Modified in favor of refusal	Modified in favor of acceptance	No change
If the receipts of the toll were assigned to improving Lyon public transport	17	48	399	1036 (69.1 %)
If the receipts of the toll were assigned to improving roads in Lyon	15	105	231	1149 (76.6 %)
If the technical system of the toll ensured the anonymity of the users	41	31	94	1334 (88.9 %)
If people with low incomes were given a reduction of the toll price	20	76	344	1060 (70.7 %)
If a preferential rate were given to the residents of the toll zone of 15 Euro/month (instead of 50 Euro/month)	18	72	344	1066 (71.1 %)
If the toll p.m. only operated from Monday to Friday from 7 a.m. to 8 p.m. for the same price	16	76	192	1216 (81.1 %)
If only those who entered the toll zone paid and not those travelling inside it (i.e. free for those living in the toll zone)	22	95	396	987 (65.8 %)

The objective of the PCA is to find the projected space noted S where the variables are not correlated. This space $S_{(n*p)}$ is a linear combination of $X_{(n*p)}$. Let P be the matrix of the projections $P_{(n*n)}$, thus we can write: S = P*X

Table 4 Socio-demographic characteristics of the sample

General variables	Detailed variables	Coding for ordered logit estimation	Numbers	Percentage
Residential location	Inside the toll zone	1	748	49.87
	Outside the toll zone	2	752	50.13
Gender	Female	1	851	56.73
	Male	2	649	43.27
Age	18–39 years-old	1	682	45.47
	40–59 years-old	2	569	37.93
	60 years-old +	3	249	16.60
Professional Category	Active	1	959	63.93
	Inactive	2	541	36.07
Number of people in household	One person	1	381	25.4
	Two to three people	2	750	50.0
	Four or more people	3	369	24.6
Car use	Rarely or never	1	359	23.93
	At least twice a month	2	126	8.40
	At least twice a week	3	356	23.73
	Every day	4	659	43.93
Type of degree	Other	Withdrawn from the base afterwards	160	10.67
	None	1	89	5.93
	Certificate	2	252	16.80
	A-level	3	265	17.67
	Degree	4	378	25.20
	Master, PhD, etc.	5	356	23.73
Income	Less than 1 500 Euro	1	531	35.40
	1 500 to 2 500 Euro	2	497	33.13
	2 500 to 3 500 Euro	3	162	10.80
	3 500 to 4 500 Euro	4	51	3.40
	More than 4 500 Euro	5	40	2.67
	NA (no answer)	Withdrawn from the base afterwards	219	14.60

The first line of the projection matrix represents a new axis that we denote *axis 1* (see next Fig. 1), in the uncorrelated set. The value resulting from this first line permits creating a new variable. Its variance is the maximum among all the possible choices (i.e. first principal component). In other words, the PCA maximizes the variance of the variables measured, explained by the factors. The second line of the projection matrix has the same properties but without the first Principal Component[5] (see *axis 2*). Lastly, we note that the relative positions are interpreted in terms of correlations on the factorial plane of the variables.

3.2.2 The ordered logit estimation

We complete our analysis with an econometric method to test in greater depth the link between the general attitudes to pricing and a vote in favor of urban tolls. To achieve this we use ordered logit estimation. The results of the survey can be considered as ordinals insofar as they can be values from 1 (absolutely disagree) to 7 (absolutely agree). Consequently, an ordered logit model can be used [41] and provides results on respondents intention. The question on the referendum is the variable to be explained, denoted R. The explanatory variables correspond to the set of 14 questions on general attitudes, denoted Y.

Thus we have: $R = f(Y)$

If Y is the response factor with K levels, then the model is written as follows:

$$P(Y \leq k|x) = \Phi\left(\theta_j - \beta' x\right)$$

with Φ being the normal cumulative function, $\theta_0 = -\infty < \theta_1 < \cdots < \theta_K = \infty$ are the thresholds, x is the vector of the explanatory variables and β is the vector of the unknown parameters. Furthermore, to facilitate analyzing the estimation results, we reduced the number of items from 7 to 3 for the questions on attitudes.[6] In addition, we withdrew from the base all the "NA" and "other" answers which could not be ordered. Finally, the sample remained satisfactory with a size of $N = 867$. This estimation was performed with different packages of the R freeware. Since the coding of the responses varies from 1 (disagree) to 3 (agree), a positive value for a variable coefficient indicates a tendency to consider the respondent agree with the proposal.

To obtain a better estimation, we also used control variables. These variables were chosen because they are significant at the end of the OLS estimation. We therefore estimate that a model comprising the 14 questions to which we added age, level of education and car use frequency.

4 Results and discussion

First we present overview results, then results of the correlations between the different responses, and the projection of the question on voting in a referendum on urban tolls. We then describe this link with ordered logit estimation and, finally, we discuss the results.

4.1 Overview

Preliminary results show results on general attitudes on pricing and urban toll with frequency distribution tables and standard OLS estimation using only socio-economic variables (income, car use, age, places of residence) as explanatory factors to start empirical analysis of the referendum question.

4.1.1 Contradictory attitudes?

Results on general attitudes to the principle of regulation, taxation and pricing for transport are presented in Table 1.

Without surprise, the level of agreement is massive and the highest for general question on using more means to protect the environment, on reducing disparities between the poor and the rich and on the high level of tax in France. While certain types of measures are currently used, like flight tickets more costly for peak hours and days in comparison to other times or road toll for financing new bridge or road, respondents are against in majority. Even if some resist, the majority of the respondents consider automatic speed camera are a good way to save lives, taxes on both the noisiest cars and two-wheeled vehicles and on air traffic are necessary, and that car and truck traffic is one of the biggest threats to the environment. They also consider they need to travel freely on public transport (bus, subway, tram, regional train) or with reduced tickets during off-peak periods. However, in the same time, the majority stays in favor of building new roads in Lyon.

4.1.2 Attitudes on the urban toll: an efficient measure for reducing car traffic

The next part of the questionnaire is focused on urban toll implementation. With the objective of reducing car traffic, we test a cordon charging of 3 Euro a day to enter and circulate within the city center. Results show respondent massively consider this measure would reduce car traffic, improve quality of life for those living in the toll zone and the time spent in bottlenecks in Lyon. In the same time, they anticipate the increase of the number of users of Lyon public transport (bus, subway, tram, regional train). However, they also point

[5] For a more complete presentation, see Yildirimoglu and Geroliminis ([66], p.49-50).

[6] From absolutely disagree to rather disagree recoded as 1 = disagree; neither agree nor disagree coded as 2, from quite agree to absolutely agree recoded as 3 = agree.

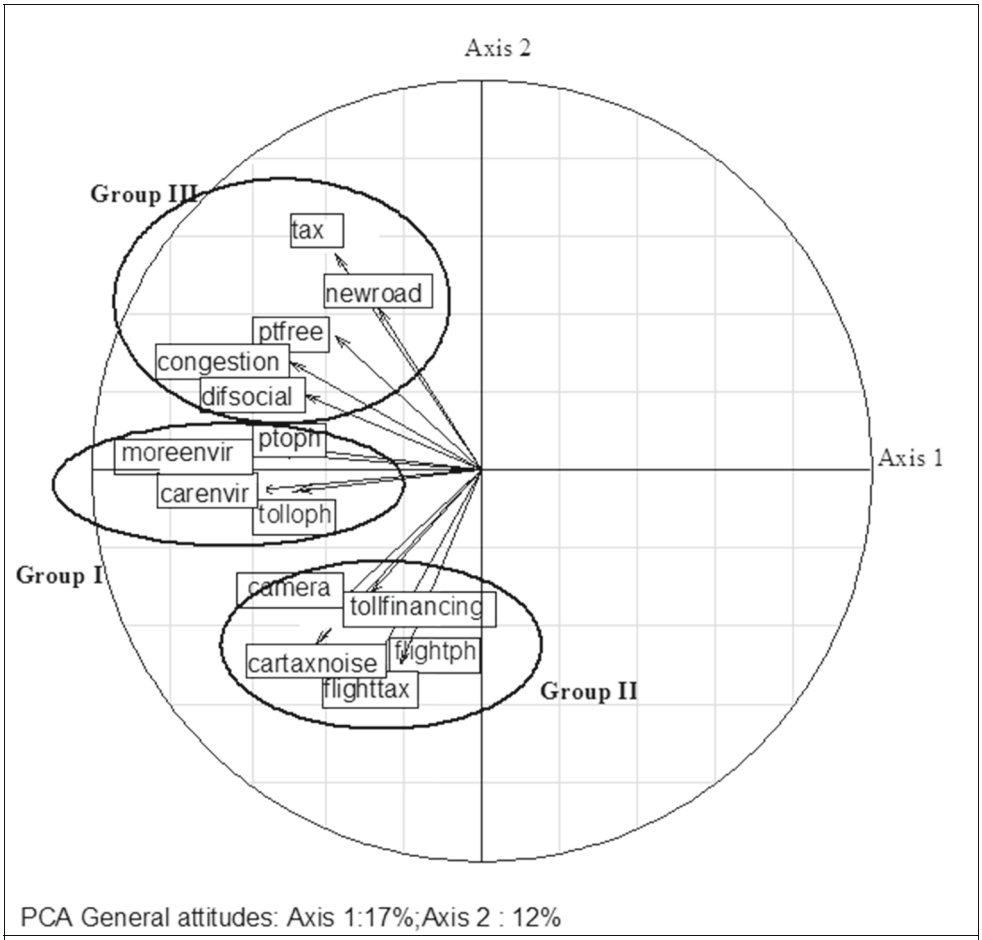

Fig. 1 Circle of correlations for questions on general attitudes

tax : Taxes are too high in France
newroad : It is reasonable to build new roads in Lyon to reduce bottlenecks on roads
ptfree : It is reasonable to travel freely on public transport (bus, subway, tram, regional train) to reduce bottlenecks on roads
congestion: Bottlenecks on roads are one of the biggest problems in Lyon
difsocial : The public authorities should give priority to reducing disparities between the poor and the rich
ptoph : It is reasonable that Lyon Public Transport offers reduced fares outside peak hours
moreenvir : Many more means should be used to protect the environment
carenvir : Car and truck traffic is one of the biggest threats to the environment
tolloph : If a bridge or road is subject to a toll, it is reasonable to offer a reduction to those travelling at off-peak hours
camera : Automatic speed camera are a good way to save lives on the road
tollfinancing : It is reasonable to fund a new bridge or road by a road toll, levied from those who use it
flightph : It is reasonable that flight tickets cost more for peak hours and days in comparison to other times
cartaxnoise : It is reasonable that the noisiest cars and two-wheeled vehicles are subject to a special tax on noise
flighttax : It is reasonable that air traffic is subject to a special environmental tax

out a negative effect of the cordon on the commercial activity in the toll zone (see Table 2).

If the cordon charging was introduced, then we proposed some possible changes: assignment of the revenues of the toll were assigned to improving Lyon public transport or roads in Lyon, the insurance of the anonymity of the users with the toll technical system of the toll, reductions of the toll price for people with low incomes, residents, and a toll only operated from Monday to Friday from 7 a.m. to 8 p.m. The respondents have to pronounce on how these changes could affect their attitudes. Responses to this part of the questionnaire are more surprising as the lack of change is the major response (see Table 3).

4.1.3 Vote on urban tolls: a strong rejection

It was no surprise that our work first shows that the rejection of a referendum on the introduction of a toll is strong (67.5 %). We can moderate this result by the overestimate quota taken for the zone of residence and the transport mode. To examine

this result more closely, and in relation to the literature, we present first cross tabulations between responses to the question on the referendum and the criteria relating to residence and job-study locality as well as to car-use frequency in the zone (Table 5). The works of Armelius and Hultkrantz [3] show these two variables have a significant effect on the results of the vote. Rather unexpectedly, they also show that there is no significant difference in voting according to whether one lives in or outside the toll zone. Furthermore, the differences start becoming more marked when car drivers work inside the toll zone. But this more marked difference can be found as much in favor of a negative vote as that of a positive one. Lastly, unsurprisingly, it appears that the staunchest opponents of the toll are those who enter the toll zone daily.

To investigate more in-depth the relations shown in Table 5, we use now a standard OLS estimation between referendum and socio-economics variables.

4.1.4 A vote linked to age, car user frequency and degree

By treating the regression function coefficients as elasticity coefficients, we estimated a relationship between response to referendum and the explanatory socio-economics variables (residential location, gender, age, job location, income, degree, car use frequency, professional category, size of the household) (see Table 6). To estimate the model's unknown parameters, we use the Ordinary Least Square (OLS) method.

Following the standard literature [21, 38], the model estimated with the OLS method must be satisfied following constraints: the variance of the error is constant (i.e. homoscedasticity or convergence); the error is independent from the explanatory variables (i.e. no multicollinearity), the errors are not correlated (i.e. independent).

The model we estimate is robust in view of the two last constraints. The model is without problem of multicollinearity (*F-statistic: 7.93 on 9 and 1490 DF, p-value: 1.612e-11, with* value of Fisher test (*F*-statistic) higher than 3.37 we can reject the null hypothesis, saying coefficients are different) and with independent errors terms (see values of *t*-student test).

However, the estimated model is subject to heteroskedasticity problem (BP = 20.775, df = 9, *p*-value = 0.01369, *p*-value of studentized Breusch-Pagan test (BP) is smaller than 0.05 - for $\alpha = 5$ %). To deal with, we add a *t*HC test (Student *t* heteroskedasticity-consistent test) [21, 38]. *t*HC results are significant, the model can be retained. However, while the model satisfies estimator properties, the low level of R^2 underlines its weak quality of fit meaning in particular the lack of some explanatory variables. We must remember first that the general objective of the survey is focused on general attitudes on urban pricing and second that OLS estimation is a preliminary step for studying political attitudes.

Results for OLS estimation show response to referendum question significantly and positively correlated to three of socio-economics variables: age, car use frequency and degree level (student test more than 1.96). We use specific overestimate quotas for the zone of residence (50 % lived inside the tolled area against 41 % for the observed population) and the transport mode (2/3 were car users against 47.4 % for the observed population) to take into account a potential rejection effect linked to these variables. However our results do not confirm the effect of residence location, only car users appears

Table 5 Votes, locations, car-users

	Completely against	Rather against	Rather for	Completely for	NA	Total (%)
Location of residence and referendum vote (%)						
Inside the toll zone	22	13	11	5	1	52
Outside the toll zone	20	13	11	4	0	48
Total (%)	42	26	22	9	1	100
Location of job-study and referendum vote (%)						
Inside the toll zone	17	9	9	4	0	39
Outside the toll zone	14	9	7	2	0	32
Inactive	11	8	6	3	1	29
Total (%)	42	26	22	9	1	100
Fréquence utilisation voiture et vote référendum (%)						
Daily	15	5	5	2	0	27
At least twice a week	9	5	4	1	0	19
At least twice a month	5	4	4	1	0	14
Rarely or never	6	6	4	2	0	18
Other	7	6	5	3	1	22
Total (%)	42	26	2	9	1	100

Table 6 OLS estimation and results for *t*HC

	Estimate coefficients	Std. error	t value	Pr(>|t|)
(Intercept)	*0.990009*	*0.216205*	*4.579*	*5.06e-06* ***
Residential location	0.097876	0.058569	1.671	0.0949 .
gender	0.046948	0.054929	0.855	0.3929
age	**0.102725**	**0.042791**	**2.401**	**0.0165** *
profcategory	0.012810	0.018786	0.682	0.4954
householdsize	−0.038836	0.040086	−0.969	0.3328
car use	**0.143701**	**0.024187**	**5.941**	**3.52e-09** ***
job location	0.012235	0.046840	0.261	0.7940
degree	**0.088201**	**0.020511**	**4.300**	**1.82e-05** ***
income	0.003639	0.016697	0.218	0.8275

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Residual standard error: 1.044 on 1490 degrees of freedom

Multiple R-squared: 0.04571, Adjusted R-squared: 0.03994

F-statistic: 7.93 on 9 and 1490 DF, p-value: 1.612e-11

Results for *t*HC test

(Intercept)	residential location	gender	age	profcategory	householdsize
4.5253274	1.6424001	0.8485635	2.3782631	0.6851496	−0.9418642
car use	job location	degree	income		
5.6492772	0.2650504	4.0779579	0.2093391		

significant. Furthermore, our results are more in line with literature in view of the impact of degree on the respondents' answers.

4.2 Three groups of responses

The resulting chart of the plane of variables is given by the circle of correlations (Fig. 1 and PCA detailed results are given in Appendix 2). The first line of the projection matrix represents the axis 1 and the axis 2 represents is the projection without the first principal component. The overall result is not very satisfactory since the variance explained by the first two components makes up only 29 % of the total.[7] The analysis of the correlation results shows that the images are not all very close to the circle, indicating that certain points were not perfectly represented by the plane.

Nonetheless, certain interesting results of the PCA can be emphasized, notably by identifying the groups of variables in opposition to each other. It is first possible to gather the different variables into three groups. The first group, denoted *group I,* is strongly negatively correlated with axis 1 (Fig. 1). This axis is interpreted, on the negative side, as representing pro-environmental values and compensatory type price incentives (make people pay less during off-peak hours). This group appears very consistent with what we found in the literature. Eliasson and Jonsson [12] show a green self-image was one of the most influential determinants of attitudes towards congestion pricing in Stockholm. Jaensirisak et al. [28] find that an ability to achieve substantial environmental improvements is more important for acceptability than the scheme's perceived ability to deliver concerning congestion relief. Axis 2 comprises two groups in clear opposition with each other: *group II and group III* (Fig. 1). This factorial axis is negatively correlated with *group II* and positively correlated with *group III*. This axis opposes the positive side with attitudes against taxes, worries about congestion and social equity, in favor of improving roads and free public transport, versus the negative side with attitudes in favor of strong regulations (speed camera), financing roads through tolls and the taxation of environmental

[7] As we explain, our objective is to extract a limited number of factors to identify new variables while simultaneously discarding as little of the information in the original variables as possible. In the following Table of Eigen values, we can see that the third and the fourth components are both around 9–10 %. Consequently, it is difficult to separate these two components and means we need to take into account fourth axis. We consider that 4 components are not in line with our objective to extract a limited number of factors.

Table of Eigen values (in percentage)

C1*	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
17.21	11.85	9.97	9.03	6.75	6.33	5.62	5.42	5.05	4.92	4.84	4.61	4.37	4.03

*C1 : Component 1

externalities and congestion. The diversity of the composition of these groups makes the analysis less immediate while the ordered logit estimation allows refining their analysis

The analysis of the results of the circle of correlations also shows that all the variables are located on the same side, i.e. on the left hand side, meaning that the respondents more or less agree with the proposals made. How did we obtain such an unexpected result? The main explanation lies in the formulation of the questions. Indeed, eight of the fourteen questions were formulated as follows: "*It is reasonable that …*" and four other questions were assertions (for example, "taxes are too high…"). For the two remaining questions, although more conditional, their general and almost "obvious" nature (for example "Far more resources should be used to protect the environment") encouraged favorable responses, thus situated more on the left of the graph.

However, it was surprising to find on the left side two assertions with which the respondents did not agree, that is to say "toll financing" ("*It is reasonable to finance a new bridge or road by a road toll collected from those that use it*") and "flightph" ("*It is reasonable that plane tickets cost more during peak hours or days than at other times*"). Indeed, as already explained, with three other questions ("camera", "car tax noise" and "flight tax"), they composed a group characterized by the maximal disagreement with transport pricing.

We shall now focus on the projection of the question of voting on the toll and on general attitudes to question of pricing.

Figure 2 represents the average of projections of individuals. The axis 1 represents the pro-environmental value and the pricing compensations. The projections of individuals are located next to the variables for which they have values above the average and opposite variables for which they have values lower than the average. This axis 2 represents preference for regulation. First there is a difference according to respondents' votes (Fig. 2). A monotonous relationship can be seen from for to against, from left to right of the factorial plane and also from the bottom upwards. This positioning of responses on the referendum is consistent with the "map" of attitudes expressed by the factorial plane. Those who voted "absolutely for" or "rather for" are located towards the left, in the direction of pro-environmental values and fare compensations, and towards the bottom, in the direction of strong regulations. On the side of the opponents, only those who voted "absolutely against" can be distinguished clearly, in opposition to the direction of pro-environmental values and that of strong regulations. Jaensirisak et al. [29] and de Groot and Steg (2006) showed this positive effect of taking environmental questions into account on acceptance of a toll. This is also the case of the more recent works of Rotaris et al. [51] on the case of the urban toll of Milan.

4.3 Can the results of a referendum on urban tolls be predicted?

We use now an ordered logit estimation to perform a more in-depth test of this relation between attitudes to pricing and to voting on the issue of urban tolls. The results of the ordered logit estimation relating to the question on the referendum are presented in Table 7. The referendum question is variable to be explained. As we explain at the end of section 3, 14 variables on general attitudes tested with PCA and significant socio-demographic variables are the explanatory variables coming from OLS estimation. For estimating the ordered probit model [34, 64], we use "Mass Package "of the software R [47].

Nine attitude variables have significant influence on the response to the referendum (cf. Student *t* test in Table 7). Those who are in favor of an environmental tax on air transport, a tax on road transport noise and peak hour tolls to finance roads, and who support environmental values and are in favor of speed camera to save lives, tend to vote rather "for" or "absolutely for" a referendum on the toll. As already mentioned, this result highlights the role of environmental concerns, consistent with the literature. The less negative

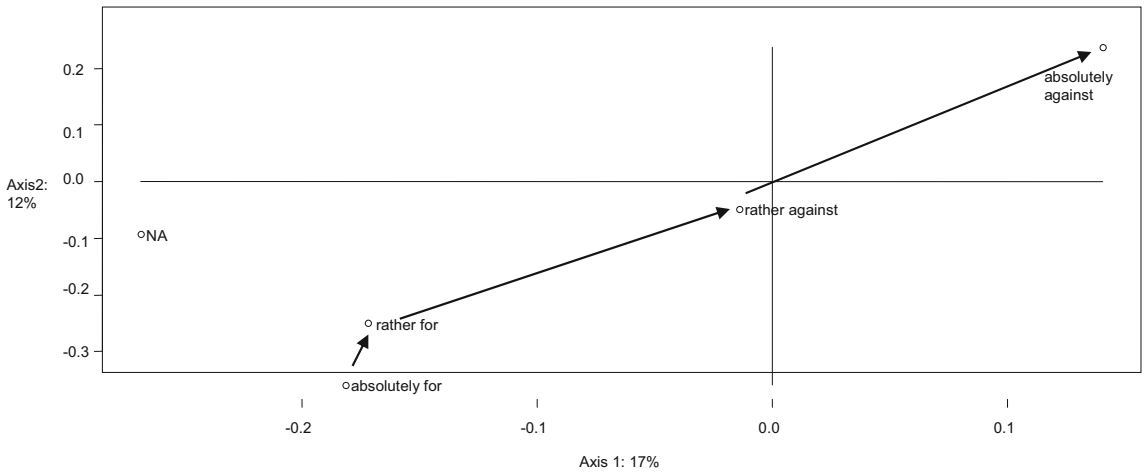

Fig. 2 Projections for the "referendum" variable

Table 7 Ordered logit estimation on the referendum

Coefficients	Value	Std. error	t value
flightph2	0.24348	0.2293	1.06161
flightph3	0.26865	0.1594	1.68516
flighttax2	.02382	0.2797	0.08518
flighttax3	**0.58317**	**0.1928**	**3.02430**
ptoph2	−0.28323	0.2822	−1.00373
ptoph3	0.07166	0.1711	0.41871
cartaxnoise2	**0.64174**	**0.2654**	**2.41828**
cartaxnoise3	**0.78232**	**0.1649**	**4.74385**
tollfinancing2	**0.50294**	**0.2040**	**2.46551**
tollfinancing3	**0.72583**	**0.1612**	**4.50365**
tolloph2	**0.81963**	**0.2697**	**3.03914**
tolloph3	0.25054	0.1717	1.45884
ptfree2	−0.08996	0.2423	−0.37126
ptfree3	−0.08753	0.1636	−0.53494
newroad2	−0.34952	0.2441	−1.43198
newroad3	**−0.59539**	**0.1643**	**−3.62337**
congestion2	−0.01549	0.2329	−0.06652
congestion3	0.15340	0.1813	0.84613
carenvir2	−0.24042	0.2568	−0.93604
carenvir3	**0.42778**	**0.2056**	**2.08091**
tax2	−0.44687	0.2780	−1.60718
tax3	**−0.78590**	**0.1870**	**−4.20200**
camera2	**0.51683**	**0.2343**	**2.20598**
camera3	**0.57051**	**0.1641**	**3.47675**
moreenvir2	−0.06320	0.4329	−0.14599
moreenvir3	0.26089	0.3561	0.73259
difsocial2	−0.05644	0.2686	−0.21015
difsocial3	**−0.49082**	**0.2116**	**−2.31906**
Car2	−0.21047	0.2218	−0.94905
Car3	0.05367	0.2035	0.26378
Car4	0.15316	0.1719	0.89091
Degree2	**−0.89302**	**0.3712**	**−2.40602**
Degree3	−0.49838	0.3626	−1.37445
Degree4	−0.45557	0.3500	−1.30179
Degree5	−0.62054	0.3533	−1.75644
Age2	0.08990	0.1546	0.58157
Age3	−0.12638	0.2003	−0.63110
Intercepts	*Value*	*Std. Error*	
1|2	*0.2801*	*0.5343*	
2|3	*1.5819*	*0.5374*	
3|4	*3.4021*	*0.5499*	
Residual Deviance: 1754.026 AIC: 1834.026			

attitude towards a toll based on reduction pollution objectives indicates a possible path for the introduction of a toll regulated according to the level of emissions of vehicles, in the model of the Ecopass Scheme in Milan [51]. The trend is reversed for those who think that new roads should be built to combat bottlenecks, that taxes are too high in France, or that the reduction of disparities between the rich and the poor should be a priority. The analysis of those groups is less obvious. Nonetheless, we hypothesize that these responses are examples of the link between voting intention and the quest for personal interest. In our case study, a rational and self-interested driver would only support congestion pricing if revenue from the system is spent on something valued by him. In the 2005 referendum on congestion pricing in Edinburgh, Gaunt et al. [17] find that car drivers are significantly more prone to voting « no » than non-car drivers. The correlations are less significant for the five remaining questions.

The results of the ordered logit estimation on the question of the referendum (**variable to be explained**) are given in Table 7 (**see significant explanatory variables in bold text**).[8, 9]

Lastly, among the socio-demographic variables present in the estimation, only that of having a university degree remains significantly correlated with the question on the referendum which is in line with the results of Jaensirisak et al. [29]. Less well-educated respondents tend to vote no to the referendum on the toll. This effect of education on the attitudes of individuals is a relatively classical result. Harsman and Quigley [24] showed that a large fraction of residents with a post-secondary education were more favorable to the referendum. Souche et al. [60] highlighted significant differences in attitudes to tolls as a function of the level of degree of the person questioned. For example, especially among diploma holders, the non-working people perceived all the regulatory rules proposed as unfair and were more adamantly against the urban toll.

5 Concluding remarks

Despite the many works in the literature on the introduction of new pricing measures such as urban tolls, few focus on their political dimension. We sought to better understand the *ex-ante* determinants of a vote in favor of a referendum on a possible urban toll. This issue is topical at present in France since the law known as “Grenelle II” (2010) authorizes conurbations with more than 300,000 inhabitants to experiment with urban tolls.

Regarding the question specific to the referendum, we first showed that it would be rejected by electors. We can moderate

[8] Note 1: Coding is as following: flightph2 (neutral) is compared to flightph1 (in disagreement) which serves as item of reference. flightph3 (in agreement) is also compared to flightph1 (in disagreement. A positive value for a variable coefficient indicates a tendency to consider the respondent agree with the proposal (vote “for”). A negative value indicates a tendency to consider the respondent disagree with the proposal (vote “no”).

[9] Note 2: polr() is the fitting function for the MASS package. Model fit is given by AIC (Akaike Information Criterion) which is a measure of the goodness of fir that takes the number of fitted parameters into account; AIC = −2*log L + k*edf With L the Likelihood and edf the equivalent degree of freedom of fit, k the weight of the edf.

this point by the specific quotas we take for two variables, but the unbalance in favor of rejection is validated. This result is in line with that of Jaensirisak et al. [28] and also with what occurred in Stockholm at the end of the trail [13]. Our results highlight a significant link between the attitudes to control by legislation or by taxes and transport pricing on the one hand, and the attitude to a referendum on urban tolls on the other.

In a first step, even if the number of items is quite small, we apply PCA method to identify common variables between several questions. Then, we use projections for the "referendum" variable which allow to clearly separating the pros and cons an urban toll scheme: those who voted "for" a road pricing scheme are both in favor of pro-environmental values, fare compensations and strong regulation; on the opposite those who voted "against" do not support pro-environmental values, fare compensations, and strong regulation. In a last step, we use ordered logit estimation to test in particular socio-demographic variables influencing voting intention. Results show that only of having a university degree remains significantly correlated with the question on the referendum: less well-educated respondents tend to vote "no" to the referendum on the toll.

Moreover, our results confirm that individual self-interest matters a lot in political attitudes (e.g. how much one drives, how many cars one has, what is my value of time), but that other types of motives also matter strongly (e.g. environmental concerns, whether one thinks taxes are too high). As a consequence, a real-life political analysis cannot be limited to classical "economic" variables, even if they matter too obviously. Lastly, our results should be placed in relation with those concerning the more global issue of the acceptability of a new pricing measure through, for example, that of the compensation to be implemented.

Obviously, it is to be hoped that the results obtained by researchers do not end as so many cries of Cassandra, whose predictions went unheard, since the risk of rejection of a possible referendum would be both financially and politically costly for local authorities whose financial resources are now greatly limited.

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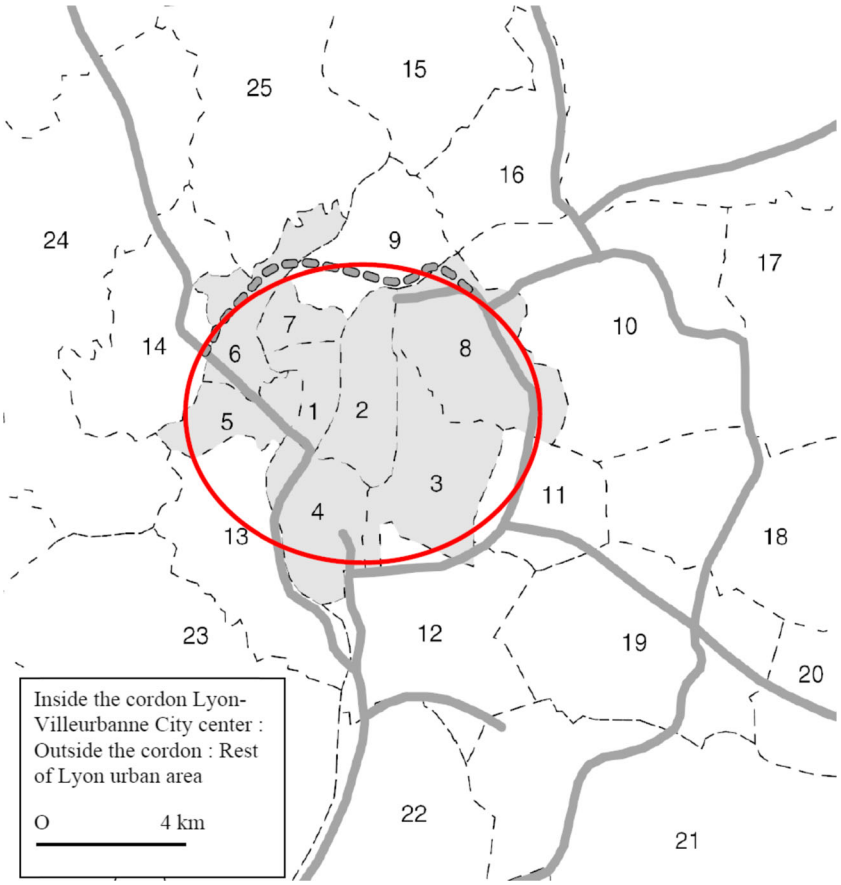
Appendix 1



The toll zone represents a target population was the one living in a radius of 15 km around the center of Lyon (1,234,843 persons).

Appendix 2

Principal component

Column normed scores	CS1	CS2	CS3	CS4	CS5
Percentage of original variance	17.21	11.85	9.96	9.03	6.75
flightph	−0.3243037	−0.93773102	−0.70263420	−0.35888382	−0.02704178
flighttax	−0.3046202	−0.66828472	−0.54235353	−0.19852254	−0.27314240
ptoph	−0.4451506	0.06383313	−0.47224183	0.57041298	0.21060132
cartaxnoise	−0.3463386	−0.43708789	0.07591123	0.19224322	0.26233656
tollfinancing	−0.1730574	−0.23388032	−0.29579629	0.15775089	−0.60288379
tolloph	−0.2790612	−0.03925360	−0.29366739	−0.32178073	0.17629970
ptfree	−0.1891979	0.20935908	0.12073194	−0.32389822	0.02254140
newroad	−0.1295326	0.24404690	−0.26215386	0.18582865	−0.27369263
congestion	−0.2239202	0.15172279	−0.01028211	0.22947814	0.17985106
carenvir	−0.2542904	−0.02874725	0.13977748	0.18357313	0.16053925
tax	−0.1639006	0.29059408	−0.07167798	0.13634658	0.02004502
camera	−0.1544854	−0.17304447	−0.06581128	0.21712315	0.09299406
moreenvir	−0.2066786	0.01962530	0.25051098	0.01544969	−0.09953978
difsocial	−0.1646900	0.08414749	0.18596374	−0.12987156	−0.22729593
	CS6	CS7	CS8	CS9	CS10
Percentage of original variance	6.33	5.62	5.42	5.05	4.92
flightph	1.04328370	1.21236423	−0.17436517	0.33425478	−0.99252333
flighttax	0.54768473	0.05673966	0.11040773	0.04222731	0.93163499
ptoph	−0.09017578	0.04160436	−0.16412440	−0.18161677	0.43473993
cartaxnoise	0.23646090	−0.83406130	0.14822577	−0.22725172	−0.12227405
tollfinancing	−0.05349749	−0.22765166	−0.20969185	0.17833343	−0.06712481
tolloph	−0.30115802	−0.09252558	−0.11899480	−0.09645145	0.04003772
ptfree	0.21607484	−0.07857340	0.41018061	0.25747287	−0.12821021
newroad	0.13962712	0.03942181	0.30745197	−0.16470476	0.17187116
congestion	0.24767709	0.04549915	−0.12127779	−0.31920858	−0.16186235
carenvir	−0.07337946	0.01806359	−0.13181854	0.33079669	−0.01545578
tax	0.29897599	0.17169990	0.35990163	0.03410379	−0.02125591
camera	−0.29897599	0.17169990	0.35990163	0.03410379	−0.02125591
moreenvir	−0.07843391	0.23265041	−0.10251417	−0.16259850	0.10599742
difsocial	−0.13857000	−0.04787078	−0.01040128	−0.07815296	−0.25795325
	CS11	CS12	CS13	CS14	
Percentage of original variance	4.84	4.61	4.37	4.03	
flightph	0.628174817	0.17799553	0.29051671	0.065399422	
flighttax	0.144535288	0.03009386	−0.76702543	−0.102559864	
ptoph	−0.26539146	−0.18670620	0.11802665	0.879798520	
cartaxnoise	0.354019827	−0.03933175	0.44781230	0.102271650	
tollfinancing	−0.369378020	−0.22261507	0.01630622	−0.107478917	
tolloph	0.119196719	0.18636573	−0.13563271	−0.541488233	
ptfree	−0.253740516	−0.13258668	0.08812982	−0.159124173	
newroad	0.093872298	0.36463215	0.08032166	0.007831401	
congestion	−0.218147542	−0.12045085	−0.26245356	−0.065553746	
carenvir	−0.185219414	−0.39217658	0.01710201	0.097057240	
tax	0.349074903	−0.25098342	−0.03658406	−0.018507649	
camera	0.028662253	−0.19458680	−0.10487780	0.044915960	
moreenvir	−0.008473403	−0.09368542	0.35211272	−0.131469161	
difsocial	0.163860405	0.05995749	−0.17206137	0.163278361	

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