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▶ **To cite this version:**

Stéphanie Souche, Charles Raux, Yves Croissant. On the perceived justice of urban road pricing: An empirical study in Lyon. Transportation Research Part A: Policy and Practice, 2012, 46 (7), pp.1124-1136. 10.1016/j.tra.2012.01.009 . halshs-01026420

HAL Id: halshs-01026420
https://shs.hal.science/halshs-01026420

Submitted on 5 Nov 2014

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Published in: Souche S., Raux C., Croissant Y. (2012), "On the perceived justice of urban road pricing: An empirical study in Lyon", *Transportation Research Part A: Policy and Practice,* Vol. 46, n°. 7, p. 1124-1136. Doi 10.1016/j.tra.2012.01.009.

On the perceived justice of urban road pricing: an empirical study in Lyon

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Abstract

Various methods of restricting automobile traffic, by price (tolls) or by quantity (odd/even license plates or limited days of traffic), are tested in a survey (N~400) about attitudes toward traffic restrictions in Lyon, France. Ordered probit models with a random-effects panel allow us to estimate the survey respondents' perceptions of these methods, as well as the roles of individual socio-demographic characteristics in the formation of these perceptions. Both the restriction of automobile traffic and its regulation by congestion (waiting in line) are widely considered unjust by the respondents, regardless of whether they work and whether they are drivers or non-drivers. Their attitudes towards tolls justified by the pollution caused by automobile traffic are less negative. As regards compensation, in addition to emergency vehicles and those that transport people with limited mobility, respondents believe car-pooling ought to benefit of a toll exemption. The support for a reduced rate for low-income users shows a concern for justice to which it will be necessary to respond. The respondents' socio-professional status, level of education, car use or non-use, and residence inside or outside of the toll zone clearly play a role in their perceptions of these methods of regulation and compensation.

Key-words: urban road pricing, justice, attitudes, ordered probit with random-effects panel

Classification J.E.L.: R41, R48, C35

Introduction

London, Stockholm or Milan are signature examples of the recent implementation of urban road user charging (for London, see Santos and Fraser, 2006 and Leape, 2005; for Stockholm, see Eliasson, 2008; for Milan, see Rotaris et *al.*, 2010). These implementations represent the concrete realisation of relatively old economic ideas, such as the use of price (or taxes) to regulate the consumption of, or access to, scarce resources (Pigou, 1920), through the use of road tolls to effectively regulate congestion (Walters, 1961; Vickrey, 1963).

Following these examples, other cities around the world plan to implement similar regulatory schemes. However, at the same time, many advanced urban toll projects have been rejected by the resident populations through *ex-ante referenda*, such as those in Edinburgh and Manchester (Riley and Gjersoe, 2006), or other political processes, as in Manhattan (Schaller, 2010).

The evaluation of the costs and benefits that result from changes (Prud'Homme and Kopp, 2005; Mackie, 2005; Santos and Bhakar, 2006; Jansson, 2008; Eliasson, 2009) is necessary to understand this question of acceptability. However, acceptability is a more complex notion which remains subject to debate (Marccucci, 2001 and for a survey see Schade and Schlag, 2003). A part of this debate is focused on the question of justice. Authors are interested in analysing the distribution effects of road pricing (see Richardson, 1974; Small, 1983; Cohen, 1987; Giuliano, 1992; Gomez-Ibanez and Meyer, 1993; Bureau and Glachant, 2008). They evaluate and compare the progressivity of different road pricing schemes and identify "winners " and "losers" groups. Without compensation mechanisms, Small (1983) or Giuliano (1992) show that low income category loses most with a road pricing measure. More recently, Ramjerdi (2006) and Karlström and Franklin (2009) use Gini and Theil indicators to point out an increase of income dispersion after road pricing implementation.

The perceived justice of a situation is also important to understand people attitudes. Konow (2003) proposes a positive theory of justice based on principles of justice. The literature on principles of justice is vast and clearly exceeds the strict question of transportation (Kahneman et *al.*, 1986; Zajac, 1995; Young, 1995; Raux et *al.*, 2009). However after a broad literature review, Konow concludes that perceptions of justice depend on the context, which includes the nature of the good to be shared and the individuals' personal characteristics, values and beliefs, but also what is normal, customary and expected in the type of situation in question.

Following Konow, we want to understand this perception of justice in the road pricing case study. Thus, the persistent resistance to regulation by prices leads us to examine why the implementation of an urban toll was perceived as unjust and whether direct compensation, in specified forms, would receive the support of the population. To our knowledge, only Baron and Jurney (2003) and Eriksson et *al.* (2006) works tackle this issue using this justice perception but without reference to justice principles.

The basis of our study is an opinion survey of around 400 people in the Lyon metropolitan area of France to whom we present a potential toll situation in the city centre. We conduct an in-depth econometric analysis of different methods of regulation by quantities or by queuing to see if they receive more support than pure price regulation. Different forms of compensation are also considered.

Our results show that restriction based on price or quantity is generally considered unjust. At the same time, urban tolls are considered less unjust if they hold automobile drivers responsible for reducing pollution. Moreover, there are significant differences depending on the employment statuses of the respondents (working/non working), their socio-professional statuses, their educational levels and their use or non-use of automobiles. We also demonstrate the existence of a "moral" or "ethical" dimension of the compensation, which is clearly distinguished from other aspects of compensation and plays the role of a true "reference transaction" (Kahneman et *al.*, 1986). Finally, our results shed light on the factors involved in the acceptance of tolls.

It seems indispensable for us to proceed first with a literature review, which enables us to formulate the questions that we then test empirically with a survey. Second, in the methodological section, we present the survey, the questionnaire and the ordered probit model with random-effects panel. Finally, we present and discuss the results of this analysis.

1. Literature review and questions

Perceptions of the justice of various methods of allocating scarce resources were tested empirically by Frey and Pommerehne (1993), using water as an example. These authors show that the rules of allocation by price are considered less fair than a bureaucratic procedure (in which the administration performs the allocation on the basis of its own judgement) but more fair than allocation by lottery. The queuing method is considered the fairest.

Conversely, Taylor et *al.* (2003) show that in the absence of a price system, a lottery is generally more acceptable than the queuing method. In accordance with the economic theory of bureaucracy (Niskanen, 1971), the bureaucratic procedure is considered especially intrinsically unjust.

By exploring situations of scarce parking spaces or seats on a train, Raux et *al.* (2009) show that regulation by price is still overwhelmingly rejected. They find that the order of preference of regulation methods, from the most to the least fair, is as follows: queuing and peak pricing with an additional service (seats on a train or additional parking spaces), peak pricing with a constant level of service, administrative allocation, and assignment by lottery. However, this study confirms the influence of context, notably depending on the type of good being studied, on the perception of these allocation methods.

Therefore, it seems essential to test these regulation methods in the specific case of transportation and urban tolls (Question 1).

Question 1: To solve a problem of excessive demand in urban transportation, is regulation by queuing or a quantity control considered fairer than regulation by price control?

For Kahneman et *al.* (1986), injustice occurs when the exchange no longer considers the "reference transaction," such as when the exchange consists of rules that are largely used in commercial or administrative organisations, like waiting in line ("first come, first served"), or when priority is given in these lines to pregnant women or to handicapped people. The exchange can also consist of "reference prices", that is to say current prices observed in the market.

Meanwhile, Vaidyanathan and Aggarwal (2003) and Bolton et *al.* (2003) show that an offer of an additional service that justifies the price increase can change the negative attitudes that formed response to the reference transaction. Raux et *al.* (2009) likewise show that

accompanying the price increase with an additional service can reduce opposition in cases involving certain goods, such as parking spaces or seats on a train.

So it seemed interesting to see whether the proposal of additional supply which justifies the price increase can modify attitudes to allocation by prices (Question 2).

Question 2: Can the addition of an extra service tied to the price increase cause the price increase to be perceived as more just in the case of urban tolls?

The question of compensation is at the forefront of this issue. It has been established since the works of Hicks (1939) and Kaldor (1939) that, in the context of standard cost-benefit analysis, compensation can justify a policy as long as the benefits accorded to the winners are greater than the losses of the losers. Thus, in theory, effective compensation could counterbalance the perceived injustice of a price-based regulation mechanism.

Frey and Oberholzer-Gee (1996), however, are critical of the use of compensation. In a situation where the debate relates to the installation of equipment not desired by neighbours, such as nuclear waste, Frey and Oberholzer identify four principal reasons for opposition to compensation. First, the direct and visible transfer of money can be perceived by the neighbours as a bribe. In this case, the compensation reinforces the local opposition. Second, the explicit monetary compensation can also be considered an implicit admission of the risk imposed by the installation and could lead to demands by the neighbours for an unreasonable level of compensation. Third, the neighbours may equate acceptance of monetary compensation with accepting a certain status quo. In other words, it may give the impression that the parties have reached an agreement even when the neighbours consider the measure unjust. Finally, if citizens would otherwise have accepted an unwanted installation out of social obligation, the offer of monetary compensation undermines the neighbours' sense of civic duty and reduces the possibility of such acquiescence. Frey et *al.* (1996) show that the compensation mechanism is incomplete because it ignores the influence of moral principles. When public spirit prevails, monetary compensation for nuclear waste installations is less acceptable because the monetary reward deprives individuals of the opportunity to yield to altruistic sentiments.

From the works of Zajac (1995), one can identify different principles of positive justice. For example, economic rights dictate that no one can receive less than a minimal sum to satisfy his basic economic needs (Konow, 2003). Under these circumstances, the denial of basic economic rights is considered unjust. In addition, when circumstances permit, equal distribution according to the principle of equality of rights and pains provides an element of justice.

Based on the principles stated by Rawls in his theory of justice (1971), Raux and Souche (2004) developed a framework to analyse the acceptability of price changes in the transportation sector that combines economic efficiency with three dimensions of equity: vertical equity, which directs attention to the most economically vulnerable people; horizontal equity, which divides cost among payers and users of transportation and among users of different modes of transportation; and territorial equity, which refers to guaranteed access to amenities and the freedom to come and go.

So the third question relates to the compensation proposed (Question 3).

Question 3: Are the different forms of compensation proposed—compensation as a function of revenues, of location, of professional activity, or of mobility practices—considered fair?

In studying the principles of regulation and compensation, it is important to establish whether people's economic situations affect their attitudes toward justice. According to Sah (1987), the

poor would gain more through the use of rationing, and the rich benefit more from regulation by the market. In Stockholm, Armelius and Hultkrantz (2006) show that the middle income classes who use the car and who live on the outskirts of Stockholm lose the most when a toll is introduced. For Eliasson and Mattson (2006), the impact of a toll on this population category would increase as their incomes and capacities to adapt decrease. Their capacities to adapt depend on their travel purposes. The work purpose allows them the least latitude.

Furthermore, agents can be strategic in their response. Hurd et *al.* (1998) point out the strategic misrepresentation of the respondent when he anticipates a possible link between his response and some economic outcome in which he has an interest. In our survey, agents will be strategic because we present them with a road pricing scheme they will have to pay and which is quite close to their situation. We don't want to deny this bias: we want to get more information about this strategic behaviour in particular in relation with the respondent own situation.

This review of the literature on urban road pricing shows that working people are the most penalised by the introduction of urban tolls. This penalisation occurs whether the workers live inside or outside the toll zone and regardless of whether they are in management positions. In other words, it seems that whether an individual works is the most discriminating variable in determining her perception of the toll. We hypothesise that this result will also be valid in the case of Lyon. This drives us to Question 4.

Question 4: Do the attitudes of the respondents vary as functions of their personal socio-economic situations?

The questions that we have just presented were the subject of the empirical investigation based on a survey that we shall now describe.

2. Methodology, survey and econometric model

2.1 The survey and the questionnaire

The survey comprised face-to-face interviews of 401 people, a representative sample of the inhabitants of the Lyon metropolitan area (whose total population is 1.2 million) in January 2003. Respondents were randomly chosen according to the quota method (place of residence, age classes, gender and employment status) representative of the city of Lyon. Acknowledging that increased automobile traffic in large cities poses more and more serious problems, including congestion, pollution, noise and lack of safety, researchers suggested introducing a toll for driving in the city. That is to say drivers who travel inside the toll zone have to pay. It is important to note that such a transportation policy measure was not being debated publicly in Lyon or in France at the time (see the questionnaire in Annex 1). Furthermore, 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). Then because of the congestion, the principle "first come, first served" is the reference for private cars.

The literature review has enabled us to identify relevant question. We want to test these in a real situation. We detail and adapt these questions to a familiar situation for people and then test them empirically with the survey. London and others urban congestion pricing experiences give us a useful help to translate relevant question into more familiar ones (see

Santos, 2004). Although fictional, the story described situations, which were grounded in reality. Different methods for solving problems of congestion or of pollution (*i.e.*, of excessive demand) were proposed, as well as different forms of compensation in case of road pricing; for each of the solutions, respondents were asked whether they found it very fair, rather fair, rather unfair or very unfair (see Annex 1).

The following regulation methods were presented to the respondents:

- Queuing (or "first come, first served" procedure) is the traditional management method. It entails allowing automobile transport to regulate itself based on the level of traffic ("Queuing") (see Question 1 in the previous literature review).
- Two methods of regulating by allocating quantities fixed by the administration were proposed: administrative rule 1, limiting cars to driving three days of the driver's choice per week between Monday and Friday ("3 days"), and administrative rule 2, allowing cars to drive only every other day, with days assigned according to their license plates ("Odd/Even") (see Question 1).
- "Peak pricing with a constant level of service" is the classic method recommended by economists that reflects the scarcity of resources. This method involves charging a toll, either in peak periods ("Peak pricing"), or to hold drivers accountable for the pollution resulting from the automobile traffic ("Pollution") (Question 1).
- Offering a new supply, e.g., new roads financed by toll revenues, is a variation on peak pricing ("New road") (Question 2).

The methods of compensation in the case of urban tolls are the following:

- Low income compensation consists of lower toll rates for those with the lowest incomes ("Low income rate") (Question 3).
- Compensation for residents consists of lower toll rates for people residing within the toll zone ("Resident rate") (Question 3).
- Compensation for professionals consists of lower toll rates for users who need to travel for their professional activities, for example, artisans ("Business rate") (Question 3).
- Exemptions from tolls were granted for people with low mobility ("Handicap"), drivers of carpools ("Carpool"), and emergency vehicles ("Emergency") (Question 3).

2.2 The econometric model

The responses to the survey can be viewed as ordinal since they are assigned the values 1 (very unfair), 2 (unfair), 3 (fair), and 4 (very fair). Thus, the statistical model used here is an ordered probit model (McCullagh, 1980).

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

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

where Φ is the cumulative normal function,

$\theta_0 = -\infty < \theta_1 < \cdots < \theta_K = \infty$ are the thresholds,

x is the vector of explanatory variables, and β is the vector of unknown parameters to be estimated.

As each individual responds to a series of questions related to his perceptions of justice (one for each regulation or compensation rule), a fixed effect model can be developed. However, because of the problems presented by the incidental parameter, this fixed effect model cannot be estimated. The use of a conditional probit model could solve this problem, but again, the individual variables would disappear in the specification. The introduction of a random effect circumvents this problem (Butler and Moffitt, 1982). For this reason, we shall estimate an ordered probit model with random panel effects, using the "pglm" package (Panel Generalized Linear Model) of the software R (2010).

In total, 401 individuals were questioned: each individual gave an opinion of each of the six methods of regulation and the six methods of compensation, so for each of the two categories, up to 2,406 observations could be collected, including the missing values. As we use a face-to-face questionnaire, the number of missing values is weak (it varies between 1 for "3 days", "Business rate", "Handicap", "Emergency" to 5 for "Carpool").

The characteristics of the sample are presented in Table 1.

Table 1 : The socio-demographic characteristics of the sample

Socio-demographic characteristic	Definition	Percentage (%)
Sex	1=male	47
	2=female	53
Age	1=less than 30 years	28.5
	2=between 30 and 39 years	19.5
	3=between 40 and 49 years	18.5
	4=between 50 and 59 years	13
	5=60 years and over	20
Holding a driver's license	1=yes	84
	2=no	16
Education	1=no diploma	8.5
	2=lower certificate	29
	3=A level	24
	4=bachelor	18
	5=postgraduate diploma and over	16
Socio-professional category	2=small businesses and retailers	6.5
	3=managerial and other top level professionals	12
	4=intermediate-level professionals	9
	5=lower-level employees	28
	6=blue-collars	6
	7=retirees	19
	8=students and housewives	19
Residential location	1=inside the toll zone	52
	2=outside the toll zone	48
Mode of transportation	1=exclusive user of public transportation (bus, train, metro, tramway)	20
	2=exclusive car user	36
	3=other (walking, car+public transport, bicycle, car+train, motorcycle, bicycle+public transport, bus+public transport+car, car+motorcycle)	44
Location of employment	1=employment inside the toll zone	35
	2=employment outside the toll zone	34
	3=not applicable	31

As the income question has a high level of non-responses (see Riphahn and Serfling, 2005), we only have indirect information on this point based on the level of education and profession.

3. Results and discussion

Even if, in reality, the questions of regulation and compensation have a mutual influence, we want to study them separately. From the perspective of the analysis, the questions of regulation and compensation do not relate to the same concerns. Without a separate treatment, an important risk was to underestimate or miss this difference. Regulation is motivated by an objective of economic efficiency, compensation by one of justice. This difference in objectives justifies their separate treatment. It's not a hypothesis but a way to present results.

For both the regulation and compensation situations, we first present a global analysis of the perception of the underlying methods, and we then analyse the influence of individual socio-demographic variables on the perceptions of these methods.

3.1 Perception of the methods of regulation

a) Overview

Table 2 gives an overview of the perceptions of the methods of regulation.

Table 2: Perceptions of the methods of regulation

Regulation method	Question	% fair or very fair
Peak pricing with a constant level of supply	To hold people responsible for traffic jams, drivers must be charged a toll during peak hours "**Peak pricing"**	22%
Administrative rule 1	To reduce the automobile traffic, cars must be limited to driving only every other day, depending on whether they have even or odd license numbers "**Odd/Even"**	32%
Peak pricing with additional supply	If the money will be used to expand or build new roads, drivers can be charged a toll "**New road"**	34%
Administrative rule 2	To reduce automobile traffic, cars must be limited to driving only three days per week, of their choosing, between Monday and Friday "**3 days"**	35%
Queuing	Automobile traffic must be allowed to evolve; people will naturally adapt "**Queuing"**	35%
Pollution pricing	Drivers must be charged a toll to compensate for the pollution they cause by driving "**Pollution"**	37%

Regulation by pricing at peak hours ("Peak pricing") is considered the most unjust. We therefore use it as the reference method to which we compare the other methods.

b) The influence of socio-demographic variables on perceptions of the regulation methods

The fact that an individual works and the demands that imposes on mobility—especially car mobility—suggest that the attitudes of this category of people will be different from those of the rest of the population. We test this hypothesis to estimate separate models for working and non-working people (retirees, students and homemakers). We reject the hypothesis of

stability; in other words, the two models (working and non-working) are different (p-value close to 0, cf. Table 7 in the Appendix 1).

We consider the effects of socio-demographic variables on perceptions of the regulation methods by both working and non-working people. After several trials (Student test, 5% critical probability, *t-value* > 1.96), a certain number of significant socio-demographic variables are selected, which we then seek to simplify. A likelihood test, which compares a model based on the simplified socio-demographic variables with a model containing the non simplified variables, shows that one cannot reject the null hypothesis of identical models as to either working or non-working people (cf. Table 8 and Table 9 in Appendix 1).

For the working people, the variables of age, socio-professional category and mode of transport are simplified in the following way (Likelihood test): a group of people over 30 years old is compared to those under 30 years old; a group of small businesses and retailers, intermediate professionals and workers is compared to a group containing managers and lower-level employees; the exclusive automobile users are compared to the users of other modes of transportation.

Our results (cf. Table 3) show that managers and employees perceive all the proposed regulation rules more favourably, whereas the reverse is true for exclusive automobile users. These results also show that only the principle of paying for pollution is significantly more accepted than all the other regulation methods. These solutions are rejected, matched by the reference principle, *i.e.* -the peak pricing.

The standard deviation of random effect is highly significant (see *Sigma*), which justifies *ex post* the use of a random effects model.

Table 3: Perceptions of regulation methods by working individuals (ordered probit model with random-effects panel)

Variable	Coef.	Std.error	t value	P (>t)
Constant	0.08	0.125428	0.6514	0.514766
Under 30	0.13	0.107336	1.2172	0.223523
Managers and employees	0.32	0.100124	3.2065	0.001344 **
Exclusive automobile users	-0.26	0.096185	-2.6756	0.007460 **
3days	0.15	0.104460	1.4703	0.141493
Odd/even	0.06	0.105425	0.5815	0.560891
New road	0.05	0.104495	0.4540	0.649854
Pollution	0.22	0.104406	2.1010	0.035644 *
Queuing	0.17	0.104260	1.6449	0.099989
Threshold parameters for index model				
Mu(01)	0.89	0.039795	22.4147	<2.2e-16 ***
Mu(02)	2.01	0.065400	30.7112	< 2.2e-16 ***
Std. Deviation of random effect				
Sigma	0.78	0.071886	10.7853	< 2.2e-16***
Log Likelihood function	- 1676.525			
Hessian	98.1934			
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

For non-working people, the simplification of socio-demographic variables distinguishes those who have drivers' licenses from those who do not, and those who have diplomas from those who do not.

The results show (cf. Table 4) that for non-working people, those who have diplomas perceive all the proposed regulations as more unfair. Conversely, non-working people who do not have

drivers' licenses perceive the proposed regulations as more fair. In addition, for non-working people, tolls for constructing new roads or for fighting pollution are judged as significantly fairer than simple peak pricing.

In this instance, the standard deviation of random effect is again highly significant (see *Sigma*), which justifies *ex post* the use of the random effects model.

Table 4: Perception of the regulation methods by non-working individuals (ordered probit model with random-effects panel)

Variable	Coef.	Std.error	t value	P (>t)
Constant	0.33	0.105063	3.1496	0.001635 **
No driver's license	0.53	0.101552	5.1725	2.310e-07 ***
Diploma	-0.61	0.135730	-4.4728	7.720e-06 ***
3days	0.19	0.131619	1.4390	0.150149
Odd/even	-0.06	0.132782	-0.4296	0.667484
New road	0.35	0.131491	2.6877	0.007194 **
Pollution	0.37	0.132046	2.8368	0.004557 **
Queuing	0.19	0.132451	1.4429	0.149035
Threshold parameters for index model				
Mu(01)	0.98	0.052220	18.7045	< 2.2e-16 ***
Mu(02)	2.35	0.091766	25.6020	< 2.2e-16 ***
Std. Deviation of random effect				
Sigma	0.53	0.088830	5.9265	3.095e-09 ***
Log Likelihood function	- 1027.385			
Hessian	86.42834			
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

3.2 Perception of the methods of compensation

a) Overview

Table 5 gives an overview of the perceived justice of each of the compensation methods examined in the case of urban tolls.

Table 5: Perceptions of compensation methods

Compensation method	Question	% fair or very fair
Resident	People who live inside the zone have the right to a reduced rate, 1 € per day instead of 3, for a single car per household ("**Resident rate")**	71%
Professional	Professionals (artisans, delivery services ,taxis) who need to move often have the right to a reduced rate ("**Business rate"**)	71%
Low income	People who have lower incomes have the right to a reduced rate ("**Low income rate")**	75%
Exemption 1	Handicapped drivers are not required to pay the toll ("**Handicap"**)	79%

Exemption 2	Cars containing at least 3 people are not required to pay the toll, to encourage people to carpool ("**Carpool")**	80%
Exemption 3	Emergency vehicles (fire trucks, ambulances, police) are not required to pay the toll ("**Emergency")**	97%

The least accepted method of compensation is a reduced rate for those who live in the toll zone ("Resident rate"). We therefore use this method as the reference method.

b) The influence of socio-demographic variables on perception of compensation

Again, we first verify the hypothesis that employment is a discriminating variable in the perception of compensation methods. The likelihood test (critical probability of 0.34, Table 10 in Appendix 1) allows us to reject the separation of the models for working and non-working people.

We again seek to simplify the socio-demographic variables (critical probability of 0.08, cf. Table 11 in Appendix 1). This simplification of the socio-demographic variables distinguishes a group of people under 50 from those older than 50, the exclusive users of cars from the others, and toll zone residents from non-residents.

Our results (cf. Table 6) show that the compensation methods are perceived as more unjust by those under 50 years old and by those who live outside the toll zone. In contrast, exclusive users of cars have no fixed position, in one direction or another, on these compensation methods.

The results confirm that the measures that would exempt emergency vehicles or people with limited mobility are significantly more widely accepted than the others. At the same time, the exemption for carpools and the reduced rate for low incomes also receive significantly higher acceptance, in contrast to the reduced rate for professional users, which is not significantly different from the reference method of the reduced rate for residents of the toll zone.

The use of the random effect model is once again justified by the highly significant nature of the standard deviation of random effect (see *Sigma*).

Table 6: Perceptions of compensation methods (ordered probit model with random-effects panel)[1]

Variable	Coef.	Std.error	t value	P (>t)
Constant	1.51	0.095393	15.8409	< 2.2e-16 ***
Age under 50	-0.22	0.075565	-2.9062	0.003658 **
Exclusive automobile user	-0.13	0.074191	-1.7539	0.079453 .
Residence outside toll zone	-0.17	0.071516	-2.3547	0.018535 *
Carpool	0.22	0.080533	2.7083	0.006764 **
Emergency	1.87	0.103252	18.0872	< 2.2e-16 ***
Handicap	0.79	0.084372	9.3349	< 2.2e-16 ***
Low income rate	0.19	0.080820	2.3124	0.020754 *
Business rate	0.16	0.080534	1.9505	0.051116 .
Threshold parameters for index model				
Mu(01)	0.72	0.039582	18.2261	< 2.2e-16 ***
Mu(02)	1.94	0.052739	36.8556	< 2.2e-16 ***
Std. Deviation of random effect				
Sigma	0.71	0.057203	12.3624	< 2.2e-16 ***
Log Likelihood function	- 2401.476			
Hessian	51.97			
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

3.3 Discussion

The opposition to peak pricing with a constant level of supply and to pure rationing (even/odd plates) is fairly strong. At the same time, regulation by queuing seems to be equally rejected, a result which conflicts with results from the literature in other contexts (cf. table 3). For example, Frey and Pommerehne (1993) show that the traditional procedure of "first come, first served" is preferred, by far, over pricing. Raux et *al.* (2009) reach a similar result in the context of scarce parking spaces or seats on a train.

Result 1: Regulation by peak pricing with a constant level of supply and by rationing are widely perceived as unjust. At the same time, regulation by queuing appears to suffer the same rejection.

Whether for working or non-working people, the principle of making cars pay for the pollution they cause by driving is perceived as significantly different and less unjust than the other methods (cf. tables 3 and 4).

Result 2: A toll justified by the pollution caused by automobile traffic is less strongly rejected than the other forms of regulation.

As regards the aversion to pricing, Frey and Pommerehne claim that a price increase is less likely to be rejected when one expects the level of supply to increase. Likewise, Raux et *al.* (2009) show that negative attitudes towards peak pricing with a constant level of supply can be significantly moderated by the manner in which the revenues are allocated.

According to our results, this the case for non-working people who are more likely to perceive a toll for new road construction to be fairer than the peak pricing (cf. table 4).

Result 3: For the least constrained users (non-working people), the negative attitudes towards pricing can be moderated by an increase in the road supply.

[1] The strongly significant constant coefficient is not a sign of a wrong specification of the model but is linked to the answer structure between very unfair, unfair, fair, very fair.

We proceed by detailing the analysis of the socio-demographic variables. Our results show that the differences in perception between working and non-working people exist when they are evaluating regulation methods but not when they are evaluating compensation methods (cf. tables 3 and 4).

As regards the regulation methods, our results show that the socio-professional category and the mode of transport are the significant variables for working people. Unsurprisingly, being an exclusive automobile driver and at work leads a person to perceive all regulation methods as more unfair. Nevertheless, it appears that employees and managers are less inclined to reject peak pricing (cf. table 3). We can suggest the idea that given the choice between dealing with congestion and pollution or paying a toll, employees and managers are not totally opposed to a toll.

On the side of the non-working people, although they seem a priori to be less constrained than the others, the opposition to a toll remains strong, especially among diploma holders (cf. table 4). However, non-working people who do not have a driver's license perceive all the proposed regulation methods as less unfair.

Result 4: Socio-professional status, educational level, and use or non-use of a car clearly play a role in individuals' perceptions of the regulation methods.

As regards perceptions of compensation methods, our results show that there are clear differences in perceptions among the methods. The “ethical” or “moral” compensation, which consists of exempting emergency vehicles from the toll, is the compensation method considered the most fair, significantly beyond all other forms of compensation. In second place is another “moral rule,” namely, the exemption for handicapped people (cf. table 6). These two moral rules seem to play the role of a reference transaction as described by Kahneman et *al.* (1986).

Next in the order of acceptance of compensation methods is the exemption for carpools, followed by the reduced rates for people with the lowest incomes. Finally, in last place, but still considered very fair, are the reduced rates for residents of the toll zone or for certain categories of working people.

Result 5: The exemption from the toll for emergency vehicles and vehicles used by handicapped people clearly play the role of moral or ethical compensation methods. The exemption for carpools and the reduced rates for low-income individuals are the next most accepted methods of compensation.

Overall, these compensation methods are considered less fair by those who live outside the toll zone or who are under 50 years old (cf. table 6).

Result 6: People's perceptions of the justice of the compensation methods are clearly influenced by their socio-demographic situation, particularly by their ages and whether they live inside or outside the toll zone.

4. Conclusion

Different methods of regulation and of compensation to limit automobile traffic, derived from the empirical and theoretical literature on justice, were examined in the specific context of Lyon, France. The results may appear deceptive to the promoters of urban toll systems. The restriction of automobile traffic by prices (road tolls) or by quantities (even/odd plates or limitation of the number of days of driving) is widely considered unfair by those surveyed, whether they are working or non-working people, drivers or non-drivers.

Meanwhile, regulation by congestion (queuing) seems to attract the same opposition, although it is the method that is most commonly used today. Moreover, the less negative attitude towards a toll based on pollution 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 (Rotaris et *al.*, 2010).

Individuals' socio-demographic situations have clear influences on their attitudes towards the regulation methods. Among non-working people, in contrast to working people, tolls to finance new roads attract less opposition. Moreover, socio-professional status, educational level and use or non-use of an automobile play clear roles in individual perceptions of the regulation methods.

As regards compensation, there is a clear hierarchy in the perceived justice of the compensation methods. There is no doubt that emergency vehicles and those transporting people with reduced mobility should benefit from an exemption from the toll. Carpooling then appears in second place, as also deserving an exemption; this again indicates a factor in the acceptability of a toll system. However, there is a lack of explanatory variables that we need to focus on in a future research. For example, more information about the respondent constraints could be useful. Moreover, the favourable reactions to the reduced rates for low incomes indicate a concern for justice, which will be necessary to address in one form or another, although this type of compensation may be difficult to implement in the framework of an urban toll.

In addition, the socio-demographic situations of individuals, in particular, whether they live inside or outside the toll zone, also have clear influences on their attitudes towards the compensation methods. This aspect should be explored in greater detail, in particular as regards the geographic redistribution of the advantages (or inconveniences) of a toll.

These results must be understood as specific to the area in which they were taken, Lyon, and that area's or country's social, cultural, and political contexts. It is necessary to compare these results with those obtained in other urban contexts.

Acknowledgements

The research on which this article is based was supported by the ADEME (French Agency for the Environment and the Control of Energy), Grant n° 00 03 040).

We would like to thank the two reviewers of Transportation Research Part *A* for their constructive comments.

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Appendix : Tests of likelihood, "working people" and "non-working people" models

The likelihood test indicates if the stability hypothesis is rejected or not. It's a test for nested models. Scale issue is solved by the way that the error term follows a normal distribution (unitary variance).

Table 7: Likelihood ratio test for the regulation methods

	Regulation Model I "working" + "non-working"	Regulation Model II "working"	Regulation Model III "non-working"
Number of variables	30 5 for regulation, 1 for driving license, 1 gender, 4 age, 4 diploma, 6 professional status, 2 employment status, 2 transport mode, 1 residence inside/outside, 1 constant, 1 individual effect, 2 thresholds	28	25
LnL	- 2799.072	- 1715.829	- 1047.637
Likelihood Ratio Test	Model II + Model III – Model I		
LR	71.212		
df	23		
p-value	7.892696e-07		

Table 8: Likelihood ratio test to simplify the socio-demographic variables for the regulation methods ("working people")

	Regulation Model IV "working"
Number of variables	12 5: regulation method, 1 age, 1 professional status, 1 transport mode, 1 constant, 1 individual effect, 2 thresholds
LnL	- 1614.51
Likelihood Ratio Test	Model IV – Model II
LR	9.33
df	12
p-value	0.68

Table 9: Likelihood ratio test to simplify the socio-demographic variables for the regulation methods ("non-working people")

	Regulation Model VII ("non-working")
Number of variables	11 5: regulation methods, 1 driving license, 1 diploma 1 constant, 1 individual effect, 2 thresholds
LnL	-1051.399
Likelihood Ratio Test	Model VII – Model III
LR	7.524
df	14
p-value	0.9126234

Table 10: Likelihood ratio test of working/non-working people for the compensation methods

	Compensation Model I "working" + "non-working"	Compensation Model II "working"	Compensation Model III "non-working"
Number of variables	30	28	25
	5 compensation methods, 1 driving license, 1 gender, 4 age, 4 diploma, 6 professional status, 2 employment status, 2 transport mode, 1 residence, 1 constant, 1 individual effect, 2 thresholds		
LnL	-2482.858	-1539.119	-931.16
Likelihood Ratio Test		Model II + Model III – Model I	
LR		25.158	
df		23	
p-value		0.3421906	

Table 11: Likelihood ratio test to simplify the socio-demographic variables for the compensation methods

	Compensation Model IV
Number of variables	12
	5 compensation methods, 1 age, 1 transport mode, 1 residence, 1 constant, 1 individual effect, 2 thresholds
nL	-2496.903
Likelihood Ratio Test	Model IV - Model I
LR	26.902
df	18
p-value	0.08085203

Annex 1: The questionnaire

The increase of automobile traffic in large cities like Lyon brings more and more serious problems, including congestion, pollution, noise and lack of safety. To stop this phenomenon, and improve the quality of life for everybody, we search now new solutions.

One of the idea studies by researchers will be to introduce a toll all around the city. That is to say drivers who travel inside the toll zone have to pay.

In Lyon, zone where toll will be applicated, would integrate central borough of Lyon and Villeurbanne. *SHOW MAP and TOLL SCHEME*.

Principle would be that all the car users who get through and move inside the tolled area (*SHOW)* would pay 3 Euro *per* day, Monday to Friday, between 7 a.m. to 7 p.m.

Revenues from the toll would be earmarked to the improvement of transport in Lyon, Villeurbanne and other town of the Lyon Urban Community: modernisation and extension in subway, tramway and

buses, improvement of the security on the public transport, road maintenance, participation for financing road to avoid the city centre, improvements for walking and bicycle.

Moreover, researchers study the idea to modify bus, subways and tramway tariffs according to the hour of the trip and its distance.

Firstly, some general opinions we can have on this idea, you tell me if you find them very unfair, rather unfair, rather fair, very fair.

QUESTIONS ROTATION

	very unfair	rather unfair	rather fair	very fair
Drivers must be charged a toll to compensate for the pollution they cause by driving				
To hold people responsible for traffic jams, drivers must be charged a toll during peak hours				
If the money will be used to expand or build new roads, drivers can be charged a toll				
To reduce automobile traffic, cars must be limited to driving only three days per week, of their choosing, between Monday and Friday				

There would be the possibility to have different tariffs according to the type of user. I'm presenting the possibilities, and for each of them, you tell me if you find it very unfair, rather unfair, rather fair, very fair.

	very unfair	rather unfair	rather fair	very fair
Emergency vehicles (fire trucks, ambulances, police) are not required to pay the toll				
Cars containing at least 3 people are not required to pay the toll, to encourage people to carpool				
People who live inside the zone have the right to a reduced rate, 1 € *per* day instead of 3, for a single car *per* household				
People who have lower incomes have the right to a reduced rate				
Professionals (artisans, delivery services, taxis) who need to move often have the right to a reduced rate				
Handicapped drivers are not required to pay the toll				

And at last, if the idea of toll was applied in the city of Lyon, tell me if you will be agree or not agree with the following assertions

	agree	not agree
Automobile traffic must be allowed to evolve; people will naturally adapt		
To reduce the automobile traffic, cars must be limited to		

driving only every other day, depending on whether they have even or odd license numbers		