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Estimating the willingness-to-pay for road safety improvement

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Abstract

Few studies have explored, to date, the issue of the monetary valuation of non-fatal injuries caused by road traffic accidents. The present contribution seeks to raise interest in this question and to estimate, by contingent valuation, French households' willingness-to-pay (WTP) to improve their road safety level and reduce their risk of non-fatal injuries following a road accident. Much of the literature focused on estimating WTP for a reduction in the risk of fatal accident and on the calculation of the value or price of the risk, collectively named "the value of a statistical life". In contrast, the present paper is interested in the valuation of more or less serious non-fatal injuries caused by traffic accidents. More specifically, it estimates road users' WTP for a reduced risk of being a victim of various types of non-fatal injury.

To do so, contingent valuation was conducted on the adult population (aged 18 years and older) of a French administrative Département (Rhône) during the year 2012. A survey was conducted in 2013 by telephone interview from 2,216 inhabitants, randomly selected from the Rhône population. The stratification of the sample was made by geographic region (two areas in Greater Lyon and outside). This study was based on the stated preference method. Respondents were asked their WTP to avoid diverse consequences of a road accident.

More precisely, the questionnaires contained five categories of questions: (1) personal experience in dealing with road accidents, (2) driving behavior and traffic accident risk perception, (3) use of means of transport (4) general socio-economic characteristics, and (5) willingness to pay to reduce the risk of non-fatal injury following a road traffic accident.

Participants had to envisage contributing financially to the implementation of a local project to improve the safety of road users in the Rhône Département. Since the participants were themselves inhabitants of the Rhône, they should feel immediately concerned by a project within their own area for their routine travel.

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To test the relationship between WTP and injury severity, three road safety projects were independently presented. Each was characterized by the types of injury against which it offered protection. For each project, respondents were asked whether they were willing to pay for the project to be implemented, if so, the maximum amount of money they were willing to pay each year. If not, zero WTP was assigned, and follow-up questions tried to identify the reasons for this choice; this allowed "genuine zero values", consistent with an economic decision, to be distinguished from protest responses.

A Tobit and a type-II Tobit model were estimated to identify factors for WTP. The results highlighted the significant and positive influence of injury severity on WTP. Experience of road traffic accidents seemed to play an important role, positively influencing valuation of non-fatal injury. The young people seemed to be more willing to invest in improving their road safety. As predicted by economic theory, the study confirms the positive relationship between WTP and income level.

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1. Introduction

Economic researches in terms of road safety remain scarce in France while the socio-economic issues are very important. Indeed, impacts of traffic accidents on the economy are considerable. These impacts are often assessed in terms of direct market costs (medical, materials and overhead costs) and indirect costs (loss of future production of those killed and wounded) and in terms of non-market costs (moral damage ...). According to the figures of the French road safety department, the cost of injury accidents is estimated at 9.7 billion in 2011. The reduction of mortality due to traffic accidents is therefore a major public health issue by its consequences on human life and economy. Economic analyzes in this area should allow policy makers to better target their prevention against road accidents.

In this field of study, the economic assessment is done by calculating the economic value of human life and the value equivalent to the damage injury. We use an approach that takes into account; avoided premature deaths, life year gained in health economics and environment, Chanel and Vergnaud, (2004). However, some reluctances appear on part of our societies at the thought of monetizing the suffering caused by an injury or the loss of a life of a road user. There are two main methods, the human capital and the willingness to pay. The first is to enhance the damage (death, injury) according to their impact on the economy, that is to say all the market costs. The second method lies in the assessment of the value people attach to life from investigation where one seeks to know the maximum amount of money that people are willing to pay to reduce the risk of losing life prematurely through various scenarios. Researches on the monetization were made particularly in environment and health fields. Indeed, Chanel et al. (2000) conducted work on the monetization of transport externalities, including air pollution and its health effects. As Alberini and Chiabai (2007), Navrud (2002) meanwhile were interested in the monetization of noise; their work has focused on the relationship between noise and housing prices using hedonic price approach, including Renew et al. (1996), Grue et al. (1997).

The main objective of this article is to study the WTP of the road users to reduce their risk of being injured in a road traffic accident with more or less severe consequences. This is to determine the factors involved in the users' willingness to pay for improving road safety.

This study joins particularly in an approach of monetary valuation of profits bound to the measures of road safety and more generally in cost-benefit analyses. The second section of this paper presents the methodological framework of the study, that is to say the structure of the questionnaire with the development of the scenarios (scenario chosen in a random way among four level projects of different risks) and data collection. The third section highlights the results. These will be discussed in the fourth section and it will finish with some concluding remarks.

2. Material and Methods

2.1. Questionnaire and data collection

The data used in this paper are extracted from an investigation based on the method of the contingent evaluation (EC) concerning the risk of personal accident on the traffic. [Beattie and al. (1998) Carthy and al (1998)]. This method was applied to assess the risk of road accident perceived by the user. It rests on the principle of a situation of hypothetical market in which we ask a road user for the maximal amount it would be ready to pay to reduce its risk of being a victim of a personal accident of the traffic. Thus it is an intention, and not a technical real behavior.

The target population of the study corresponds to the individuals of at least 18 years at the time of the survey and living in the Rhône department, in France. They divide into two groups, either exposure or no-exposure to a road accident. Exposed ones were pulled of the "Register of the victims of the personal accidents of the road traffic of the Rhône" during year 2011. Not-exposed ones were inhabitants of the Rhône having had no personal accident during the same year. Among the 2226 people surveyed, we record all in all 594 exposed subjects and 1622 non exposed subjects.

2.2. Scenarios

To assess the WTP of the subjects interviewed to improve their road safety, a scenario has been set up. Individuals have the option of paying a unique contribution to a departmental agency whose objective is to introduce measures to reduce the risk of personal traffic accident consequences as described in the scenario. Four projects were envisaged, differing in the level of severity of injury: An A project to reduce the risk of minor injuries without sequelae; a B project to reduce the risk of injuries with light sequelae; a C Project to reduce the risk of injuries with serious sequelae; a D project to reduce the risk of fatal injuries.

By random edition, a single project among 4 was allocated to every participant. We then ask every individual if he is ready to contribute in order for the project that was just displayed to him(her) to be set up. If the subject accepts, we collect, in euros, the maximal amount he is ready to pay (in the form of an open question). Otherwise, we collect the reasons of his refusal and a value of 0 allocated by default to his willingness to pay.

3. Results

3.1. Descriptive statistics

3.1.1. Contribution decision

Only 38.2 % of the subjects agreed to participate in the project of improvement of the road safety. Among them, 29.2 % are subjects exposed to the road accidents.

The table 1 puts advances the characteristics of the people which agreed to participate in the project of the strengthening of the road safety. Indeed, 76 % of them have for zone of house Grand Lyon and are male for more than half (56 %). Let us note that the sample consists essentially of individuals between 25 and 44 years old. The young people and the seniors are least interested in participating in this project. Concerning their level of studies, more than half of the refusing individuals do not possess a diploma upper to the high school diploma.

It is also important to underline that the majority of the subjects accepting the project were not confronted in an indirect way with a physical accidents on the traffic, because 68 % declare not to know any person of their close circle of acquaintances recently hurt during a road accident during the last 12 months. Besides, these individuals use small modes of travel which are most subject to risk, such as 2 RM or bikes (respectively 2 % and 6 %). Furthermore, 78 % of the subjects move mainly for forced purpose, in particular to commute. About the evocation of the risk of road accident, about 71 % of our samples declare themselves anxious or very anxious.

Table 1. Sample characteristics.

	Total Number N=2216	Exposed n=592	Non Exposed n=1622
<i>Residential zone***</i>			
Grand Lyon	1610	405	1205
Hors Grand Lyon	606	189	417
<i>Gender ***</i>			
Female	993	235	758
Male	1223	359	864
<i>Age***</i>			
18-24	315	114	201
25-44	832	231	601
45-64	697	187	510
>=65	372	62	310
<i>Diploma level***</i>			
Certificate of professional competence	800	238	562
Bachelor	444	120	324
Bachelor+2	307	90	217
2 nd or 3 ^d University degree	660	146	514
<i>Status***</i>			
In couple (married, ...)	1305	334	971
Other (divorced, single, widow)	911	260	651
<i>A relative or a close injured during the last 12 months***</i>			
Yes	573	211	362
No	1643	383	1260
<i>Level of anxiety about the risk of road accident (Scale from 1 to 10)*</i>			
1-4	740	179	561
5-6	896	240	656
7-10	580	175	405
<i>2MW-Main trip mode***</i>			
Yes	50	34	16
No	2166	560	1606
<i>Cyclist- Main trip mode</i>			
Yes	97	45	52
No	2119	549	1570
<i>Main trip purpose</i>			
Compelling reasons (work, studies...)	1530	428	1102
Non-compelling reasons (shopping, spare time, visits...)	682	163	519

Note: *, **, *** Significance of Chi-square test performed between the exposed and unexposed populations, at the 10% threshold, 5% and 1%, respectively.

3.1.2. WTP amount

If we focus on the amount of willingness to pay, we notice that the average is 56 euros. However, the max and min WTP varies of 34 euros from the average WTP. Therefore, the standard deviation is raised, which means that there is a big dispersal between the declared amounts.

About the amount of the contributions, it is important to insist on the notions of a true and a false zero. Indeed, the invalid values require a particular treatment. A "true" zero corresponds to the situation in which the questioned person

considered that his level of utility will remain unchanged before and after the implementation of the project. This zero corresponds to the following motives for refusals:

- The project seems to me useless
- My financial means do not allow me to finance the project
- I do not feel concerned (e) by the subject

On the contrary, a "false" zero, means that the investigated does not give the real value which it grants to the studied scenario. Consequently, the individuals do not reveal their real willingness to pay. It is thus necessary to take it into account in analyses. This false zero corresponds to the motives for following refusals:

- It does not belong to me to pay
- I don't have enough information to decide
- I do not want to pay for the others
- Other discussing objections

Therefore, if we consider the rate of real refusal, that is by keeping only the following motives for refusals: "the project seems to me useless", "I have no sufficient financial means to contribute to the project ", and "I do not feel concerned by the subject". We notice then a significant reduction in the rates of refusal (62 % vs 24 %). So, this rate of real refusal underlines the real indifference.

3.2. Modelisation

This article tries to determine at first, the factors influencing the decision of an individual to contribute financially to reduce his risk of getting wounded because of a road accident, and this, taking into account their past exposure at the risk. To do it, we modelled the choice of contribution of the individuals by means of the conditional model Logit developed by McFadden, (1973).

Indeed, our dependent variable is coded 1 when the people agreed to contribute to the project and 0 should the opposite occur. The results of the model are postponed in the Table 1. We estimated our model on the total sample and then only on actual protesters. Remember that are considered "real protesters" people who refused to contribute to the project by real disinterest or financial inability.

The model shows the significant influence of age on the probability of contributing to the project. Indeed, young people, particularly those aged 18-24, have a probability 5 times greater to contribute than those aged 25-44 (RR = 4.996 [1326-18819]). The 45-64 year-olds, meanwhile, a smaller probability to contribute than those aged 25-44 (RR = 0.758 [0598-0960]). On socio-economic factors, the level of education of the individual positively influences the decision to contribute.

Indeed, the lower level or non-graduated are less likely to accept the proposal than university graduates (2nd or 3rd university cycle) (RR = 0.600 [0426-0847]), as well as for holders of a certificate of professional competence (RR = 0.704 [0520-0953]). Furthermore, the anxiety level of individuals and their indirect experience regarding road accidents are factors playing a positive role in the choice of contribution. Indeed, very anxious individuals (score between 8 and 10 on a scale of 1 to 10) were 1.8 times more likely to accept the project than those only a little anxious (score between 1 and 4) (RR = 1.787 [1.269 2516]). Individuals claiming to know someone in their entourage injured in a road accident are more likely to accept the proposal (RR = 1.285 [from 1007 to 1640]). In regards of mobility, it is important to stress that people moving for unconstrained reasons (leisure, visits ...) refuse more often the project compared to people forced to move for compelled reasons such as commuting or work (RR = 0.739 [0550-0993]). This result is not surprising as these people move less.

If the sample is restricted to real protesters, our model loses statistical power. The age of individuals is no longer significant. However, the influence of the explanatory variables of degree level and movement pattern is strengthening. The status of the individual becomes significant. Indeed, the group of divorced, widowed and single people less likely to contribute to the project than couples (RR = 0.706 [0515-0970]).

Table 2. Results of the conditional logit model to exposure to the risk of accident.

Conditional Logit model		General		With only	thru protesters
Variables		Wald Chi-Square	Odds Ratio (95% C.L.)	Wald Chi-Square	Odds Ratio (95% C.L.)
General Variables					
<i>Residential Zone</i>					
	Grand Lyon		1		1
	Hors Grand Lyon	2.83*	0.814[0.641-1.035]	3.54*	0.719 [0.510-1.014]
<i>Age</i>					
	18- 24	5.65**	4.996[1.326-18.819]	2.31*	3.473 [0.698-17.278]
	25-44				1
	45-64	5.29**	1	0.22	1.092 [0.758-1.572]
	65-74	2.44*	0.758[0.598-0.960]	0.00	1.016 [0.333-1.311]
	75 & over	1.20	0.708[0.459-1.092] 0.741[0.433-1.267]	1.41	
<i>Gender</i>					
	Female		1		1
	Male	1.64	0.872[0.706-1.075]	0.39	0.908 [0.671-1.228]
Socio-economic characteristics					
<i>Diploma level</i>					
	No diploma or first degree	8.45***	0.600 [0.426-0.847]	22.38***	0.324 [0.204-0.517]
	Certificate of professional competence	5.17**	0.704 [0.520-0.953]	11.00***	0.475 [0.306-0.738]
	Bachelor	0.45	0.899 [0.659-1.226]	1.90	0.719[0.450-1.149]
	Bachelor+2	0.60	0.880 [0.637-1.216]	0.17	0.898[0.534-1.509]
	2 nd or 3 ^d University degree		1		1
<i>Status</i>					
	In couple (married, ...)			4.62**	1 0.706[0.515-0.970]
	Other(divorced, single, widow)				
Risk and perception					
<i>A relative or a close injured during the last 12 months</i>					
	No		1		1
	Yes	4.07**	1.285[1.007-1.640]	5.09**	1.527[1.057-2.202]
<i>Level of anxiety about the risk of road accident (Scale from 1 to 10)</i>					
	1 - 4		1		1
	5 - 7	15.46***	1.602[1.267-2.027]	7.52***	1.627[1.149-2.304]
	8 - 10	11.03***	1.787[1.269-2.516]	0.99	1.263[0.798-1.999]
Week day mobility					
<i>Trip purpose</i>					
	Compelling reasons (work, studies...)		1		1
	Non-compelling reasons (shopping, spare time, visits...)	4.03**	0.739[0.550-0.993]	5.99***	0.608[0.409-0.906]

Note : *, **, *** these stars indicate that the variable is significant at the 10% threshold, 5% and 1%, respectively.

Now that we have characterized the profile of contributors to road safety project, we will try to explain the amount of contributions reported by individuals. Given the high rate of refusal of individuals and thus the high proportion of zero willingness to pay, we will use the model TOBIT censored left [Tobin, 1958]. Therefore, sensible to quantify the effects of the explanatory variables on the dependent variable, we will calculate the average marginal effects. Indeed, they measure the effects of an increase of one unit of an explanatory variable on the dependent variable, here the amount of the contribution. The model results are reported in Table 1.

As for the contribution decision, the variables influencing the level of contributions seem mostly identical to those involved in the decision process. Indeed, age, vicarious experience of road accidents, the anxiety level of individuals

and trip purpose are also factors affecting the WTP level. While the level of severity of injury had no impact on the likelihood of contribution by individuals, it seems here to have an influence on the amount of the contributions; similarly to the living area and the monthly net household income (as predicted by economic theory).

Table 3. Results from the simple Tobit model.

Simple Tobit Model		Full model		With only	the real protesters
Variables of interest		T Value	Marginal effects	T Value	Marginal effects
<i>Residential Zone</i>					
	Grand Lyon		1		1
	Outside Grand Lyon	-2.20**	-4.19	-2.32**	-6.33
<i>Age</i>	18-24	2.90***	23.65	1.99**	20.01
	25-44		1		1
	45-64	-3.33***	-6.34	-0.72	-1.94
	65-74	-1.79*	-6.19	-0.08	-0.38
	>=75	-1.18	-5.03	-1.18	-6.89
<i>Gender</i>					
	Female				
	Male	-0.91	-1.53	0.08	0.18
<i>Project</i>					
	Without sequelae	0.05	0.11	0.87	2.89
	Minor sequelae	0.56	1.30	0.71	2.34
	Severe sequelae	1.94**	4.48	2.53***	8.26
	Fatal sequelae		1		1
<i>Population</i>					
	Exposed		1		1
	Not exposed	-0.96	-1.82	0.82	-0.62
<i>Socio-economic characteristics</i>					
<i>Net monthly household income (in euros)</i>			-		
	<=1,600 €	-2.65***	-7.23	-7.57***	-28.84
	1,601-2,400 €	-2.16**	-5.42	-5.51***	-19.69
	2,401-3,600 €	-3.01***	-6.64	-3.54***	-11.63
	>3,600 €		1		1
<i>Risk and perception</i>					
<i>A relative or a close injured during the last 12 months</i>					
	No		1		1
	Yes	2.89***	5.57	3.79***	10.27
<i>Level of anxiety about the risk of road accident (Scale from 1 to 10)</i>					
	From 1 to 4		1		1
	From 5 to 7	3.76***	7.06	2.38**	6.49
	From 8 to 10	3.52***	9.54	1.54*	5.75
<i>Mobility of the week day</i>					
<i>Main travel purpose</i>					
	Compelling reasons (work, studies...)		1		1
	Non constraint (shopping, spare time, visits...)	3.30***	7.89	3.59***	12.09

Note: *, **, *** these stars indicate that the variable is significant at the 10% threshold, 5% and 1%, respectively.

Specifically, a decreasing relationship was observed between age and the amount of contributions. Young people (18-24) agree to give 24 euros more than the people between 25 and 44 years. While the 45-64 and 65-74 years report 6 euros less than the reference range. Regarding the severity level assigned to each project participant, one notices that individuals report higher amount to hedge the risk of serious sequelae compared to fatal injuries or lesser severity levels (4.5 euros more). On socio-economic characteristics, only the income seems to have a significant impact on the WTP of the participants. Wealthier individuals are willing to pay larger amounts than individuals of lower income. The more people are poor, the more the amount provided is small. Indeed, households' income below or equal to 1600 euros are willing to give 7 euros less than the richest households (over 3,600 euros). In terms of mobility week practice, individuals moving units for unconstrained state 8 euros more compared to forced.

Finally, the way individuals perceive their anxiety level against the phenomenon has a significant impact on the amount of WTP. Indeed, the very anxious subjects (level between 8 and 10) report a higher amount of €9.5 compared

to less anxious (level between 1 and 4). People knowing someone close crashed recently have an amount of contribution increased by €6. They seem to be more sensitive to the risk reduction project.

If it is confined to real protesters as in the previous model, we see that the age and the level of anxiety of people lose their significance in favor of other variables. Nevertheless, the role of young people regarding the 25-44 years is still as important (20 vs 24 euros). Furthermore, the amount reported to protect against serious consequences compared to fatal consequences doubles regarding the general Tobit model (8 vs 4 euros). The effect of income level on WTP is amplified. In other words, the less wealthy are willing to give 29 euros less than the wealthier (gradient in the marginal effects).

Regarding the indirect experience of road accident, the amount of contributions increases in the same way: people, who have had a relative injured during the year, contributes more than persons without indirect experience of accident. This amount is higher of 6 to 10 euros. We observe the same result for the effect of trip purpose (Table 2).

4. Discussion

The monetary quantification of profits associated with road safety measures was for a long time limited to the valuation of the number of avoided deaths. An important part of the literature focused on the estimation of the WTP for a reduction of the risk of fatal accident and on the calculation of the value or the price of the risk, more collectively named as "the value of a statistical life": Hojman et al., (2005); Iraguen and Ortuzar (2004); Rizzi and Ortuzar (2003). Numerous Swedish studies were also interested in the individual WTP for a total elimination of the risk of fatal accidents or severe wounds: Andersson (2007), (2008); Hultkrantz et al. (2006); Svensson and Johansson (2010), taking support on the famous concept of "Vision zero" which aims to achieve a highway system with no fatalities or serious injuries in road traffic.

Our study broaches this theme in a more general way than the previous works on French data which were limited to the specific population of the young drivers from 18 to 25 years old: Lahatte et al. (2006); Lassarre et al. (2005). In these studies, the participants were asked to give their WTP to not experiment diverse consequences resulting from a road accident. An increasing relation between the level of WTP and the gravity of the injuries likely to be avoided was revealing. Our study also distinguishes itself from that of Hensher et al. (2009) on Australian data which was more indirectly interested in this dimension of gravity by using the method of discreet choices to reveal individual preferences, Louviere et al. (2000). More exactly, in the paper of Hensher et al. (2009), individuals were asked to choose among different choices of route for a particular trip. The attribute levels of each alternative (the probability of death or non-mortal physical wounds, the time of travel and the cost) vary according to a statistical design. The individual choices allowed to observe the making choices between different attribute level bundles and to estimate the WTP of the subjects for a reduction of their risk of fatal accident and not mortal injuries. The study showed that the average WTP is higher for mortal wounds than non-mortal ones. Moreover, a hierarchy in the levels of WTP is observed between the various levels of injuries gravity: permanent injuries requiring hospitalization and engendering irreversible consequences present a WTP superior to major or minors injuries without impairment.

Our study tried to see if such conclusions were confirmed in the French context by using the declared preferences method as a technique of monetary valuation. We use more precisely the contingent valuation to estimate the value of a reduction of the risk of being victim of various types of non-mortal physical injuries following a road accident. We brought to light several phenomena. The most considerable one certainly remains the significant impact of the injuries gravity on the WTP. This last one increases with the gravity of the injuries likely to be incurred. The individuals are more ready to invest and grant to pay more important amounts of money to reduce their risk of heavy injuries in comparison to minor and moderate ones. These results follow on from previous studies and confirm the necessity to take into account the level of gravity of injuries in studies of valuation of non-mortal consequences of traffic accidents.

The survey results also advance the strong influence of the individual accidental experience, that it is direct or indirect, on their WTP. The individuals having recently been victims of a road accident or whose close relatives has been hurt further to a road accident are more ready to invest to improve their road safety and reduce their risk of personal accident. This result strengthens the interest to lead case-control studies with inclusion of a damaged population.

Concerning the apprehension of the individuals when facing road accidents, studies on risk showed that people report making behavioral adaptations as a consequence of worry about accidents, see Backer-Grondahl et al. (2009);

Rundmo et al. (2011). The individual relative anxiety in front of road traffic and road accidents influences their use of means of transport and their behavior as road users. The anxious people show themselves more selective on the choice of their means of transportation and care more about their road safety. It can seem relevant to pursue the efforts realized in this direction and take into account this dimension in future analyses of sensibility in devices of road safety.

5. Conclusion

The factors affecting the project contribution decision are age and educational level, subjects who experienced traffic accident around them and those who travel often for work or for other reasons, are more willing to contribute. These are the same factors that affect the level of contribution of the subjects, similarly to the living area and the monthly net household income as predicted by economic theory.

However some small differences remain: While the level of severity of injury had no impact on the likelihood of contribution of individuals, it seems here to have an influence on the amount of contributions. People are willing to pay more in order to avoid any heavy squeals. Therefore, they seem to give more importance to the consequences of severe accident than fatal ones. Furthermore, having relatives who had an accident increases the likelihood to participate to the project. Also, the way they see the risk have an impact on the amount of their WTP. Indeed, the more their anxiety toward the risk is high, the more they are likely to have WTP for the improvement of their safety on the road traffic and to give a bigger amount than the average one.

Ultimately, two principal factors seem to intervene in the amount determination: the age and the monthly net household income. Generally speaking, it seems that people aged 18 to 24, and living within a household with monthly net income superior to 3600 are investing the most for their road safety.

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