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How do travellers respond to health and environmental policies to reduce air pollution?

C. Orset

UMR Economie Publique
Avenue Lucien Brétignières – 78850 Grignon
16 rue Cl. Bernard – 75005 Paris
Tel. +33 (0)1 30 81 53 30
Fax. +33 (0)1 30 81 53 68
http://www.grignon.inra.fr/economie-publique

How do travellers respond to health and environmental policies to reduce air pollution?

Caroline Orset*

Abstract

Despite the various measures taken to reduce air pollution in France, the French continue to use high emitting vehicles. We propose to evaluate the traveller's willingness to pay (WTP) for four means of transport: two high emitting vehicles (taxi diesel and personal diesel car) and two low-emission vehicles (rented electric vehicle and public transport). We get that individuals prefer personal cars. We propose different health and environmental policies to encourage people to adopt low-emission vehicles. Successive messages revealing the effects of air pollution on health and the environment are provided to individuals in a different order. We find that the information and order of information affect the WTP of individuals. This information campaign increases demand for low-emission vehicles, but demand for high emitting vehicles is somewhat affected. Indeed, individuals prefer to ignore information, they behave as in the theory of the tragedy of the commons. We then propose a system of tax subsidies and a standard subsidy system. These two policies drive individuals to switch from high emitting vehicles to low-emission vehicles. The regulator will have to choose between an incentive intervention (with a system of tax subsidies) and a coercive intervention (with a standard subsidy system).

Keywords: Air Pollution; Information campaign; Mean of transport; Standard-subsidy system; Tax-subsidy system; Traveller's willingness to pay.

*Economie Publique, AgroParisTech, INRA, Université Paris-Saclay, 78850 Thiverval-Grignon, France. Email: caroline.orset@agroparistech.fr. We thank Audrey Haubert, Amandine Menu and the MS ALISEE. The views expressed in this article are the sole responsibility of the author and do not necessarily reflect those of its institution. The traditional disclaimer applies. We declare that we have no relevant or material financial interests that relate to the research described in this paper.

1 Introduction

Many actions have been conducted in France to reduce the negative impacts of means of transport, such as taxis or diesel cars, on air quality. These actions were aimed at encouraging people to use low emission vehicles, in particular public transport and electric cars. Actually, many studies about the adverse effects of air pollution on health have been done. Dockery et al (1993) and Krewski et al (2004) found a consistent and statistically significant association between long-term exposure to the fine particles with a diameter of $2.5\mu m$ ($PM_{2.5}$) coming from fossil fuels in vehicles and the risk of mortality. Using the fifty-one cities from the American Cancer Society study, Pope et al (2009) reported that wide reductions in $PM_{2.5}$ concentration between 1980 and 2000 were strongly associated with an increase in life expectancy. In 2015, according to the French Senate committee, once the cost of all measures to fight air pollution has been deducted, the net health benefit for France of combating air pollution would be over €11 billion per year.

Moreover, air pollutants have also negative impacts on the environment.[1] When fossil fuels are burned, it may create acid rain, which damages trees, buildings and makes the water unsuitable for wildlife. In addition, cars contributes to the eutrophication, which stimulates blooms of algae and causes fish kills, loss of plant and animal diversity. Air pollution from high emitting vehicle also increases haze. Air pollution can also damage crops and trees in reducing growth and survivability of tree seedlings and increasing plant susceptibility to disease. In addition, air pollution is responsible of greenhouse gases, which is a source of the global climate change. In 2015, the French Senate committee estimates the cost of air pollution in France to more than €100 billion per year.

So why do the French continue to use high emitting vehicles? Are they aware about the negative impacts of air pollution on health and the environment? How to lead them to use low emission vehicles? We build a questionnaire in which we inform respondents about these negative impacts. We consider two groups of respondents that receive two different questionnaires. The questionnaires only differ by the information order received by the respondents. Group 1 first receives information on the negative impact on health and then on the environment of air pollution. While Group 2 first receives information on the negative impact on the environment and then on health. In order to characterize the respondents' preferences for each mean of transport we use the Willingness To Pay method (WTP). Policy makers are faced with difficult choices when implementing air pollution reduction measures. Understanding people's preferences for these measures allows policy makers to choose the best health and environmental policies.

Our approach relies on two building blocks. First, our paper is linked to the literature that examines the interaction between the WTP and information acquisition. The WTP approach has already been used in air pollution issues. Kotchena et al (2013) have studied the WTP for the climate-change policies in the United States, Suna et al (2016) and Wanga et al (2016) have focused on the WTP for smog mitigation in China. Our paper contributes to this literature

[1] See the US Environmental Protection Agency (EPA) for more details.

by investigating the WTP for four means of transport (low emission vehicles: public transport and rented electric vehicle, and high emitting vehicles: taxi and personal car) in France. We get that people have a strong preference for personal car that is one of the high emitting means of transport. Moreover, we also introduce the precise impact of information on the travellers' WTP for the different means of transport. We then conduct an analysis to elicit the WTP for different means of transport with increasing levels of information on the negative impacts of air pollution on health and the environment. We find information and the information order matter. However, some messages are counterproductive and do not lead respondents to choose a low emission mean of transport. Although information increases the demand for low emission vehicles, personal car is still the preferred mean of transport. Thus, the individuals adopt a behaviour of information ignorance, they act as in the tragedy of commons theory. This behaviour is not Pareto optimal.

Furthermore, we contribute to the economics literature on the reduction of air pollution. There is a consensus on the prejudicial consequences on health and the environment of air pollution due to high emitting vehicles. We then propose three health and environmental policies: an information campaign on the consequences on health and the environment of air pollution, a tax-subsidy policy in which we tax high emitting vehicle and we subsidy low emission vehicle, and finally a standard (which may be combined with a subsidy) in which high emitting vehicles are forbidden. Some works have analysed the impact of air pollution policies on the structural changes at the sector level and on energy use (Bollena and Brink, 2014; Naqvi and Zwickl, 2017). Others consider that the volume of pollution produced by an automobile is determined by driver's behaviour along three margins (vehicle selection, kilometres driven, an on-road fuel economy) and they study the optimal policies which could change the driver's behaviour (Montag, 2015). Agostinia and Jimnez (2015) have focused on the gasoline tax as the best instrument of climate policy. Nevertheless, none of these works has studied the impact of health and environmental policies on the traveller's behaviour concerning its mean of transport choice. We find information campaign increases respondents' preference for low-emission vehicles, but does not reduce their preferences for high emitting vehicles. We get that giving first information on the impact of air pollution on the environment implies a higher traveller surplus and a higher number of travellers using the low emission vehicles than giving first information on health. We also propose a tax-subsidy system and a standard-subsidy system. These two policies drive individuals to switch from high emitting vehicles to low-emission vehicles. The regulator will have to choose between an incentive intervention (with a system of tax subsidies) and a coercive intervention (with a standard subsidy system).

The paper is organized as follows. Section 2 details the study. Section 3 presents the results with a descriptive analysis and an econometric estimation. Section 4 shows the welfare analysis and the regulation advices. Finally, section 5 concludes.

2 The study

According to Avem,[2] pollution related to transport has increased by over 30% in 20 years. The main cause being the increase in car traffic. Indeed, urban congestion contributes to 75% of photochemical pollution and 40% of acid deposition. We then propose to analyse the willingness to pay of French travellers to reduce air pollution related to transport.

2.1 Target respondents

During February 2015, we conducted the study through Marketest.[3] We asked Marketest to make two groups of respondents. Each group were selected by using the quota method, i.e., the same proportions of gender, age and socio-economic status (income and occupation) criteria in the group of respondents as in the census report of French population by the Institut national de la statistique et des études économiques (INSEE). We had especially prepared two questionnaires, one for each group, to be posted online. The two questionnaires only differed by the information order received by the respondents. Group 1 first received information of air pollution on the negative impact on health and then on the environment. While Group 2 first received information on the negative impact on the environment and then on health. The Group 1's target respondents consists of 177 French people aged between 20 and 65. The Group 2's target respondents of 165 French people aged between 20 and 80.

Table 1 presents the socio-economic characteristics (gender, age, income, and occupation) of the respondents. Differences between the two groups and INSEE are tested using the Pearson chi-squared test. A P-value (against the null hypothesis of no difference) of less than 5% is considered significant. The results in the last three columns of Table 1 suggest that the three groups are not significantly different.

[2]See: http://www.avem.fr/index.php?page=pollution
[3]For more details on Marketest see: http://www.marketest.co.uk/.

Description	Group 1 (%)	Group 2 (%)	INSEE (%)	Chi2 test P-value between Group 1 and Group 2	Chi2 test P-value between Group 1 and INSEE	Chi2 test P-value between Group 2 and INSEE
Gender						
Female	50.3	53.3	51.5	0.58	0.83	0.74
Male	49.7	46.7	48.5			
Age						
[20-24]	13.6	17.0	16.0	0.28	0.68	0.14
[25-59]	75.7	67.9	75.8			
60≤	10.7	15.1	8.1			
Monthly net income of the household (€)						
<1000	11.9	12.1	10.0	0.75	0.63	0.10
[1000-1500)	20.9	13.9	20.0			
[1500-2500)	23.1	30.3	20.0			
2500≤	44.1	43.7	50.0			
Socio-professional categories						
Farmer	0.6	0	1.0	0.19	0.24	0.07
Craftsman	3.4	3.6	3.0			
Self-employed and executive	28.8	21.8	22.6			
Employee and worker	33.9	35.2	29.2			
Retired person, unemployed person, and homemaker	33.3	39.4	44.2			

Table 1: Socio-economic characteristics of respondents.

Through informational questions on the respondents, we get that the price is the first criteria, for selecting their means of transport, for 41.8% of the Group 1's respondents and 34.6% of the Group 2's respondents. 29.4% of the Group 1's respondents and 36.9% of the Group 2's respondents take first into account the ride time, and 28.8% of the Group 1's respondents and 28.5% of the Group 2's respondents the wellbeing during the ride. Only 33.3% of the Group 1's respondents and 33.9% of the Group 2's respondents are directly or indirectly (through family) affected by air pollution health issues as asthma, respiratory disorders or allergies. Finally, 56.5% of the Group 1's respondents and 65.5% of the Group 2's respondents take into account of the recommendations when a pollution peak is announced. So the majority of the respondents in the two groups feel concerned by the air pollution recommendations.

2.2 Means of transport

We have chosen to focus on the journey from the center of Paris (Châtelet, Paris Métro) to the Paris Charles de Gaulle Airport (around 33km (20 miles) by the Highway A_1 Saint Denis by cars, the public transport also follows this road, with a 30-minute travel time for each means of transport). Actually, this journey is used every day for leisure and business trips. Therefore, even French people who do not live in Paris can have made this trip. Moreover, the Highway A_1 Saint Denis is one of the most polluted portion road in France. Table 2 shows that standards are often exceeded in this portion road.

Polluting	Limit Value	Target Value	Quality Goal
PM_{10}	Exceeded		Exceeded
$PM_{2.5}$	Exceeded	Exceeded	Exceeded
NO_x	Respected		
CO	Respected		

Table 2: Situation of different pollutants regulated in relation to air quality standards on Highway A_1 Saint Denis in 2015. From Air Parif (2016).

We propose to respondents four means of transport for the journey: a taxi (T), a personal car (PC), a rented electric vehicle (REV), and public transport (PT) (bus, subways...).[4] These means of transport emit very different levels of pollutants. Table 3 sums up for each transport making the journey, the ride cost, the level of carbon dioxide (CO_2), the level of carbon monoxide (CO), the level of nitrogen oxide (NO_x) which is the sum of nitrogen monoxide (NO) and nitrogen dioxide (NO_2), and the level of particulates (PM_{10} and $PM_{2.5}$).[5]

[4]These means of transport were and are still the only ones proposed to make this journey. A taxi corresponds to a Parisian taxi and to a car transport driver.

[5]The price for a ride for each mean of transport is the market price in February 2015. For the taxi: http://www.parisaeroport.fr/en/passengers/access/paris-charles-de-gaulle/taxi/paris-cdg-taxi; For the personal car: from ViaMichelin (which considers fuel and highway fees); For the rented electric vehicle: from Autolib, https://www.autolib.eu/fr/ ; for the public transport: from RATP. Moreover, we have chosen to present these pollutants because they are the ones selected by CAR LABELLING ADEME, which imposes no-claims bonus to vehicles. For Public transport: CO_2: RATP-GETTING AROUND-TIMETABLE, NO_x and Particulates: Air Parif (http://www.airparif.asso.fr/etat-air/air-et-climat-quelques-chiffres, and CO: CITEPA (http://www.citepa.org/fr/air-et-climat/analyse-sectorielle/transports)); for Taxi, Personal Car, Rented Electric Vehicle: CO_2, CO, NO_x and Particulates: CAR LABELLING ADEME (mean of diesel cars for Taxi and Personal Car, and mean of electric cars for rented electric vehicle).

Means of Transport	Cost (€)	CO_2 (g)	CO (g)	NOx (g)	Particulates (g)
Taxi	50	5620	9.874	1.782	0.033
Personal Car	3.7	5620	9.874	1.782	0.033
Rented Electric Vehicle	13.5	0	0	0	0
Public Transport	10	108	0.047	0.032	0.003

Table 3: Costs and levels of pollution for each kind of transports.

According to World Health Organization (WHO), the CO can cause poisoning causing headaches and dizziness or even coma or death for prolonged exposure. The limit value for the protection of health is 10,000 $\mu g/m^3$ on average over 8 hours. Its oxidation results in the formation of CO_2, which is a greenhouse gaz. CO_2 emissions affect the climate in the short and long terms. From a certain concentration in the air, the CO_2 is dangerous or fatal. The exposure limit is 3% over a period of 15 minutes. At 25% CO_2 in air, respiratory arrests resulting in death. In addition, the NO_x does not have direct health effects. However, NO_2 can cause inflammation of the airways, an increase of bronchitis symptoms and reduced lung function. Moreover, NO_x contributes to the phenomenon of acid rain that deplete the natural environment (soil and vegetation). The particles (PM_{10} and $PM_{2.5}$) have adverse effects on health. Chronic exposure helps increase the risk of contracting cardiovascular and respiratory diseases, and lung cancers. The annual limit value to protect health are 40 $\mu g/m^3$ annual average for PM_{10} and 25 $\mu g/m^3$ for $PM_{2.5}$. The particles also have a harmful effect on the environment. They degrade the buildings. They have an impact on the climate by absorption and scattering of solar radiation as well as the formation of clouds.

Therefore, it looks important to propose the use of low emission means of transport because they have the less negative impacts on health and the environment. According to Table 3, we see that rented electric vehicle and public transport are low emission means of transport while taxi and personal car are high emitting means of transport. Note that we have informed the respondents we consider diesel taxis and diesel personal cars. Actually, in Paris, diesel taxis represent 99.9% of the taxi fleet and diesel personal cars, 62.2% of the personal car fleet.[6]

[6] http://www.paris.fr/taxis#subventions-taxis-propres3 and http://www.ccfa.fr/IMG/pdf/cpparcfrance_2016ok.pdf.

2.3 Experimental design and information revealed

In each questionnaire, successive messages emphasizing health and environmental impacts of air pollution are delivered to the survey respondents. Means of transport are a source of air pollutants. According to Air Parif,[7] transport sector represents 24.3% of the CO_2 emissions, 57% of the NO_x emissions, 32% of the PM_{10} emissions, 38% of the $PM_{2.5}$ emissions in île de France (administrative area in which the journey from the center of Paris (Châtelet, Paris Métro) to the Paris Charles de Gaulle Airport is realized).

We want to raise awareness the respondents to health and the environmental issues linked to their means of transport decisions. In order to characterize their preferences for each mean of transport, we use the Willingness To Pay method (WTP). WTP is elicited after each message with the following question: *How much would you be willing to pay at the maximum for a trip from the center of Paris (Châtelet, Paris Métro) to the Paris Charles de Gaulle Airport by taxi, public transport, rented electric vehicle and personal car?.* The study is divided into several stages as described in Figure 1.[8]

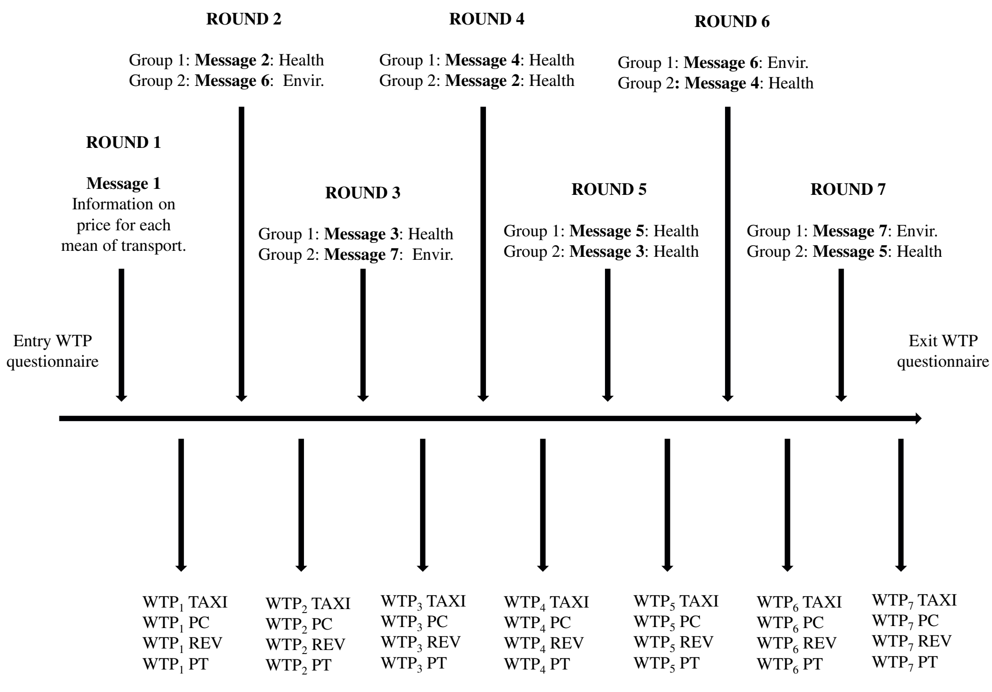

Figure 1: Questionnaire design.

The sequence of information revealed differ between the two groups. Group 1 first received

[7]For more details see: http://www.airparif.asso.fr/etat-air/air-et-climat-quelques-chiffres.
[8]Messages are given in Appendix.

information on the negative impact of air pollution on health and then on the environment. While Group 2 first received information on the negative impact on the environment and then on health. Each questionnaire was given to respondents as follows: first, a text helps respondents to understand the purpose of the study: *'This study is conducted by economists working in the University without any link with administration interest. This survey focuses on different means of transport that may be used to make the journey from the center of Paris (Châtelet, Paris Métro) and Roissy Charles De Gaulle airport. The travel time is 30 minutes whatever the means of transport that you will choose.'* We do not give more information to limit framing effect and anchoring bias.[9] Then, respondents fill in an entry questionnaire with informational and socio-demographic characteristics questions. We needed this information in order to analyse the WTP determinants. Finally, based on different types of information revealed to respondents, seven messages of WTP elicitation are successively determined.

We have decided to divide the set of information into air pollution impact on health and into air pollution impacts on the environment. Table 4 describes the messages and the respondents' behaviours expected.

Message	Category	Description	Respondents' behaviour expected	Comment
Message 1		Prices of each mean of transport for a ride.		Cheap talk as Lusk (2003) suggests to limit hypothetical bias. The hypothetical bias refers to the fact that the situation presented is described hypothetical, and therefore that the WTP may differ from the actual WTP.
Message 2	Health	Consequences of air pollution on the number of premature deaths (more than 2 million) each year worldwilde.	Decrease of the WTP for taxi and personal car. Increase of WTP for public transport and rented electric vehicle.	Aspect of global pollution.
Message 3	Health	Consequences of air pollution on the number of premature deaths (400,000 in Europe, 42,000 in France, 1,400 in Paris) each year.	Decrease of the WTP for taxi and personal car. Increase of WTP for public transport and rented electric vehicle.	Aspect more local of the pollution.
Message 4	Health	Data on actual and recommended level of fine particules and on the impact of fine particles on the life expectancy of parisians and persons from the suburbs.	Decrease of the WTP for taxi and personal car. Increase of WTP for public transport and rented electric vehicle.	Aspect more technical. See whether people are sensitive to data.
Message 5	Health	Health costs of air pollution in France.	Decrease of the WTP for taxi and personal car. Increase of WTP for public transport and rented electric vehicle.	Aspect economics. See whether people are sensitive to the health costs of air pollution.
Message 6	Environment	Air pollution impact on buildings.	Decrease of the WTP for taxi and personal car. Increase of WTP for public transport and rented electric vehicle.	Aspect urban preservation.
Message 7	Environment	Consequences of air pollution on climate change and ecosystem.	Decrease of the WTP for taxi and personal car. Increase of WTP for public transport and rented electric vehicle.	Aspect ecological.

Table 4: Description of the messages and respondents' behaviour expected.

[9] Framing effect is the tendency to be influenced by the way a problem is presented. The anchoring bias is the tendency unduly to use information as a reference.

3 Results

3.1 Descriptive analysis

Figures 2 and 3 present, with boxplots, the distributions of the WTP for each mean of transport and the information (message) provided for Group 1 and for Group 2, respectively. For each boxplot, we indicate the mean with a cross and the median with a line.

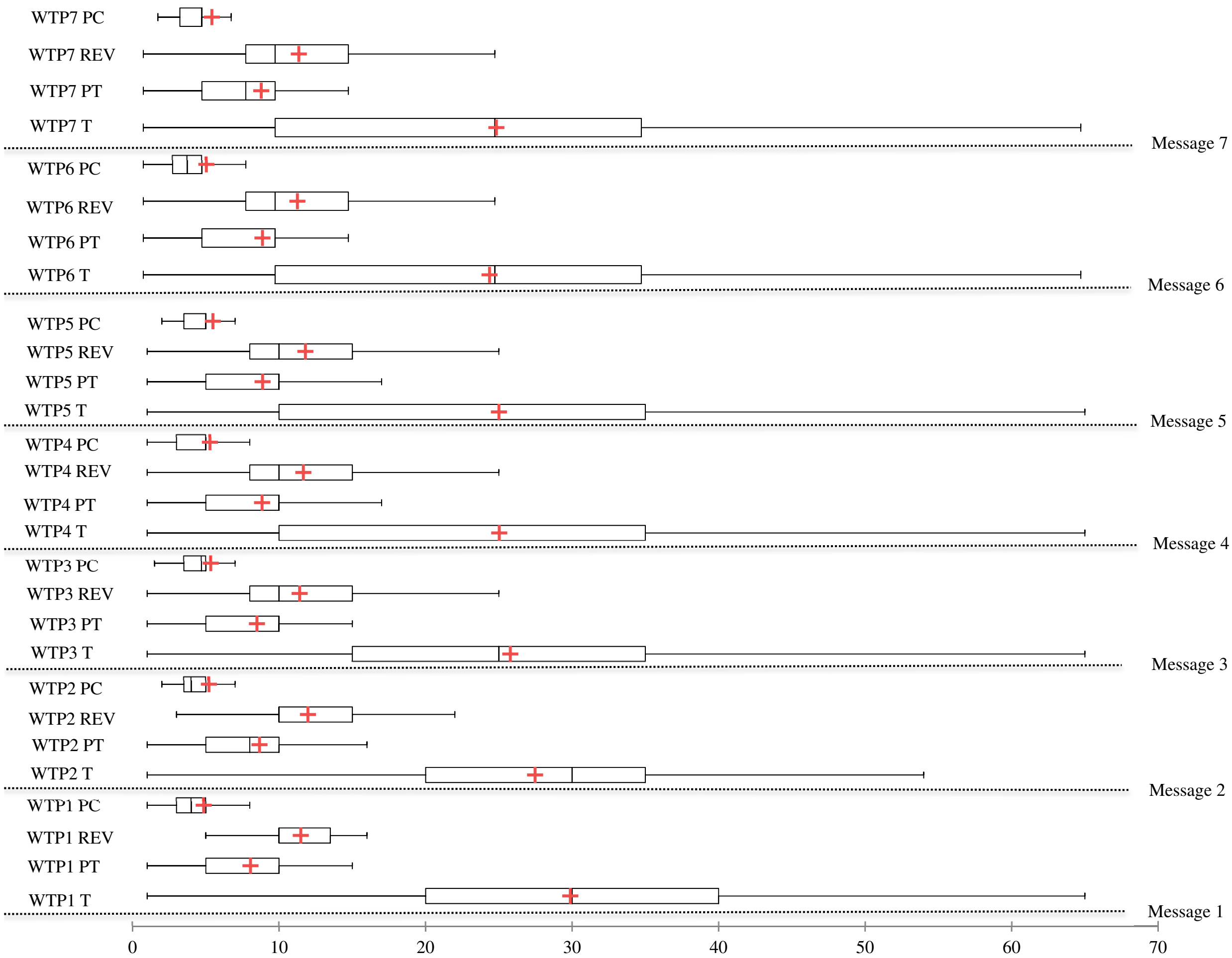

Figure 2: Distribution of the Willingness-To-Pay for each mean of transport in euro for Group 1.

We get that the dispersion for the WTP for the personal car and the WTP for the public transport is not affected by the messages. However, the means of these WTP have a tendency to increase with information. Therefore, this result is adapted to the respondents' behaviour expected for the public transport but does not for the personal car when information concerns the negative impact of air pollution on health. However, environmental arguments (message 6) make respondents to decrease their WTP for personal car. Respondents do not associated the negative impact of air pollution with personal car except when we introduce messages on the impacts on the environment.

Message 2 is the first message on the negative impact on health that respondents received.

It reduces the WTP for the taxi decision range and the mean because respondents converge toward the idea that taxi is responsible of air pollution. However, the introduction of other messages leads the respondents' WTP to diverge although the mean continues to go down until message 7. Indeed, after message 7, the mean increases. This shows that the ecological aspect does not affect respondents as expected.

The dispersion of the WTP for the rented electric vehicle increases with the successive messages while the mean stays stable, around €11.6. Therefore, on average respondents do not modify their preferences for rented electric vehicle with information. Either they do not see the advantages of using rented electric vehicle for health and the environment because do not know so much on electric energy. Alternatively, they prefer ignoring information.

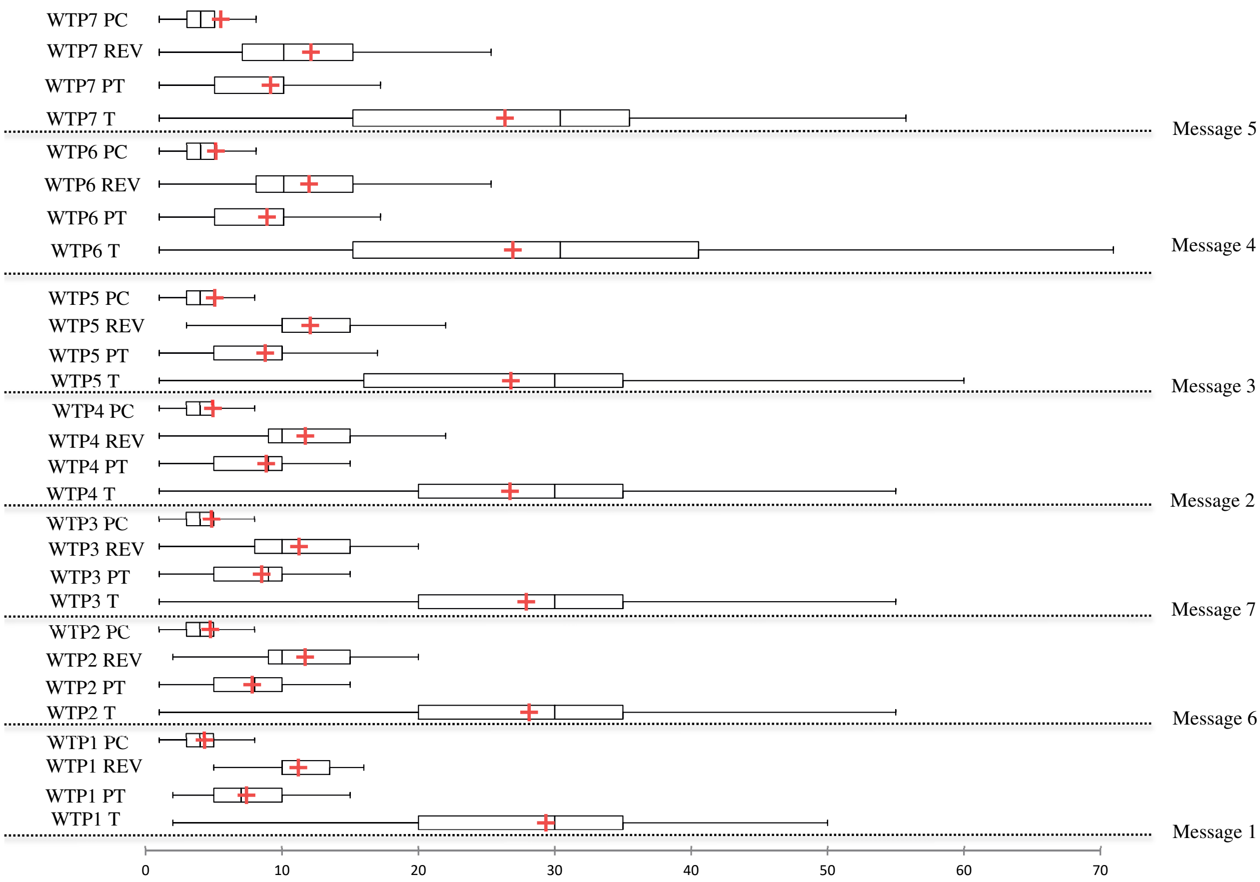

Figure 3: Distribution of the Willingness-To-Pay for each mean of transport in euro for Group 2.

As for the Group 1, respondents behave as expected for the public transport but do not for personal car. We note that the order of information is important because on average respondents of Group 2 always increases their WTP for personal car. The increase is higher than the one of the Group 1 (€4.3 to €5.4 for Group 2 and €4.9 to €5.7 for Group 1).

From message 3, the dispersion of the WTP for the taxi increases. Therefore, messages on the negative impacts on health creates a divergence between the respondent implying an increase in the range of WTP decisions. The mean has a tendency to decrease with information. As expected, the respondents' WTP for the taxi decreases with information. Therefore, respondents associate the use of taxi to a source of air pollutant. However, we note that the order of information influences the respondents' WTP. The WTP decrease for Group 1 is higher than the one for Group 2 (€29.9 to €25.1 for Group 1 and €29.4 to €26 for Group 1).

Finally, the effect of messages on the dispersion and on the mean of the WTP for the rented electric vehicle is ambiguous. However, after all information, the WTP increases ranging from €11.2 to €12. Therefore, respondents' behaviour is globally adapted to our expectation.

We now test, for each group of respondents, the significance of the average WTP differences linked to the information revelation with the Wilcoxon test for paired samples. We consider the significance of the differences at the 5% level. The test is made as follows: we compare the average WTP before and the average WTP after each message. This allows us to measure the impact of information revelation on the average respondents' WTP for a given mean of transport.

For the Group 1, message 2 leads to a statistically significant decrease of the average WTP for the taxi and a statistically significant increase of the average WTP for the personal car and public transport. For the Group 2, it leads to a statistically significant decrease of the average WTP for the taxi and a statistically significant increase of the average WTP for the rented electric vehicle. Therefore, giving the global negative effect of the air pollution by specifying the number of death (more than 2 million) modifies the respondents' WTP. However, it does not always incentive them to use low emission mean of transport.

Messages 3 and 5 only affect significantly the respondents of Group 1. Message 3 leads to a statistically significant decrease of the average WTP for the taxi and for the rented electric vehicle, and message 5 to a statistically significant increase of the average WTP for the personal car. Giving a local vision of the negative impact of air pollution emphasises the decrease of WTP for one of the most polluting mean of transport. Nevertheless, it has a surprising and unexplainable effect on the WTP for rented electric vehicle. The economics argument is counterproductive. It does not convince the respondents to reduce their WTP for personal car (one of the most polluting mean of transport) but even leads them to increase their WTP. Here, we may note that respondents play as in the Prisoner's dilemma or the tragedy of the commons. They do not think collectively (reducing health costs of air pollution) but individually (pleasure being in its own car).

Moreover, we get that message 6 (on buildings preservation) leads to significant decrease of the average WTP for the personal car for Group 1 and a significant increase of the average WTP for the public transport for Group 2. Respondents then favour the reduction of air pollutants. Message 7 leads to significant increase of the average WTP for the personal car for Group 1 and a significant increase of the average WTP for the public transport for Group 2. Message 7 about ecological damages of air pollution, does not affect respondents of Group 1 as expected. Surely, the respondents underestimate the consequences on their own well-being to preserve the ecosystem and fight against the global warming. On the other hand, respondents of Group 2 are sensitive to the ecological argument and increase their WTP for one of the less polluting means of transport.

Finally, we observe that 17.5% of the respondents of Group 1 and 22.4% of respondents of Group 2 have the same WTP before and after receiving all the messages. Then, informing these respondents on the damages on health and the environment of air pollution does not change their preferences for the means of transport. Individuals prefer ignoring information even whether there are potential damages on health and on the environment because this behaviour maximises their own well-beings (Chemarin and Orset, 2011).

3.2 Econometric estimations: Willingness-To-Pay

We now investigate the determinants of WTP through estimations. We use a Random-Effect Panel model[10] on pooled data (2,394 observations). It includes dummies for the type of information Health or Environment (Information on Environment: 0 for no and 1 for yes), for the order of the received message (Message X received first: 0 for no and 1 for yes), for available information at the moment of the WTP elicitations (Message X: 0 for no and 1 for yes). The model also includes eight additional control variables: having its health impacted by air pollution (asthma, respiratory disorders, allergies), the individual importance attached to the air pollution index, the individual's confidence on air pollution recommendation, gender, income, age, socio-professional categories, and individual's localisation in Ile de France area. Having its health impacted by air pollution is a dummy variable (0 for no and 1 for yes), Individual importance attached to the air pollution is divided into four variables (Importance attached to the air pollution index-0: none; Importance attached to the air pollution index-1: weak ; Importance attached to the air pollution index-2: high; Importance attached to the air pollution index-3: very high), the individual's confidence on air pollution recommendation is divided into four variables (Confidence on recommendation-0: none; Confidence on recommendation-1: weak ; Confidence on recommendation-2: high; Confidence on recommendation-3: very high). Age is a quantitative variable and gender is a dummy variable (1 for woman and 0 for man). We have divided income into four variables (Income-0: $1000<$; Income-1: [1000,1500) ; Income-2: [1500,2500) ; Income-3: $2500\leq$), socio-professional categories into five variables (SPC-0: Farmer ; SCP-1: Craftsman ; SCP-2: Self-employed and executive ; SCP-3: Employee and worker ; SCP-4: Retired person, unemployed person and homemaker), and individual's localisation in Ile de France area (IDF) is a dummy variable (1 for yes and 0 for no). In the models, Importance attached to the air pollution index-0, Confidence on recommendation-0, Income-0 and SCP-0 are reference modalities. Table 5 presents the estimations results.

[10] According to the Breusch-Pagan test and the Hausman test, the Random-Effect Panel model is preferred to the Ordinary Least Square regression model and Fixed-Effect Panel model.

Endogenous variable: Model: Random-Effect Panel	Pooled Willingness To Pay for taxi in € (1)	Pooled Willingness To Pay for Personal Car in € (2)	Pooled Willingness To Pay for Rented Electric Vehicle in € (3)	Pooled Willingness To Pay for Public Transport in € (4)
Constant	27.616** (13.274)	2.781 (4.213)	14.526*** (5.624)	7.568* (4.166)
Information on Environment (1/0)	0.136 (1.562)	-0.396 (0.497)	-0.381 (0.678)	-0.789 (0.512)
Message 2 received first (1/0)	-1.213 (0.939)	0.264 (0.303)	0.025 (0.459)	0.291 (0.373)
Message 3 received first (1/0)	-1.749* (0.939)	-0.001 (0.303)	-0.934** (0.459)	-0.105 (0.373)
Message 4 received first (1/0)	-0.542 (0.939)	-0.085 (0.303)	0.494 (0.459)	0.326 (0.373)
Message 5 received first (1/0)	0.544 (0.939)	-0.147 (0.303)	0.006 (0.459)	-0.223 (0.373)
Message 6 received first (1/0)	-0.857 (0.939)	0.603** (0.303)	0.775* (0.459)	0.149 (0.373)
Message 7 received first (1/0)	-0.675 (0.939)	-0.287 (0.303)	-0.543 (0.459)	0.782** (0.373)
Message 2	-1.194* (0.676)	0.092 (0.218)	0.464 (0.330)	0.327 (0.268)
Message 3	0.061 (0.676)	0.130 (0.218)	0.364 (0.330)	-0.072 (0.268)
Message 4	-0.209 (0.676)	0.030 (0.218)	-0.242 (0.330)	0.021 (0.268)
Message 5	-0.567 (0.676)	0.347 (0.218)	0.138 (0.330)	0.258 (0.268)
Message 6	-0.373 (0.652)	-0.172 (0.210)	-0.275 (0.319)	0.266 (0.259)
Message 7	0.469 (0.652)	0.375* (0.210)	0.096 (0.319)	-0.084 (0.259)
Having its health impacted by air pollution (1/0)	2.659* (1.536)	-0.485 (0.487)	-0.627 (0.651)	0.390 (0.482)
Importance attached to the air pollution index-1 (-0)	2.388 (1.705)	0.533 (0.541)	1.818** (0.722)	0.485 (0.535)
Importance attached to the air pollution index-2 (-0)	0.281 (2.251)	0.317 (0.715)	1.969** (0.954)	0.754 (0.706)
Importance attached to the air pollution index-3 (-0)	-1.666 (4.027)	0.871 (1.278)	2.442 (1.706)	-0.796 (1.264)
Confidence on recommandation-1 (-0)	-0.661 (2.377)	0.787 (0.754)	-0.979 (1.007)	0.336 (0.746)
Confidence on recommandation-2 (-0)	0.290 (2.347)	0.906 (0.745)	-1.305 (0.994)	1.099 (0.736)
Confidence on recommandation-3 (-0)	-0.880 (2.701)	0.326 (0.857)	-0.928 (1.144)	1.563* (0.847)
Gender (1/0)	-0.163 (1.404)	-0.457 (0.446)	0.044 (0.595)	-0.126 (0.441)
Income-1 (-0)	0.233 (2.654)	-0.013 (0.842)	-0.882 (1.124)	0.100 (0.833)
Income-2 (-0)	-2.802 (2.546)	-1.223 (0.808)	-1.597 (1.079)	0.229 (0.799)
Income-3 (-0)	3.239 (2.427)	-0.836 (0.770)	-1.262 (1.028)	0.052 (0.761)
Age	0.073 (0.052)	0.015 (0.016)	-0.048** (0.022)	-0.009 (0.016)
SPC-1 (-0)	-9.067 (13.311)	1.262 (4.225)	-1.925 (5.639)	-0.897 (4.176)
SPC-2 (-0)	-4.487 (12.811)	1.633 (4.066)	0.850 (5.427)	0.174 (4.019)
SPC-3 (-0)	-2.595 (12.816)	1.203 (4.068)	0.422 (5.429)	-0.354 (4.021)
SPC-4 (-0)	-3.149 (12.828)	1.487 (4.071)	0.109 (5.434)	-0.302 (4.025)
IDF (1/0)	1.146 (1.838)	0.815 (0.583)	-0.611 (0.779)	-0.482 (0.577)
Observations	2,394	2,394	2,394	2,394
R^2	0.082	0.043	0.049	0.042
Log-likelihood	-9628.259	-6887.654	-7639.641	-6974.127

*p<0.1; **p<0.05; ***p<0.01. Standard errors in parentheses.

Table 5: Results from Random-Effect panel model about pooled WTPs in levels.

We get that providing first message 3 significantly decreases both the WTP for the taxi by €1.749 and the WTP for the rented electric vehicle by €0.934. Providing first message 6 significantly increases both the WTP for the personal car by €0.603 and the WTP for the rented electric vehicle by €0.775. In addition, providing first message 7 increases the WTP for public transport. Therefore, choosing to introduce first message on health reduces the individual's preferences for one of the high emitting means of transport (taxi) but it also reduces the ones for one of the low emission vehicles (rented electric vehicle). On the other hand, choosing to introduce first message on the environment increases the individual's preferences for the two low emission means of transport (rented electric vehicle and public transport) but also increases the ones for one of the high emitting vehicles (personal car). Then, the order of information given impacts respondents' WTP. However, the choice between introducing first health and introducing first the environment is ambiguous.

Moreover, providing message 2 leads the respondents to reduce their preferences for a polluting mean of transport (significantly decreases the WTP for the taxi by €1.194) while message 7 increases their preferences (significantly increases the WTP for the personal car by €0.375). Message 7 is then counterproductive for the policy of reduction of air pollution.

In addition, having its health impacted by air pollution significantly increases the WTP for the taxi by €2.659. The discomfort dues to air pollution leads these respondents to have a larger valuation than the others for taxi, which allows them not to walk so much during the journey.

Moreover, whether the importance of the respondent to the air pollution index is low or high, the WTP for the rented electric vehicle increases. However, this WTP decreases with age, surely due to lack of knowledge about the means of electric transport and / or their habit.

Finally, a high level of confidence on air pollution recommendation implies a higher preference for public transport. So giving confidence to respondent would be useful for convincing him to use public transport, which is one of the low emission mean of transport.

4 Welfare and regulation

In this section, based on elicited WTP for the means of transport, we investigate the welfare impact of various health and environmental policies (information campaign, tax and subsidy, and standard). We assume that all means of transport (taxi, public transport, personal car and electric rented vehicle) are available on the market. We first present the demands and supplies for each mean of transport.

4.1 Mean of transport demand and supply

To convert the WTP to demand curves, it is assumed that each participant would make a choice related to the largest difference between its WTP and the market price. This choice is inferred because the real choice is not observed in the study, which only elicits WTP. Despite this limitation, this methodology is useful for estimating ex ante individuals' reactions to regulatory instruments.

Figure 4 shows the ordered WTP of the two groups' respondents for the four means of transports.[11] The cumulative number of respondents (equivalent to one used mean of transport per participant) is represented on the X-axis and the ordered WTP (in euro) corresponding to the cumulative number of respondents is represented on the Y-axis in decreasing order. The grey ordered curve is the elicited WTP directly observed from the panel study, the dotted curve is the predicted WTP with the random effect panel estimation, and the dashed line is the real supply that is the actual price paid by individual for a ride (€50 for taxi, €3.7 for personal car, €13.5 for rented electric vehicle, and €10 for public transport).[12]

[11]The results after the other messages are available under request.

[12]Note that the WTP in all the curves is ordered, which means that a given number on the X-axis indicates the ranking of WTP related to each curve and not a specific participant.

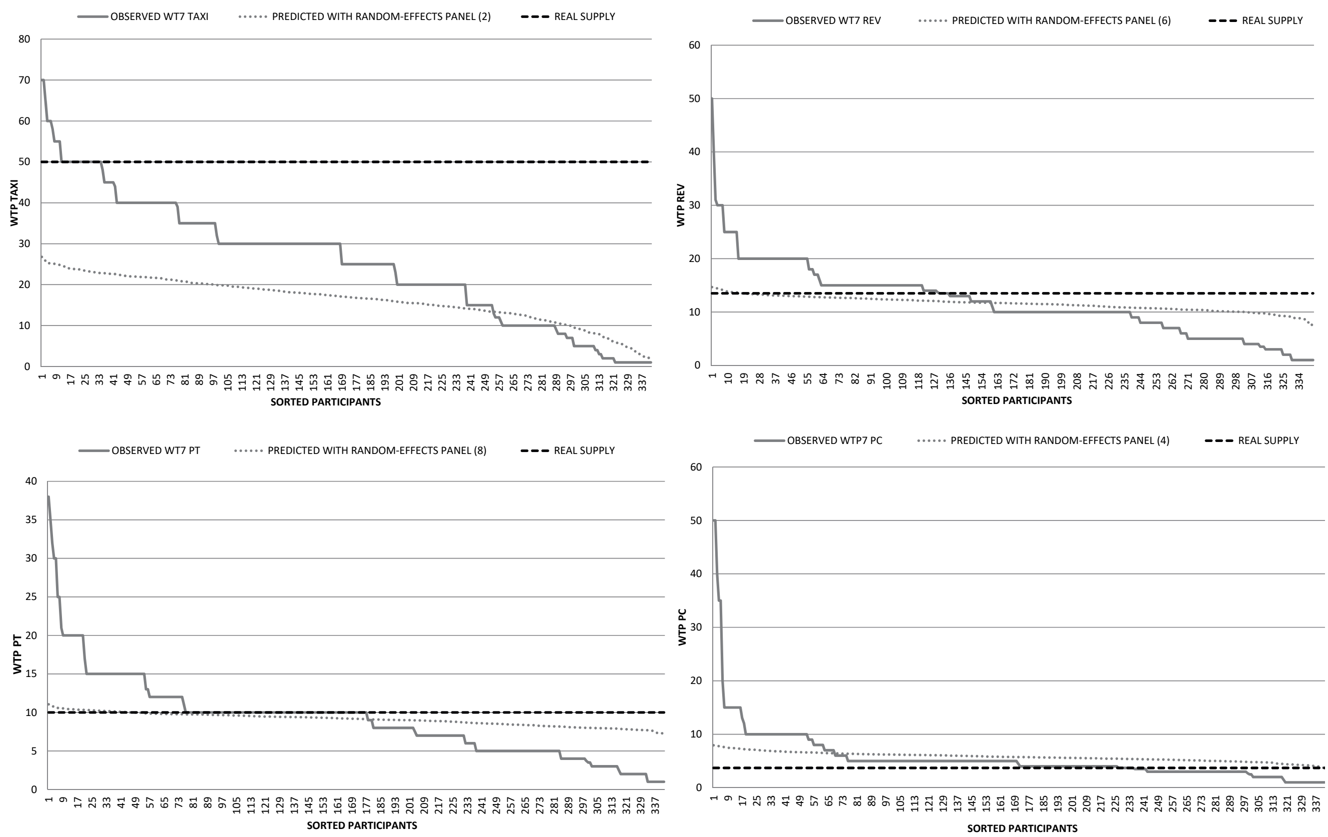

Figure 4: Observed and predicted demand functions of the two groups' respondents for the four means of transport (in euro) after all the information that is at round 7.

The left sides (right sides) of each graphs show that, for relatively high-values (low-values) of WTP, the elicited WTPs directly observed from the panel study are significantly higher (lower) than the WTPs predicted.

4.2 Regulatory interventions

In France, the measures implemented for reducing air pollution are aimed at encouraging the use of low emission vehicles. We propose different regulatory interventions for reaching this goal. We first suggest an information campaign, then a taxation of the high emitting means of transport (taxi and personal car) completed by a subsidy for the low emission means of transport (rented electric vehicle and public transport), and finally a standard imposing the use of low emission vehicles (rented electric vehicle and public transport). We then analyse the impacts of these three regulatory interventions on the respondents' decisions.

4.2.1 Information campaign

We suppose that the regulator makes a complete campaign of information on air pollution impacts on health and on the environment. For the moment, in France, the information only concerns the level of polluting induced by the means of transport and not their health and environmental consequences. CO_2 labelling of passenger cars was made compulsory in 2006 for new vehicles. It aims to educate buyers of vehicles emissions. Moreover, since October 1, 2013, passenger transport providers are required to provide information on the amounts of CO_2-induced services. The law on the energy transition to green growth of 17 August 2015 extending the information obligation CO_2 to all greenhouse gases. Here, we consider that public intervention consists in a very intense information campaign, perfectly understood by all travellers and revealing information on the damages of air pollution on health and the environment. For the two groups of respondents, this leads to round 7.

Following this information campaign, travellers are perfectly informed. Travellers directly internalize all information provided by the campaign. For each mean of transport $k \in \{T, PT, REV, PC\}$ and for each respondent $i \in N$, the traveller's surplus before the information and the traveller's surplus after the information are, respectively:

$$W_i^{BL}(k) = max\{0, WTP_{i1}k - P(k)\} \text{ and } W_i^{AL}(k) = max\{0, WTP_{i7}k - P(k)\}$$

with P(T)=€50, P(PT)=€10, P(REV)=€13.5 and P(PC)=€3.7, the market price for a ride with a taxi, public transport, a rented electric vehicle, and a personal car, respectively. Then, for each mean of transport k, we define the average variation in traveller surplus by $\sum_{i=1}^{N} \frac{1}{N} \left[W_i^{AL}(k) - W_i^{BL}(k)\right]$. We consider that a traveller is counted up in the number of travellers who take the mean of transport k before and after the information when he gets a demand for the mean of transport k, that is when $WTP_{i1}k \geq P(k)$ and $WTP_{i7} \geq P(k)$, respectively. We then define the variation in number of travellers by the difference between the number of travellers who take the mean of transport k after information and the number of travellers who take the mean of transport k before information. With a number $N = 177$ for Group 1 and $N = 165$ for Group 2, we detail the average variation in traveller surplus in euro, the number of travellers using each mean of transport before and after the information, and the variation in number of travellers, with elicited and predicted values from random-effect panel model (Table 5) in Table 6.

	Taxi	Public Transport	Rented Electric Vehicle	Personal car	None
	Group 1				
Elicited WTP					
Average variation in traveller surplus	0.08	1.19	0.69	0.87	
Number of travellers before the information	21	80	53	126	36
Number of travellers after the information	19	87	72	129	26
Variation in number of travellers	-2	7	19	3	-10
Predicted WTP with model Random effect panel					
Average variation in traveller surplus	0	0.05	-0.01	0.79	
Number of travellers before the information	0	1	8	158	19
Number of travellers after the information	0	26	5	176	1
Variation in number of travellers	0	25	-3	18	-18
	Group 2				
Elicited WTP					
Average variation in traveller surplus	0.30	1.13	1.16	1.22	
Number of travellers before the information	14	59	46	103	41
Number of travellers after the information	15	90	63	106	22
Variation in number of travellers	1	31	17	3	-19
Predicted WTP with model Random effect panel					
Average variation in traveller surplus	0	0.04	0.03	1.09	
Number of travellers before the information	0	0	6	147	18
Number of travellers after the information	0	19	14	165	0
Variation in number of travellers	0	19	8	18	-18

Table 6: Average variation in traveller surplus in euro, number of travellers before and after information, variation in number of travellers over the 177 (Group 1) and 165 (Group 2) respondents.

We see that for the two groups, the average variation in traveller surplus is positive for each mean of transport. Therefore, in term of traveller surplus, information campaign is good.

We get for the two groups, the total number of travellers marginally increases for the high emitting means of transport, taxi and personal car, and it strongly increases for the low emission means of transport, public transport and rented electric vehicle. Then, information campaign creates a higher demand for low emission vehicles. Indeed, after information 49.2% (before information: 45.2%) of the Group 1's respondents and 54.5% (before information: 35.8%) of the Group 2's respondents have a demand for public transport and 40.7% (before information: 29.9%) of the Group 1's respondents and 38.1% (before information: 27.9%) of the Group 2's respondents for the rented electric vehicle. So giving first information on health increases more the demand for rented electric vehicle while giving first information on the environment increases more the demand for public transport. However, in the absolute value, the demand for personal car is still the highest with information campaign, and it has increased (from 71.2% to 72.9% for Group 1, and from 62.4% to 64.2% for Group 2) for the two groups. Since personal car is not expensive and comfortable as mean of transport, respondents surely prefer ignoring information of its consequences on air pollution. They even increase their preferences for it in order to avoid being in contact with outdoor air. Therefore, respondents act independently according their own self-interest and do not act for the common interest. This is exactly the behaviour expresses in the tragedy of commons with the air as the shared resource.

Moreover, we observe that before information, 20.3% of the Group 1's respondents and 24.8% of the Group 2's respondents do not have a demand for none of the means of transport proposed. This rises an issue. The actual price of the means of transport for the journey from the center of Paris (Châtelet, Paris Métro) to the Paris Charles de Gaulle Airport is perceived as being too expensive for them. Thanks to the information campaign, this part is reduced at 14.7% for the Group 1 and at 13.3% for the Group 2.

Finally, giving first messages on the impacts of air pollution on the environment leads to a lower number of travellers who do not have a demand for a mean of transport proposed and implies a higher demand for low emission vehicles than giving first message on health. Note that the impact on demand for high emitting vehicles is closed for the two Groups. In addition, giving first messages on the impacts of air pollution on the environment increases more the traveller surplus than giving first messages on health. Therefore, when an information campaign is implemented, it is preferable to give first messages on the environment on the traveller surplus viewpoint.

4.2.2 A per-unit tax and a per-unit subsidy

The public intervention consists in the adoption of a per-unit tax τ for the high emitting means of transport, that is taxi and personal car, and a per-unit subsidy s for the low emission means of transport, that is public transport and rented electric vehicle. In France, the bonus malus system was implemented. It allows to participate in the significant reduction in average CO_2 emissions by subsidizing for low-emission transport and by taxing high emitting vehicles, which fell from 149 CO_2g/km in 2007 to 113 CO_2g/km in 2014. The amounts and thresholds are periodically revised to improve device performance. Since April 1, 2015, in the framework of the law on the energy transition to green growth, the schedule of bonus was reduced to 60 CO_2g/km, favouring electric vehicles and public transport. Traveller i can choose between five outcomes: a taxi at price $P^\tau(T)$ euro, public transport at price $P^s(PT)$ euro, a rented electric vehicle at price $P^s(REV)$ euro, a personal car at price $P^\tau(PC)$ euro, or neither. We propose to simulate different scenario. First, we consider that travellers have no precise knowledge about the consequences of air pollution on health and the environment, which corresponds to the situation of round 1 (before information) for the two groups. Second, we consider that the regulator makes a complete campaign of information on air pollution impacts on health and the environment, which corresponds to the situation of round 7 (after information) for the two groups. For each mean of transport $k_1 \in \{T, PC\}$ and $k_2 \in \{PT, REV\}$, and for each respondent $i \in N$, the traveller surplus when the mean of transport is subject to a tax and when it is subject to a subsidy before information are, respectively:

$$W_{i1}^\tau(k_1) = max\{0, WTP_{i1}k_1 - P^\tau(k_1)\} \text{ and } W_{i1}^s(k_2) = max\{0, WTP_{i1}k_2 - P^s(k_2)\}$$

and after information are, respectively:

$$W_{i7}^{\tau}(k_1) = max\{0, WTP_{i7}k_1 - P^{\tau}(k_1)\} \text{ and } W_{i7}^{s}(k_2) = max\{0, WTP_{i7}k_2 - P^{s}(k_2)\}$$

where $P^{\tau}(T) = P(T) + \tau^{T}$, $P^{s}(PT) = P(PT) - s^{PT}$, $P^{s}(REV) = P(REV) - s^{REV}$ and $P^{\tau}(PC) = P(PC) + \tau^{PC}$ with P(T)= €50, P(PT)= €10, P(REV)=€13.5 and P(PC)=€3.7, the market price for a ride with a taxi, public transport, a rented electric vehicle, and a personal car, respectively. The regulator chooses the optimal taxes for taxi and for personal car and the optimal subsidies for public transport and for rented electric vehicle. The regulator chooses the lowest tax for taxi (for personal car) which leads no respondents to use the taxi (personal car) anymore. Then, we propose two ways for implementing the subsidy for the low emission vehicles. First, the regulator chooses the lowest subsidy for public transport (for rented electric vehicle) which leads all the respondents to use public transport (rented electric vehicle). Second, the regulator chooses the lowest subsidy for public transport and the lowest subsidy for rented electric vehicle, which leads the respondents to use at least one of the low emission vehicles that is either public transport or a rented electric vehicle.

We define the average variation in traveller surplus when the mean transport $k_1 \in \{T, PC\}$ is subject to the optimal tax τ^* before information and after information by $\sum_{i=1}^{N} \frac{1}{N}\left[W_{i1}^{\tau^*}(k_1) - W_i^{BL}(k_1)\right]$ and $\sum_{i=1}^{N} \frac{1}{N}\left[W_{i7}^{\tau^*}(k_1) - W_i^{AL}(k_1)\right]$, respectively. We define the average variation in traveller surplus when the mean of transport $k_2 \in \{PT, REV\}$ is subject to the optimal subsidy s^* before information and after information by $\sum_{i=1}^{N} \frac{1}{N}\left[W_{i1}^{s^*}(k_2) - W_i^{BL}(k_2)\right]$ and $\sum_{i=1}^{N} \frac{1}{N}\left[W_{i7}^{s^*}(k_2) - W_i^{AL}(k_2)\right]$, respectively. We consider that a traveller is counted up in the number of travellers who take the mean of transport $k_1 \in \{T, PC\}$ ($k_2 \in \{PT, REV\}$) before and after the information when $WTP_{i1}k_1 \geq P^{\tau^*}(k_1)$ ($WTP_{i1}k_2 \geq P^{s^*}(k_2)$), and when $WTP_{i7}k_1 \geq P^{\tau^*}(k_1)$ ($WTP_{i7}k_2 \geq P^{s^*}(k_2)$), respectively. We then define the variation in number of travellers by the difference between the number of travellers who take the mean of transport $k_1 \in \{T, PC\}$ ($k_2 \in \{PT, REV\}$) with the tax (with the subsidy) and the number of travellers who take the mean of transport $k_1 \in \{T, PC\}$ ($k_2 \in \{PT, REV\}$) without tax (without subsidy). With a number $N = 177$ for Group 1 and $N = 165$ for Group 2, and before and after information, we detail the level of taxes in euro, the level of subsidies in euro, the average variation in traveller surplus in euro, the number of travellers using each mean of transport with taxes and subsidies, and the variation in number of travellers, with elicited and predicted values from random-effect panel model (Table 5) in Table 7.

Case in which all the respondents use public transport and rented electric vehicle

Before information	Group 1					Group 2				
	Taxi	*Public Transport*	*Rented Electric Vehicle*	*Personal car*	*None*	*Taxi*	*Public Transport*	*Rented Electric Vehicle*	*Personal car*	*None*
Elicited WTP										
Level of tax	15.10			36.40		0.10			21.40	
Level of subsidy		9.00	12.50				8.00	11.50		
Average variation in traveller surplus	-0.27	6.67	9.51	-1.44	0	0	4.88	7.84	-0.95	
Number of travellers	0	177	177	0	0	0	165	165	0	0
Variation in number of travellers	-21	97	124	-126	-36	-14	106	119	-103	-41
Predicted WTP with model Random effect panel										
Level of tax	0			3.36		0			3.13	
Level of subsidy		3.71	5.35					4.53	7.27	
Average variation in traveller surplus	0	1.80	3.35	-1.19	0	0	1.84	4.64	-0.98	
Number of travellers	0	177	177	0	0	0	165	165	0	0
Variation in number of travellers	0	176	169	-158	-19	0	165	159	-147	-18

After information	Group 1					Group 2				
	Taxi	*Public Transport*	*Rented Electric Vehicle*	*Personal car*	*None*	*Taxi*	*Public Transport*	*Rented Electric Vehicle*	*Personal car*	*None*
Elicited WTP										
Level of tax	15.10			46.40		20.10			46.40	
Level of subsidy		9.00	12.50				9.00	12.50		
Average variation in traveller surplus	-0.38	6.96	9.61	-2.48	0	-0.30	6.75	9.02	-2.23	
Number of travellers	0	177	177	0	0	0	165	165	0	0
Variation in number of travellers	-19	90	105	-129	-26	-15	75	102	-106	-22
Predicted WTP with model Random effect panel										
Level of tax	0			4.19		0			4.25	
Level of subsidy		2.71	5.49				2.88	6.77		
Average variation in traveller surplus	0	1.88	3.59	-2.13	0	0	1.94	4.96	-2.14	
Number of travellers	0	177	177	0	0	0	165	165	0	0
Variation in number of travellers	0	151	172	-176	-1	0	146	151	-165	0

Case in which the respondents use at least one of the low emission vehicle (either public transport or a rented electric vehicle)

Before information	Group 1					Group 2				
	Taxi	*Public Transport*	*Rented Electric Vehicle*	*Personal car*	*None*	*Taxi*	*Public Transport*	*Rented Electric Vehicle*	*Personal car*	*None*
Elicited WTP										
Level of tax	15.10			36.10		0.10			21.40	
Level of subsidy		9.00	0				8.00	0		
Average variation in travellers' surplus	-0.27	6.67	0	-1.44	0	0	4.88	0	-0.95	
Number of travellers	0	177	53	0	0	0	165	46	0	0
Variation in number of travellers	-21	97	0	-126	-36	-14	106	0	-103	-41
Predicted WTP with model Random effect panel										
Level of tax	0			3.36		0			3.13	
Level of subsidy		3.71	0				4.53	0		
Average variation in travellers' surplus	0	1.80	0	-1.19	0	0	1.84	0	-0.98	
Number of travellers	0	177	8	0	0	0	165	6	0	0
Variation in number of travellers	0	176	0	-158	-19	0	165	0	-147	-18

After information	Group 1					Group 2				
	Taxi	*Public Transport*	*Rented Electric Vehicle*	*Personal car*	*None*	*Taxi*	*Public Transport*	*Rented Electric Vehicle*	*Personal car*	*None*
Elicited WTP										
Level of tax	15.10			46.40		20.10			46.40	
Level of subsidy		9.00	0				9.00	0		
Average variation in travellers' surplus	-0.38	6.96	0	-2.48	0	-0.30	6.75	0	-2.23	
Number of travellers	0	177	72	0	0	0	165	63	0	0
Variation in number of travellers	-19	90	0	-129	-26	-15	75	0	-106	-22
Predicted WTP with model Random effect panel										
Level of tax	0			4.19		0			4.25	
Level of subsidy		2.71	0				2.88	0		
Average variation in travellers' surplus	0	1.88	0	-2.13	0	0	1.94	0	-2.14	
Number of travellers	0	177	5	0	0	0	165	14	0	0
Variation in number of travellers	0	151	0	-176	-1	0	146	0	-165	0

Table 7: Levels of taxes and of subsidies in euro, average variation in traveller surplus in euro, number of travellers with taxes and subsidies, variation in number of travellers, before and after information over Group 1 (177 respondents) and Group 2 (165 respondents).

With the elicited WTP, we first note that the global variation in traveller surplus is always positive for the two groups, whatever the cases and the level of information. In addition, the variation in traveller surplus is always higher for the Group 1 than for the Group 2. However, in the two cases, the variation in traveller surplus of Group 1 decreases with information acquisition while it increases for Group 2. Therefore, the tax-subsidy policy is good on the traveller surplus point of view. Nevertheless, according to this point of view, for Group 1 information is detrimental while it is good for Group 2.

We observe, with the elicited WTP, for Group 1 neither the cases implemented nor the level of information have an impact on the level of the optimal tax for taxi and the level of the optimal subsidy for the public transport. On the other hand, the level of the optimal subsidy for rented electric vehicle changes with the implemented case, and the level of the optimal tax for personal car increases with information acquisition. For Group 2, with information acquisition, the levels of the optimal tax for taxi and personal car increase just like the levels of the optimal subsidy for public transport and rented electric vehicle. Then, only the level of the optimal subsidy for rented electric vehicle changes with the implemented case.

Finally, we observe that with this policy, all the respondents have a demand for one of the transport. We avoid the eviction effect of one part of the population.

4.2.3 A Standard

The public intervention consists in the adoption of a standard limiting the use of the high emitting means of transport that is taxi and personal car. In Paris, since 2015 a day per year without polluting vehicles inside the city has been organized by Paris city hall. In addition, since January 23, 2017, an "Air Quality Certificates" device classifies vehicles into five categories according to age and therefore its level of pollutant. It must allow regulator to modulate the incentive or restrictive measures he wants to put in place. First, we consider that travellers have no precise knowledge about the consequences on health and the environment of air pollution, which corresponds to the situation of round 1 (before information). Second, we consider that the regulator makes a complete campaign of information on air pollution impacts on health and the environment, which corresponds to the situation of round 7 (after information). We consider that the regulator only authorizes public transport at price P(PT)=€10 and a rented electric vehicle at price P(REV)=€13.5 euro. The use of taxi and personal car is forbidden.

For the mean of transport $k_2 \in \{PT, REV\}$ and for each respondent $i \in N$, the traveller surplus before information and the traveller surplus after information with the standard application are, respectively:

$$W_i^{BLS}(k_2) = max\{0, WTP_{i1}k_2 - P(k_2)\} \text{ and } W_i^{ALS}(k_2) = max\{0, WTP_{i7}k_2 - P(k_2)\}.$$

As taxi and personal car cannot be used, there is no traveller surplus. Then, for each mean of transport k_2, we define the average variation in traveller surplus by $\sum_{i=1}^{N} \frac{1}{N} \left[W_i^{BLS}(k_2) - W_i^{BL}(k_2)\right]$ and $\sum_{i=1}^{N} \frac{1}{N} \left[W_i^{ALS}(k_2) - W_i^{AL}(k_2)\right]$ before and after information, respectively. For each mean of transport $k_1 \in \{T, PC\}$, we define the average variation in traveller surplus by $\sum_{i=1}^{N} \frac{1}{N} \left[-W_i^{BL}(k_1)\right]$

and $\sum_{i=1}^{N} \frac{1}{N} \left[-W_i^{AL}(k_1)\right]$ before and after information, respectively. We consider that a traveller is counted up in the number of travellers who take the mean of transport k_2 before and after information with standard application when he gets a demand for the mean of transport k_2, that is when $WTP_{i1}k_2 \geq P(k_2$ and $WTP_{i7}k_2 \geq P(k_2$, respectively. We then define the variation in number of travellers by the difference between the number of travellers who take the mean of transport $k \in \{T, PT, REV, PC\}$ with the standard application and the number of travellers who take the mean of transport k without standard application. With a number $N = 177$ for Group 1 and $N = 165$ for Group 2, we detail the average variation in traveller surplus in euro, the number of travellers using each mean of transport with the standard application, and the variation in number of travellers with elicited and predicted values from random-effect panel model (Table 5) in Table 8.

Before information	Group 1					Group 2				
	Taxi	*Public Transport*	*Rented Electric Vehicle*	*Personal car*	*None*	*Taxi*	*Public Transport*	*Rented Electric Vehicle*	*Personal car*	*None*
Elicited WTP										
Average variation in traveller surplus	-0.27	0	0	-1.44		0	0	0	-0.95	
Number of travellers	0	80	53	0	80	0	59	46	0	84
Variation in number of travellers	-21	0	0	-126	44	-14	0	0	-103	43
Predicted WTP with model Random effect panel										
Average variation in traveller surplus	0	0	0	-1.19		0	0	0	-0.98	
Number of travellers	0	1	8	0	168	0	0	6	0	159
Variation in number of travellers	0	0	0	-158	149	0	0	0	-147	141

After information	Group 1					Group 2				
	Taxi	*Public Transport*	*Rented Electric Vehicle*	*Personal car*	*None*	*Taxi*	*Public Transport*	*Rented Electric Vehicle*	*Personal car*	*None*
Elicited WTP										
Average variation in traveller surplus	-0.38	0	0	-2.48		-0.30	0	0	-2.23	
Number of travellers	0	87	72	0	70	0	90	63	0	63
Variation in number of travellers	-19	0	0	-129	44	-15	0	0	-106	41
Predicted WTP with model Random effect panel										
Average variation in traveller surplus	0	0	0	-2.13		0	0	0	-2.14	
Number of travellers	0	26	5	0	148	0	19	14	0	132
Variation in number of travellers	0	0	0	-176	147	0	0	0	-165	132

Table 8: Average variation in traveller surplus in euro, number of travellers with standard application, and variation in number of travellers, before and after information, over Group 1 (177 respondents) and Group 2 (165 respondents).

We first observe that the average variation in traveller surplus is globally negative. Implementing a standard is not profitable for travellers. In addition, many travellers prefer not using neither public transport nor rented electric vehicle. Indeed, before information (after information), 45.2% (49.1%) of the Group 1's respondents have a demand for public transport, 29.9% (40.6%) for the rented electric vehicle and 45.2% (39.5%) for none of these means of transport. Moreover, before information (after information), 35.8% (54.5%) of the Group 2's respondents have a demand for public transport, 28.9% (38.2%) for the rented electric vehicle and 50.9% (38.2%) for none of these means of transport.

We note that in order to motivate the travellers who do not have a demand for public transport and rented electric vehicle, we could add the same subsidies for these two means of transport than in Table 7.

4.2.4 Summary

We note that the recommendations depend to the point of view taken. For the traveller surplus point of view, we recommend to the health and the environmental regulator the policy, which leads the traveller surplus to to increase with the policy. For the level of subsidy point of view, we recommend the policy, which leads to the global lowest government's expense for the subsidy. For the number of travellers who do not take any mean of transport point of view, we recommend the policy, which avoids the eviction of travellers on the means of transport market. In other words, we recommend the policy, which leads all the travellers to choose at least one of the means of transport proposed. Table 9 sums up our results. Then, featuring between these policies will depend on regulator's priorities.

Point of view of	**Policy recommended**
Traveller Surplus	Information campaign policy (giving first information on the environment). Tax-Subsidy policy without information campaign policy and with subsidy defining by the case in which all the respondents use low emission vehicles (public transport and rented electric vehicle).
Level of subsidy (Government expenses)	Tax-Subsidy policy without information campaign policy and with subsidy defining by the case in which the respondents use at least one of the low emission vehicles, that is either public transport or a rented electric vehicle.
Number of travellers who do not take any mean of transport	Tax-Subsidy policies. Standard-Subsidy policies

Table 9: Overview of the recommended policies.

5 Conclusion

In this paper, we have analysed the the preferences of travellers for the means of transport. This is useful for public authorities' choices (health and environmental policies).

We find that the order of messages given to individual has an impact on its WTP for the different means of transport. Indeed, giving first messages on the air pollution impacts on the environment leads individual to increase its preference for rented electric vehicle while its preference does not change when he first receives messages on the impacts on health.

Moreover, a message may be counterproductive for reducing the preferences of respondents for high emitting vehicles. Indeed, message 7 leads the respondents to increase their preferences for the personal car. The impact on the ecosystem and the climate change do not incentive the respondents to reduce their preferences for high emitting vehicle (personal car). However, other messages, as message 2 based on the number of deaths involving by the air pollution in the world, lead the respondents to reduce their preferences for high emitting vehicle.

From this study, we get a better understanding about the non-adoption of low emission vehicles through many awareness campaigns. Actually, in our two groups, respondents prefer personal car. An information campaign marginally modifies this preference. Even the information campaign, which increases the most the traveller surplus, that is the one giving first messages on the impacts of air pollution on the environment, does not modify this preference. Ignoring information on the harmful impacts of personal car on health and the environment clearly recall the tragedy of commons behaviour (considering air as a shared-resource). There, we need a tax-subsidy system or a standard-subsidy system to lead respondents to give up personal cars and to choose low emission vehicles as public transport and rented electric vehicle. This result supports and helps the actual policies taken on the reduction of air pollution by the mayor of Paris.

Although, this study may be replicated, our paper presents some limitations. First, as in all WTP approaches, there might be a hypothetical bias in our study. As suggested by Lusk (2003) we have tried to reduce this bias with a cheap talk detailing to respondents the means of transport we were presented them and explaining them the goal of the study. Second, we did not consider controversies or incorrect messages leading to respondents' confusion or misunderstanding. To correct this, we would introduce a probability of being wrongly informed δ, namely a probability of having respondents with misunderstanding regarding mean of transport, such that the average variation in traveller surplus for information campaign would become $\sum_{i=1}^{N}\left[(1-\delta)W_i^{AL}(k)-\delta W_i^{BL}(k)\right]/N$. This assumption would decrease the traveller surplus. Third, the way to collect data might be discussed. We have used an online study. Cobanoglu et al (2001), Couper (2000), and McDonald and Adam (2003) highlight that online studies allow to save time and efforts in collecting data. Moreover, Fricker et al (2005), Kreuter et al (2008) and Heerwegh and Loosveld (2008) show that online studies make it possible to get higher quality answers with less 'I do not know' and less unanswered than telephone survey and personal interview survey. Therefore, on the quality data collection, online studies do not look to present more disadvantage than other kinds of surveys.

Appendix

Message 1: *A ride from the center of Paris (Châtelet, Paris Métro) and Roissy Charles De Gaulle airport by taxi costs about 50 euro, 10 euro in public transport, 13.50 euro in rented electric car (Autolib type) and 3.70 euro in own car.*

Message 2: *According to WHO (World Health Organization): "Breathing clean air is considered essential for health and well-being of man. However, the air pollution continues to pose a major threat in terms of health around the world. [...] More than 2 million premature deaths each year can be attributed to the effects of outdoor air pollution in cities [...] worldwide".*

Message 3: *In France, we talk about 42,000 premature deaths, including 1,400 in Paris in 2011. According to the latest report of the European Environment Agency, nearly 400,000 deaths in Europe related to air pollution.*

Message 4: *If fine particles levels were in compliance with WHO quality targets 10 g/m as an annual average, Parisians and persons from the suburbs would gain six months of life expectancy. In 2013, the average fine particles levels was 26 g/m, more than double of what it is recommended.*

Message 5: *The Ministry of Ecology, Sustainable Development and Energy estimated in 2012 that health costs of air pollution outdoors in France rose annually by 20 to 30 billion euro, which corresponds to about 400 to 500 euro/year/person.*

Message 6: *Air pollution induced corrosion due to sulphur dioxide, blackening and crusts of buildings by largely dust from the combustion of petroleum products, as well as various changes in combination with the gel, moisture and micro-organisms.*

Message 7: *The air pollution is caused by the emission of components of different kinds into the atmosphere. While they are issued locally (at a city for example), these pollutants have consequences both at local, regional and global ("acid rain" which alter ecosystems, contributing to the effect greenhouse and global warming).*

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