How consumers of plastic water bottles are responding to environmental policies?

Caroline Orset, Nicolas Barret, Aurélien Lemaire

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Caroline Orset* Nicolas Barret† Aurélien Lemaire‡

Abstract

Although plastic induces environmental damages, almost all water bottles are made from plastic and the consumption never stops increasing. This study evaluates the consumers' willingness to pay (WTP) for different plastics used for water packaging. Successive messages emphasizing the characteristics of plastic are delivered to participants allowing explaining the influence of information on the consumers' WTP. We find that information has a manifest effect on WTP. We show there is a significant premium associated with recycled plastic packaging and organic and biodegradable plastic packaging. As there is no consensus on the plastic which is the most or the least dangerous for the environment, we propose different policies for protecting the environment. We discuss about the impact of these policies on consumer's purchasing decisions: switching one plastic packaging for another, or leaving water plastic bottles' market. We see that from the standpoint of consumer surplus, regulation is effective with certain environmental policies. Choosing between them then depend on the priorities of the regulator and pressure of lobbies.

Keywords: Biodegradable plastic bottles; Bioplastic bottles; Consumer's willingness to pay; Information campaign; Recycling plastic bottles; Regulatory instruments.

JEL Classification: D12, D60, H23, Q53, Q58 .

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1 Introduction

Plastic packaging is widely used everywhere in the world. This kind of packaging produces an important quantity of waste. One of the most common plastic used is polyethylene terephthalate abbreviated PET. This plastic is strong and durable, chemically and thermally stable. It has low gas permeability and is easily processed and handled. This almost unique combination of properties makes PET a very desirable material for a wide range of applications including food and beverage packaging especially water bottles at a very cost effective price. Globally 389 billion of PET bottles had been produced in 2010, 46% of them for water packaging (ELIPSO, 2012). But this stability leads PET to be highly resistant to environmental biodegradation. Biodegradation of one PET bottle left in nature can last around 500 years. Thus, this causes many and varied environmental concerns for both terrestrial and marine areas. Its accumulation is particularly impressive in the world's oceans where ends around 10% of the global plastic production every year (Fitzgerald, 2011). A seafaring scientist named Captain Charles Moore discovered and confirmed the existence of the Great Pacific Garbage Patch in 1997. In 2010, another similar area had been discovered in the Atlantic Ocean: The North Atlantic Garbage Patch. Finally, in 2013, a French expedition named the 7^{th} Continent expedition studied the Great Pacific Garbage Patch (Bossy, 2013) and started a new expedition in May 2014 in the North Atlantic Ocean.[1] The vast majority of all those marine debris is plastic materials and many of them are made of PET. According to Azzarello and Van Vleet (1987), Derraik (2002), Moore (2008), Saido (2014), and Sazima et al. (2002) plastic debris create a direct threat to wildlife, with many and varied species documented as being negatively impacted by those small plastic items. The main danger for most marine species is ingestion. Juvenile animals often become entangled in plastic debris, which can result in serious injury as the animal grows. Plastic ingested by animals persists in the digestive system implying a decrease feeding stimuli, secretion of gastric enzymes and levels of steroid hormones, leading to reproduction problems.

As very often concerning highly complex topics, the range of possible solution for protecting the ecosystem of plastic pollution is wide. Recently on the 13^{th} of March 2014, San Francisco municipality has made a step with an ordinance to ban the sale of PET water bottles on city-owned property (Timm, 2014). On the 2^{nd} July 2014, the European Commission adopted the Packaging and Packaging Waste Directive 94/62/EC, which currently concerns plastic bags However, as with plastic bags, plastic bottles are the most emblematic plastic wastes, this directive could be extended to plastic bottles.

Suppliers are also working on the reduction of plastic wastes. The significant environmental drawbacks of plastic disposal via both landfill and incineration are the driving force behind the development of plastic recycling processes (Paponga et al, 2014). PET is now recycled in many countries that are developing specific waste management policies. The recycled PET is named r-PET. In France, this solution has been used 20 years ago. In 2010, 310,000 tons of PET bottles have been collected in France: it represents a recycling rate of 51%. Around 30% of this

[1] For more details see: $http://expedition-7eme-continent.e-monsite.com/en/pages/page.html$.

collected PET can be used in order to produce food grade r-PET quality.[2] Another solution is the development of new plastics with less environmental impact like bio-based (plant-derivative) plastics. The two most known biopolymers are polyactic acid (PLA) and polyethylene-furanoate (PEF). They are derived from renewable biomass sources. PLA is produced from glucose and it is biodegradable. La Mantia et al (2012) prove that there is a better impact on environment of PLA compared to PET. However, PLA production is still low because even if PLA is mentioned as biodegradable plastic its needs anaerobic conditions. Its degradation is a source of methane that is a very powerful greenhouse effect gas. In addition, PLA recycling processes are still in progress. Loopla[3] by Galatic uses PLA wastes in order to recycle them but their process does not lead to 100% recycling of PLA. In addition, since the introduction of PLA in PET process recycling can lead to problems concerning PET recycling quality, few recycling companies invest in PLA recycling. Hence, in our study, we do not consider the recyclable property of PLA. By contrast, PEF is fully recyclable like PET but it is poorly biodegradable. PEF is made by converting sugars from sugarcane into plastic. Nowadays more than 2.5 billion plastic bottles made of biopolymers are already in use around the world, but this only represents less than 1% of global production. One of the main limiting aspects is the cost.

Today, 89 billion litre of water are bottled and consumed each year worldwide. Overall consumption of bottled water in the world in 2004 was almost double that of 1997.[4] Moreover, annual growth rate of plastic water bottle consumption in the world from 2008 to 2013 is at 6.2%.[5] So do consumers care about plastic water bottles' environmental impacts? Which environmental policies could be proposed and which one(s) is(are) optimal on the point of view of the consumer surplus? How environmental policies change consumers' purchasing decisions? To address these questions, we propose to study the consumers' perceptions through a willingness-to-pay (WTP) analysis. Indeed, consumers' perceptions are not only essential for packaging companies' choices but they are also for 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. Food experiments constitute some (for instance, on palm oil, Disdier et al, 2013; on milk, Marette and Millet, 2014, and on organic apples, Marette et al, 2012). Our paper contributes to this literature by investigating the precise impact of information on the plastic water bottles consumers' WTP. We believe to be the first study focusing on the consumer perception regarding plastic bottles. We first conduct an analysis to elicit the WTP for different kinds of plastic bottles with increasing levels of information on the use of various plastic bottles, and their environmental impacts. We find that information matters in terms of WTP. Bernard and Bernard (2009), Bougherara and Combris (2009), Disdier et al.(2013), Marette et al (2012), Marette and Millet (2014) and Yue et al. (2009) show that a significant proportion of consumers are willing to pay substantial premiums for environmentally friendly products. We then propose to analyse the premiums for

[2] For more details see ELIPSO (2012).

[3] For more details see *http://www.loopla.org/cradle/cradle.htm*.

[4] See: *http://www.planetoscope.com/dechets/321-consommation-mondiale-de-bouteilles-d-eau-en-plastique.html*.

[5] See: *http://www.bottledwater.org/economics/industry-statistics*.

organic, recycled, and biodegradable plastic water bottles.

Furthermore, we contribute to the ecological economics literature on the reduction of pollution and waste on the environment by proposing environmental policies and instruments which incentive consumers to purchase plastic bottles with a lower negative impact on the environment. However, contrary to questions about trade-off between regular and organic products in which regulator chooses to support organic products because they are more safety for health and their production reduces damages on the environment, the question of plastic bottles packaging is more technical and complex. Indeed, there is no consensus on the plastic which is the most or the least dangerous for the environment, we propose different policies for protecting the environment. We propose four policies: an information campaign on the characteristics of each plastic, an organic policy favouring plastic bottles issued of renewable products, a biodegradable policy favouring biodegradable plastic bottles, and a recycling policy favouring recyclable plastic bottles. A lot of works have been done on the producer side, essentially on the producer responsibility regulations based on the Extended Producer Responsibility principle to reduce waste and pollution in the environment (Da Cruz et al., 2012, 2014; Hage, 2007; Mayers, 2007; Numata, 2009; Palmer and Walls, 1997). But none of these works have studied this issue from the consumers' side. In this paper, from the consumers' revealed and estimated preferences on plastic used for water bottles packaging, we analyse the impact of environmental policies on the social welfare. This allows us both to identify the effects of each policy on the consumers' and producers' welfare, and to recommend optimal environmental policies. We discuss about the impact of these policies on consumer's purchasing decisions: switching one plastic packaging for another, or leaving water plastic bottles' market. We see that from the standpoint of consumer surplus, regulation is effective with certain environmental policies. Choosing between them then depend on the priorities of the regulator and pressure of lobbies.

The paper is organized as follows. Section 2 details the study. Section 3 focuses on the results. From a welfare analysis, section 4 displays the regulator's choices between different environmental policies and tools. Finally, section 5 concludes.

2 The study

After an increase by 2% in 2010, the market of plastic water bottles has increased by 6% in 2011 in France with 5,5 billions of litres consumed. In 2014, the consumption of plastic bottles is around 7,7 billions of litres (around 118 litres per inhabitant), namely an increase by 28.6% from 2011.[6] Today, French are the third biggest water bottles consumers after Italian and American people. According to TNS Sofres, 85% of the French citizen drink water bottles. We then propose to analyse the French consumers' perception on plastic water bottles.

[6]Data from Chambre Syndicale des Eaux Minérales: $http : //eaumineralenaturelle.fr/chambre - syndicale/leau - minerale - en - chiffres$.

2.1 Target respondents

During February 2014, we conducted the study through Marketest.[7] Marketest had selected French participants by using the quota method, i.e., the same proportions of gender, age and socio-economic status (occupation, income, education) criteria in the group of respondents as in the census report of French population by INSEE.[8] We had especially prepared the questionnaire to be posted online on the internet. The target respondents consists of 148 French people aged between 18 and 66.

Table 1 presents the socio-economic characteristics (gender, age, education, household composition, income, and occupation) of the participants. Differences between our panel 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 column of Table 1 suggest that the two groups are not significantly different.

Description	Study panel (%)	INSEE (%)	Chi2 test P-value
Gender			
Female	54.7	51.5	0.518
Male	45.3	48.5	
Age			
<20	14.9	25.0	0.063
[20-64]	65.5	57.0	
>64	19.6	18.0	
Education			
No baccalaureate (BAC)	45.9	59.0	0.062
BAC	21.0	16.0	
3 years after BAC	16.2	11.0	
More than 3 years after BAC	16.9	14.0	
People living in the household			
1 person	29.7	34.0	0.662
2 persons	27.7	26.0	
3 persons and more	42.6	40.0	

Notes : Baccalaureate is the French high school diploma.

Description	Study panel (%)	INSEE (%)	Chi2 test P-value
Monthly net income of the household (€)			
<1000	12.2	10.0	0.973
[1000-1500)	20.3	20.0	
[1500-2500)	20.3	20.0	
[2500-4000)	29.0	30.0	
[4000-6000)	10.1	10.0	
6000 ≤	8.1	10.0	
Socio-professional categories			
Farmers	0.0	1.0	0.987
Craftsman or trading	2.7	3.0	
Executives and professionals	9.5	9.6	
Freelance workerds	14.2	13.0	
Employees	16.9	17.0	
Workers	12.8	12.2	
Retired or looking for a job	27.7	26.5	
Without any professionnal activities	16.2	17.7	

Table 1: Socio-economic characteristics of participants.

Through informational questions on the respondents, we have selected buyers and consumers of plastic water bottles. The price is important for their plastic bottle decisions for 86.5% of them. Plastic bottles uses do not create damages on the environment for 19.6% of the participants. Bottle producers' communication campaign on the safety of their product for the

[7] For more details on Marketest see: *http : //www.marketest.co.uk/*.

[8] INSEE (Institut national de la statistique et des études économiques) is the census bureau in France.

environment does not convince 43.2% of the participants while 43.3% of them believe on bottle producers environment friendly engagement to protect the environment. 62.8% of the participants feel up to concerning environmental damages of plastic bottles. The use of recyclable packaging is an important innovation for the water bottle packaging sector for 88.5% of the participants. It is also important for 88.5% of the participants that the packaging be in recyclable material. Finally, 64.2% of the participant are sensitive to the environmental protection.

2.2 Products

Our study focuses on plastic water bottles. We consider a pack of six plastic water 1.5L bottles. Different kinds of plastic are proposed: PET, r-PET, PLA and PEF. PET is currently the most-widely used polyester in bottles. It is petroleum based and 100% recyclable but not biodegradable. r-PET is PET which has been recycled and is 100% recyclable. PLA is a biodegradable plastic. We do not mention its possible recyclable property in this work because since now only few recycling companies have invested in its recycling and the actual processes do not lead to 100% recycling of PLA.[9] It is derived from renewable resources. PLA is then considered as a bioplastic as well as PEF which is also made from renewable resources. PEF is 100% recyclable but not biodegradable. We have then decided to study these four kinds of plastic because they allow us to compare the demand for bioplastics, recyclable and biodegradable plastics for water bottles packaging.

In average, the observed pack of six water 1.5L bottles price is at 3.6 euro.[10] In our study, we only focus on the kind of plastic used for water bottles packaging.[11]

2.3 Experimental design and information revealed

In the questionnaire, successive messages emphasizing the plastic bottles characteristics and their environmental impacts are delivered to the survey participants. WTP is elicited after each message with the following question: *What is the maximum price you are willing to pay for a pack of six water 1.5L bottles with a packaging made of this plastic?* Only PET plastic bottles are presented in the three first rounds, then r-PET and biopolymer bottles (PLA and PEF) are introduced in the fourth round and in the fifth round, respectively. The experiment is divided into several stages as described in Figure 1.[12]

[9] This allows us to separate biodegradable and recycling participants' interest.
[10] This price is estimated from our enquiry at Naturalia and Carrefour market, in November 2013.
[11] We do not mention trademark to participants in order not to influence their decision.
[12] Messages are given in Appendix.

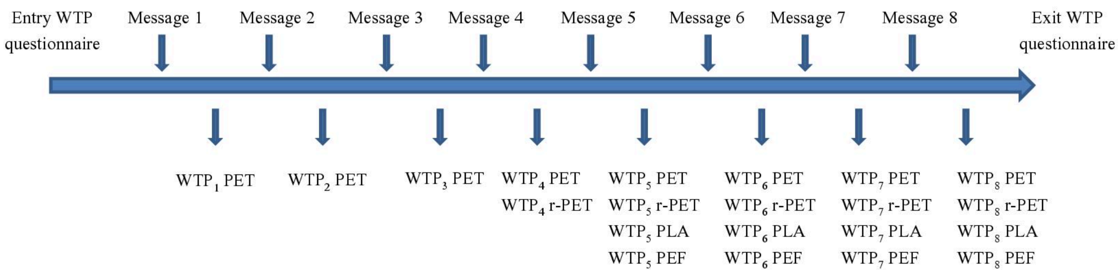

Figure 1: Questionnaire design.

The sequence of information revealed does no differ between the participants. As pre-tests have showed changing the order of the messages appear difficult to the participant's understanding.[13] Marketest has its own panel of respondents and pays them for replying to questionnaire. The questionnaire is as follows: first, a text helps participants to understand the purpose of this study. No information is given about the different kinds of plastic bottles. Then, participants fill in an entry questionnaire on consumption behaviour and socio-demographic characteristics. Finally, based on different types of information revealed to participants, eight rounds of WTP elicitation are successively determined.

The observed retail price for a pack of six plastic water 1.5L bottles, 3.6 euro is revealed in message 1, before the first WTP elicitation, allowing us to control the anchorage effect for the first message.[14] Messages 2 and 3 reveal detailed information about the negative consequences of PET bottles on the environment (pollution and non-biodegradability). Messages 4 and 5 introduce the r-PET and biopolymers (PLA and PEF) bottles, respectively. Then in message 6, biopolymers are divided in two categories of plastic, the biodegradable one, PLA, and the non-biodegradable one, PEF. Message 7 gives information on the negative impact of PLA bottles

[13] We have first tested our questionnaire on small samples of respondents before sending our questionnaire to Marketest. We call this pre-test.

[14] See Drichoutis et al. (2008) for a discussion on the issue of provision of reference prices prior to the auctions.

on the environment by clarifying that PLA bottles are polluting. Finally, message 8 informs the participants that PEF is a non-biodegradable biopolymer but it is recyclable.[15]

3 Results

3.1 Descriptive analysis

Figure 2 presents the distributions of the WTP for a pack of six water 1.5L bottles according to the type of plastic and the information (message) provided. It shows that r-PET and PLA bottles attract the highest WTP for any level of information while PET bottles WTP is the lowest. The reduction of WTPs for PLA and PEF bottles following an information on the negative impact of these products[16] is more important in absolute values than the increase when information specify that these products do not affect the environment.[17] In their prospect theory, Kahneman and Tversky (1979) observe that the impact of a loss on utility is twice higher than the impact of a symmetric gain on the utility. Our result presents this observation too. In addition, we find that the average and median WTPs are lower than the reference price for a pack, which is 3.6 euro. Hence, at this price, the demand for a pack of plastic bottles of our panel is low.

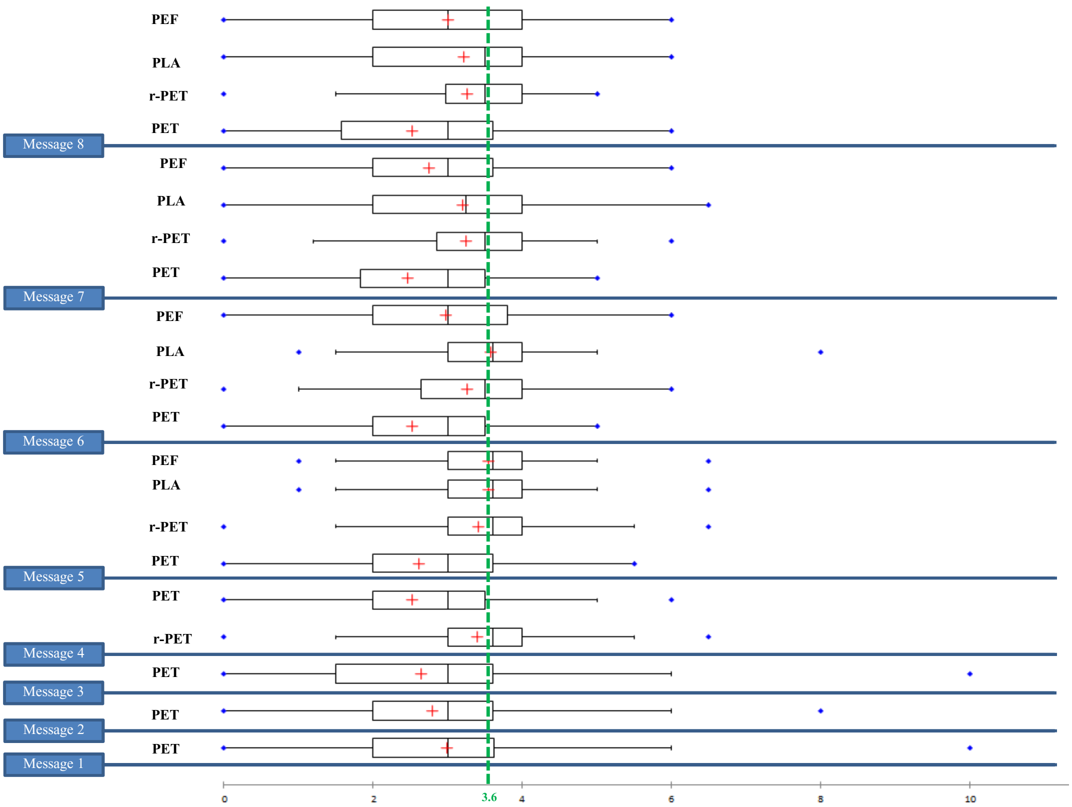

Figure 2: Distribution of the Willingness-To-Pay for a pack of six plastic water 1.5L bottles (in euro).

[15]See messages in appendix.
[16]Message 7 for PLA bottles and message 6 for PEF bottles.
[17]Message 6 for PLA bottles and message 8 for PEF bottles.

In Figure 3, we present the average WTP in euro for one pack of six plastic water 1.5L bottles expressed by all participants i after each message j with $j = 1, 2, ..., 8$. The standard deviation is reported in parentheses. Analysed vertically, each column indicates the average WTP of participants for each pack (PET bottles in very light-gray, r-PET bottles in light-gray, PLA bottles in gray, and PEF bottles in black), separately. We test for the significance of the WTP differences linked to the information revelation with the Wilcoxon test for paired samples. The test is made as follows: between messages j (between bars) for measuring the impact of information revelation on the average WTP for a given pack; For each specific message j for measuring the average WTP differences between two packs (between bars on a given column of two graphs).

We first note that information matters. Indeed, following the revelation of information, participants change their WTP. We observe that after messages on the negative impact on the environment of the plastic bottles (message 7 for PLA bottles and message 6 for PEF bottles) and the possibility of alternative plastic use more friendly for the environment (message 5 for PET and r-PET), the WTP for plastic bottles significantly decreases while it significantly increases after messages specifying that the kind of plastic does not affect the environment (message 8 for PEF bottles).

In average, the WTP for PET bottles is significantly lower than the ones for r-PET bottles, PLA bottles and PEF bottles. In average, after message 6, the WTP for PEF bottles is significantly lower than the ones for PLA and r-PET bottles. Then, until message 7, the WTP for PLA is significantly higher than the one for r-PET. To sum up, for our panel, in average, $WTP_{PET} < WTP_{PEF} < WTP_{PLA} \simeq WTP_{r-PET}$.

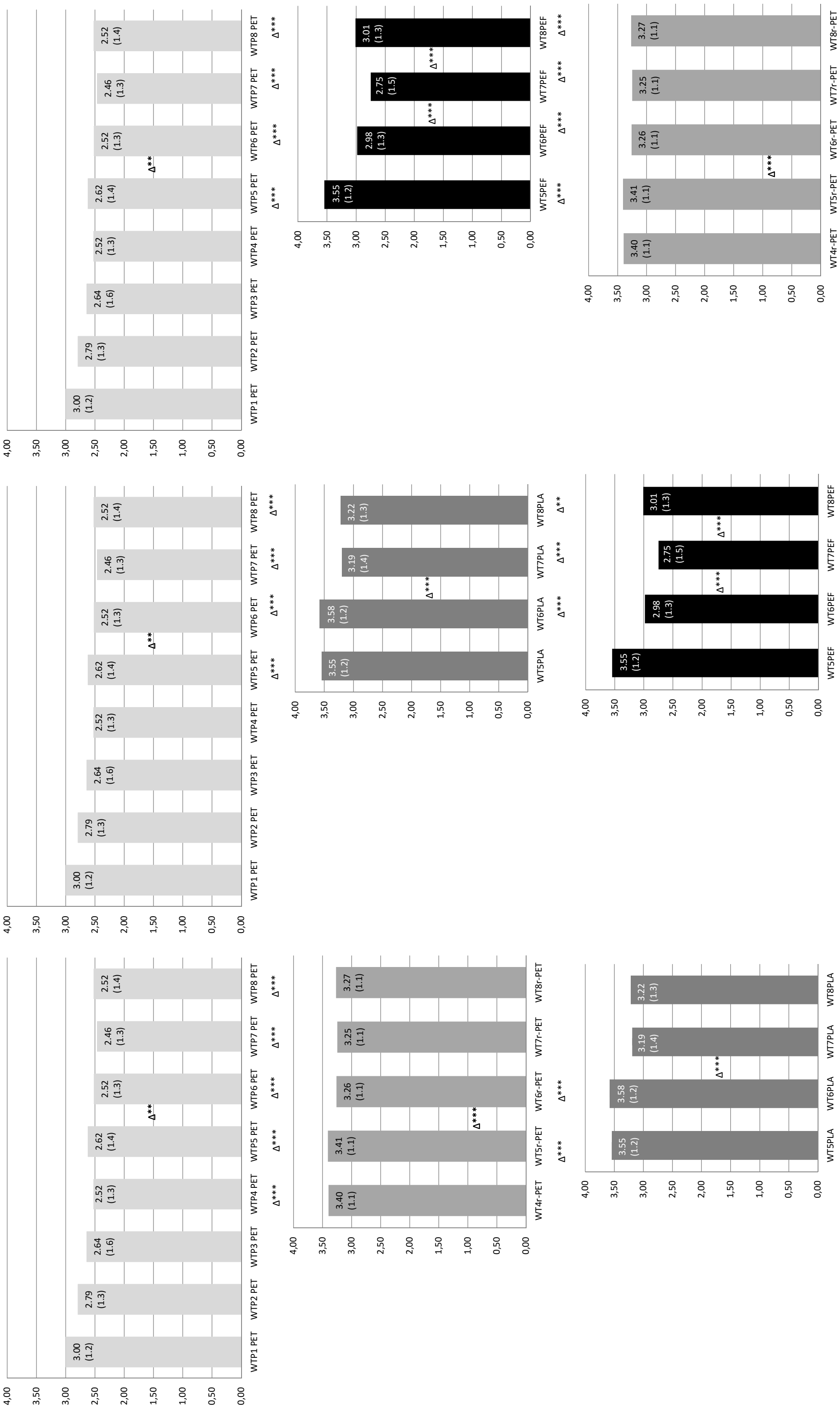

Figure 3: Average WTP for one pack of six plastic water 1.5L bottles and variations after information revelation. Note: Average WTP (in euro); Standard deviation in parentheses; Δ^{***} and Δ^{**} denote significant differences at the 1% and 5% levels, respectively, as tested by the Wilcoxon test.

3.2 Econometric estimations

3.2.1 Willingness-To-Pay

We now investigate the determinants of WTP through estimations. We use an ordinary least square regression (OLS) model on pooled data (L = 2,960). It includes dummies for the considered plastic bottles, and for available information at the moment of the WTP elicitations. The model also includes six additional control variables: age, sex, income, the individual importance attached to the protection of the environment, the individual's confidence to bottle producers' communication campaign, and the individual's confidence on bottle producers' environment friendly engagement.[18] Age is a quantitative variable and sex is a dummy variable (0 for woman and 1 for man). We have divided income in five variables (Income-0: 1000$<$; Income-1: [1000,1500) ; Income-2: [1500,2500) ; Income-3: [2500,4000) ; Income-4: [4000,6000) ; Income-5: 6000$\leq$), individual attachment to the protection of the environment in fives variables (Importance attached to the protection of environment-0: does not know ; Importance attached to the protection of environment-1: none ; Importance attached to the protection of environment-2: weak ; Importance attached to the protection of environment-3: high ; Importance attached to the protection of environment-4: very high), the individual's confidence on bottle producers' communication campaign in three variables (Confidence to bottles producers' communication campaign-0: does not know ; Confidence to bottles producers' communication campaign-1: yes ; Confidence to bottles producers' communication campaign-2: no), and the individual's confidence on bottle producers' environment friendly engagement in three variables (Confidence to bottles producers' environment friendly engagement-0: does not know ; Confidence to bottles producers' environment friendly engagement-1: yes ; Confidence to bottles producers' environment friendly engagement-2: no). In the model, PET bottles, Importance attached to the protection of environment-4, Confidence to bottles producers' communication campaign-2, Confidence to bottles producers' environment friendly engagement-2, and Income 5 are reference modalities.

[18] Bazoche et al (2013), Bernard and Bernard (2009), Crociata et al (2015), Hughnet et al (2007), Polyzou et al (2011) and Smed (2012) have showed the importance of control variables for studying good consumption behaviours, recycling behaviours, and WTP for environmental goods.

Table 2 presents the estimation results.

Endogenous variable: *Pooled Willingness To Pay in €/pack of six water bottles*
Model: *OLS Estimation*

	Coefficient	Standard errors
Const	2.848	0.168
Age	0.006***	0.001
r-PET (PET)	0.762***	0.064
PLA (PET)	0.755***	0.065
PEF (PET)	0.337***	0.065
Importance attached to the protection of environment-0 (4)	−0.719**	0.293
Importance attached to the protection of environment-1 (4)	0.909***	0.215
Importance attached to the protection of environment-2 (4)	0.000	0.072
Importance attached to the protection of environment-3 (4)	−0.178***	0.069
Confidence to bottles producers' communication campaign-0 (2)	0.141**	0.057
Confidence to bottles producers' communication campaign-1 (2)	−0.015	0.065
Confidence on bottles producers' environment friendly engagement-0 (2)	−0.196**	0.079
Confidence on bottles producers' environment friendly engagement-1 (2)	0.148*	0.076
Sex (0/1)	0.115**	0.048
Income-0 (5)	−0.170	0.109
Income-1 (5)	−0.058	0.098
Income-2 (5)	−0.079	0.102
Income-3 (5)	−0.367***	0.095
Income-4 (5)	0.370***	0.112
Message 2 (0/1)	−0.207	0.145
Message 3 (0/1)	−0.148	0.145
Message 4 (0/1)	−0.063	0.130
Message 5 (0/1)	−0.006	0.098
Message 6 (0/1)	0.048	0.079
Message 7 (0/1)	−0.171**	0.072
Message 8 (0/1)	0.091	0.072
Observations	2,960	
R^2	0.122	
Adjusted R^2	0.114	
Log-likelihood	-4840.983	
P-value(F)	$1.07*10^{-65}$	

*p<0.1; **p<0.05; ***p<0.01.

Table 2: Results from OLS regression model about pooled WTPs in levels.

In model the R^2 is about 12.2%. Relative to the PET bottles, the WTPs for the other kinds of plastic bottles are on average higher. The WTPs for PLA bottles and for r-PET bottles are on average the highest while the one for PEF bottles is on average the lowest. That is participants have on average a higher valuation for organic and biodegradable plastic, and recycled plastic than for organic and recyclable plastic.

Providing message 7, on the polluting impact on the environment of the biodegradable biopolymer, PLA, significantly modifies the WTP, by decreasing the WTP for all the plastic bottles by €0.171.

We find that the youngest participants have a lower WTP for plastic water bottles than the oldest one. The WTP of men for plastic bottles is on average €0.115 higher than women. Relative to the participants who attaches a very high importance to the protection of environment, the WTP of participants who do not attach importance to the protection of environment is on average €0.719 lower, the WTP of participants who do not know their attachment importance to the protection of environment is on average €0.909 higher and the WTP of participants who attaches a high importance to the protection of environment is on average €0.178 lower. Relative to the participants who do not be confident to bottles producers' communication campaign, the WTP of participants who do not know whether they are confident to bottles producers' communication campaign is on average €0.141 higher. Relative to the participants who do not be confident to bottles producers' environment friendly engagement, the WTP of participants are confident to bottles producers' environment friendly engagement is on average €0.148 higher, and the WTP of participants do not know whether they are confident to bottles producers' environment friendly engagement is on average €0.196 lower. Finally, relative to participant with the highest income (more than €6000 per month), the WTP of participants who earn between €4000 and €6000 per month is on average €0.370 higher while the WTP of participants who earn between €2500 and €4000 per month is on average €0.367 lower.

3.2.2 Premiums

We now analyse the difference in WTP between two kinds of plastic bottles. Hence, as we examine difference in WTP and not the WTP itself, some differences may be negative. We do not exclude them because a negative premium implies an individual preference for the other plastic bottles. Nevertheless, we do not consider the WTP expressed before message 4 since only PET bottles were available on the market. The results are presented in Table 3.

Average premium in %/ pack of six water 1.5L bottles

	Average premium for r-PET bottles instead of PET bottles	Average premium for PLA bottles instead of r-PET bottles	Average premium for PEF bottles instead of r-PET bottles	Average premium for PLA bottles instead of PET bottles	Average premium for PLA bottles instead of PEF bottles	Average premium for PEF bottles instead of PET bottles
Message 4	25.67					
Message 5	23.09	4.09	4.09	35.33	0	35.33
Message 6	22.77	9.91	-8.52	29.73	16.77	15.57
Message 7	24.14	-1.64	-15.40	22.87	13.98	10.33
Message 8	22.84	-1.43	-7.80	21.72	6.46	16.31
Global Mean	23.71	2.28	-10.57	24.77	12.56	14.18

Average premium in €/ pack of six water 1.5L bottles

	Average premium for r-PET bottles instead of PET bottles	Average premium for PLA bottles instead of r-PET bottles	Average premium for PEF bottles instead of r-PET bottles	Average premium for PLA bottles instead of PET bottles	Average premium for PLA bottles instead of PEF bottles	Average premium for PEF bottles instead of PET bottles
Message 4	0.87					
Message 5	0.79	2.62	2.62	3.55	0	3.55
Message 6	0.74	0.32	-0.28	1.06	0.60	0.46
Message 7	0.78	-0.05	-0.50	0.73	0.45	0.28
Message 8	0.75	-0,05	-0.25	0.70	0.21	0.49
Global Mean	0.79	0.07	-0.34	0.83	0.42	0.41

Table 3: Pooled premiums.

We first consider the premium associated with recycled plastic packaging, which is the difference between WTP for r-PET bottles and the other plastic bottles. We find that the average premium is positive and large between r-PET bottles and PET bottles whatever the information revealed. It is also positive and large between r-PET bottles and PEF after message 6. But, until message 7, it is negative and large between r-PET bottles and PLA bottles while after message 7, it becomes positive and low. Actually, on average there is a positive premium for recycled plastic which becomes small face to biodegradable plastic.

Then, we focus on the premium associated with organic plastic packaging, which is the difference between WTP for PLA bottles and PEF bottles, and the other plastic bottles. We observe on average and globally the premium is positive between PLA bottles and r-PET and PET bottles. The average premium is positive and large between PEF bottles and PET bottles whatever the information revealed, while it is negative after message 6 between PEF bottles and r-PET bottles. Then, on average there is a positive premium for organic and biodegradable plastic (PLA) while the premium for organic and recyclable plastic (PEF) is not always positive. Hence, the organic premium depends on the organic plastic used.

Finally, we study the premium associated with biodegradable plastic packaging and recycling plastic packaging, that is the difference between WTP for PLA bottles and the other plastic bottles (PET, r-PET and PEF), and the difference between WTP for PET, r-PET and PEF bottles and PLA bottles, respectively. On average we note that the biodegradable premium is positive while the recycling premium depends on the recycling plastic used.

We then analyse the determinants of these premiums through an OLS estimation model on pooled data (L = 592 to 740), dummies for available information, and the same control variables than in Table 2. In the model, PET bottles, Importance attached to the protection of environment-4, Confidence to bottles producers' communication campaign-2, Confidence to bottles producers' environment friendly engagement-2, and Income 5 are reference modalities. Table 4 presents the results.

Model: *OLS estimation*

	Endogenous variable				
	Premium in €/ pack of six water 1.5L bottles for r-PET bottles instead of PET bottles	*Premium in €/ pack of six water 1.5L bottles for PLA bottles instead of r-PET bottles*	*Premium in €/ pack of six water 1.5L bottles for PEF bottles instead of r-PET bottles*	*Premium in €/ pack of six water 1.5L bottles for PLA bottles instead of PET bottles*	*Premium in €/ pack of six water 1.5L bottles for PLA bottles instead of PEF bottles*
Const	1.280***	-0.080	-0.181	0.879**	0.128
	(0.286)	(0.364)	(0.363)	(0.350)	(0.272)
Age	−0.005	0.004	0.002	-0.002	0.003
	(0.003)	(0.004)	(0.004)	(0.004)	(0.003)
Importance attached to the protection of environment-0 (4)	−1.392**	-1.473*	-0.560	−0.894	−0.561
	(0.591)	(0.762)	(0.759)	(0.733)	(0.569)
Importance attached to the protection of environment-1 (4)	−1.521***	-0.032	0.878	−0.006	−0.533
	(0.434)	(0.559)	(0.557)	(0.538)	(0.418)
Importance attached to the protection of environment-2 (4)	−1.033***	-0.086	0.220	−0.213	−0.609***
	(0.145)	(0.186)	(0.186)	(0.179)	(0.139)
Importance attached to the protection of environment-3 (4)	−0.477***	0.006	0.089	−0.021	−0.452***
	(0.139)	(0.179)	(0.178)	(0.172)	(0.133)
Confidence to bottles producers' communication campaign-0 (2)	−0.072	-0.213	0.370**	−0.141	−0.205*
	(0.114)	(0.147)	(0.147)	(0.141)	(0.110)
Confidence to bottles producers' communication campaign-1 (2)	−0.180	0.023	0.175	−0.362**	−0.128
	(0.131)	(0.169)	(0.168)	(0.162)	(0.126)
Confidence on bottles producers' environment friendly engagement-0 (2)	0.373**	-0.035	-0.322	0.161	0.232
	(0.160)	(0.206)	(0.205)	(0.198)	(0.154)
Confidence on bottles producers' environment friendly engagement-1 (2)	0.185	0.129	0.240	0.161	0.136
	(0.153)	(0.198)	(0.197)	(0.190)	(0.148)
Sexe (0/1)	−0.381***	-0.037	0.187	−0.166	−0.164*
	(0.097)	(0.125)	(0.125)	(0.121)	(0.094)
Income-0 (5)	0.781***	0.401	0.013	0.474*	0.189
	(0.220)	(0.284)	(0.283)	(0.272)	(0.212)
Income-1 (5)	0.034	-0.030	-0.147	−0.070	0.187
	(0.198)	(0.255)	(0.254)	(0.245)	(0.190)
Income-2 (5)	0.316	0.048	-0.249	0.339	0.378*
	(0.206)	(0.266)	(0.265)	(0.256)	(0.199)
Income-3 (5)	0.501***	0.043	-0.377	0.345	0.115
	(0.192)	(0.247)	(0.247)	(0.238)	(0.185)
Income-4 (5)	0.765***	0.440	0.631**	0.867***	0.252
	(0.226)	(0.291)	(0.290)	(0.280)	(0.217)
Message 4 (0/1)					
Message 5 (0/1)	−0.086				
	(0.146)				
Message 6 (0/1)	−0.045	0.184	-0.417**	0.139	0.600***
	(0.146)	(0.168)	(0.168)	(0.162)	(0.126)
Message 7 (0/1)	0.042	-0.376**	-0.222	−0.334**	−0.154
	(0.146)	(0.168)	(0.168)	(0.162)	(0.126)
Message 8 (0/1)	−0.038	0.007	0.245	−0.031	−0.238*
	(0.146)	(0.168)	(0.168)	(0.162)	(0.126)
Observations	740	592	592	592	592
R^2	0.149	0.047	0.093	0.070	0.100
Adjusted R^2	0.126	0.017	0.064	0.040	0.072
Log-likelihood	−1209.199	-1049.577	-1047.423	-1026.665	-877.169
P-value(F)	3.75*10-16	0.061	7.43*10-6	0.001	1.34*10-6

*p<0.1; **p<0.05; ***p<0.01. Standard errors are in parenthesis.

Table 4: Results from OLS regression model about pooled premiums in levels.

With the models the R^2 varies between 5% and 15%. The difference between the WTP for r-PET bottles and PET bottles of men is on average €0.381 lower than the one of women, and the difference between the WTP for PLA bottles and PEF bottles of men is on average €0.164 lower than the one of women.

Providing message 6 on the characteristics of the two biopolymers, modifies the difference between the WTP for r-PET bottles and PEF bottles by increasing the premium associated with recycled plastic packaging by €0.417, modifies the difference between the WTP for PLA bottles and PEF bottles by increasing the premium associated with biodegradable plastic packaging by €0.6, and also modifies the difference between the WTP for PEF bottles and PET bottles by decreasing the premium associated with organic and recyclable plastic packaging by €0.461. Providing message 7 on the polluting impact on the environment of the biodegradable biopolymer (PLA), modifies the difference between the WTP for r-PET bottles and PLA bottles by increasing the premium associated with recycled plastic packaging by €0.376 and also modifies the difference between the WTP for PLA bottles and PET bottles by decreasing the premium associated with biodegradable plastic packaging by €0.334. Providing message 8 on the recyclable property of the biopolymer PEF, modifies the difference between the WTP for PLA bottles and PET bottles by decreasing the premium associated with biodegradable plastic packaging by €0.238.

Relative to the participants who attaches a very high importance to the protection of environment, the difference between the WTP for r-PET bottles and PET bottles of participants who do not attach importance to the protection of environment is on average €1.521 lower while the one of these same participants between r-PET bottles and PLA bottles is on average €1.473 higher, the difference between the WTP for r-PET bottles and PET bottles of participants who do not know their attachment importance to the protection of environment is on average €1.392 lower, the difference between the WTP for r-PET bottles and PET bottles of participants who have a weak attachment importance to the protection of environment is on average €1.033 lower, the one of these same participants between the PLA bottles and the PEF bottles is on average €0.609 lower, and the difference between the WTP for r-PET bottles and PET bottles of participants who attaches a high importance to the protection of environment is on average €0.477 lower, and the one of these same participants between the PLA bottles and the PEF bottles is on average €0.452 lower.

Relative to the participants who do not be confident to bottles producers' communication campaign, the difference between the WTP for PLA bottle and PET of participants are confident to bottles producers' communication campaign is on average €0.362 lower, the difference between the WTP for r-PET bottles and PEF bottles of participants who do not know whether they are confident to bottles producers' communication campaign is on average €0.370 lower, the one of these same participants between the PEF bottles and the PET bottles is on average €0.442 higher, and the one of these same participants between the PLA bottles and the PEF bottles is on average €0.205 lower.

Relative to the participants who do not be confident to bottles producers' environment friendly engagement, the difference between the WTP for r-PET bottles and PLA bottles of participants do not know whether they are confident to bottles producers' environment friendly engagement is on average €0.373 higher .

Finally, relative to participant with the highest income (more than €6000 per month), the difference between the WTP for r-PET bottles and PLA bottles of participants who earn between €4000 and €6000 per month is on average €0.765 higher, the difference between the WTP for r-PET bottles and PEF bottles of these same participants is on average €0.631 lower, the difference between the WTP for PLA bottles and PET bottles of these same participants is on average €0.867 higher, the difference the WTP for r-PET bottles and PET bottles of participants between who earn between €2500 and €4000 per month is on average €0.501 higher, the difference the WTP for PLA bottles and PEF bottles of participants between who earn between €1500 and €2500 per month is on average €0.378 higher, and the difference the WTP for r-PET bottles and PET bottles of participants between who earn less than €1000 per month is on average €0.781 higher.

4 Welfare and regulation

Contrary to questions about trade-off between regular and organic products in which regulator chooses to support organic products because they are more safety for health and their production reduces damages on the environment, the question of plastic bottles packaging is more technical and complex. Indeed, the regulator cannot have a clear opinion on this issue because there is no consensus on the plastic which is the most or the least dangerous for the environment. We then propose different policies which protect the environment on different way.

First, we suggest a policy which presents to people the different impacts of all kinds of plastic bottles on the environment. The goal of this information campaign is to raise awareness among people to plastic bottles damages on the environment, and specifically among plastic bottles' consumers. Remember that plastic bottles uses do not create damages on the environment for 19.6% of the participants of our panel. We will call this policy the *'information policy'*.

The use of plant products from renewable sources is interesting because it helps limit resource depletion. An independent life-cycle-analysis studies by the Copernicus Institute at the University of Utrecht has demonstrated that the carbon footprint of PEF is $50\% - 70\%$ lower than PET. In addition, as PET and r-PET, PEF is 100% recyclable but it is superior gas barrier (10 times PET for O_2 and 5 times for CO_2).[19]From Alpha Packaging,[20] the carbon dioxide transmission rate[21] in $cm^3 - mil/m^2/24hr$ of PET is 540 while the one of PLA is 201. So, from these indicators, PLA and PEF are less harmful to the environment than PET and r-PET. However, the environmental impact of organic plastics (bioplastics), PLA and PET, is often debated. Indeed, from Detzel et al (2013) PLA has advantages over the fossil polymers

[19]For more details see: $http : //www.packagingdigest.com/resins/pef - will - not - oust - pet - for - beverage - bottles - anytime - soon140724.$

[20]For more details see: $http : //www.alphap.com/bottle - basics/plastics - comparison - chart.php.$

[21]Carbon dioxide transmission is the measurement of the amount of carbon dioxide gas measure that passes through a substance over a given period. The lower the readings, the more resistant the plastic is to letting gasses through.

(PET, r-PET) with respect to climate change and resource consumption and disadvantages with respect to acidification and eutrophication as well as impact categories used to rate toxicity potentials. Moreover, PEF is not biodegradable and may create degradation to the nature if it is thrown. Hence, regulator may support an environmental policy favouring organic plastics bottles (PLA and PEF) if he wants to reduce gas barrier and to promote a production derived from renewable biomass sources. We call this policy the *'organic policy'*.

In addition, biodegradation property allows plastic (PLA) to be easily broken down by microorganisms and return to nature. Other environmental benefits are also identified: low toxicity to wildlife and flora and lower health risks, reduced use of protective equipment, no need specific storage. However, biodegradation of plastic is slowed down if the environment for microorganisms is not appropriate. For PLA, microorganisms need high oxygen conditions and require a high temperatures (more than $55°C$ ($131°F$)) to degrade PLA plastic. In addition, methane might be released when there is degradation in an anaerobic landfill environment. So biodegradation may not always solve environmental problem. However, if the regulator wants to reduce toxicity to nature and to limit wastes, he may support the use of biodegradable plastic for water bottles packaging. We will call this policy the *'biodegradable policy'*.

Finally, recycling of plastic bottles (PET, r-PET and PEF) has environmental and economic advantages over the non-recyclable plastic bottles (PLA). These recyclable plastics reduce landfills and so the pollution that it causes. Increasing the recycling rate is an interesting way for reducing greenhouse gas emissions, limiting wastes, and so for preserving the environment as mentioned in Abbott et al (2011), Acuff and Kaffine (2013), Kinnaman et al (2014). Moreover, the recycling also contributes to the economic development of a country by creating new industries (new jobs and tax revenue).[22] However, there are some environmental downsides to recycling. Plastic recycling uses different processes and some of them employ caustic chemicals which create emissions and water pollution. So if regulator wants to reduce landfill, he may support recycling plastics for water bottles packaging. We will name this policy the *'recycling policy'*.

In this section, based on elicited WTP and purchase decisions, we investigate the welfare impact of various environmental policies (information policy, organic policy, biodegradable policy and recycling policy). We assume that all kinds of plastic bottles are available on the market. We first present the elicited and predicted demands for each kinds of plastic bottles.

4.1 Plastic bottles demand

To convert the WTP to demand curves, it is assumed that each participant makes a choice related to the largest difference between his WTP and the market price. This choice is inferred because the real choice is not observed in the study, which only elicits WTP.

Figure 4 shows the ordered WTP for the four plastic bottles.[23] The cumulative number of participants (equivalent to one purchased pack of six plastic water 1.5L bottles per participant)

[22] For more details on the economic development impacts see: $http://www.epa.gov/osw/conserve/tools/localgov/benefits/$.

[23] The results for other rounds are available at the Supplemental Material.

is represented on the X-axis and the ordered WTP (in euro) corresponding to the cumulative number of participants is represented on the Y-axis in decreasing order. The black ordered curve is the elicited WTP directly observed from the panel study, the gray curve is the predicted WTP with the classical OLS estimation, and the dotted line is the sale price.[24]

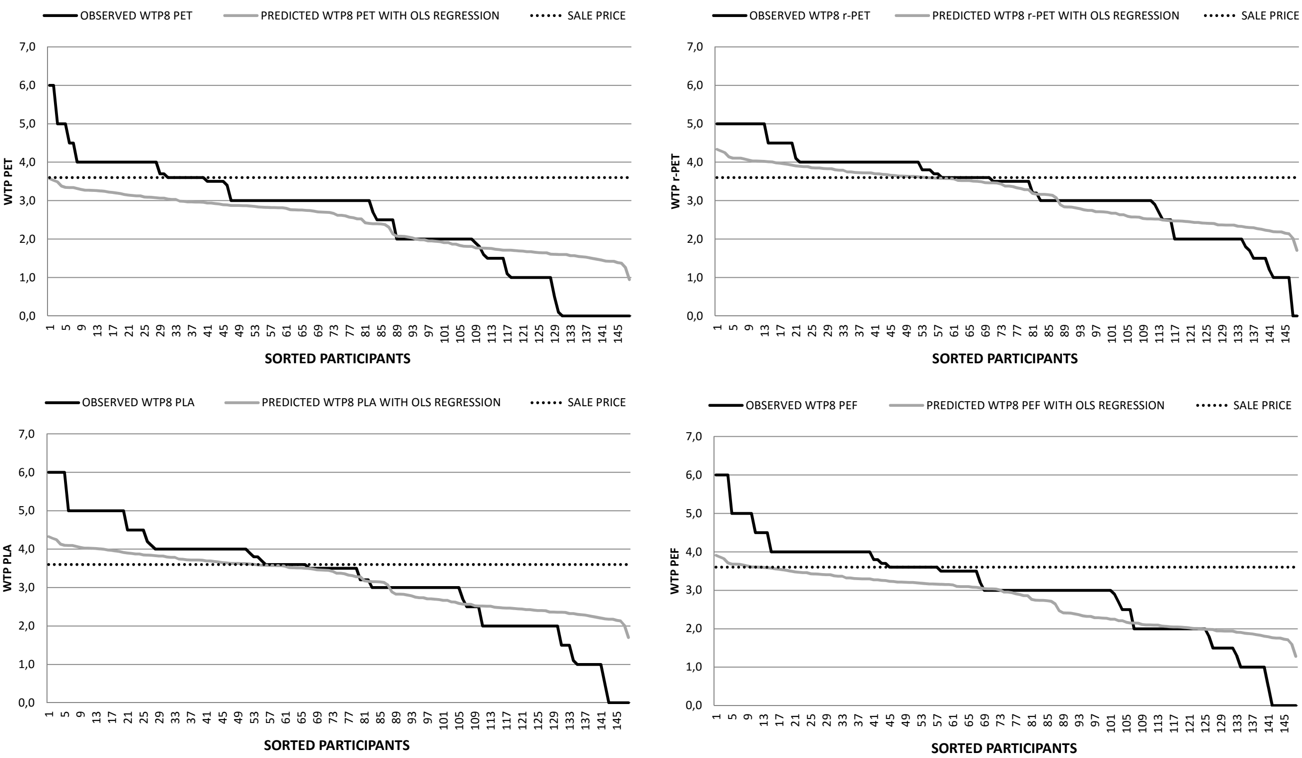

Figure 4: Observed and predicted demand functions for the four kinds of plastic bottles at round 8 (in euro).

The left sides (right sides) of each graphs shows 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. The differences between elicited WTP and the OLS estimations of WTP are not large.

4.2 Regulatory interventions and tools

We now focus on the different tools for implementing the information policy, the organic policy, the biodegradable policy and the recycling policy. First, we set up an information campaign about the positive and negative consequences of plastic on the environment for implementing the information policy. Then, for applying, the organic policy, the biodegradable policy and the recycling policy, we propose either a per-unit tax on product that does not respect the goal of

[24]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.

the policy chosen, or a per-unit subsidy on product that reaches the goal of the policy chosen, or a standard which only allows products respecting the policy chosen.

4.2.1 Information campaign

For the information policy, the regulator makes a complete campaign of information on plastic bottles' impact on the environment. That is this public intervention consists in a very intense consumer information campaign, perfectly understood by consumers and revealing complete information on plastic bottles issues linked to the environment, which leads to round #8 in our model. Following this campaign, consumers are perfectly informed. Consumers directly internalize all information provided by the campaign. Consumer i can choose between five outcomes: one pack of six water 1.5L PET bottles at price P(PET) euro, one pack of six water 1.5L r-PET bottles at price P(r-PET) euro, one pack of six water 1.5L PLA bottles at price P(PLA) euro, one pack of six water 1.5L PEF bottles at price P(PEF) euro, or none of those. We consider that purchasing decisions are determined by the consumer i's WTP for PET, r-PET, PLA and PEF pack of six water 1.5L bottles given by $WTP_{i8}PET$, $WTP_{i8}r\text{-}PET$, $WTP_{i8}PLA$ and $WTP_{i8}PEF$, respectively. We assume that a consumer may purchase one pack of six water plastic 1.5L bottles if his WTP is higher than the price observed for that pack in the supermarket. He then chooses to buy the pack of six water plastic 1.5L bottles generating the highest utility (with a utility of non-purchase normalized to zero). Because complete information is perfectly internalized by consumers, no other tool can improve the welfare. The per-unit surplus and welfare for participant $i \in N$ is as follows:

$$W_i^L = max\{0, WTP_{i8}k - P(k); k \in \{PET, r\text{-}PET, PLA, PEF\}\}. \tag{1}$$

4.2.2 A per-unit tax

The public intervention consists in the adoption of a per-unit tax, τ. To simulate the tax scenario, we consider that consumers have no precise knowledge about the concerned plastic bottles, which corresponds to the situation of round #1 for PET bottles, the situation of round #4 for r-PET bottles, and the situation of round #5 for PLA and PEF bottles. Consumer i can choose between five outcomes: one pack of six water 1.5L PET bottles at price P^τ(PET) euro, one pack of six water 1.5L r-PET bottles at price P^τ(r-PET) euro, one pack of six water 1.5L of PLA bottles at price P^τ(PLA) euro, one pack of PEF bottles at price P^τ(PEF) euro, or neither. He makes his purchasing decision based on his surplus maximization, which is equal to:

$$W_i^\tau(\tau) = max\{0, WTP_{ij}k - P^\tau(k)\}. \tag{2}$$

where $i \in N$, $k \in \{PET, r\text{-}PET, PLA, PEF\}$, and $j = \begin{cases} 1, & \text{for k=PET;} \\ 4, & \text{for k=r-PET;} \\ 5, & \text{for k=PLA and k=PEF.} \end{cases}$.

The regulator also considers the possible tax income coming from each participant. The tax is only paid by consumers purchasing one pack of six water 1.5L k bottles which does not correspond to the policy setting up by the regulator, with $k \in \{PET, r\text{-}PET, PLA, PEF\}$. We note

$$\mathbb{1}[k,i] = \begin{cases} 1 \text{ if consumer } i \text{ buys the pack of six water 1.5L } k \text{ bottles} \\ 0 \text{ otherwise.} \end{cases}$$

So the possible tax income coming from each participant i is equal to $\tau * \mathbb{1}[k,i]$ with $k \in \{PET, r\text{-}PET, PLA, PEF\}$. The optimal tax τ^* is chosen by the regulator and is given by tatonnement, maximizing the average welfare $\sum_{i=1}^{N} \left(W_i^{\tau}(\tau) + \sum_k \tau * \mathbb{1}[k,i]\right)/N$ over the $N = 148$ participants with $k \in \{PET, r\text{-}PET, PLA, PEF\}$. Table 5 presents the list of taxes and the prices of each pack of bottles according the policy implemented.

	Organic Policy		Recycling Policy		Biodegradable Policy	
k	τ	P^{τ}(k)	τ	P^{τ}(k)	τ	P^{τ}(k)
PET	τ_{NO}	P(PET)+τ_{NO}	0	P(PET)	τ_{NB}	P(PET)+τ_{NB}
r-PET	τ_{NO}	P(r-PET)+τ_{NO}	0	P(r-PET)	τ_{NB}	P(r-PET)+τ_{NB}
PLA	0	P(PLA)	τ_{NR}	P(PLA)+τ_{NR}	0	P(PLA)
PEF	0	P(PEF)	0	P(PEF)	τ_{NB}	P(PEF)+τ_{NB}

Table 5: Taxes and price for all the policies.

4.2.3 A per-unit subsidy

The public intervention consists in the adoption of a per-unit subsidy, s. To simulate the subsidy scenario, we consider that consumers have no precise knowledge about the concerned plastic bottles. Consumer i can choose between five outcomes: one pack of six water 1.5L PET bottles at price P^s(PET) euro, one pack of six water 1.5L r-PET bottles at price P^s(r-PET) euro, one pack of six water 1.5L PLA bottles at price P^s(PLA) euro, one pack of six water 1.5L PEF bottles at price P^s(PEF) euro, or neither. He makes his purchasing decision based on his surplus maximization, which is equal to:

$$W_i^s(s) = max\{0, WTP_{ij}k - P^s(k)\}. \tag{3}$$

where $i \in N$, $k \in \{PET, r\text{-}PET, PLA, PEF\}$, and $j = \begin{cases} 1, & \text{for k=PET;} \\ 4, & \text{for k=r-PET;} \\ 5, & \text{for k=PLA and k=PEF.} \end{cases}$.

The regulator also considers the possible subsidy he has to give, the subsidy expense. The subsidy only reduces the price paid by consumers purchasing one pack of six water 1.5L k bottles corresponding to the policy setting up by the regulator, with $k \in \{PET, r\text{-}PET, PLA, PEF\}$. We note

$$\mathbb{1}[k,i] = \begin{cases} 1 \text{ if consumer } i \text{ buys the pack of six water 1.5L } k \text{ bottles} \\ 0 \text{ otherwise.} \end{cases}$$

So the possible subsidy expense given to each participant i is equal to $s * \mathbb{1}[k,i]$ with $k \in \{PET, r\text{-}PET, PLA, PEF\}$. The optimal subsidy s^* is given by tatonnement, maximizing the average welfare $\sum_{i=1}^{N} \left(W_i^s(s) - \sum_k s * \mathbb{1}[k,i]\right)/N$ over the $N = 148$ participants with $k \in \{PET, r\text{-}PET, PLA, PEF\}$. Table 6 presents the list of subsidies and the prices of each pack of bottles according the policy implemented.

	Organic Policy		**Recycling Policy**		**Biodegradable Policy**	
k	s	$P^s(k)$	s	$P^s(k)$	s	$P^s(k)$
PET	0	P(PET)	s_R	P(PET)-s_R	0	P(PET)
r-PET	0	P(r-PET)	s_R	P(r-PET)-s_R	0	P(r-PET)
PLA	s_O	P(PLA)-s_O	0	P(PLA)	s_B	P(PLA)-s_B
PEF	s_O	P(PEF)-s_O	s_R	P(PEF)-s_R	0	P(PEF)

Table 6: Subsidies and price for all the policies.

4.2.4 A Standard

To simulate the standard scenario, we also consider that consumers have no precise knowledge about the concerned plastic bottles. Public intervention consists of constraining the purchase of one pack of six water 1.5L k bottles with $k \in \{PET, r\text{-}PET, PLA, \text{and/or } PEF\}$. For the organic policy, we constraint the purchase to one pack of six water 1.5L PLA bottles or PEF bottles; For the recycling policy, we constraint the purchase to one pack of six water 1.5L PET bottles, $r\text{-}PET$ bottles, or PEF bottles; For the biodegradable policy, we constraint the purchase to one pack of six water 1.5L PLA bottles. The consumer i's purchasing decision then is based on his surplus maximization, which is equal to:

$$W_i^S = max\{0, WTP_{ij}k - P(k)\} \tag{4}$$

where $i \in N$, and $j = \begin{cases} 1, & \text{for k=PET;} \\ 4, & \text{for k=r-PET;} \\ 5, & \text{for k=PLA and k=PEF.} \end{cases}$, with the k bottles allowed on the market.

4.3 Welfare analysis

To perform the welfare analysis, we consider a baseline scenario in which the four packs of six plastic water 1.5L bottles are sold without any additional regulation. This baseline welfare is defined by (2) with $\tau = 0$. We compare the welfare effects of the different environmental policies.

Table 7 presents the results of the welfare analysis for the four policies (information policy, organic policy, biodegradable policy and recycling policy) in percentage, in euro and in number of packs consumed. With a number $N = 148$, we detail the sum of welfare variations in euro with elicited and predicted values (from the OLS regression model in Table 2) linked to one purchased pack of six water 1.5L bottles.[25]

We define the variation in consumer surplus by $\Delta W_N^L = \sum_{i=1}^N \left[W_i^L - W_i^\tau(0)\right]/N$ for the information campaign. Then, we define the variation in consumer surplus by $\Delta W_N^\tau(\tau^*) = \sum_{i=1}^N \left[W_i^\tau(\tau^*) - W_i^\tau(0)\right]/N$ for a tax τ^*, and $\Delta W_N^s(s^*) = \sum_{i=1}^N \left[W_i^s(s^*) - W_i^\tau(0)\right]/N$ for a subsidy s^*, and $\Delta W_N^S = \sum_{i=1}^N \left[W_i^S - W_i^\tau(0)\right]/N$ for the mandatory standard. We note

$$\mathbb{1}[k,i,t] = \begin{cases} 1 \text{ if consumer } i \text{ buys the pack of six water 1.5L } k \text{ bottles under scenario } t; \\ 0 \text{ otherwise} \end{cases}$$

where $i \in N$, and $t = \begin{cases} 0, & \text{for the baseline scenario;} \\ \tau^*, & \text{for the tax scenario;} \\ s^*, & \text{for the subsidy scenario;} \\ S^*, & \text{for the standard scenario.} \end{cases}$

The profit for the k bottles' producers under scenario t is defined by:

$$\pi(k,t) = \frac{1}{N}\sum_{i=1}^{N}\left[P(k) * \mathbb{1}[k,i,t]\right] - C_k$$

with C_k the production cost per pack of six water 1.5L k bottles, and $k \in \{PET, r\text{-}PET, PLA, PEF\}$. The profit variation for k bottles' producers under scenario t is so $\pi(k,t) - \pi(k,0)$.[26] The tax income and the average subsidy expense are $\tau^* * \left[\sum_{i=1}^N \sum_k \mathbb{1}[k,i]/N\right]$ and $s^* * \left[\sum_{i=1}^N \sum_k \mathbb{1}[k,i]/N\right]$, respectively. Then, the expected social welfare variation is the sum of the variation in consumer surplus, the profit variation of all the plastic bottles' producers and the tax income or subsidy expense. Finally, we compute the variation in number of packs of bottles consumed as the comparison between the number of packs consumed for each policy and tool and the number of pack consumed in the baseline scenario.

Our calculations use the average price observed for the pack of six 1.5L plastic bottles, namely that is P(PET)=P(r-PET)=P(PLA)=P(PEF)=3.6 euro.[27]

[25] For the variations in percentage: from the variations in euro we compute the increase or decrease in percentage for each scenario with respect to the baseline scenario.

[26] As we compute variations, we do not need to quantify the production cost C_k.

[27] These prices are estimated from our enquiry at Naturalia and Carrefour market, in November 2013.

Variations in percentage

	Information Policy	Organic Policy			Recycling Policy			Biodegradable Policy		
	Information Campaign	Tax	Subsidy	Standard	Tax	Subsidy	Standard	Tax	Subsidy	Standard
Elicited WTP		τ_{NO}*= 0.10€	s_O*= 0.09€		τ_{NR}*= 0.01€	s_R*= 0.09€		τ_{NB}*= 0.10€	s_B*=0.09€	
Average variation in consumer surplus	-14.23	-2.17	9.49	-17.39	0	12.06	0	-2.17	9.49	-17.39
Average profit variation										
for PET bottles' producers	-4.05	-7.43	-4.05	-10.81	1.35	1.35	4.73	-7.43	-4.05	-10.81
for r-PET bottles' producers	1.35	-8.10	-8.11	-15.55	3.38	3.38	12.83	-8.11	-8.11	-15.55
for PLA bottles' producers	2.70	6.08	6.08	7.44	-20.94	-20.94	-20.94	33.11	32.44	35.81
for PEF bottles' producers	-8.11	6.08	6.08	7.44	16.22	16.22	-20.94	-20.94	-20.94	-20.94
Average social welfare variation	-2.53	-0.92	0	-3.49	0	0	-6.08	-0.92	-0.24	-3.48
Predicted WTP with model OLS		τ_{NO}*= 0	s_O*= 0		τ_{NR}*= 0	s_R*=0		τ_{NB}*= 0	s_B*=0	
Average variation in consumer surplus	-43.53	0	0	-1.76	0	0	0	0	0	-1.76
Average profit variation										
for PET bottles' producers	0	0	0	0	0	0	0	0	0	0
for r-PET bottles' producers	-13.61	0	0	-49.44	0	0	0	0	0	-49.44
for PLA bottles' producers	0	0	0	48.89	0	0	0	0	0	48.89
for PEF bottles' producers	0	0	0	0	0	0	0	0	0	0
Average social welfare variation	-3.90	0	0	-0.19	0	0	0	0	0	-0.19

Variations in euro

	Information Policy	Organic Policy			Recycling Policy			Biodegradable Policy		
	Information Campaign	Tax	Subsidy	Standard	Tax	Subsidy	Standard	Tax	Subsidy	Standard
Elicited WTP		τ_{NO}*= 0.10€	s_O*= 0.09€		τ_{NR}*= 0.01€	s_R*= 0.09€		τ_{NB}*= 0.10€	s_B*=0.09€	
Average variation in consumer surplus	-0.07	-0.01	0.05	-0.09	0	0.06	0	-0.01	0.05	-0.09
Average profit variation										
for PET bottles' producers	-0.15	-0.27	-0.15	-0.39	0.05	0.05	0.17	-0.27	-0.15	-0.39
for r-PET bottles' producers	0.05	-0.29	-0.29	-0.56	0.12	0.12	0.45	-0.29	-0.29	-0.56
for PLA bottles' producers	0.10	0.22	0.22	0.27	-0.75	-0.75	-0.75	1.18	1.17	1.29
for PEF bottles' producers	-0.29	0.22	0.22	0.27	0.58	0.58	-0.75	-0.75	-0.75	-0.75
Average tax income/Average subsidy expense		0.01	-0.05		0	-0.06		0.01	-0.05	
Average social welfare variation	-0.36	-0.13	0	-0.50	0	0	-0.88	-0.13	-0.02	-0.50
Predicted WTP with model OLS		τ_{NO}*= 0	s_O*= 0		τ_{NR}*= 0	s_R*= 0		τ_{NB}*= 0	s_B*=0	
Average variation in consumer surplus	-0.07	0	0	-0.01	0	0	0	0	0	-0.01
Average profit variation										
for PET bottles' producers	0	0	0	0	0	0	0	0	0	0
for r-PET bottles' producers	-0.49	0	0	-1.78	0	0	0	0	0	-1.78
for PLA bottles' producers	0	0	0	1.76	0	0	0	0	0	1.75
for PEF bottles' producers	0	0	0	0	0	0	0	0	0	0
Average tax income/Average subsidy expense		0	0		0	0		0	0	
Average social welfare variation	-0.56	0	0	-0.03	0	0	0	0	0	-0.03

	Information Policy	Organic Policy			Recycling Policy			Biodegradable Policy		
	Information Campaign	Tax	Subsidy	Standard	Tax	Subsidy	Standard	Tax	Subsidy	Standard
Elicited WTP		τ_{NO}*= 0.10€	s_O*= 0.09€		τ_{NR}*= 0.01€	s_R*= 0.09€		τ_{NB}*= 0.10€	s_B*=0.09€	
Variation in number of										
packs of PET bottles consumed	-6	-11	-6	-16	2	2	7	-11	-6	-16
packs of r-PET bottles consumed	2	-12	-12	-23	5	5	19	-12	-12	-23
packs of PLA bottles consumed	4	9	9	11	-31	-31	-31	49	48	53
packs of PEF bottles consumed	-12	9	9	11	24	24	-31	-31	-31	-31
packs of plastic bottles not consumed	12	5	0	17	0	0	36	5	1	17
Predicted WTP with model OLS		τ_{NO}*= 0	s_O*= 0		τ_{NR}*= 0	s_R*= 0		τ_{NB}*= 0	s_B*=0	
Variation in number of										
packs of PET bottles consumed	0	0	0	0	0	0	0	0	0	0
packs of r-PET bottles consumed	-20	0	0	-73	0	0	0	0	0	-73
packs of PLA bottles consumed	0	0	0	72	0	0	0	0	0	72
packs of PEF bottles consumed	0	0	0	0	0	0	0	0	0	0
packs of plastic bottles not consumed	20	0	0	1	0	0	0	0	0	1

Table 7: Welfare analysis in percentage and in euro, and in number of packs over the 148 participants for all the policies.

With the elicited model, giving consumers full information via a campaign increases the profit of the r-PET bottles' producers and of the PLA bottles' producers. However, information campaign decreases the profit for the producers of the other kinds of plastic (PET and PEF) bottles, the consumer surplus, and the social welfare. Hence, information policy is beneficial for producers who produce organic and biodegradable plastic and those who produce recycled plastic. From the third table, we note that information policy leads many consumers to leave the plastic water bottles market. Actually, the consumers either have moved their consumption from PET and PEF products to r-PET and PLA products, or have left the plastic bottles market. With the predicted model, consumers only buy packs of six water 1.5L r-PET bottles. Adding information on the harmfulness of plastic decreases the total number of packs consumed. This implies that with the predicted model, the number of packs of six water 1.5L r-PET bottles decreases implying a decrease of the profit variation for r-PET bottles' producers instead of increasing it as in the elicited model. Finally, both models show that the social welfare variation is negative. So in the market of plastic bottles, information campaign on the plastic damages on the environment is not beneficial for the welfare of the society.

Now, we discuss of the impacts of the organic policy on welfares. We note that none of the tools leads to an increase of the social welfare. However, the two models suggest that only an organic subsidy leads to an increase in consumer surplus. All the tools increase the profit of the PEF and PLA bottles' producers and the number of packs of PEF and PLA bottles consumed while they decrease the profits of PET and r-PET bottles' producers and the number of packs of PET and r-PET bottles consumed. With the subsidy, consumers have moved their consumption from PET and r-PET products to PEF and PLA products while with the tax and the standard, they have also left the plastic bottles market.

Now we turn to the recycling policy. We note that none of the tools leads to an increase of the social welfare. We observe that only the recyclable subsidy increases the consumer surplus. With all the tools, the recyclable (PET, r-PET and PEF) plastic bottles' producers increase their profits while the profit of the non-recyclable (PLA) plastic bottles' producers strongly decreases. With the subsidy and the tax, consumers have moved their consumption from PLA products to PET, r-PET and PEF products while with the standard, they have also left the plastic bottles market.

Then, we analyse the impacts of the biodegradable policy on welfares. We note that none of the tools leads to an increase of the social welfare. Only biodegradable subsidy increases the consumer surplus. All the tools increase the profit for PLA bottles' producers at the cost of those of the other plastic bottles' producers. With all the tools, consumers either have moved their consumption from PET, r-PET and PEF products to PLA products, or they have left the plastic bottles market.

To sum up, on the social welfare point of view, none of the policies increases the social welfare but some of them do not affect it (organic subsidy, non-recycling tax and recycling subsidy). The organic subsidy increases the consumer surplus by €0.05 (9.49%), the recycling subsidy by €0.06 (12.06%) and the biodegradable subsidy by €0.05 (9.49%). In addition, we observe that information campaign, the non-organic tax, the organic standard, the recycling standard, and the three tools of the biodegradable policy lead many consumers to leave the plastic market. These policies lead to a reduction of plastic use, as it is recommended for plastic bag. Then, featuring between these policies will depend on regulator's priorities and the pressures of the lobbies.

5 Conclusion

In this paper, we have analysed the perception and behaviour of the plastic water bottles consumers. This is useful as well for plastic bottles companies' decisions (on production, research and development) as for public authorities' choices (environmental policies).

Currently, there is no consensus on the plastic which is the most or the least dangerous for the environment. It is still difficult to perfectly rank them according to environmental indicators. We have proposed different policies linked to the actual possibilities of plastic bottles. We have found that on the consumer surplus point of view, regulation is effective with the organic subsidy, the recycling subsidy and the biodegradable subsidy. We have observed that information campaign, the non-organic tax, the organic standard, the recycling standard, and the three tools of the biodegradable policy lead many consumers to leave the plastic market. Hence, this allows us to understand that the regulator's policy and tool choice is not obvious. This will depend on the regulator's priorities (reduction of emission of CO_2, reduction of landfills, reduction of toxicity, increasing the consumer surplus, decreasing the plastic water bottles consumption...) and the pressures of the lobbies.

Ferrara and Plourdes (2003) have discussed about plastic substitution, for instance by using glass. However, glass has also negative effects on the environment and it is not clear that its use is beneficial in comparison to plastic. Tap water is also an alternative. it is less expensive than water plastic bottles (between 200 and 300 less expensive) and its quality is good in France.[28]

This work allows us to show to bottles companies that there is an interest for innovating in a plastic with a better environmental quality (with biodegradability, recycling, and organic properties). Indeed, by analysing the WTP to participants we have pointed out their preferences, and so their demands for the different plastic bottles. We have found a significant premium associated with recycled plastic packaging (r-PET) and organic and biodegradable plastic packaging (PLA). A plastic bottle with these three properties would have a consumer demand and would increase water companies' production for these kinds of plastic bottles.[29]

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 explaining to participants that they should reply as if they would pay for the pack of six 1.5L plastic bottles. Second, we did not consider controversies or incorrect messages

[28]See: $http : //www.planetoscope.com/consommation - eau/340 - litres - d - eau - en - bouteille - consommes - dans - le - monde.html$ and $http : //social - sante.gouv.fr/sante - et - environnement/eaux/article/qualite - de - l - eau - potable$.

[29]This study could then motivate more bottles companies to develop the recycling property and process for PLA.

leading to participants' confusion or misunderstanding. To correct this, we would introduce a probability of being wrongly informed δ, namely a probability of having participants with misunderstanding regarding plastic, such that the variation in consumer surplus for the information campaign would become $\Delta W_N^L = \sum_{i=1}^{N} \left[(1-\delta)W_i^L - \delta W_i^\tau(0)\right]/N$. This assumption would decrease the social benefit of using advertising campaigns. 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. So, on the quality data collection, online studies do not look to present more disadvantage than other kinds of surveys.

Appendix

Message 1: *The average price for a pack of six plastic water 1.5L bottles is 3,60 euro.*

Message 2: *PET plastic used for water bottle is 100% petroleum derived. The average weight of a 1.5L empty bottle is 32 grams : it needs 64 ml of petroleum to produce it (13 coffee spoon).*

Message 3: *Those bottles made with PET needs 500 years to be completely degraded in the nature.*

Message 4: *It is now technologically possible to produce bottles made of 100% of recycled PET, r-PET.*

Message 5: *It is now technologically possible to produce bottles made of 100% of biopolymers, PLA and PEF (derived from sugar or corn, renewable resources, and not from petroleum, fossil resource).*

Message 6: *There are two kinds of biopolymers. The first one, PEF, is not presenting a better biodegradability and has the same negative impact on the environment than PET or r-PET if it is not recycled. The second one, PLA, is biodegradable and can be composted.*

Message 7: *The biodegradable biopolymer, PLA, is a source of methane (powerful greenhouse effect gas).*

Message 8: *As for the non-biodegradable biopolymer, PEF, it is recyclable like the classical polymer.*

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