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

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 7th 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 13th 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 2nd 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

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

60 collected PET can be used in order to produce food grade r-PET quality.² Another solution is
61 the development of new plastics with less environmental impact like bio-based (plant-derivative)
62 plastics. The two most known biopolymers are polylactic acid (PLA) and polyethylene-furanoate
63 (PEF). They are derived from renewable biomass sources. PLA is produced from glucose and it
64 is biodegradable. La Mantia et al (2012) prove that there is a better impact on environment of
65 PLA compared to PET. However, PLA production is still low because even if PLA is mentioned
66 as biodegradable plastic its needs anaerobic conditions. Its degradation is a source of methane
67 that is a very powerful greenhouse effect gas. In addition, PLA recycling processes are still in
68 progress. Loopla³ by Galatic uses PLA wastes in order to recycle them but their process does
69 not lead to 100% recycling of PLA. In addition, since the introduction of PLA in PET process
70 recycling can lead to problems concerning PET recycling quality, few recycling companies invest
71 in PLA recycling. Hence, in our study, we do not consider the recyclable property of PLA. By
72 contrast, PEF is fully recyclable like PET but it is poorly biodegradable. PEF is made by
73 converting sugars from sugarcane into plastic. Nowadays more than 2.5 billion plastic bottles
74 made of biopolymers are already in use around the world, but this only represents less than 1%
75 of global production. One of the main limiting aspects is the cost.

76 Today, 89 billion litre of water are bottled and consumed each year worldwide. Overall
77 consumption of bottled water in the world in 2004 was almost double that of 1997.⁴ Moreover,
78 annual growth rate of plastic water bottle consumption in the world from 2008 to 2013 is
79 at 6.2%.⁵ So do consumers care about plastic water bottles' environmental impacts? Which
80 environmental policies could be proposed and which one(s) is(are) optimal on the point of view of
81 the consumer surplus? How environmental policies change consumers' purchasing decisions? To
82 address these questions, we propose to study the consumers' perceptions through a willingness-
83 to-pay (WTP) analysis. Indeed, consumers' perceptions are not only essential for packaging
84 companies' choices but they are also for environmental policies.

85 Our approach relies on two building blocks. First, our paper is linked to the literature that
86 examines the interaction between the WTP and information acquisition. Food experiments
87 constitute some (for instance, on palm oil, Disdier et al, 2013; on milk, Marette and Millet,
88 2014, and on organic apples, Marette et al, 2012). Our paper contributes to this literature by
89 investigating the precise impact of information on the plastic water bottles consumers' WTP. We
90 believe to be the first study focusing on the consumer perception regarding plastic bottles. We
91 first conduct an analysis to elicit the WTP for different kinds of plastic bottles with increasing
92 levels of information on the use of various plastic bottles, and their environmental impacts. We
93 find that information matters in terms of WTP. Bernard and Bernard (2009), Bougherara and
94 Combris (2009), Disdier et al.(2013), Marette et al (2012), Marette and Millet (2014) and Yue
95 et al. (2009) show that a significant proportion of consumers are willing to pay substantial
96 premiums for environmentally friendly products. We then propose to analyse the premiums for

²For more details see ELIPSO (2012).

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

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

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

97 organic, recycled, and biodegradable plastic water bottles.

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

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

124 2 The study

125 After an increase by 2% in 2010, the market of plastic water bottles has increased by 6% in
126 2011 in France with 5,5 billions of litres consumed. In 2014, the consumption of plastic bottles
127 is around 7,7 billions of litres (around 118 litres per inhabitant), namely an increase by 28.6%
128 from 2011.⁶ Today, French are the third biggest water bottles consumers after Italian and
129 American people. According to TNS Sofres, 85% of the French citizen drink water bottles. We
130 then propose to analyse the French consumers' perception on plastic water bottles.

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

131 **2.1 Target respondents**

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

138 Table 1 presents the socio-economic characteristics (gender, age, education, household com-
 139 position, income, and occupation) of the participants. Differences between our panel and INSEE
 140 are tested using the Pearson chi-squared test. A P-value (against the null hypothesis of no dif-
 141 ference) 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	Description	Study panel (%)	INSEE (%)	Chi2 test P-value
<i>Gender</i>				<i>Monthly net income of the household (€)</i>			
Female	54.7	51.5	0.518	<1000	12.2	10.0	0.973
Male	45.3	48.5		[1000-1500)	20.3	20.0	
<i>Age</i>				[1500-2500)	20.3	20.0	
<20	14.9	25.0	0.063	[2500-4000)	29.0	30.0	
[20-64]	65.5	57.0		[4000-6000)	10.1	10.0	
>64	19.6	18.0		6000 ≤	8.1	10.0	
<i>Education</i>				<i>Socio-professional categories</i>			
No baccalaureate (BAC)	45.9	59.0	0.062	Farmers	0.0	1.0	0.987
BAC	21.0	16.0		Craftsman or trading	2.7	3.0	
3 years after BAC	16.2	11.0		Executives and professionals	9.5	9.6	
More than 3 years after BAC	16.9	14.0		Freelance workerds	14.2	13.0	
<i>People living in the household</i>				Employees	16.9	17.0	
1 person	29.7	34.0	0.662	Workers	12.8	12.2	
2 persons	27.7	26.0		Retired or looking for a job	27.7	26.5	
3 persons and more	42.6	40.0		Without any professionnall activities	16.2	17.7	

Notes : Baccalaureate is the French high school diploma.

Table 1: Socio-economic characteristics of participants.

142

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

⁷For more details on Marketest see: <http://www.marketest.co.uk/>.

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

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

153 **2.2 Products**

154 Our study focuses on plastic water bottles. We consider a pack of six plastic water 1.5L bottles.
155 Different kinds of plastic are proposed: PET, r-PET, PLA and PEF. PET is currently the
156 most-widely used polyester in bottles. It is petroleum based and 100% recyclable but not
157 biodegradable. r-PET is PET which has been recycled and is 100% recyclable. PLA is a
158 biodegradable plastic. We do not mention its possible recyclable property in this work because
159 since now only few recycling companies have invested in its recycling and the actual processes
160 do not lead to 100% recycling of PLA.⁹ It is derived from renewable resources. PLA is then
161 considered as a bioplastic as well as PEF which is also made from renewable resources. PEF is
162 100% recyclable but not biodegradable. We have then decided to study these four kinds of plastic
163 because they allow us to compare the demand for bioplastics, recyclable and biodegradable
164 plastics for water bottles packaging.

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

167 **2.3 Experimental design and information revealed**

168 In the questionnaire, successive messages emphasizing the plastic bottles characteristics and
169 their environmental impacts are delivered to the survey participants. WTP is elicited after
170 each message with the following question: *What is the maximum price you are willing to pay*
171 *for a pack of six water 1.5L bottles with a packaging made of this plastic?* Only PET plastic
172 bottles are presented in the three first rounds, then r-PET and biopolymer bottles (PLA and
173 PEF) are introduced in the fourth round and in the fifth round, respectively. The experiment
174 is divided into several stages as described in Figure 1.¹²

⁹This allows us to separate biodegradable and recycling participants' interest.

¹⁰This price is estimated from our enquiry at Naturalia and Carrefour market, in November 2013.

¹¹We do not mention trademark to participants in order not to influence their decision.

¹²Messages are given in Appendix.

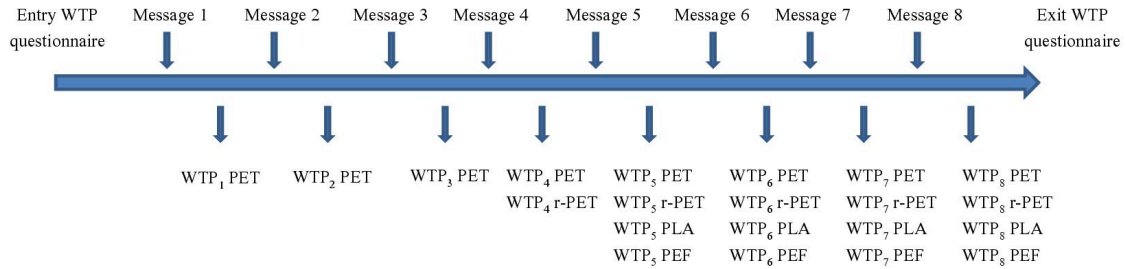


Figure 1: Questionnaire design.

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

183 The observed retail price for a pack of six plastic water 1.5L bottles, 3.6 euro is revealed in
 184 message 1, before the first WTP elicitation, allowing us to control the anchorage effect for the
 185 first message.¹⁴ Messages 2 and 3 reveal detailed information about the negative consequences
 186 of PET bottles on the environment (pollution and non-biodegradability). Messages 4 and 5
 187 introduce the r-PET and biopolymers (PLA and PEF) bottles, respectively. Then in message
 188 6, biopolymers are divided in two categories of plastic, the biodegradable one, PLA, and the
 189 non-biodegradable one, PEF. Message 7 gives information on the negative impact of PLA bottles

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

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

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

192 3 Results

193 3.1 Descriptive analysis

194 Figure 2 presents the distributions of the WTP for a pack of six water 1.5L bottles according
 195 to the type of plastic and the information (message) provided. It shows that r-PET and PLA
 196 bottles attract the highest WTP for any level of information while PET bottles WTP is the
 197 lowest. The reduction of WTPs for PLA and PEF bottles following an information on the
 198 negative impact of these products¹⁶ is more important in absolute values than the increase
 199 when information specify that these products do not affect the environment.¹⁷ In their prospect
 200 theory, Kahneman and Tversky (1979) observe that the impact of a loss on utility is twice higher
 201 than the impact of a symmetric gain on the utility. Our result presents this observation too.
 202 In addition, we find that the average and median WTPs are lower than the reference price for
 203 a pack, which is 3.6 euro. Hence, at this price, the demand for a pack of plastic bottles of our
 204 panel is low.

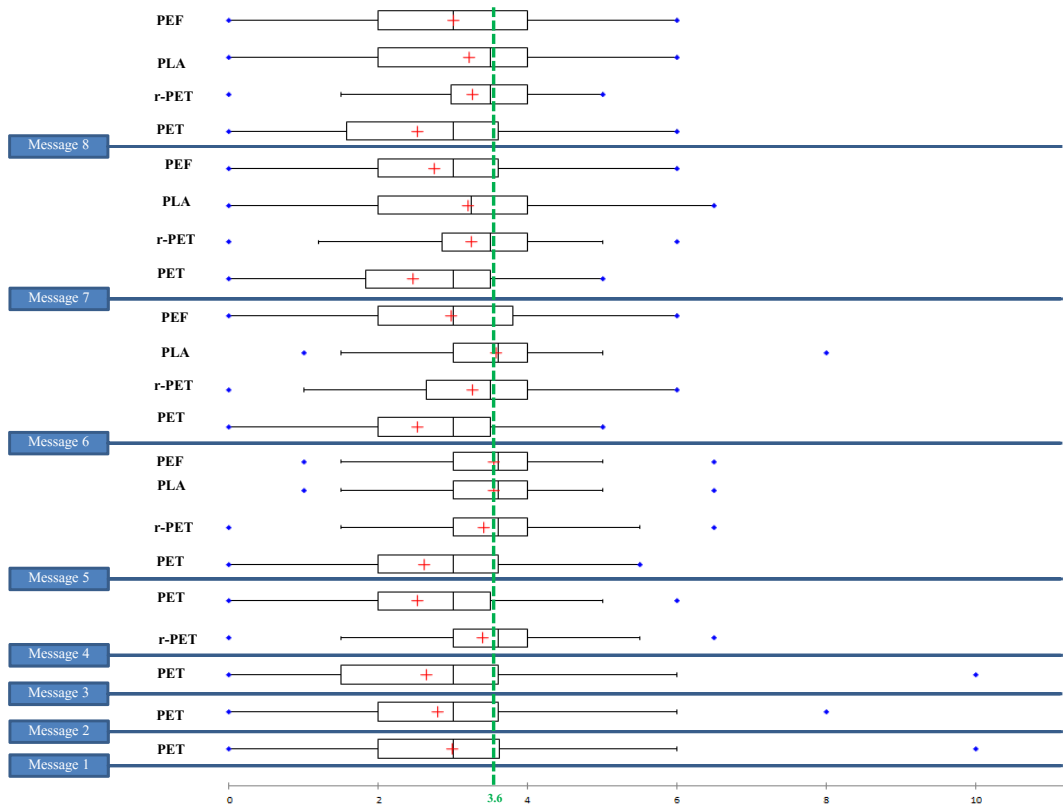


Figure 2: Distribution of the Willingness-To-Pay for a pack of six plastic water 1.5L bottles (in euro).

¹⁵See messages in appendix.

¹⁶Message 7 for PLA bottles and message 6 for PEF bottles.

¹⁷Message 6 for PLA bottles and message 8 for PEF bottles.

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

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

222 In average, the WTP for PET bottles is significantly lower than the ones for r-PET bottles,
 223 PLA bottles and PEF bottles. In average, after message 6, the WTP for PEF bottles is
 224 significantly lower than the ones for PLA and r-PET bottles. Then, until message 7, the WTP
 225 for PLA is significantly higher than the one for r-PET. To sum up, for our panel, in average,
 226 $WTP_{PET} < WTP_{PEF} < WTP_{PLA} \simeq WTP_{r-PET}$.

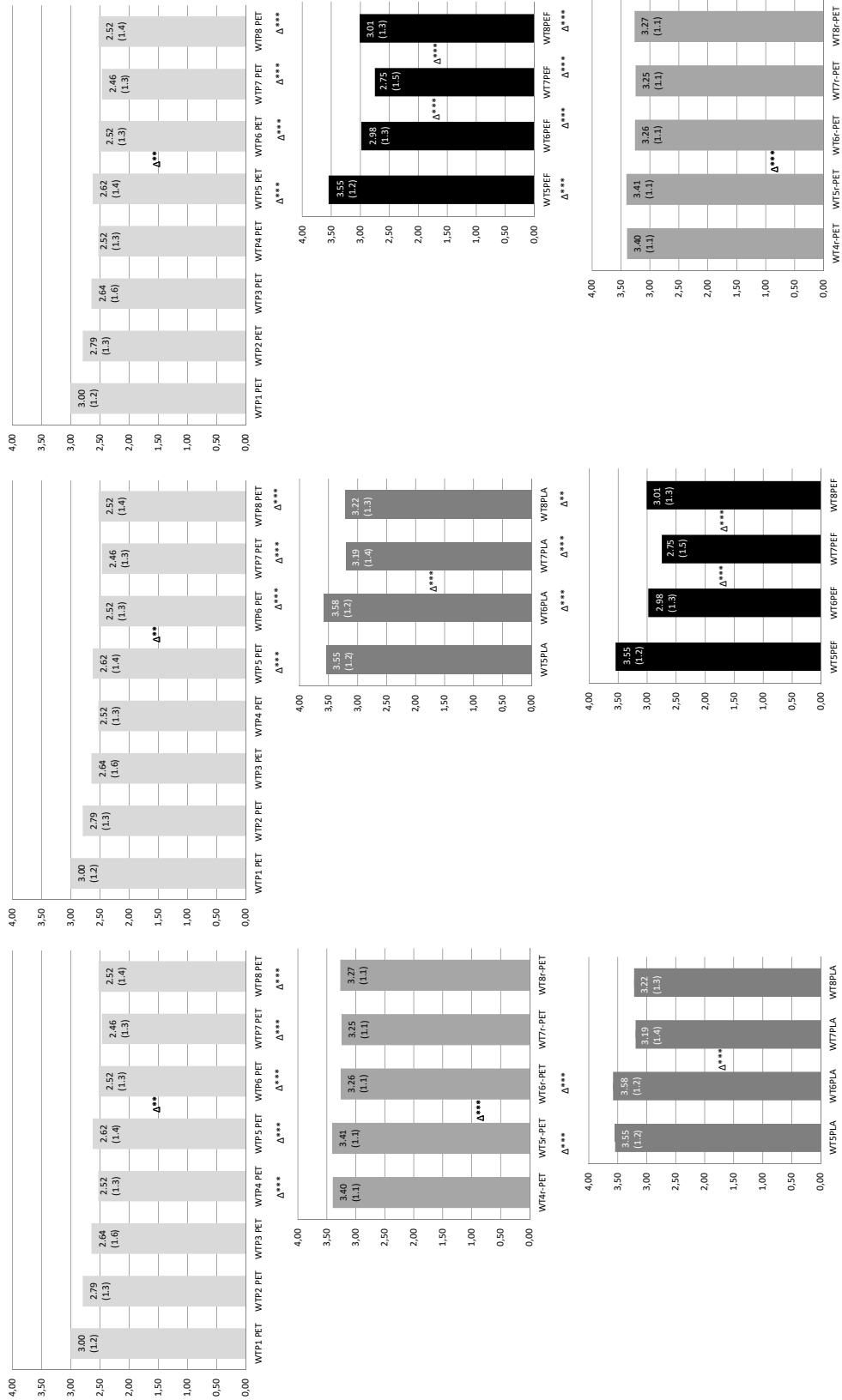


Figure 3: Average WTP for one pack of six plastic water 1.5L bottles and variations after information revelation. Note: Average WTP (in euro); Standard deviation in parentheses; Δ*** and Δ** denote significant differences at the 1% and 5% levels, respectively, as tested by the Wilcoxon test.

227 **3.2 Econometric estimations**

228 **3.2.1 Willingness-To-Pay**

229 We now investigate the determinants of WTP through estimations. We use an ordinary least
230 square regression (OLS) model on pooled data ($L = 2,960$). It includes dummies for the con-
231 sidered plastic bottles, and for available information at the moment of the WTP elicitations.
232 The model also includes six additional control variables: age, sex, income, the individual im-
233 portance attached to the protection of the environment, the individual's confidence to bottle
234 producers' communication campaign, and the individual's confidence on bottle producers' en-
235 vironment friendly engagement.¹⁸ Age is a quantitative variable and sex is a dummy variable
236 (0 for woman and 1 for man). We have divided income in five variables (Income-0: $1000 <$;
237 Income-1: $[1000,1500)$; Income-2: $[1500,2500)$; Income-3: $[2500,4000)$; Income-4: $[4000,6000)$
238 ; Income-5: $6000 \leq$), individual attachment to the protection of the environment in five vari-
239 ables (Importance attached to the protection of environment-0: does not know ; Importance
240 attached to the protection of environment-1: none ; Importance attached to the protection of
241 environment-2: weak ; Importance attached to the protection of environment-3: high ; Impor-
242 tance attached to the protection of environment-4: very high), the individual's confidence on
243 bottle producers' communication campaign in three variables (Confidence to bottles producers'
244 communication campaign-0: does not know ; Confidence to bottles producers' communication
245 campaign-1: yes ; Confidence to bottles producers' communication campaign-2: no), and the
246 individual's confidence on bottle producers' environment friendly engagement in three variables
247 (Confidence to bottles producers' environment friendly engagement-0: does not know ; Con-
248 fidence to bottles producers' environment friendly engagement-1: yes ; Confidence to bottles
249 producers' environment friendly engagement-2: no). In the model, PET bottles, Importance
250 attached to the protection of environment-4, Confidence to bottles producers' communication
251 campaign-2, Confidence to bottles producers' environment friendly engagement-2, and Income
252 5 are reference modalities.

¹⁸Bazoche 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.

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

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

262 We find that the youngest participants have a lower WTP for plastic water bottles than the
 263 oldest one. The WTP of men for plastic bottles is on average €0.115 higher than women. Rela-
 264 tive to the participants who attaches a very high importance to the protection of environment,
 265 the WTP of participants who do not attach importance to the protection of environment is on
 266 average €0.719 lower, the WTP of participants who do not know their attachment importance
 267 to the protection of environment is on average €0.909 higher and the WTP of participants who
 268 attaches a high importance to the protection of environment is on average €0.178 lower. Rela-
 269 tive to the participants who do not be confident to bottles producers' communication campaign,
 270 the WTP of participants who do not know whether they are confident to bottles producers' com-
 271 munication campaign is on average €0.141 higher. Relative to the participants who do not be

272 confident to bottles producers' environment friendly engagement, the WTP of participants are
 273 confident to bottles producers' environment friendly engagement is on average €0.148 higher,
 274 and the WTP of participants do not know whether they are confident to bottles producers' en-
 275 vironment friendly engagement is on average €0.196 lower. Finally, relative to participant with
 276 the highest income (more than €6000 per month), the WTP of participants who earn between
 277 €4000 and €6000 per month is on average €0.370 higher while the WTP of participants who
 278 earn between €2500 and €4000 per month is on average €0.367 lower.

279 3.2.2 Premiums

280 We now analyse the difference in WTP between two kinds of plastic bottles. Hence, as we
 281 examine difference in WTP and not the WTP itself, some differences may be negative. We do
 282 not exclude them because a negative premium implies an individual preference for the other
 283 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.

284

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

291 for recycled plastic which becomes small face to biodegradable plastic.

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

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

305

306 We then analyse the determinants of these premiums through an OLS estimation model
307 on pooled data ($L = 592$ to 740), dummies for available information, and the same control
308 variables than in Table 2. In the model, PET bottles, Importance attached to the protection
309 of environment-4, Confidence to bottles producers' communication campaign-2, Confidence to
310 bottles producers' environment friendly engagement-2, and Income 5 are reference modalities.
311 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 PET bottles	Premium in €/ pack of six water 1.5L bottles for PEF bottles instead of 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*** (0.286)	-0.080 (0.364)	-0.181 (0.363)	0.879** (0.350)	0.128 (0.272)
Age	-0.005 (0.003)	0.004 (0.004)	0.002 (0.004)	-0.002 (0.004)	0.003 (0.003)
Importance attached to the protection of environment-0 (4)	-1.392** (0.591)	-1.473* (0.762)	-0.560 (0.759)	-0.894 (0.733)	-0.561 (0.569)
Importance attached to the protection of environment-1 (4)	-1.521*** (0.434)	-0.032 (0.559)	0.878 (0.557)	-0.006 (0.538)	-0.533 (0.418)
Importance attached to the protection of environment-2 (4)	-1.033*** (0.145)	-0.086 (0.186)	0.220 (0.186)	-0.213 (0.179)	-0.609*** (0.139)
Importance attached to the protection of environment-3 (4)	-0.477*** (0.139)	0.006 (0.179)	0.089 (0.178)	-0.021 (0.172)	-0.452*** (0.133)
Confidence to bottles producers' communication campaign-0 (2)	-0.072 (0.114)	-0.213 (0.147)	0.370** (0.147)	-0.141 (0.141)	-0.205* (0.110)
Confidence to bottles producers' communication campaign-1 (2)	-0.180 (0.131)	0.023 (0.169)	0.175 (0.168)	-0.362** (0.162)	-0.128 (0.126)
Confidence on bottles producers' environment friendly engagement-0 (2)	0.373** (0.160)	-0.035 (0.206)	-0.322 (0.205)	0.161 (0.198)	0.232 (0.154)
Confidence on bottles producers' environment friendly engagement-1 (2)	0.185 (0.153)	0.129 (0.198)	0.240 (0.197)	0.161 (0.190)	0.136 (0.148)
Sexe (0/1)	-0.381*** (0.097)	-0.037 (0.125)	0.187 (0.125)	-0.166 (0.121)	-0.164* (0.094)
Income-0 (5)	0.781*** (0.220)	0.401 (0.284)	0.013 (0.283)	0.474* (0.272)	0.189 (0.212)
Income-1 (5)	0.034 (0.198)	-0.030 (0.255)	-0.147 (0.254)	-0.070 (0.245)	0.187 (0.190)
Income-2 (5)	0.316 (0.206)	0.048 (0.266)	-0.249 (0.265)	0.339 (0.256)	0.378* (0.199)
Income-3 (5)	0.501*** (0.192)	0.043 (0.247)	-0.377 (0.247)	0.345 (0.238)	0.115 (0.185)
Income-4 (5)	0.765*** (0.226)	0.440 (0.291)	0.631** (0.290)	0.867*** (0.280)	0.252 (0.217)
Message 4 (0/1)					
Message 5 (0/1)	-0.086 (0.146)				
Message 6 (0/1)	-0.045 (0.146)	0.184 (0.168)	-0.417** (0.168)	0.139 (0.162)	0.600*** (0.126)
Message 7 (0/1)	0.042 (0.146)	-0.376** (0.168)	-0.222 (0.168)	-0.334** (0.162)	-0.154 (0.126)
Message 8 (0/1)	-0.038 (0.146)	0.007 (0.168)	0.245 (0.168)	-0.031 (0.162)	-0.238* (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.

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

316 Providing message 6 on the characteristics of the two biopolymers, modifies the difference
317 between the WTP for r-PET bottles and PEF bottles by increasing the premium associated
318 with recycled plastic packaging by €0.417, modifies the difference between the WTP for PLA
319 bottles and PEF bottles by increasing the premium associated with biodegradable plastic pack-
320 aging by €0.6, and also modifies the difference between the WTP for PEF bottles and PET
321 bottles by decreasing the premium associated with organic and recyclable plastic packaging by
322 €0.461. Providing message 7 on the polluting impact on the environment of the biodegradable
323 biopolymer (PLA), modifies the difference between the WTP for r-PET bottles and PLA bot-
324 tles by increasing the premium associated with recycled plastic packaging by €0.376 and also
325 modifies the difference between the WTP for PLA bottles and PET bottles by decreasing the
326 premium associated with biodegradable plastic packaging by €0.334. Providing message 8 on
327 the recyclable property of the biopolymer PEF, modifies the difference between the WTP for
328 PLA bottles and PET bottles by decreasing the premium associated with biodegradable plastic
329 packaging by €0.238.

330 Relative to the participants who attaches a very high importance to the protection of envi-
331 ronment, the difference between the WTP for r-PET bottles and PET bottles of participants
332 who do not attach importance to the protection of environment is on average €1.521 lower
333 while the one of these same participants between r-PET bottles and PLA bottles is on average
334 €1.473 higher, the difference between the WTP for r-PET bottles and PET bottles of partic-
335 ipants who do not know their attachment importance to the protection of environment is on
336 average €1.392 lower, the difference between the WTP for r-PET bottles and PET bottles of
337 participants who have a weak attachment importance to the protection of environment is on
338 average €1.033 lower, the one of these same participants between the PLA bottles and the PEF
339 bottles is on average €0.609 lower, and the difference between the WTP for r-PET bottles and
340 PET bottles of participants who attaches a high importance to the protection of environment
341 is on average €0.477 lower, and the one of these same participants between the PLA bottles
342 and the PEF bottles is on average €0.452 lower.

343 Relative to the participants who do not be confident to bottles producers' communication
344 campaign, the difference between the WTP for PLA bottle and PET of participants are confi-
345 dent to bottles producers' communication campaign is on average €0.362 lower, the difference
346 between the WTP for r-PET bottles and PEF bottles of participants who do not know whether
347 they are confident to bottles producers' communication campaign is on average €0.370 lower,
348 the one of these same participants between the PEF bottles and the PET bottles is on average
349 €0.442 higher, and the one of these same participants between the PLA bottles and the PEF
350 bottles is on average €0.205 lower.

351 Relative to the participants who do not be confident to bottles producers' environment

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

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

366 4 Welfare and regulation

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

373 First, we suggest a policy which presents to people the different impacts of all kinds of plastic
374 bottles on the environment. The goal of this information campaign is to raise awareness among
375 people to plastic bottles damages on the environment, and specifically among plastic bottles'
376 consumers. Remember that plastic bottles uses do not create damages on the environment for
377 19.6% of the participants of our panel. We will call this policy the '*information policy*'.

378 The use of plant products from renewable sources is interesting because it helps limit re-
379 source depletion. An independent life-cycle-analysis studies by the Copernicus Institute at the
380 University of Utrecht has demonstrated that the carbon footprint of PEF is 50% – 70% lower
381 than PET. In addition, as PET and r-PET, PEF is 100% recyclable but it is superior gas
382 barrier (10 times PET for O_2 and 5 times for CO_2).¹⁹From Alpha Packaging,²⁰ the carbon
383 dioxide transmission rate²¹ in $cm^3 - mil/m^2/24hr$ of PET is 540 while the one of PLA is 201.
384 So, from these indicators, PLA and PEF are less harmful to the environment than PET and
385 r-PET. However, the environmental impact of organic plastics (bioplastics), PLA and PET, is
386 often debated. Indeed, from Detzel et al (2013) PLA has advantages over the fossil polymers

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

²⁰For more details see: <http://www.alphap.com/bottle-basics/plastics-comparison-chart.php>.

²¹Carbon 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.

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

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

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

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

418 **4.1 Plastic bottles demand**

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

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

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

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

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

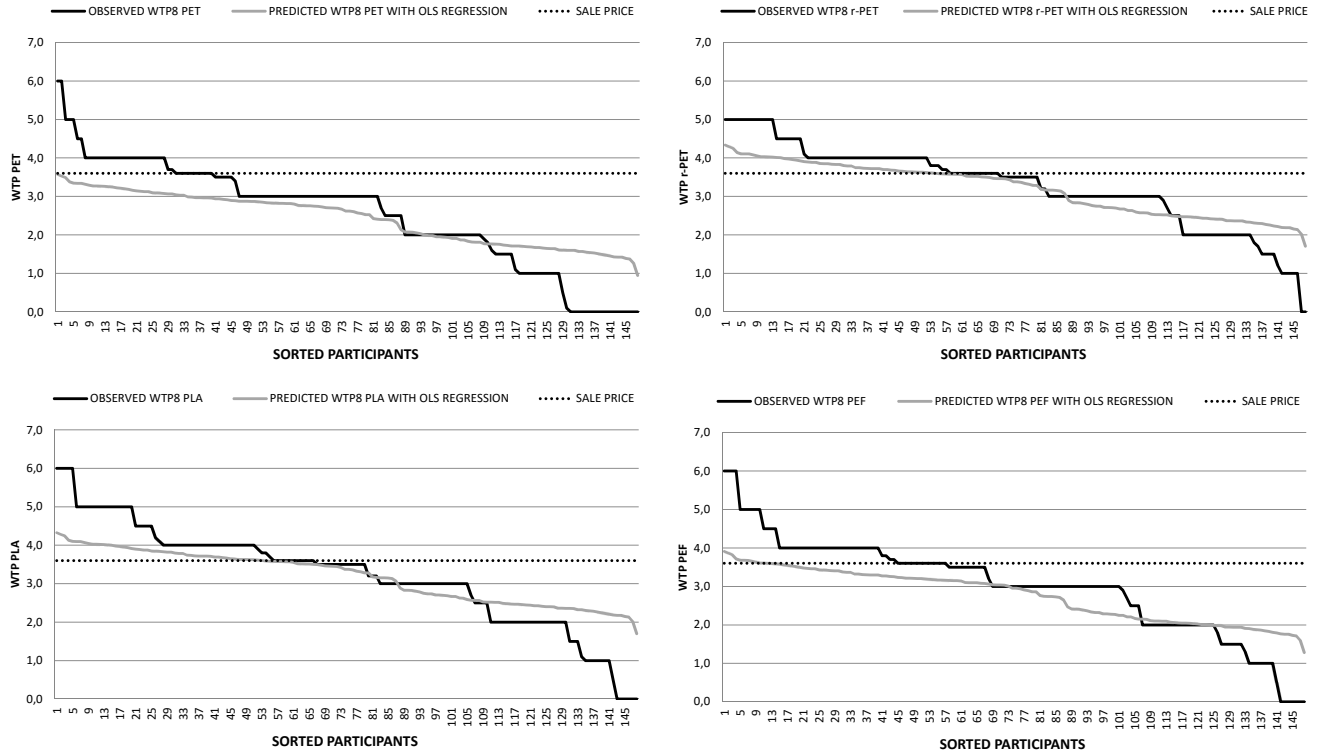


Figure 4: Observed and predicted demand functions for the four kinds of plastic bottles at round 8 (in euro).

428 The left sides (right sides) of each graphs shows that, for relatively high-values (low-values) of
 429 WTP, the elicited WTPs directly observed from the panel study are significantly higher (lower)
 430 than the WTPs predicted. The differences between elicited WTP and the OLS estimations of
 431 WTP are not large.

432 4.2 Regulatory interventions and tools

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

²⁴Note 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.

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

440 4.2.1 Information campaign

441 For the information policy, the regulator makes a complete campaign of information on plastic
 442 bottles' impact on the environment. That is this public intervention consists in a very intense
 443 consumer information campaign, perfectly understood by consumers and revealing complete
 444 information on plastic bottles issues linked to the environment, which leads to round #8 in
 445 our model. Following this campaign, consumers are perfectly informed. Consumers directly
 446 internalize all information provided by the campaign. Consumer i can choose between five
 447 outcomes: one pack of six water 1.5L PET bottles at price $P(\text{PET})$ euro, one pack of six water
 448 1.5L r-PET bottles at price $P(\text{r-PET})$ euro, one pack of six water 1.5L PLA bottles at price
 449 $P(\text{PLA})$ euro, one pack of six water 1.5L PEF bottles at price $P(\text{PEF})$ euro, or none of those.
 450 We consider that purchasing decisions are determined by the consumer i 's WTP for PET,
 451 r-PET, PLA and PEF pack of six water 1.5L bottles given by WTP_{i8}^{PET} , $WTP_{i8}^{\text{r-PET}}$,
 452 WTP_{i8}^{PLA} and WTP_{i8}^{PEF} , respectively. We assume that a consumer may purchase one
 453 pack of six water plastic 1.5L bottles if his WTP is higher than the price observed for that
 454 pack in the supermarket. He then chooses to buy the pack of six water plastic 1.5L bottles
 455 generating the highest utility (with a utility of non-purchase normalized to zero). Because
 456 complete information is perfectly internalized by consumers, no other tool can improve the
 457 welfare. The per-unit surplus and welfare for participant $i \in N$ is as follows:

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

458 4.2.2 A per-unit tax

459 The public intervention consists in the adoption of a per-unit tax, τ . To simulate the tax
 460 scenario, we consider that consumers have no precise knowledge about the concerned plastic
 461 bottles, which corresponds to the situation of round #1 for PET bottles, the situation of round
 462 #4 for r-PET bottles, and the situation of round #5 for PLA and PEF bottles. Consumer i
 463 can choose between five outcomes: one pack of six water 1.5L PET bottles at price $P^\tau(\text{PET})$
 464 euro, one pack of six water 1.5L r-PET bottles at price $P^\tau(\text{r-PET})$ euro, one pack of six water
 465 1.5L of PLA bottles at price $P^\tau(\text{PLA})$ euro, one pack of PEF bottles at price $P^\tau(\text{PEF})$ euro,
 466 or neither. He makes his purchasing decision based on his surplus maximization, which is equal
 467 to:

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

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

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 $k \in \{PET, r-PET, PLA, PEF\}$. We note

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

469 So the possible tax income coming from each participant i is equal to $\tau * \mathbb{1}[k, i]$ with $k \in$
 470 $\{PET, r-PET, PLA, PEF\}$. The optimal tax τ^* is chosen by the regulator and is given by
 471 tatonnement, maximizing the average welfare $\sum_{i=1}^N (W_i^T(\tau) + \sum_k \tau * \mathbb{1}[k, i]) / N$ over the $N =$
 472 148 participants with $k \in \{PET, r-PET, PLA, PEF\}$. 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	$P^T(k)$	τ	$P^T(k)$	τ	$P^T(k)$
PET	τ_{NO}	$P(PET) + \tau_{NO}$	0	$P(PET)$	τ_{NB}	$P(PET) + \tau_{NB}$
r-PET	τ_{NO}	$P(r-PET) + \tau_{NO}$	0	$P(r-PET)$	τ_{NB}	$P(r-PET) + \tau_{NB}$
PLA	0	$P(PLA)$	τ_{NR}	$P(PLA) + \tau_{NR}$	0	$P(PLA)$
PEF	0	$P(PEF)$	0	$P(PEF)$	τ_{NB}	$P(PEF) + \tau_{NB}$

Table 5: Taxes and price for all the policies.

473

474 4.2.3 A per-unit subsidy

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

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

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

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 $k \in \{PET, r-PET, PLA, PEF\}$.

We note

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

482 So the possible subsidy expense given to each participant i is equal to $s * \mathbb{1}[k, i]$ with $k \in$
 483 $\{PET, r-PET, PLA, PEF\}$. The optimal subsidy s^* is given by tatonnement, maximizing
 484 the average welfare $\sum_{i=1}^N (W_i^s(s) - \sum_k s * \mathbb{1}[k, i]) / N$ over the $N = 148$ participants with $k \in$
 485 $\{PET, r-PET, PLA, PEF\}$. 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.

486

487 4.2.4 A Standard

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

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

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

498 **4.3 Welfare analysis**

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

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

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

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

508 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:

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

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

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

²⁵For 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.

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

²⁷These 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		$\tau_{NO}^*=0.10\text{€}$ $s_0^*=0.09\text{€}$			$\tau_{NR}^*=0.01\text{€}$ $s_R^*=0.09\text{€}$			$\tau_{NB}^*=0.10\text{€}$ $s_B^*=0.09\text{€}$		
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		$\tau_{NO}^*=0$ $s_0^*=0$			$\tau_{NR}^*=0$ $s_R^*=0$			$\tau_{NB}^*=0$ $s_B^*=0$		
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		$\tau_{NO}^*=0.10\text{€}$ $s_0^*=0.09\text{€}$			$\tau_{NR}^*=0.01\text{€}$ $s_R^*=0.09\text{€}$			$\tau_{NB}^*=0.10\text{€}$ $s_B^*=0.09\text{€}$		
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		$\tau_{NO}^*=0$ $s_0^*=0$			$\tau_{NR}^*=0$ $s_R^*=0$			$\tau_{NB}^*=0$ $s_B^*=0$		
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		$\tau_{NO}^*=0.10\text{€}$ $s_0^*=0.09\text{€}$			$\tau_{NR}^*=0.01\text{€}$ $s_R^*=0.09\text{€}$			$\tau_{NB}^*=0.10\text{€}$ $s_B^*=0.09\text{€}$		
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		$\tau_{NO}^*=0$ $s_0^*=0$			$\tau_{NR}^*=0$ $s_R^*=0$			$\tau_{NB}^*=0$ $s_B^*=0$		
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.

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

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

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

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

555 To sum up, on the social welfare point of view, none of the policies increases the social welfare
556 but some of them do not affect it (organic subsidy, non-recycling tax and recycling subsidy).
557 The organic subsidy increases the consumer surplus by €0.05 (9.49%), the recycling subsidy by
558 €0.06 (12.06%) and the biodegradable subsidy by €0.05 (9.49%). In addition, we observe that

559 information campaign, the non-organic tax, the organic standard, the recycling standard, and
560 the three tools of the biodegradable policy lead many consumers to leave the plastic market.
561 These policies lead to a reduction of plastic use, as it is recommended for plastic bag. Then,
562 featuring between these policies will depend on regulator's priorities and the pressures of the
563 lobbies.

564 **5 Conclusion**

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

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

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

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

590 Our paper presents some limitations. First, as in all WTP approaches, there might be a
591 hypothetical bias in our study. As suggested by Lusk (2003) we have tried to reduce this bias
592 with a cheap talk explaining to participants that they should reply as if they would pay for the
593 pack of six 1.5L plastic bottles. Second, we did not consider controversies or incorrect messages

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

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

594 leading to participants' confusion or misunderstanding. To correct this, we would introduce
595 a probability of being wrongly informed δ , namely a probability of having participants with
596 misunderstanding regarding plastic, such that the variation in consumer surplus for the infor-
597 mation campaign would become $\Delta W_N^L = \sum_{i=1}^N [(1 - \delta)W_i^L - \delta W_i^T(0)] / N$. This assumption
598 would decrease the social benefit of using advertising campaigns. Third, the way to collect data
599 might be discussed. We have used an online study. Cobanoglu et al (2001), Couper (2000),
600 and McDonald and Adam (2003) highlight that online studies allow to save time and efforts in
601 collecting data. Moreover, Fricker et al (2005), Kreuter et al (2008) and Heerwegh and Loosveld
602 (2008) show that online studies make it possible to get higher quality answers with less 'I do
603 not know' and less unanswered than telephone survey and personal interview survey. So, on
604 the quality data collection, online studies do not look to present more disadvantage than other
605 kinds of surveys.

606 Appendix

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

608

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

611

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

614

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

617

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

621

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

625

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

628

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

631

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