Consumers' preferences and environmental tax : results from an experiment with milk

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Abstract

This paper investigates how consumers value environmental characteristics through milk consumption, in order to estimate the optimal environmental policy. An experiment was conducted in France for eliciting the willingness-to-pay (WTP) for 4 products - namely, regular cow's milk, organic cow's milk, regular soy milk and organic soy milk - with increasing levels of information about the relative impacts of these products on environment, animal welfare and health. Environmental messages focused on greenhouse gas emissions and chemicals used for getting feed. Our results underline a significant organic premium associated with both cow's and soy milks, and a significant premium for soy milk compared to cow's milk. These WTP are integrated in a model measuring the impact of regulatory instruments. From this model, the welfare maximization leads to the selection of a positive tax on regular milks coming from cows and soy associated with a positive subsidy on organic milks coming from cows and soy. This estimated tax

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on regular milk is higher than the tax that could be alternatively computed from carbon prices, determined by the Intergovernmental Panel on Climate Change (IPCC). Such a tax based on the IPCC would be too low for being efficient according to our model.

Keywords: consumers; lab experiment; organic premium; environmental premium; soy milk; milk demand.

1 Introduction

The actual food system, from plantation to consumption, has a significant impact on the environment, particularly with greenhouse gas (GHG) emissions and chemical pollution. Indeed, in Europe, one fifth of GHG emissions is produced by the agricultural sector and the food industry. Half of agricultural GHG emissions is caused by cattle breeding (Eurostat, 2015), which raises the question of the best way to reduce the contribution of cattle to GHG emissions.

Regulation is necessary for reducing this negative impact of cattle breeding on the environment. However, one major barrier for determining policies comes from the difficulty to give monetary values to environmental damages. Regarding climate change problems, the Intergovernmental Panel on Climate Change (IPCC) gives advice concerning the optimal carbon price in order to limit climate change. It suggests a per-ton carbon price between €40 and €80 in 2020, €50 to €100 in 2030 and €125 to €140 in 2040 (IPCC, 2014), as references for an international carbon market. These carbon prices are provided without any clear indication on the process used to determine them. They can be used as a basis for thinking tax mechanisms related to carbon emissions of products, but such a method does not directly consider market mechanisms and product diversity.

The purpose of this paper consists in developing an alternative method for computing taxes and subsidies. We determine a socially optimal tax/subsidy program accounting for milk market, environmental damages and consumers' welfare. To obtain this socially optimal tax/subsidy program, we use the results of a laboratory experiment, determining willingness-to-pay (WTP) with performance-based financial incentives. To convert the WTP into demand curves and surpluses, we assume that each participant would purchase one unit of the product that provided the largest surplus approximated by the difference between WTP and the market price. We conducted a lab experiment in Dijon (France) in 2017. Several types of milk were offered by taking into account revealed messages about pesticides, greenhouse gas, animal welfare and cholesterol.

The experiment examined the WTP for Regular Cow's Milk (RCM), Organic Cow's Milk (OCM), Regular Soy Milk (RSM) and Organic Soy Milk (OSM). We consider these products because (i) milk bottles are easy to handle and offer in the lab, (ii) French consumers favor organic milk even if it represents only 2% of the French milk production (FranceAgriMer, 2017), (iii) vegetable milk is a nascent but trendy market in France and (iv) the culture of organic soy has a relatively low impact on the environment. It is interesting to study in which conditions French people could dwindle their consumption of cow's milk, and increase their consumption of soy milk.

Our results underline a significant organic premium associated with both cow's milk and soy milk, and a significant premium for soy milk compared to cow's milk. Consumers value more the organic characteristic than the vegetable characteristic coming from soy. These WTP are integrated in a model measuring the impact of regulatory instruments. From this model, the welfare maximization leads to the selection of a positive tax on regular milks coming from cows and soy associated with a positive subsidy on organic milks coming from cows and soy. By favoring organic products, these tax and subsidy deter the consumption of regular cow's milk. This decrease in the consumption of regular cow's milk is not outweighed by the increase in the consumption of organic cow's milk, which leads to a significant decrease of GHG emissions. This estimated per-unit tax is higher than the tax that could be alternatively computed from carbon prices, determined by the Intergovernmental Panel on Climate Change (IPCC). Such a tax related to the IPCC would be too low for implying sufficient consumption shifts and being efficient according to our model integrating WTP.

Our paper innovates in comparison to previous experiments studying the impact of ecolabels or organic labels (see Vlaeminck et al. (2014), Van Loo et al. (2015) or Min et al. (2014)). In particular, some previous experiments only studied regular and organic cow's milk as Bernard & Bernard (2009),Bai et al. (2013), and Akaichi et al. (2012), while our paper introduces new vegetable alternatives with important consequences on market mechanisms and regulation. Some other papers examine the impact of mandatory and complete information on welfare, estimated with elicited WTP as shown by Rousu et al. (2007) and Rousu et al. (2009). Even if we briefly present such a policy leading to perfect information, this paper mainly details taxes and subsidies computed with various methods. Indeed, our welfare model also integrates taxes estimated with the IPCC carbon prices applied to emissions of various milk bottles, which was not made before.

Moreover, by offering four products with different influences on GHG emissions, our study is also related to the experimental literature on climate change. It sheds a new light compared to the public-good experiment run by Hasson et al. (2010), in which mitigation of greenhouse gases is viewed as a public good and adaptation to climate change is viewed as a private good, but without any reference to existing products sold in supermarkets, as our offered bottles of milk.

Our paper also contributes to the experimental literature studying the Pigouvian taxation for limiting pollution and/or GHG emissions. Tax aversion appears as a real issue when some participants have to implement the tax that is imposed on other participants, as shown by Kallbekken et al. (2011). Moreover, Sarr et al. (2016) and Lanz et al. (2017) explore various difficulties for implementing the Pigouvian tax. Our paper is different because both optimal tax and subsidies are inferred from the surplus maximization linked to our model, which avoids the tax aversion problems and the difficulties coming from the implementation of the policy. Additionally, our tax and subsidy are products specific, which is not the case in these previous experiments. Because our model integrates WTP, our paper differs from recent theoretical contributions studying the Pigouvian taxation with a lot of details on market adjustments, but without elicited WTP (see Borger & Glazer (2017), Gahvari (2014), McAusland & Najjar (2015) and MacKenzie & Ohndorf (2016)).

The paper is organized as following. The protocol is explained in section 2. Section 3 analyses the elicited WTP. Section 4 presents the welfare analysis of regulatory tools and section 5 concludes. We now turn to the presentation of the experiment.

2 Methods

2.1 Experiment

This subsection successively details the sample, the products, the mechanism for getting WTP, the organization of sessions, the revealed information.

2.1.1 Sample

We conducted the experiment in Dijon, in France, in 8 sessions over 2 days in March 2017. Participants were randomly selected based on the quota method and were representative for age groups and socio-economic status for the French population. Participants were recruited by phone. They were informed that the experiment would focus on milk consumption and it would last about one hour with a €10 participation indemnity (complemented by €5 during the session as explanined below). Participants consuming milk and/or dairy products, even occasionally, were selected for targeting potential buyers. As the cow's milk that we used contains lactose, lactose intolerant people were excluded. Each experimental session lasted 50 minutes in average, and included between 11 and 18 participants, depending on participants availability. 123 participants attended the sessions. Table 1 presents some descriptive statistics about the participants.

[Insert table 1]

2.1.2 Products

The experiment focused on four products : regular cow's milk (RCM), organic cow's milk (OCM), regular soy milk (RSM) and organic soy milk (OSM). Table 2 presents a picture of each product. These four products were a priori substitutable. In order to facilitate WTP comparisons, we chose 4 products from the same brand offered by an important company with several supermarkets in the Dijon area. The average prices of these products were relatively close at the time of the experiment as reported under each picture.

[Insert table 2]

2.1.3 Mechanism for purchasing one unit of product

For eliciting WTP with performance-based financial incentives, we used the Becker, DeGroot and Marschak (BDM) procedure (Becker et al., 1964). At each round and for each product, participants were asked to choose WTP, namely the maximum price they would buy the product. At each new round, we recalled that participants could choose a new WTP, or keep the one indicated in the previous round. At the end of the experiment, two random selections were realized by each participant: one among several prices going from 0.10 euros to 3.50 euros for determining the purchasing price, and another one indicating the round and the product concerned by the BDM procedure. If the indicated WTP was greater than the purchasing price, the participant bought one unit of the concerned product at the purchasing price. If the indicated WTP was lower than the purchasing price, the participant did not buy the concerned product.

2.1.4 Organization of the sessions

At the beginning of the experiment, some initial explanations were read. We insisted on the fact that all replies were anonymous, since participants were identified by a number. We started with a trial round for explaining the BDM mechanism. Simulations with a candy bar help participants understand the mechanism. The possibility of writing zero bids with the BDM procedure for avoiding purchases was carefully detailed. We explained that to allow them to buy one unit of product, they will receive €5 in addition to the €10 indemnities for their participation to the session. We made clear that only one WTP among all elicited WTP will be randomly selected at the end of this experiment for determining whether participants will have to buy only one unit of product. We didn't give participants any information on the average prices of bottles sold in supermarkets. We insisted on the absence of "good" or "bad" replies, but rather on the possibility to freely indicate choices reflecting their preferences. Before starting with milk bottles, participants signed a consent form.

Round #1 was realized with only RCM and OCM bottles for which participants were supposed to be familiar with. They had 2 minutes for observing the 2 bottles. Without any message, participants wrote down on a page their maximum WTP for these 2 products. Then, in the second round, we introduced RSM and OSM bottles and indicated that soybean dedicated to milk was produced in France. After 2 minutes for observing those additional products, participants wrote down their WTP for the 4 products. The rounds #3 to #6 were organized as following. First, one of the 4 messages was given to participants on a paper sheet and read by the organizer. Then, participants wrote their WTP for the 4 products. A few questions were also asked at the end of each round.

After these 6 rounds, participants completed an exit questionnaire with various questions on dairy products and socio-demographics. The experiment concluded by randomly selecting one only one WTP among all elicited WTP for comparing this WTP for one product to the purchasing price that was also randomly selected. Purchasing choices were enforced according to the BDM procedure.

2.1.5 Information disclosure

From rounds #3 to #6, four different messages were communicated to participants before the WTP elicitations. The 4 messages were written after studying articles coming from environmental, health and nutrition fields. The messages were relatively short, because previous works underline that a short message is more efficient than a long message with complex information (Wansink et al., 2004). The 4 messages translated from the French and preceding the WTP determinations were the following.

Message about greenhouse gases "Cows emit methane, which is a greenhouse gas. In France, they emit 92% of the methane produced by agricultural activities. Greenhouse gases contribute to global warming. The production of soybean emits very little greenhouse gas."

Message about pesticides "Neither pesticides nor fertilizers degrading the environment are used for the production of organic cow feed, giving organic cow's milk. Conversely, pesticides and fertilizers are used in the feeding of cows in conventional breeding producing standard cow's milk. No pesticides or fertilizers impacting the environment are used in organic soybean production for organic soy milk. A few pesticides and fertilizers are used in the conventional soybean crop, used to produce the standard soy beverage."

Message about animal welfare "In most conventional farms, producing regular cow's milk, dairy cows are prone to a set of animal welfare problems. They have little or no access to pasture and are confined in uncomfortable buildings. Organic dairy cows, giving organic cows' milk, have access to pasture and have less restrictive living conditions than cows in conventional breeding. Soy milk completely comes from vegetable sources. Its production does not involve the exploitation of any animal."

Message about cholesterol "Cow's milk contains cholesterol and saturated fatty acids. This cholesterol, consumed in large quantities, can have an impact on health and develop the risks of cardiovascular diseases. Unlike cow's milk, the soy beverage does not contain cholesterol and low saturated fat, which helps to limit the risk of cardiovascular disease."

The order of these different messages was precisely controlled with variations of orders across 4 different groups of participants. Since we wanted to insist on environmental messages, the messages dealing with GHG and pesticides where always in first positions. We were secondarily interested on the effect of message on animal welfare and cholesterol, appearing in last positions. There were 4 groups, G1, G2, G3 and G4, with different orders of messages. Participants were randomly allocated to one of 4 groups before coming to a session. Table 3 presents the order of messages and the number of participants for each group.

[Insert table 3]

2.2 Policy and regulation based on surpluses

2.2.1 A simple model

With the WTPs coming from the experiment, we can estimate the impact of alternative policies on consumers' surplus. We first assume that each participant purchases the product that provides the largest surplus, if this surplus is positive. Such a choice is inferred because "real" choices are not observed in the lab that only elicits WTP.

The elicited WTP for RCM, OCM, RSM and OSM are compared to the respective market prices of products.[1] Participants' surpluses are approximated by the estimated WTP minus the observed market price if they buy the product, and zero otherwise (Disdier & Marette, 2012). At the time of the experiment, the average observed price are given by table 2, namely

[1]Results are robust when we consider predicted WTP generated with the econometric estimations of table 5 and the independent variables representing rounds and characteristics of participants.

P_{RCM} = €0.80, P_{OCM} = €1.10, P_{RSM} = €1.20 and P_{OSM} = €1.30. For simplicity, these prices are assumed constant under all configurations and, for simplicity, we overlook producers' profits.[2]

With our model, the participants' surplus with the integration of the effect of ignorance leads to a positive surplus variation only when the purchasing decision changes after the revelation of information, which is fully compatible with the value of information defined under the welfare theory (Foster & Just, 1989).

2.2.2 Surpluses with the baseline scenario

We first consider a situation in which consumers chooses whether or not to purchase one unit of product without any information. This situation corresponds to the round #2 of our experiment, when the four types of products were offered without explanatory messages. The WTP for the participant i is denoted $WTP2_{II,i}$, for the product $II = \{RCM, OCM, RSM, OSM\}$. The surplus that the participant i receives for purchasing one unit of RCM is $(WTP2_{RCM,i} - P_{RCM})$ if $WTP2_{RCM,i} > P_{RCM}$. If $WTP2_{RCM,i} < P_{RCM}$, the participant can turn to other options by following the same methodology. If participant i purchases one unit of product, he/she chooses the product that generates the highest surplus, CS^i_A, as seen by equation (1) in the appendix.

However, the lack of information leads to a decision the consumer could subsequently regret once information would be fully revealed. When complete information is not revealed, we consider the effect of ignorance linked to the lack of information, since some participants would make different decisions under complete information. With the revelation of complete information, participants who could not initially purchase a product could want to buy one of the products; participants who could initially purchase a product might stop buying the product; or participants who could initially purchase a product might decide to switch to a different product. Since we focus on the impact of the environmental messages only, we restrict our attention to the case with complete environmental information. This is equivalent to the round #4, with both messages about pesticide and GHG revealed to participants. We denote $WTP4_{II,i}$ this willingness-to-pay of the participant i for the product

[2] Extensions could consider prices adjustments and profits variations following a policy implementation.

$II = \{RCM, OCM, RSM, OSM\}$.[3]

For a participant i, we consider the effect of ignorance linked to the absence of complete environmental information about a characteristic for a product II at round 2 without information. This effect of ignorance is equal to $J_{II,i}[WTP4_{II,i} - WTP2_{II,i}]$, where $J_{II,i}$ is an indicator variable taking the value of 1 if participant i is predicted to have chosen the product $II = \{RCM, OCM, RSM, OSM\}$ at the market price P_{II} and 0 otherwise. This effect of ignorance is added to the surplus given by the equation (1) for leading to the complete surplus considered by a regulator defining the policy. From equation (1), we define CS^i_B, the complete surplus accounting for the ignorance when one unit of product is purchased (see equation (2) in the appendix). This complete surplus is taken into account as the initial reference in the surplus variations detailed below.

2.2.3 The perfect information scenario

The first regulation provides perfect environmental information about products for all consumers via a public advertising campaign. Here we consider as perfect environmental information, the information composed by the message about GHG emission and the message about pesticides. Such a campaign might involve widespread mass media advertising. For this first regulation, we assume that the two environmental messages are perfectly received by all participants in similar conditions to the one of the experiment. For simplicity, we do not detail the cost of advertising.

Consumers choose the product leading to the highest consumer surplus. With an information campaign where all consumers receive information, a participant i receives the surplus CS^i_c presented in the equation (3) in the appendix. Under complete revelation of information, there is no cost of ignorance since messages are fully internalized in WTP. The welfare effect of perfect information is measured by the average variation in surplus given by equation (4).

[3]Results are robust when we consider the case with complete information also integrating the messages about cholesterol and animal welfare, which is equivalent to the round # 6.

2.2.4 The scenarios with optimal tax and subsidy under the absence of information

In real life, precise information is very hard to convey to consumers facing information overload and imperfect recall. When perfect information is missing, a per-unit tax t and/or a per-unit subsidy s can be applied for thwarting consumers' ignorance. Regarding our different cases, the prices $P_{II} + t$ and $P_{II} - s$ with $II = \{RCM, OCM, RSM, OSM\}$ replace the previous prices without taxes and subsidy in the equation (1) to the equation (3) in the appendix. In the revised equation (2), $J_{II,i}$ equal to 1 if the product II is purchased at price $P_{II} + t$ or $P_{II} + s$. The regulator also considers the subsidy cost and the tax income. The subsidy/tax program aims at internalizing the non-internalized benefit/damage linked to the absence of information.

We focus on 3 scenarios : S1, S2, and S3. In the scenario S1, there is a tax on the RCM and a subsidy on the RSM and the OSM. In the scenario S2, there is a tax on the RCM and the OCM and a subsidy on the RSM and the OSM. In the scenario S3, there is a tax on the RCM and the RSM and, a subsidy on the OCM and the OSM. By taking into account the complete surplus integrating the effect of ignorance (or the non-internalized damage/benefit) and the estimated subsidy cost and tax income, we define $CS^i_{D1}(s,t)$, $CS^i_{D2}(s,t)$ and $CS^i_{D3}(s,t)$, the surpluses for participant i, respectively for the scenarios S1, S2 and S3, corresponding respectively to the equations (5), (6) and (7) in the appendix. The improvement linked to the tax/subsidy program is captured by the surplus variation $CS^i_{Dk}(s,t) - CS^i_B$ for a participant i and a scenario k with k={1,2,3} for S1, S2 and S3. The welfare effect is measured by the average variation in surplus given by $\Delta CS_2(s,t)$ in equation (8).

For each scenario, the optimal subsidy s^* and tax t^* are given by a groping process maximizing the average surplus $\Delta CS_2(s,t)$. The groping process was realized on the *Excel* software. We will report the lowest value of s^* and tax t^* maximizing $\Delta CS_2(s,t)$. In the estimation, we will report variations in market shares of products. We will also report average surplus variation given by equation (8) for 1 liter of milk. Eventually, we will extrapolate this average surplus variation $\Delta CS_2(s,t)$ for 1 liter of milk to overall consumption of liquid milk over a given year. In 2016, the milk consumption in France was 3.347 billion liters. Because $\Delta CS_2(s,t)$ is given for 1 liter of milk, the overall variation over a year $\sum CS_2(s,t)$ is calculated by multiplying $\Delta CS_2(s,t)$ with $3.347 * 10^9$. Such an extrapolation is limited, since no price adjustments of products are considered and no quality differentiation is taken into account.

2.2.5 Taxes based on the IPCC carbon price

We also consider an alternative method for determining taxes t depending on the GHG emissions. Regarding climate change, the Intergovernmental Panel on Climate Change (IPCC) indicates carbon prices which are supposed to cap GHG emissions. This panel suggests a gradual implementation of a per-ton carbon price, namely between $40 and $80 in 2020, between $50 and $100 in 2030, and eventually, between $125 and $140 in 2040 (IPCC, 2014). These values can be applied to the 1 liter milk bottles of our experiment for having a tax that can be compared to the optimal taxes obtained with the scenarios S1, S2 and S3 previously presented. Using a life cycle analysis, it is possible to evaluate the carbon emissions coming from milk production. González et al. (2011) present the carbon emissions of several crops and food products, including milk and soybean. Based on IPCC values, these emissions for one liter lead to a per-liter carbon price that can be considered as the environmental cost for the society. It is assumed that this cost is internalized via a per-unit/liter tax that is passed onto consumers into the price. We assume that the GHG emissions for organic milks are the same that for the regular milks. The previous welfare model integrate taxes estimated with the IPCC carbon prices applied to emissions of various milk bottles. Interestingly, our methodology using consumers' preferences endorses an assessment of possible taxes based on the IPCC carbon price.

3 Data

3.1 Analysis of WTP

We first analyze the initial participants' WTP under the absence of information. Table 4 presents the descriptive statistics of the participants' WTP at round #2 when no message was revealed. We observe that there are WTPs equal to zero for all the products. As we could have expected, there are more bids for soy milk than for cow's milk. This means that the more participants who do not want to buy soy milk, than cow's milk. The RSM is the product that obtained the more bids. Without information, there is 9 participants who do not want to buy this product. The RCM has a lower average WTP and the OSM has the higher one, which is consistent with observed market prices of products presented in table 2.

[Insert table 4]

We now turn to the impact of messages on WTP for RCM, OCM, RSM and OSM. We start by simply presenting the average WTP for each of the four products. Figure 1 shows the average WTP for RCM (blue), OCM (grey), RSM (yellow) and OSM (orange). On each chart, the 6 rounds of WTP elicitation are represented on the X-axis, and the WTP are represented on the Y-axis starting at €0.40, to €1.20. The different charts correspond to the different groups G1, G2, G3 and G4. For each chart, the order of explanatory messages are different, as detailed in table 3. The types of messages preceding the WTP elicitation are indicated above the X-axis in the order that they have been delivered for the group. An average variation in WTP coming from one message is represented by the difference between two successive points. Figure 1 shows variations in WTP of different products, with the reduction in WTP for RCM that is more pronounced than variations for other products.

[Insert figure 1]

3.2 Econometric estimations

We now turn to the complete study of the statistical significance of messages on WTP. The econometric estimation of WTP is presented in table 5, for measuring the impact of the different messages. We pooled the observations corresponding to participants' WTP, elicited in the five last successive rounds. For the following analysis, we will only focus on the last five WTP written buy each participant i for each of the four products. We omit the first round because there is no message and it concerned only cow's milk. The random effect imposes constraints on the structure of the variance-covariance matrix, so we use the random effects tobit estimator. Our data are left censored in 0 because people can't have a negative WTP and when they have a WTP aqual to 0, it means that they don't want to buy the product. This justify the use of a tobit model. We apply as well a Ordinary Least Square (OLS) model to the data, and obtain the same results in terms of significant variables and almost the exact coefficients. This can be explained by the fact that we have only few zeros (between 1 and 5 depending on the product). So, in our case, for the explanation and the predictions of the WTP, the OLS model is as relevant as the tobit model.

Models (1), (3), (5) and (7), for the RCM, OCM, RSM and OSM respectively, are left censored tobit model with the messages variables, the control variables and the interactions between the messages and the orders. The model (2), (4), (6), (8), for the RCM, OCM, RSM and OSM respectively, are the left censored tobit models with the message variables and the control variables only. Each message is identified by a dummy variable equal to 1, when it is the last message delivered before the WTP elicitation and 0 otherwise. Regarding the order of the messages, we consider that each message can only have 2 positions : first or second position for each the two environmental messages, and third or fourth position for the messages about animal welfare and cholesterol. So there is two dummy variables of order : one for the environmental messages, equal to 1 when the message about pesticides is at the first position and 0 otherwise, and the other for the message about animal welfare and the message about cholesterol, equal to 1 when the message about animal welfare is at the third position and 0 otherwise.

The influence of the messages on consumers' WTP and the interactions of messages and orders is presented in the first part of table 5. For each model, the participants' perceptions and socio-economic characteristics coming from the exit questionnaire are in the second and the third part of the table 5.

The econometric models show that the messages have a significant impact on the WTP for RCM only ($p < 0.05$). The four messages have an negative impact on the WTP for the RCM. This means that participants decrease their WTP for the RCM when they learn about the environmental impacts of the use of pesticides and chemical pollution, animal welfare and the cholesterol. These messages has no significant impact on OCM, RSM and OSM. Thanks to those results we understand that regarding environment, cholesterol and animal welfare, participants can decrease their WTP for the RCM but can't change their WTP for the other milks. Consumers do not want to pay more than the current price for milk. This suggests that a public policy could change the consumption of those products, and particularly the consumption of RCM.

4 Results for regulatory scenarios

4.1 The perfect information scenario

Table 6 first details the impact of the perfect information about environmental issues. The first four columns show the variation of the market share of each product with the parenthesis indicating the sales under perfect information, the fifth column shows the mean per unit variation of consumers' surplus, and the last column shows the total consumers' surplus regarding the total milk consumption in one year. This leads to the highest average surplus variation. Because of this full internalization, there is no need of an additional per-unit tax and per-unit subsidy that are equal to zero. The perfect information scenario are almost impossible to implement in real context, because many consumers with an imperfect recall never take into account environmental criteria in their purchasing choices.

These results are presented as variations form the baseline scenario. We observe that under the perfect information scenario, only 40 of the 124 consumers purchase a product. The number of RCM purchased decrease of 52%, the purchase of OCM do is constant, the purchase of OSM increase of 22% and there is no purchase of RSM because the only one which is purchased in the baseline scenario is not purchased in this perfect information scenario. In this perfect information scenario, the per unit consumers' surplus increased of 13.2 percents, which represents 0.0215€ . This correspond to a total surplus of €71.98 million for a year.

[Insert table 6]

4.2 The scenarios with optimal tax and subsidy under the absence of information

Table 7 details the economic impacts of regulatory tools when consumers have no environmental information regarding the products. The first column presents the different scenarios with the optimal subsidy s^* or/and tax t^* that are given by a groping process maximizing the average surplus. The second and the third columns present, for each scenario, the optimal tax and subsidy maximizing the welfare. From the fourth to the seventh columns, we detail the market share variations of different products. The eighth column underscores the total variation of sold bottles. The ninth column shows the average variations in surplus linked to the purchase of one liter of milk. The tenth column shows the overall surplus variation, extrapolated to all milk bottles sold over the year 2016 in France. The three last column shows the regulator's revenue coming from taxes, the regulator's cost coming from subsidies and the total regulator's budget.

Regarding the taxation scenarios, a tax can be imposed on products because of their negative impact on environment via GHG emissions and/or pesticides. The products which can be concerned by a tax in our scenarios are RCM, RSM and OCM and the one which can be concerned by a subsidy are OCM, RSM and OSM. In the scenario S1 a tax is applied on the RCM to internalize the negative externalities due to the GHG emissions and the use of pesticides and a subsidy is applied on the RSM and the OSM. In the scenario S2 both products the RCM and the OCM are concerned by a tax in order to internalize the externalities due to GHG emissions and the RSM and the OSM are concerned by a subsidy. In the scenario S3, the RCM and the RSM are taxed because of the externalities coming from the use of pesticides and other chemicals and a subsidy is applied on the OCM and the OSM. For each of those scenarios, we select the couple of tax and subsidy that maximize the welfare variations. Recall that the tax and the subsidy maximize the welfare by favoring the products with the lowest effect of ignorance, namely the ones that consumers would choose under perfect information.

The ninth and tenth columns of table 7 clearly show that the scenario S3, with a tax equal to €0.4 imposed on both RCM and RSM and a subsidy equal to €0.1 imposed on both OCM and RSM, leads to the greatest surplus variations. With S3, the relative increase of the welfare is equal to 3.9% compared to the baseline scenario. By favoring organic products, this tax on regular milks and this subsidy on organic milks deter the consumption of regular cow's milk. Among these previous consumers of regular cow' milk, half of them turn to the organic cow's milk, one quarter of them choose organic soy milk, and the last quarter of them stop consuming milk. The decrease in the consumption of the regular cow's milk is not outweighed by a symmetric increase in the consumption of organic cow's milk, which leads to a significant decrease in GHG emissions. This result is consistent with the WTP variations underlining a significant organic premium associated with both cow's milk and soy milk. As consumers value more the organic characteristic than the vegetable characteristic coming from soy, the tax on regular products and the subsidy on organic products help consumers turn towards these organic products.

[Insert table 7]

4.3 Taxes based on IPCC carbon prices

The production of 1 kg of milk leads to the emission of 1.0kg CO_2eq (Cederberg & Stadig, 2003). Multiplying this level of emission by the carbon price suggested by the IPCC, and considering the exchange rate of 1.15 dollars for 1 euro, we obtain a cost per-liter defining the per-unit tax. The per-unit taxes are presented in table 8. All these per-unit taxes are much lower than the per-unit taxes t* estimated from participants' WTP in the second column of table 7. Recall that the tax levels of table 7 were maximizing the welfare accounting for consumers preferences. It means that different tax levels related to the IPCC's estimates could be acceptable for consumers who are implicitly ready to pay higher levels of taxes, as the ones showed in table 7. This is an important result suggesting that an IPCC carbon taxation is endorsed by consumers' preferences and welfare maximization.

The production of 1kg of soybean delivers 505g/kg CO_2eq, with González et al. (2011) presenting the protein content related carbon emissions. Referring to the nutritional value of soy milk, we observe that 100ml of soy milk contains 3.8g of protein, which correspond to 38g of protein per liter of product. We can deduce that 1 liter of soy milk produces around 0,075 kg CO_2eq. Applied to the carbon prices proposed by the IPCC, we obtain the per-unit taxes presented in table 8. We observe that the per-unit taxes on the soy milk are 13.33 times lower than those on the cow's milk. The per-unit taxes for cow's milk are going from 3 cents of euros in 2020, to 12 cents of euros in 2040, and for soy milk, from 0.2 cents of euros in 2020 to 0.9 cents of euros. We observe that the taxes from the IPCC carbon prices are largely lower than the optimal tax found in our scenarios (3.3 times lower than the tax for the higher IPCC carbon price for 2040 and 11.5 times lower for the tax from the lower IPCC carbon price for

2020).

[Insert table 8]

The IPCC carbon prices are supposed to cap GHG emissions. So, it is interesting, in order to observe the impact of carbon prices on consumers' surplus, to apply the taxes corresponding to the IPCC carbon prices, to the process of welfare maximization, considering as complete information, the message about GHG emissions only. We observe that scenarios with taxes from IPCC carbon price applied to cow's milk only and to cow's milk and soy milks, lead to a decrease of the welfare in both cases. Indeed, all tax scenarios with the framework, considering as WTP complete information, the GHG emissions message, decrease the welfare. Regarding the welfare variation in function of the tax levels for the framework taking into account only the WTP after the message about GHG emission, we that there is no tax level leading to a positive welfare variation. Higher is the tax, higher is the loss of welfare. This results can be explained by the low consumer sensitivity for the impact of GHG emissions from cow's milk. In fact, regarding only consumers' WTP for GHG emissions, we can't say that consumers' are able to accept a tax.

Moreover, it is interesting to analyze the impact on the welfare of regulatory scenarios on the carbon taxes from IPCC carbon prices, with our framework considering as complete environmental information, the messages about GHG emissions and the message about pesticides. Table 9 presents the impacts of these taxes on welfares for scenarios corresponding to the carbon prices suggested by the IPCC for 2020 and 2040. We observe that surplus variations from these scenarios are negative (namely, lower than the surplus in the baseline scenario). Indeed, scenarios with the taxes corresponding to the IPCC carbon prices applied to cow's milk only and to cow's milk and soy milks, lead to a decrease of the welfare in both cases. Regarding the welfare variation in function of the tax levels for the framework taking into account the WTP after the GHG emission and the pesticides information, we observe that only a tax between €0.50 and €0.65, can lead to a positive welfare variation. Per-unit taxes lower than €0.50 on cow's milks leads to a negative welfare variation because the tax revenue are not high enough to bridge the loss of consumer surplus due to the decrease of the direct surplus and the stop of milk consumption of some consumers. Per-unit taxes upper than 0.65 on cow's milks leads to a negative welfare variation because there is no cow's milk consumption for this scenarios, so, there is no tax revenue (in the case with tax only on cow's milks) or very few tax revenue (in the case of with a tax on cow's milks and soy milks). The surplus variations from the scenarios based on taxes from IPCC carbon prices are negative because the per-unit taxes may implies changes in consumers' choices, but are too low for generating enough tax revenue to fill the loss of welfare due to decrease of the direct consumers' surplus.

Table 9 means that different tax levels related to the IPCC's estimates are acceptable for consumers who are implicitly ready to pay higher levels of taxes, as the ones showed in table 7. The comparison between table 9 and table 7 shows that an efficient tax program for reducing GHG emissions should also examine markets adjustments for a specific type of product, including the diversity of sub-segments, like the rgular and organic products.

[Insert table 9]

5 Conclusion

This paper explores the following question: Is a carbon tax compatible with consumers' preferences? For replying to this question, a method based on the maximization of consumers' surplus using WTP as been developed. The study of participants' WTP indicates that there is a significant organic premium associated with both cow's milk and soy milks, and a significant premium for soy milk compared to cow's milk. Simulations shows the optimality of the scenario S3, applying a positive per-unit tax on both regular cow's milk and regular soy milk and a per-unit subsidy on both organic cow's milk and organic soy milk. By reducing the market share of regular cow' milk, this scenario would allow an effective reduction of chemical contamination and GHG emissions. It means that an environmental tax taking into account externalities from GHG emissions and chemical pollution is compatible with consumers' preferences.

Thanks to a life cycle analysis, alternative taxes on milk have been calculated based on carbon price proposed by the IPCC, for cow's milk and soy milk. The alternative taxes obtained from IPCC carbon prices are lower than the optimal tax resulting in the maximization of the consumers' surplus. Scenarios with the alternative IPCC carbon taxes lead to a low reduction of cow's milks market share and a decrease of the welfare. We can say that carbon taxes based on carbon prices proposed by IPCC can be endorsed by consumers' preferences but are lower than the optimal tax in consumers' point of view. It means that an efficient tax program for reducing GHG emissions should also examine markets adjustments for various specific products rather than considering a general carbon price.

There are shortcomings with the methods developed in this paper. Our methodology does not elicit a willingness to accept a tax, but it determines optimal taxes coming from a maximization of the welfare that uses elicited WTP for products. Another limitation of our methodology comes from the focus only on one type of product, namely the milk. The experimental analysis should consider configurations for which the regulation targets a basket with many goods and characteristics. WTP for a good/characteristic may vary depending on whether it is evaluated on its own, or as part of a "broad basket" of goods/characteristic, which ultimately raises the question of the stability of WTP. Kahneman & Knetsch (1992) underlined the sub-additivity effect that occurs, when the estimated WTP for the improvement of one characteristic/good plus the estimated WTP for another characteristic/good is greater than the "common WTP", when participants are asked to value the two goods/characteristics together. In other words, the non-internalized premiums given by the WTP differences following messages were determined for one type of product, but not for many types of products belonging to the purchased basket by consumers. The premiums justifying the tax on regular products are likely to decline when many products are considered. The decrease of premiums that could emerge when many other products are considered could lead to lower levels of optimal taxes compared to the ones of table 7. However, as optimal taxes from table 7 are relatively high, there is a chance that new levels of taxes imposed on many products would be higher than alternative taxes based on the IPCC carbon price.

More works should be done for understanding how consumers value environmental damages. Despite limitations, our experimental results are useful for guiding public debates and understanding consumers' preferences regarding environmental challenges.

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Appendix : consumers' surpluses

The surplus CS^i_A for the baseline scenario is:

$$CS^i_A = max\{WTP2_{RCM,i} - P_{RCM}, WTP2_{OCM,i} - P_{OCM}, WTP2_{RSM,i} - P_{RSM}, WTP2_{OSM,i} - P_{OSM}, 0\} \quad (1)$$

By starting from equation (1), the complete surplus accounting for the ignorance when one unit of product is purchased is:

$$\begin{aligned} CS^i_B = max\{&WTP2_{RCM,i} - P_{RCM}, WTP2_{OCM,i} - P_{OCM}, \\ &WTP2_{RSM,i} - P_{RSM}, WTP2_{OSM,i} - P_{OSM}, 0\} \\ &+ J_{RCM,i}[WTP4_{RCM,i} - WTP2_{RCM,i}] + J_{OCM,i}[WTP4_{OCM,i} - WTP2_{OCM,i}] \\ &+ J_{RSM,i}[WTP4_{RSM,i} - WTP2_{RSM,i}] + J_{OSM,i}[WTP4_{OSM,i} - WTP2_{OSM,i}] \end{aligned} \quad (2)$$

With an information campaign where all consumers receive information, a participant i receives the surplus:

$$\begin{aligned} CS^i_c = max\{&WTP4_{RCM,i} - P_{RCM}, WTP4_{OCM,i} - P_{OCM}, \\ &WTP4_{RSM,i} - P_{RSM}, WTP4_{OSM,i} - P_{OSM}, 0\} \end{aligned} \quad (3)$$

By using equation (2) and equation (3), the average variation in surplus following the broadcast of perfect information is equal to

$$\Delta CS_1 = \sum_{i=1}^{N} [CS^i_C - CS^i_B]/N \quad (4)$$

where N is the overall number of participants.

For the tax and subsidy, the complete surplus integrates the effect of ignorance and the estimated subsidy cost, $J_{II}s$, when the product II is subsidized and purchased, and the estimated tax income, $J_{III}t$, when the product III is taxed and purchased. The complete surplus related for participant i, for the **scenario S1**, applying a tax on the RCM and a subsidy on the RSM and the OSM, is equal to:

$$
\begin{aligned}
CS^i_{D1}(s,t) = [max\{&WTP7_{RCM,i} - P_{RCM} - t, WTP7_{OCM,i} - P_{OCM,i},\\
&WTP7_{RSM,i} - P_{RSM} + s, WTP4_{OSM,i} - P_{OSM} + s, 0\}]\\
&+ J_{RMC,i}[WTP4_{RCM,i} - WTP2_{RCM,i} + t] + J_{OCM,i}[WTP4_{OCM,i} - WTP2_{OCM,i}]\\
&+ J_{RSM,i}[WTP4_{RSM,i} - WTP2_{RSM,i} - s] + J_{OSM,i}[WTP4_{OSM,i} - WTP2_{OSM,i} - s] \quad (5)
\end{aligned}
$$

For the **scenario S2**, applying a tax on the RCM and the OCM, and a subsidy on the RSM and the OSM, the participant's complete surplus is equal to:

$$
\begin{aligned}
CS^i_{D2}(s,t) = [max\{&WTP7_{RCM,i} - P_{RCM} - t, WTP7_{OCM,i} - P_{OCM,i} - t,\\
&WTP7_{RSM,i} - P_{RSM} + s, WTP4_{OSM,i} - P_{OSM} + s, 0\}]\\
&+ J_{RMC,i}[WTP4_{RCM,i} - WTP2_{RCM,i} + t] + J_{OCM,i}[WTP4_{OCM,i} - WTP2_{OCM,i} + t]\\
&+ J_{RSM,i}[WTP4_{RSM,i} - WTP2_{RSM,i} - s] + J_{OSM,i}[WTP4_{OSM,i} - WTP2_{OSM,i} - s] \quad (6)
\end{aligned}
$$

For the **scenario S3**, applying a tax on the RCM and the RSM, and a subsidy on the OCM and the OSM, the participant's complete surplus is equal to:

$$
\begin{aligned}
CS^i_{D3}(s,t) = [max\{&WTP7_{RCM,i} - P_{RCM} - t, WTP7_{OCM,i} - P_{OCM,i} + s,\\
&WTP7_{RSM,i} - P_{RSM} - t, WTP4_{OSM,i} - P_{OSM} + s, 0\}]\\
&+ J_{RMC,i}[WTP4_{RCM,i} - WTP2_{RCM,i} + t] + J_{OCM,i}[WTP4_{OCM,i} - WTP2_{OCM,i} - s]\\
&+ J_{RSM,i}[WTP4_{RSM,i} - WTP2_{RSM,i} + t] + J_{OSM,i}[WTP4_{OSM,i} - WTP2_{OSM,i} - s] \quad (7)
\end{aligned}
$$

The average variation in surplus linked to the purchase of one unit is equal to:

$$\Delta CS_2(s,t) = \sum_{i=1}^{N} [CS^i_{Dk}(s,t) - CS^i_B]/N \quad (8)$$

where N is the overall number of participants and k={1,2,3} indicates the scenario S1, S2 or S3.

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Table 1: Statistics about the sample in the experiment

Income	
<=2000	31.7%
between 2000 and 4000	49.6%
between 4000 and 6000	13.0%
>6000	1.6%
no answer	3.3%
Academic	
no degree	0.8%
high school degree	51.2%
bachelor to Master degree	48.0%
Sex	
Female	49.6%
Male	50.4%
Do you regularly consume organic cow's milk?*	
yes	57.7%
Do you regularly consume soy milk?*	
yes	17.1%

* These questions come from the exit questionnaire filled at the end of the experiment.

Table 2: The four products presented to the participants

Picture				
Code	RCM	OSM	RSM	OSM
Type	Cow's milk	Cow's milk	Soy milk	Soy milk
Characteristics	Regular	Organic	Regular	Organic
Market price (€)	0.80	1.10	1.20	1.30

Table 3: The groups and the order of messages

	Round # 1	Round # 2	Round # 3	Round # 4	Round # 5	Round # 6
Group G1 31 participants	no message	no message	PES	GHG	AWF	CHO
Group G2 32 participants	no message	no message	GHG	PES	AWF	CHO
Group G3 28 participants	no message	no message	PES	GHG	CHO	AWF
Group G4 32 participants	no message	no message	GHG	PES	CHO	AWF

Table 4: Descriptive statistics of the WTP (€) with no message

	Min	Max	Mean	SD	Number of bids
RCM	0	2.00	0.71	0.35	4
OCM	0	2.70	0.91	0.45	3
RSM	0	3.15	0.87	0.57	9
OSM	0	3.50	1.06	0.69	6

Table 5: Left censored Regression on WTP (1/3)

	Dependent variable:							
	RCM		OCM		RSM		OSM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
INFOPEST1	-0.085^{*}	-0.105^{*}	-0.002	-0.018	0.030	0.029	0.032	0.036
	(0.048)	(0.060)	(0.058)	(0.073)	(0.075)	(0.096)	(0.087)	(0.112)
INFOGHG1	-0.044	-0.018	-0.027	-0.030	0.027	0.018	0.016	0.015
	(0.048)	(0.060)	(0.058)	(0.073)	(0.075)	(0.096)	(0.088)	(0.112)
INFOAWF1	-0.134^{***}	-0.118	-0.029	-0.034	0.043	0.018	0.048	0.030
	(0.048)	(0.087)	(0.058)	(0.106)	(0.075)	(0.138)	(0.087)	(0.162)
INFOCHO1	-0.110^{**}	-0.073	-0.045	-0.049	0.030	0.020	0.041	0.026
	(0.048)	(0.087)	(0.058)	(0.106)	(0.075)	(0.138)	(0.087)	(0.162)
INFOPEST0:ORDER1		0.174^{***}		0.240^{***}		0.167^{**}		0.219^{***}
		(0.045)		(0.055)		(0.072)		(0.084)
INFOPEST1:ORDER1		0.215^{***}		0.272^{***}		0.169		0.210
		(0.071)		(0.087)		(0.113)		(0.133)
INFOGHG1:ORDER1		-0.054		0.007		0.018		0.002
		(0.080)		(0.097)		(0.127)		(0.149)
INFOAWF0:ORDER2		0.148^{***}		0.238^{***}		-0.016		0.089
		(0.055)		(0.067)		(0.087)		(0.102)
INFOAWF1:ORDER2		0.127		0.244^{**}		0.016		0.113
		(0.086)		(0.104)		(0.136)		(0.159)
INFOCHO1:ORDER2		-0.047		0.005		0.013		0.020
		(0.095)		(0.116)		(0.151)		(0.177)

Left censored Regression on WTP (2/3)

	Dependent variable:							
	RCM		OCM		RSM		OSM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SEXF	−0.0002	0.019	−0.013	0.023	0.108**	0.102**	0.126**	0.138**
	(0.032)	(0.032)	(0.039)	(0.039)	(0.050)	(0.051)	(0.058)	(0.059)
ACADEMICBAC	−0.067	−0.120	0.011	−0.050	−0.056	−0.161	0.286	0.191
	(0.216)	(0.212)	(0.264)	(0.258)	(0.339)	(0.336)	(0.397)	(0.395)
ACADEMICBAC+2/+6	−0.022	−0.075	0.053	−0.007	−0.060	−0.173	0.315	0.214
	(0.217)	(0.213)	(0.265)	(0.259)	(0.339)	(0.337)	(0.397)	(0.396)
INCOME>2000;<4000	0.056	0.071**	−0.009	0.012	−0.010	0.012	−0.062	−0.038
	(0.035)	(0.035)	(0.043)	(0.042)	(0.056)	(0.055)	(0.065)	(0.065)
INCOME>4000;<6000	0.135***	0.125**	0.095	0.080	0.136*	0.131	0.081	0.072
	(0.052)	(0.050)	(0.063)	(0.061)	(0.081)	(0.080)	(0.095)	(0.094)
INCOME>6000	0.217*	0.185	0.213	0.165	0.196	0.177	0.161	0.128
	(0.124)	(0.121)	(0.151)	(0.147)	(0.194)	(0.192)	(0.227)	(0.226)
INCOMENOANSWER	−0.053	−0.021	−0.104	−0.049	−0.319	−0.310	−0.105	−0.075
	(0.125)	(0.122)	(0.152)	(0.149)	(0.195)	(0.194)	(0.229)	(0.227)
CONSOORGMILKNO	−0.021	−0.018	−0.082*	−0.083**	0.0002	0.020	−0.028	−0.016
	(0.035)	(0.034)	(0.042)	(0.042)	(0.055)	(0.054)	(0.064)	(0.064)
CONSOSOYMILKNO	−0.023	−0.024	−0.034	−0.030	−0.334***	−0.352***	−0.434***	−0.445***
	(0.045)	(0.044)	(0.055)	(0.054)	(0.070)	(0.070)	(0.082)	(0.082)

Left censored Regression on WTP (3/3)

	Dependent variable:							
	RCM		OCM		RSM		OSM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
KNOWENV1	0.067	0.106**	0.090	0.155**	−0.011	0.009	0.026	0.067
	(0.052)	(0.052)	(0.064)	(0.063)	(0.082)	(0.083)	(0.096)	(0.097)
KNOWGHG1	0.140***	0.111**	0.193***	0.152***	0.377***	0.350***	0.447***	0.412***
	(0.044)	(0.044)	(0.054)	(0.053)	(0.070)	(0.070)	(0.082)	(0.082)
KNOWAWF1	0.050	0.041	0.095*	0.073	0.144**	0.162**	0.183**	0.184**
	(0.046)	(0.046)	(0.056)	(0.055)	(0.072)	(0.073)	(0.084)	(0.085)
KNOWCHO1	−0.047	−0.050	−0.042	−0.050	−0.213***	−0.204***	−0.208***	−0.206***
	(0.037)	(0.036)	(0.045)	(0.044)	(0.058)	(0.058)	(0.068)	(0.067)
logSigma	−1.004***	−1.025***	−0.803***	−0.830***	−0.555***	−0.567***	−0.398***	−0.406***
	(0.030)	(0.030)	(0.030)	(0.030)	(0.031)	(0.031)	(0.030)	(0.030)
Constant	0.583**	0.420*	0.666**	0.400	0.818**	0.838**	0.663	0.562
	(0.236)	(0.238)	(0.288)	(0.289)	(0.370)	(0.376)	(0.433)	(0.442)
Observations	595	595	595	595	595	595	595	595
Log Likelihood	−269.846	−258.727	−379.317	−363.459	−527.867	−521.459	−611.762	−606.527

Note: *p<0.1; **p<0.05; ***p<0.01

Table 6: Perfect information scenario

	ΔMS_{RCM} nb of unit	ΔMS_{OCM} nb of unit	ΔMS_{RSM} nb of unit	ΔMS_{OSM} nb of unit	$\Delta CS(s,t)$ € /unit	$\sum CS(s,t)$ million €
Value	-12 (13)	0 (3)	-1 (0)	+4 (22)	+0.0215	+71.98
Percentage	-52	0	-100	+22	+13.2	+13.2

Note: () : Number of unit purchased under perfect information

Table 7: Scenarios with optimal tax and subsidy

Scenarios	t^* € /unit	s^* € /unit	ΔMS_{RCM} nb of unit	ΔMS_{OCM} nb of unit	ΔMS_{RSM} nb of unit	ΔMS_{OSM} nb of unit	ΔMS_{tot} nb of unit	$\Delta CS(s,t)$ €	$\sum CS(s,t)$ million €	R_{tot} million €
S1										
Value	0.4	0.1	-25 (0)	+2 (5)	+1 (2)	+10 (28)	-12 (35)	+0.0037	+8.57	-200.87
Percentage			-100.0	+66.7	+100.0	+55.6	-25.5	+2.2	+2.2	
S2										
Value	0.4	0.1	-24 (1)	-2 (1)	+1 (2)	+11 (29)	-14 (33)	+0.0020	+4.49	-154.00
Percentage			-96.0	-66.7	+100.0	+61.1	-28.9	+1.2	+1.2	
S3										
Value	0.4	0.1	-25 (0)	+12 (15)	-1 (0)	+7 (25)	-7 (40)	+0.0063	+17.0	-234.35
Percentage			-100.0	+400	-100.0	+38.9	-14.9	+3.9	+3.9	

Note: () : the market share under optimal scenario with taxes and subsidies indicated in the second and third columns.

Table 8: Taxes based on carbon prices suggested by IPCC

Milk	Emission kg$eqCO_2$/unit	Tax_{2020} €/unit	Tax_{2030} €/unit	Tax_{2040} €/unit
Cow's milk	1.0	0.0348-0.0696	0.0435-0.0870	0.1087-0.1217
Soy milk	0.075	0.0026-0.0052	0.0033-0.0065	0.0082-0.0091

Table 9: Scenarios with IPCC carbon price

Scenarios	p_{CO_2} \$/ton	$t_{cowmilk}$ € /unit	$t_{soymilk}$ € /unit	ΔMS_{RCM} nb of unit	ΔMS_{OCM} nb of unit	ΔMS_{RSM} nb of uni t	ΔMS_{OSM} nb of unit	ΔMS_{tot} nb of unit	$\Delta CS(s,t)$ € /unit	$\sum CS(s,t)$ million €	$R_{TotalTax}$ million €
S4 : 2020											
Value	40	0.0348	0.0026	-1 (24)	0 (3)	0 (1)	+3 (21)	+2 (49)	-0.0025	-8.07	66.74
Percentage				-4.0	0.0	0.0	+16.7	+4.0	-1.5	-1.5	
S5 : 2020											
Value	80	0.0696	0.0052	-9 (16)	0 (3)	0 (1)	-4 (22)	-5 (42)	-0.0041	-11.55	96.55
Percentage				-36.0	0.0	0.0	22.2	-11	-2.5	-2.5	
S6 : 2040											
Value	125	0.1087	0.0033	-17 (8)	-1 (2)	-1 (0)	+5 (23)	-13 (34)	-0.0066	-14.96	85.96
Percentage				-68.0	-33.3	-100.0	++27.8	–28.0	-4.0	-4.0	
S7 : 2040											
Value	145	0.1217	0.0082	-17 (8)	-1 (2)	0 (1)	+5 (23)	-13 (34)	-0.006	-14.98	96.11
Percentage				-68.0	-33.3	0.0	+27.8	-28.0	-4.0	-4.0	

Note: () : the market share under optimal scenario with taxes and subsidies indicated in the third and fourth columns.

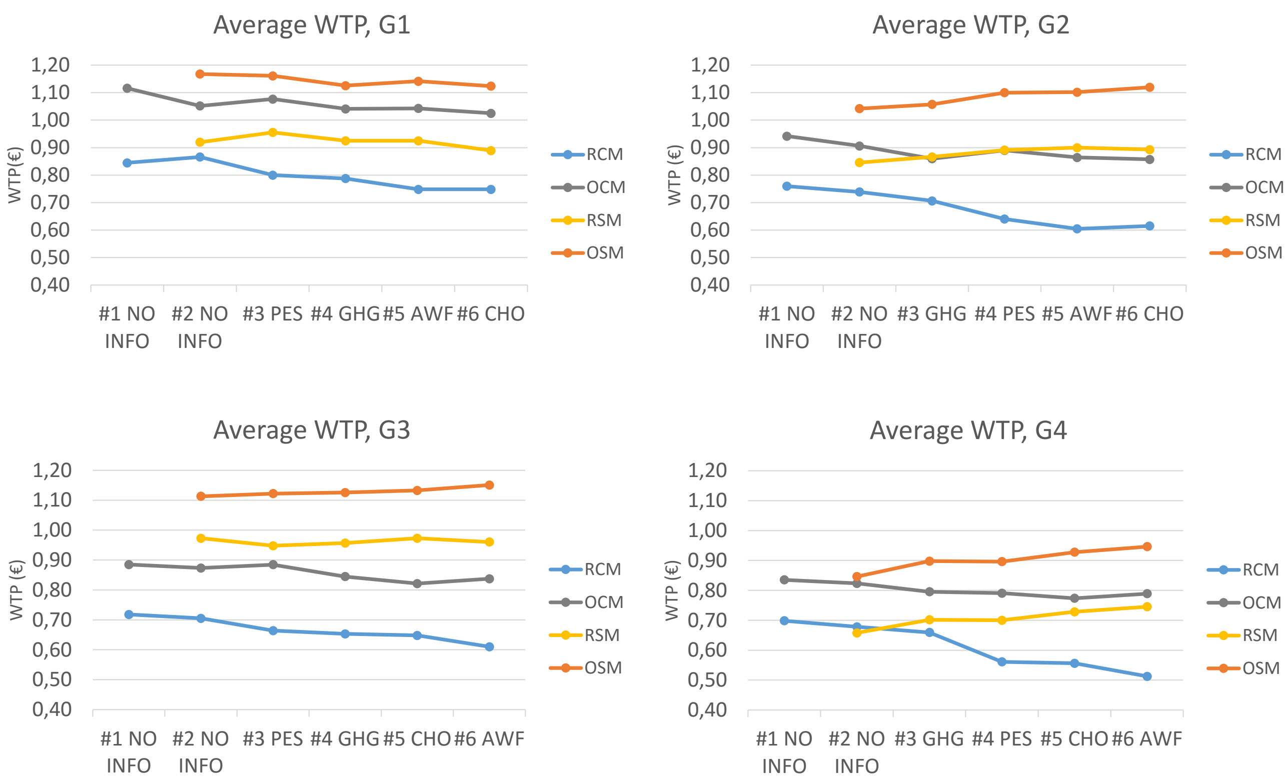

Figure 1: Average WTP for different bottles