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Are consumers concerned about palm oil? Evidence from a lab experiment

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ABSTRACT

A lab experiment evaluates the consumers' willingness to pay (WTP) for food products made with and without palm oil. Palm oil production induces environmental damages, and its consumption presents a health risk. However, the production of alternative oils raises land use issues. In the experiment, successive messages emphasizing the characteristics of palm oil and palm oil-free products are delivered to participants. Information has a significant influence on WTP when it underlines the negative impact of the related product. This effect is stronger for the palm oil product than for the palm oil-free product. The experiment also compares the welfare effects of two regulatory instruments, namely a consumer information campaign versus a per-unit tax. Because of the respective attributes of both palm oil and palm oil-free products, the information campaign improves welfare with a much larger impact than the tax.

Introduction

Palm oil is increasingly used in many cosmetics (soaps, shampoos, creams) and food products (margarine, ice cream, crisps, chips, instant noodles, pastry, chocolate, cereals, instant soup, etc.) sold in developed countries. One in 10 products sold in UK supermarkets includes palm oil (Friends of the Earth, 2005). Its production, mainly in Malaysia and Indonesia, has become a sensitive topic. Non-governmental organizations (NGOs) have conducted several intensive campaigns against its use (e.g., Greenpeace, 2007). Academic researchers have also highlighted environmental damage related to palm oil production (e.g., Warr and Yussuf, 2011). These academic and non-academic works underline the destruction of rainforests in Southeast Asia and their replacement by gigantic palm groves, with numerous detrimental consequences for biodiversity, endangered species, such as orangutans, and greenhouse gas emissions. The health impact of palm oil, which has a high concentration of saturated fat, is another sensitive issue generally overlooked by NGOs and the media.

This palm oil debate is of crucial importance for food multinationals, such as Nestlé, Kraft Foods or Unilever. Being publicly perceived as an environmentally unfriendly company could lead to financial losses and a negative image. Following a Greenpeace campaign in 2008, Unilever agreed to support an immediate moratorium on deforestation for palm oil in Southeast Asia (Greenpeace, 2009). Firms and growers also joined the Roundtable on Sustainable Palm Oil for defining a "sustainable" palm oil. However, world demand for sustainable palm oil has been sluggish, and there are many disagreements about the certification process and the precise definition of a sustainable standard (The Economist, 2010).

An additional difficulty arises when looking for an environmentally friendly substitute to palm oil. The production of alternative oils (e.g., groundnut, cotton, sunflower, soy or rapeseed oil) raises the issue of land use. To supply the same amount of oil, one would need to plant 5–10 times as much land with other oleaginous plants compared to palm groves (SIFCA, 2009). In other words, palm oil is relatively advantageous for the land use despite other environmental and health problems.

While the debate is technical due to the complexity of agronomic, environmental and health questions, little attention has been given to consumers' perceptions. These perceptions are essential not only for food multinationals but also for non-governmental organizations arranging boycotts or "buycotts" (i.e., active campaigns to buy clean products). Consumers' attitudes are also important for policymakers defining regulatory interventions.

Our paper sheds light on issues linked to palm oil and consumer valuation. In particular, we investigate the following questions: Do consumers pay attention to the effects of the palm oil production and consumption on the environment, land use and health? Do these effects impact their purchasing decisions? Which regulatory

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policies could be implemented to address this issue and improve consumer welfare?

Our paper addresses these questions by using a lab experiment conducted in France in 2011 and focused on milk rolls made with and without palm oil. Food is particularly well suited to lab experiments with auction mechanisms (Lusk and Shogren, 2007) by eliciting environmental values stemming from differences between consumers' willingness to pay (WTP) for milk rolls before and after the revelation of information about various environmental issues (Lusk and Norwood, 2009; Norwood and Lusk, 2011). This experimental approach has the advantage of relying on data from non-hypothetical choices, representing a type of quasi-revealed preference data.[1]

Our experiment evaluates consumers' WTP for milk rolls made with and without palm oil. Palm oil-free milk rolls using sunflower oil were introduced in the French market only two months prior to the experiment. Therefore, the label indicating the absence of palm oil can be considered new to participants. We use the procedure defined by Becker, DeGroot and Marschak (1964), hereafter BDM, to elicit WTP for both products, in which participants are asked to indicate the maximum price they are willing to pay for each product. Successive messages are delivered to the participants revealing the effects of both products on the environment, land use and health. The BDM procedure is incentive-compatible because, at the end of the experiment, participants buy one of the two products if their WTP is higher than a randomly selected price of exchange. Our results highlight a statistically significant influence of information on participants' WTP when the negative impact of the related product is underlined in the message.

As messages significantly impact WTP, it suggests that the demand for products does not fully internalize all dimensions linked to palm oil. Regulation is legitimate because consumers are not perfectly informed. The simulated regulation is only based on consumers' preferences including preferences for a better environment. In particular, direct measures of both losses and benefits for inhabitants and palm oil producers in Malaysia and Indonesia are not considered, even if they matter for a complete cost-benefit analysis.

This paper also compares the welfare effects of two regulatory instruments, namely a campaign for informing consumers or a per-unit tax. The per-unit tax recently gains momentum, since the French government plans to impose a per-unit tax linked to the use of palm oil in food products (Daily News, 2012). We show that a campaign decided by the regulator and perfectly informing all participants generates the highest welfare increase, but is practically hard to implement. The welfare impact of a per-unit tax on the palm oil product is also positive but relatively low, because of the heterogeneity of participants' preferences. For some participants, the tax indeed leads to inappropriate changes in consumption compared to an information campaign.

In this paper, we present what we believe to be the first lab experiment focusing on the perception regarding palm oil. This paper completes previous works on new products or new technologies in food, such as genetically modified organisms (Hu et al., 2005; Huffman et al., 2003; Lusk et al., 2005), irradiation (Fox et al., 2002). Except for the case of irradiation fighting food pathogens, previous experiments have focused on the new product tested in the experiment without revealing information about existing or alternative products.

We contribute to the literature by clearly eliciting WTP for issues such as deforestation or land use change that are missing in many agronomic or environmental studies. Our experiment is based on consequential WTP coming from one real-payment experiment with products sold with an incentive compatible auction, while many contributions on environmental characteristics are based on hypothetical WTP coming from contingent valuations. For instance, Solomon and Johnson (2009) set up a classical survey for eliciting hypothetical valuation of mitigating global climate change through the WTP for "cellulosic" ethanol. Conversely, our experiment shows the possibility to use real products for environmental questions.

We also contribute to the public debate by precisely studying the impact of two regulatory instruments (per-unit tax versus consumer information campaign). Gintis (2000) underlines the advantage of determining policy with experimental results. Previous studies (e.g., Huffman et al., 2003; Lusk et al., 2005) have mainly investigated the value of information and labels without any attention on other instruments such as a per-unit tax, a ban or a standard. Our paper focuses on the impact of a per-unit tax as Marette et al. (2011), but it does not use data coming from field experiments.

The paper is organized as follows. Section 'The experiment' focuses on the experimental design, and Section 'Results' presents the results. Section 'Consumer welfare and regulation' discusses the implications for regulatory policies. Section 'Conclusion' concludes.

The experiment

This section details the respondents, the product, the experimental procedure and the information revealed.

Target respondents

We conducted the experiment in Paris, France, in multiple sessions in March 2011. We selected the participants with the help of one of the major French survey institute using the quota method, which uses the same proportions of sex, age and socio-economic status (occupation, income, education) criteria in the group of respondents as in the general French population. Our panel is extracted from a pre-existing database of French consumers built by the survey institute. Our targeted group is relatively representative of the age-groups and the socio-economic status of the French population although well-educated people are slightly overrepresented (which is a characteristic of Paris compared to the rest of France). Participants were first contacted by phone and informed that they would earn a participation fee of €20 for replying to questions about food for 1 h. The target respondents consist of 101 people aged between 19 and 74.[2] In the experiment, we divide our respondents into two groups and randomly assign participants to one group. Group I includes 53 participants, and Group II includes 48 participants. The two groups receive the same information but in a different order (see below).

Table 1 presents the socio-economic characteristics (gender, age, education, income, household composition) of the participants within each group and the frequency of their milk roll consumption. Differences between the two groups are tested using the Pearson chi-squared test. A *P*-value (against the null hypothesis of no difference) of less than 5% is considered significant. The results in the last column of Table 1 suggest that the two groups are not significantly different.

[1] Lab experiment data may be subject to criticisms of external validity, which allows one to generalize the relationships found in one experiment to other contexts (e.g., Harrison and List, 2004). However, as shown by Lusk (2011), experiments with food products have a relative high level of external validity compared to experiments dealing with non-food products or with topics such as real estate, charity or contribution to public goods.

[2] The exclusion of unengaged participants bidding zero at each round does not change the nature of the results. Results are available upon request.

Table 1
Socio-economic characteristics of participants and milk roll consumption.

Description	Group I (53 participants) %	Group II (48 participants)%	Chi2 test *P*-value
Gender			
Male	42.3	48.9	0.508
Female	57.7	51.1	
Age			
<30	15.7	32.6	0.145
[30–60]	66.7	54.4	
>60	17.6	13.0	
Education			
No baccalaureate (BAC)	5.8	6.5	0.728
BAC or 2 years after BAC	40.4	32.6	
More than 2 years after BAC	53.8	60.9	
Monthly net income of the household (€)			
⩽1500	30.8	27.9	0.129
]1500–4000[	50.0	34.9	
⩾4000	19.2	37.2	
Children at home			
No	59.6	58.7	0.926
Yes	40.4	41.3	
Milk roll consumption			
Never or rarely	28.3	14.9	0.257
Between once a week and once a month	66.0	76.6	
At least four times a week	5.7	8.5	
Milk rolls and health			
Milk rolls are healthy	31.3	18.2	0.148
Milk rolls are not healthy	68.7	81.8	

Notes: For each characteristic, missing observations and answers of "do not know" are dropped. Baccalaureate is the French high school diploma.

Products

Our experiment focuses on industrial milk rolls that are popular *viennoiserie* products in France and sold in packs of ten.[3] We offer a pack sold by the brand Harry's and one sold by the supermarket brand Casino. Three facts motivate the selection of the products from both brands. First, the choice between two products reproduces conditions for milk rolls very close to real supermarket shelves, where one national brand usually competes with the supermarket brand. Second, both brands are familiar to French consumers, and their products present characteristics adequately related to our experiment. Harry's[4] is a well-known brand in France and sold in almost all supermarkets. The choice of the Casino brand, which is one of the biggest French supermarket chains, is motivated by the absence of palm oil in its milk rolls. These palm oil-free rolls were introduced in the market less than two months before the experiment and without strong advertising in the media. The absence of palm oil is clearly mentioned by a sticker on the pack. Therefore, the label indicating the lack of palm oil can be considered new to participants. Third, these two products are positioned in the price segment for milk rolls observed in several places. Observed milk rolls' prices vary between €0.5 and €2.5; the Casino pack's average price is €1.3 and Harry's is €1.5.

Experimental design and information revealed

To elicit participants' WTP, our experiment uses the BDM procedure (Becker et al., 1964). The exact question is as follows: "What is the maximum price you are willing to pay for the product?" Successive items of information are revealed to participants, and WTP is elicited after each message. Both products (with and without palm oil) are presented in each round except for the first round where only the palm oil product is offered. In the first round, only this product was made available to the participants because it was already sold on the market before the introduction of the palm oil-free product. We conduct the experiment in two treatments, varying the order of information provided to each group of participants. The experiment is divided into several stages as described in Fig. 1. The sequence of information revealed differs between the two groups. Group I successively receives information about the environment, land use and health, whereas Group II successively receives information about health, the environment and land use. For both groups, land use information follows environmental information, as pre-tests revealed that messages about land use appear difficult to introduce before any reference to the environment. The timing of the experiment is as follows:

- The session starts with a trial round to explain the BDM mechanism. Simulations help participants understand the mechanism.[5] The possibility of zero bids in the BDM procedure is carefully explained, as well as the possible use of the €20 compensation for making the real purchase. We also make clear that one of the elicited WTP will be randomly selected at the end of this experiment for determining whether participants will have to buy one pack of milk rolls (i.e., performance-based financial incentives).
- Participants fill in an entry questionnaire on consumption behavior and socio-demographic characteristics.

[3] France is the European leader for the production, consumption and export of *viennoiserie* products. In 2010, 75% of the *viennoiserie* products consumed in France were of industrial origin (Source: http://www.boulangerie-industrielle.fr/).

[4] The brand Harry's was launched in France in 1970. Today, Harry's is the French leader of industrial sandwich bread and *viennoiserie* products. About two-thirds of French households consume Harry's products. Since 2008, Harry's aims to develop a new marketing strategy based on a variety of basic products to be consumed daily. Source: http://www.harrysgroup.com/ (accessed 12.07.12).

[5] With this training session and the opportunity for participants to ask questions, the effects of learning the experimental procedure should not be a problem in latter rounds with the real product of interest.

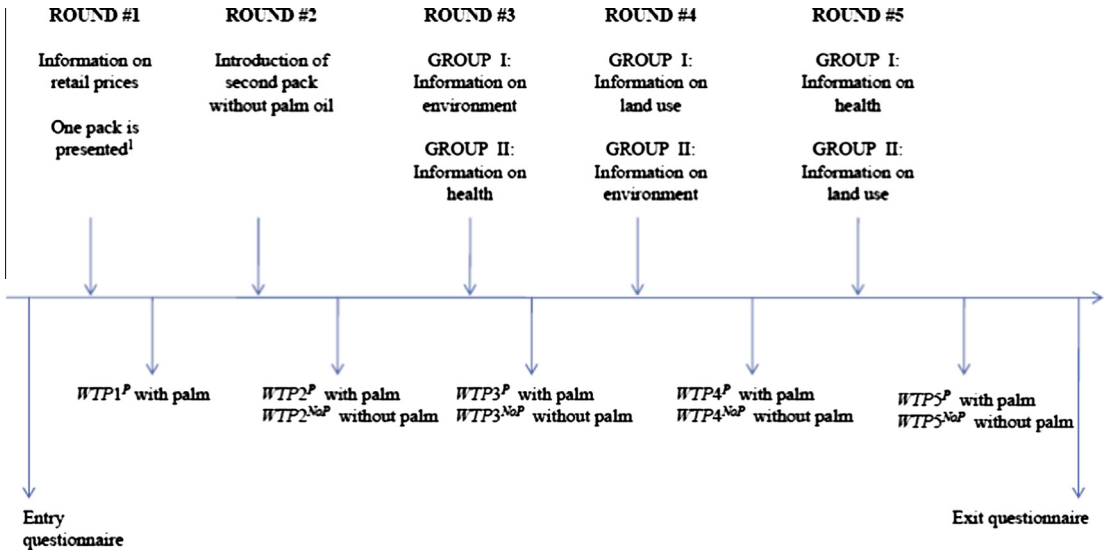

Fig. 1. Experiment design and timeline. Note: [1]This pack is the one with palm oil (but this is not mentioned in the information revealed to participants in round #1).

- Based on different types of information revealed to participants, five rounds of WTP elicitation with the BDM procedure are successively determined. The Appendix details the messages revealed to participants. In the first round of the experiment, only the pack of milk rolls with palm oil is made available to the participants. The pack of the palm oil-free milk rolls is introduced in the second round with a simple message indicating the presence or the absence of palm oil in each pack of rolls. Consequently, the first round only elicits participants' WTP for the product with palm oil, while the subsequent rounds elicit WTP for the products with and without palm oil.
- The range of observed retail prices for one pack of milk rolls (€0.5–2.5) is only revealed before the first WTP elicitation, which allows us to control the anchorage effect for the first round. We do not post any prices between rounds to avoid any confusion regarding the effects linked to price information and the effects linked to information on palm oil issues.[6]
- Rounds #3, #4 and #5 reveal detailed information about the environment, land use and health (see Appendix). These messages are based on press releases and reports concerning palm oil. The messages are simple but as close as possible to reality because some participants may have prior knowledge of the palm oil issue.[7] The messages about the environment and health reveal positive information on the palm oil-free product and negative information on the palm oil product: plantations of palm trees destroy rainforests, and palm oil has a large amount of saturated fat. The message about land use makes the opposite argument: palm tree substitutes (such as sunflowers, for example) require more land for producing one liter of oil.
- Participants complete an exit questionnaire on related issues. The experiment concludes by randomly selecting one pack of rolls (with or without palm oil) and one of the five elicited WTP, which are used to determine whether participants take the pack away with them. A price between €0.1 and €5 is also drawn at random,[8] and purchasing choices are enforced. If the selected WTP is smaller than the randomly drawn price, the participant receives the €20 indemnity. If the WTP is higher, the compensation is equal to €20 less the price randomly drawn, and the participant receives the pack of milk rolls.

Results

Descriptive analysis

Fig. 2 shows the average WTP in euros for one pack of milk rolls expressed by all participants i after each round of information j with $j = \{1, 2, \ldots, 5\}$. The standard deviation is reported in parentheses. The top of the figure details information revealed before WTP elicitation. The two graphs in each row of Fig. 2 indicate the average WTP for the same product for each group of participants separately, which allows the reader to identify the effect of information order. Analyzed vertically, each column of Fig. 2 indicates the average WTP for the same group of participants but for each product (with and without palm oil) separately, which allows the reader to identify the effect of information on each product.

We test for the significance of the WTP differences linked to the information revelation with the Wilcoxon test for paired samples. The test is made as follows:

- Between rounds j for a given product and a given group of participants i for measuring the impact of information revelation on WTP (that is, between $WTPj_i$ and $WTPj+1_i$, represented by bars in each graph).
- For each specific round j and a given group of participants i for measuring the WTP differences between both products (that is, between $WTPj_i^P$ and $WTPj_i^{NoP}$, represented by bars on a given column of both graphs).

A P-value (against the null hypothesis of no difference) of less than 5% is considered significant. The indicators Δ^{***} and Δ^{**} show statistically significant WTP differences at the 1% and 5% levels. The slanted line between both graphs compares the initial WTP for the

[6] The issue of provision of reference prices prior to the auctions is discussed in the literature, as it could influence participants' bids. Using a second price Vickrey auction, Drichoutis et al. (2008) show that this provision increases bid values.

[7] At the end of round #2, we questioned participants about their knowledge on palm oil: 85% of them declared to have previously heard about palm oil, and 62% thought that palm oil had a negative connotation.

[8] No information is revealed to participants about the distribution of the randomly generated number acting as a market price. This absence of revelation about the distribution avoids the anchoring effect on WTP, as Bohm et al. (1997) show that results are sensitive to the choice of the upper bound of the generated buyout prices.

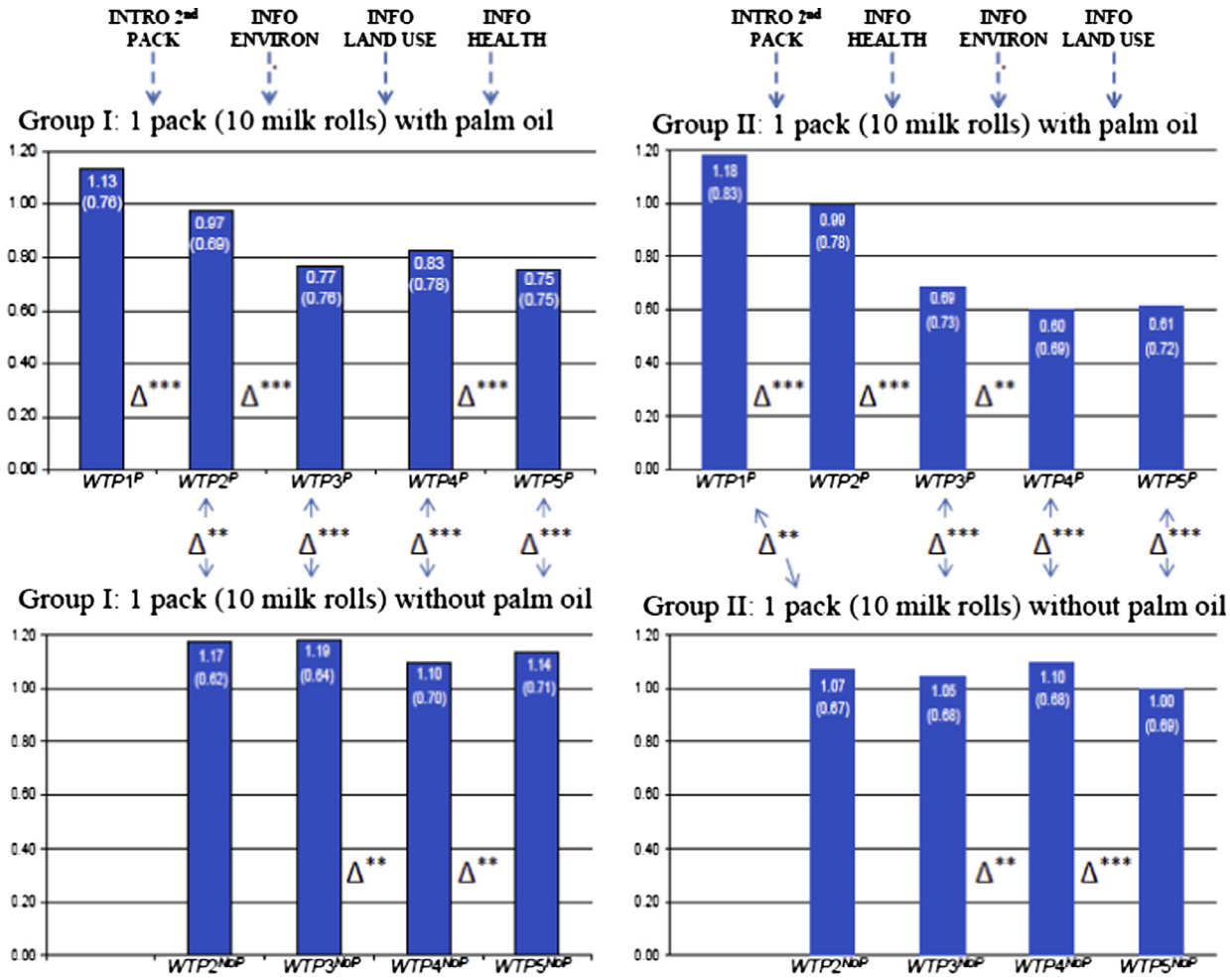

Fig. 2. Mean WTP (€) and variations after information revelation. Note: Mean WTP (€); standard deviation in parentheses; Δ^{***} and Δ^{**} denote significant differences at the 1% and 5% levels, respectively, as tested by the Wilcoxon test; Group I includes 53 participants, and Group II includes 48 participants.

palm oil product ($WTP1_i^P$) and the WTP for the palm oil-free product introduced in the second round without additional information ($WTP2_i^{NoP}$).

Finally, using the Mann–Whitney-*U* test, we investigate whether the two groups of participants are initially similar, i.e., whether the WTP expressed in the first round is statistically similar between the two groups. The test result suggests no significant difference at the 5% level.

Our results first highlight some competition or substitution patterns between products available on the market. The introduction in round #2 of the palm oil-free milk rolls leads to a statistically significant decrease ($P < 0.01$) of the WTP expressed for those with palm oil (from €1.13 to €0.97 for Group I and from €1.18 to €0.99 for Group II). Based on a simple WTP comparison, the palm oil-free product mainly attracts participants who previously purchased the palm oil product.

Our analysis also shows that information matters. Following the revelation of information about the environment, land use and health (at rounds #3, #4 and #5), consumers change their WTP. This result suggests that, for participants, not all relevant and complete information is internalized via the "palm oil free" sticker set on the pack (and revealed in round #2) or via their previous "imperfect" knowledge of the palm oil issue.

As highlighted by Fig. 2, information per se has a significant effect on the related product. Environmental and health messages negatively affect the WTP expressed for the palm oil product, while land use information negatively influences the WTP expressed for the palm oil-free product. However, land use information has a smaller impact compared to the one observed for environmental and health information. For Group I, the relative decrease in WTP for palm oil milk rolls is equal to 20.6% following the environmental message (round #3) and 9.6% following the health message (round #5), while the WTP for palm oil-free milk rolls decreases only 7.6% following the land use message (round #4). For Group II, the declines in WTP for palm oil milk rolls are 30.3% after the health message (round #3) and 13.0% after the environmental message (round #4), but WTP for palm oil-free rolls only declines by 9.1% after the land use message (round #5).

Lastly, our analysis suggests that the first piece of negative information has a larger influence than the second one. This result is observed for the palm oil milk rolls, about which two successive pieces of negative information are delivered to participants. For Group I, the average WTP decreases by €0.20 after the environmental message (round #3) and by €0.08 after the subsequent health message (round #5). For Group II, the average WTP decreases by €0.30 after the health message (round #3) and by €0.09 after the subsequent environmental message (round #4). However, the order of information (environmental versus health) does not seem crucial, which differs from previous contributions, like Marette et al. (2008) showing that the order of information between messages on risks and benefits matters (see a complete review in Lusk

Table 2
Distribution of participants.

	Group I		Group II	
	Number	%	Number	%
Participants boycotting the palm oil product				
Such that $WTP1_i^P > 0$ and $WTP5_i^P = 0$	10	18.9	13	27.1
Participants boycotting palm oil substitutes (sunflower oil, etc.)				
Such that $WTP2_i^{NoP} > 0$ and $WTP5_i^{NoP} = 0$	5	9.4	3	6.3
Participants indifferent to the palm oil messages				
Such that $WTP1_i^P > 0$ and $WTP1_i^P = WTP5_i^P$	5	9.4	5	10.4
Such that $WTP2_i^{NoP} > 0$ and $WTP2i_i^{NoP} = WTP5_i^{NoP}$	17	32.1	17	35.4

and Shogren, 2007). A Mann–Whitney-*U* test shows that $WTP5_i^P$ is not significantly different between Groups I and II.

Fig. 2 presents average values, but these averages hide the strong reactions from some consumers. According to Table 2, the number of consumers boycotting the palm oil product (with a WTP dropping to zero at the end of the experiment) is much higher than the number of indifferent consumers (with a similar strictly positive WTP for that product at the beginning and at the end of the experiment).[9] A significant proportion of consumers, therefore, appears to be strongly negative toward palm oil. Table 2 also shows that some consumers ready to buy the palm oil-free product at the beginning of the experiment decide to boycott it following land use information. However, their number is much smaller than the number of indifferent consumers (with the same strictly positive WTP for palm oil free product at the beginning and end of the experiment).

Econometric estimations

We now provide more explanations regarding the results of Fig. 2 and investigate the determinants of WTP. To that end, we regress the difference in WTP expressed by participants between choices #j + 1 and #j (with $j = 2,\ldots,4$) on information. We do not consider the WTP expressed in round #1 since only one product was available on the market. As our group of respondents includes 101 participants, the number of observations for the estimations is 303 (=101 * 3). The results are presented in Table 3. Given that each participant i makes multiple choices, there should be some correlation across data points relating to WTP. Furthermore, WTP cannot be negative and is left-censored at zero. In addition, the first message signals the observed retail price of one pack of milk rolls (between €0.5 and €2.5) to participants. No participant would rationally bid higher than this retail price if the product being valued were considered a perfect substitute. Therefore, WTP is likely also censored at the upper bound of 2.5. To address all these issues, we use the random effects tobit estimator. Since our dependent variable is the difference in WTP expressed by participants in two successive rounds and not the WTP itself, some differences may be negative. We control for this issue by defining a negative lower limit for censoring in our regressions. We tested for the influence on WTP of participants' socio-economic characteristics and their initial perception about milk rolls' healthiness. As none of the estimated coefficients of these variables were statistically significant, we decided to remove them from the estimations. We also performed a sensitivity analysis on our upper truncation bound. Results remain unchanged.

Table 3 confirms the influence of information on WTP highlighted in Fig. 2. Column (1) tests for the influence of environmental and health information on WTP for the palm oil product, while column (1bis) tests for the influence of land use information on WTP for the palm oil-free product. All estimated coefficients are negative and significant at the 1% level, showing a significant influence of information on participants' WTP when the negative impact of the related product is underlined by a given message. Interestingly, the estimated coefficient on environmental information (0.15) is lower than the one on health information (0.18) but the difference is not significant, which is an interesting result. Our experiment highlights a real concern for the environment compared to the priority generally given by participants to health information which differs from Lusk and Briggeman (2009). Furthermore, as shown in the descriptive statistics, land use information has a smaller impact on WTP than that observed for environmental and health information. In columns (2) and (2bis), we investigate the effect of land use information on WTP for the palm oil product and the effect of environmental and health information on WTP for the palm oil-free product. Estimated coefficients are not significant, suggesting that information does not affect the WTP expressed for the alternative product. Lastly, columns (3) and (3bis) introduce interaction terms between the focus of information (environment versus health) and the order of the message (received first or not). These columns therefore provide a decomposition of the information order for each type of message. As expected given the results in column (2bis), none of these interaction terms are significant in column (3bis). More interestingly, column (3) shows that it is the first message (health or environment) that matters for influencing WTP for the palm oil product. The effect of the second message is less significant or even insignificant.

Consumer welfare and regulation

Previous results show that consumers are concerned by the palm oil issue. In this section, we investigate the relevance of regulatory intervention by public authorities for dealing with this issue based on elicited WTP.[10] We assume that both palm oil and palm oil-free products are available on the market, which is becoming the case for an increasing number of food products. The regulation mainly focuses on the consumers' side, namely for improving their surplus (an extension integrating producers' profits is introduced at the end of this section). When land use or global warming are at stake, there are also other dimensions like public goods to consider for having a complete cost-benefit analysis. While the analysis focuses only on consumer welfareand not producer welfare and environmental impacts, it could be argued that a cost-benefit

[9] Similar WTP between elicitation rounds are common in experiments, since participants not sensitive to a message have a WTP that is directly anchored to the previous WTP.

[10] The welfare analysis in this section mainly focuses on consumers' perspectives. It could be extended for taking into account palm oil employments, benefits and costs in the supply chain producing palm oil or substitutes to milk roll as bread, cookies or cereal that consumers may purchase.

Table 3
Influence of information on WTP.

Model	(1)	(2)	(3)	(1bis)	(2bis)	(3bis)
Product	Palm oil product			Palm oil-free product		
Dependent variable	Difference in WTP between choices #j + 1 and #j expressed by participant i, with $j = 2,\ldots,4$ ($WTPj + 1_i - WTPj_i$)					
Specification	Tobit random effects					
Information on environment (0/1)	−0.15[a] (0.04)	−0.15[a] (0.04)			0.03 (0.03)	
Information on environment X received first (0/1)			−0.21[a] (0.05)			0.01 (0.04)
Information on environment X received second (0/1)			−0.09[c] (0.05)			0.05 (0.04)
Information on health (0/1)	−0.18[a] (0.04)	−0.18[a] (0.04)			0.01 (0.03)	
Information on health X received first (0/1)			−0.30[a] (0.05)			−0.02 (0.04)
Information on health X received third (0/1)			−0.07 (0.05)			0.04 (0.04)
Information on land use (0/1)		0.04 (0.04)	0.04 (0.04)	−0.10[a] (0.03)	−0.10[a] (0.03)	−0.10[a] (0.03)
Observations	302	302	302	303	303	303
Log likelihood	−141.08	−140.58	−135.06	−49.20	−48.42	−47.54

Notes:
[a] Significant at 1%.
[c] Significant at 10%. Standard errors in parentheses.

analysis for an EU regulator should mostly focus on the impact in Europe and not on other continents.

We consider two different public interventions. We first consider a configuration #1 where the public intervention consists in a very intense consumer information campaign on the palm oil issue. Following this campaign, consumers are perfectly informed. In configuration #2, we assume that consumers are imperfectly informed about the palm oil issue even if they see a label/logo (such as a palm oil-free logo) posted on one product. In that configuration, the public intervention consists in the adoption of a per-unit tax on the palm oil product. To be efficient, the information campaign must convey to consumers complete information about the palm oil issue, while the tax does not require consumers' perfect knowledge. Because conveying complete information to consumers is very hard in practice (Roosen and Marette, 2011), the tax becomes an interesting substitute for modifying behaviors.

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

Configuration #1: a campaign with complete information on palm oil and palm oil-free products

The first configuration consists in an information campaign perfectly understood by consumers and revealing complete information on both palm oil and palm oil-free products, which corresponds to the situation in round #5. In a similar way to round #5, the campaign reveals exhaustive information on both palm oil and palm oil-free products. The use of an additional regulatory instrument (such as a Pigouvian tax for example) is useless. Consumers directly internalize all information provided by the campaign.

Consumer i can choose between three outcomes: the product with palm oil at price P_P, the palm oil-free product at price P_{NoP} or neither. Purchasing decisions are determined by considering the WTP for the palm oil product given by $WTP5_i^P$ and for the palm oil-free product given by $WTP5_i^{NoP}$. We assume that a consumer purchases a pack of milk rolls if his WTP is higher than the price observed for that pack in the supermarket. He chooses the option generating the highest utility (with a utility of non-purchase normalized to zero).[11] Because complete information is perfectly internalized by consumers, no other tool can improve the welfare. The per-unit surplus and welfare for participant i is as follows:

$$W_i^L = \max\{WTP5_i^P - P_P, WTP5_i^{NoP} - P_{NoP}, 0\}. \quad (1)$$

In many concrete situations, the consumers' information is however very limited, which differs a lot from the situation presented in configuration #1.

Configuration #2: incomplete consumer information about the palm oil issue and a per-unit tax on the palm oil product

To simulate the tax scenario, we consider a situation where both palm oil and palm oil-free products are sold on the market with the "No palm oil" logo on the latter product identified by consumers. Beyond the logo, consumers have no additional precise knowledge about the palm oil issue, which corresponds to the situation in round #2. The public intervention consists here in the adoption of a per-unit tax on the palm oil product. $WTP2_i^P$ and $WTP2_i^{NoP}$ are considered by the regulator in determining the welfare impact of the tax.[12] As previously, consumer i can choose between three outcomes: the palm oil product at price $P_P + t$, the palm oil-free product at price P_{NoP} or neither. He makes his purchasing decision based on his surplus maximization, which is equal to:

$$CS_i(t) = \max\{WTP2_i^P - (P_P + t), WTP2_i^{NoP} - P_{NoP}, 0\}. \quad (2)$$

Eq. (2) differs from Eq. (1) because of the tax t and because of different WTP linked to different contexts of information as elicited in rounds #2 and #5. The consumers' choices can be distorted because of the absence of complete information, which is not the case with Eq. (1) related to a configuration under perfect information.

The absence of complete information about the palm oil issue leads to a non-internalized damage/benefit[13] and biases the purchasing decision in round #2. When complete information (round #5) is revealed, some consumers stop buying the product they previously bought. The non-internalized damage/benefit linked to the palm oil product is $I_i \times (WTP5_i^P - WTP2_i^P)$, where I_i is an indicator variable taking the value of 1 if $WTP2_i^P - (P_P + t) >$

[11] This utility of non-purchase could be equal to a strictly positive reservation utility linked to the purchase of substitutes like cookies cooked with alternative oils.

[12] We also tested the combination of a per-unit tax on the palm oil product and a subsidy on the palm oil-free product. However, this scenario does not improve welfare because the subsidy is relatively costly and does not lead to many changes by participants.

[13] This non-internalized damage/benefit is slightly different from the cost of ignorance suggested by Foster and Just (1989). In their framework, consumers incur a cost of ignorance from consuming a contaminated product that could cause detrimental health effects without knowledge of the adverse information.

Table 4
Behavioral changes and welfare variation for different regulatory tools.

Impact of regulatory tool		Configuration #1 information campaign		Configuration #2 tax t^* = €0.61	
Before tool	After tool	Number K	ΔW_K^L (€/pack)	Number K	ΔW_K^t (€/pack)
No purchase	Palm oil product	1	0.40	0	0
No purchase	Palm oil-free product	6	0.23	0	0
Palm oil product	No purchase	4	0.80	2	0.55
Palm oil product	No purchase with $\Delta W_K^t < 0$			3	−0.43
Palm oil product	Palm oil-free product	3	0.53	2	0.55
Palm oil product	No purchase with $\Delta W_K^t < 0$			3	−0.11
Palm oil-free product	Palm oil product	2	0.40	0	0
Palm oil-free product	No purchase	2	0.35	0	0
Average per-unit welfare variation					
All switchers		18	0.44	10	0.05
All participants		101	0.08 (59%)[a]	101	0.005 (4%)[a]

Note:
[a] Relative change in parentheses.

$\max\{WTP2_i^{NoP} - P_{NoP}, 0\}$, namely if consumer i is predicted to have chosen the palm oil product at price $P_P + t$ in round #2 (I_i equals 0 otherwise). Similarly, the non-internalized damage/benefit linked to the palm oil-free product is $J_i \times (WTP5_i^{NoP} - WTP2_i^{NoP})$, where J_i is an indicator variable taking the value of 1 if $WTP2_i^{NoP} - P_{NoP} > \max\{WTP2_i^P - P_P - t, 0\}$, namely if consumer i is predicted to have chosen the palm oil-free product at price P_{NoP} in round #2 (J_i equals 0 otherwise). By using (2), the complete surplus integrating the non-internalized damage/benefit is defined by:

$$C_i(t) = CS_i(t) + I_i \times (WTP5_i^P - WTP2_i^P) + J_i \times (WTP5_i^{NoP} - WTP2_i^{NoP}). \quad (3)$$

This complete surplus integrates the non-internalized damage/benefit represented by WTP differences following the revealed messages. With this complete surplus, the regulator also considers the possible tax income coming from each participant. The tax is only paid by consumers purchasing the palm oil product with $I_i = 1$ leading to a possible income tI_i received by the regulator (I_i equals 0 when products with palm oil are not purchased). By taking into account the complete surplus integrating the non-internalized damage/benefit and the estimated tax income tI_i, the per-unit welfare related to a participant i is as follows:

$$W_i(t) = \max\{WTP2_i^P - (P_P + t), WTP2_i^{NoP} - P_{NoP}, 0\} + I_i \times (WTP5_i^P - WTP2_i^P) + tI_i + J_i \times (WTP5_i^{NoP} - WTP2_i^{NoP}). \quad (4)$$

The optimal tax t^* is given by *tatonnement*, maximizing the average welfare $\sum_i^K W_i(t^*)/K$ over the 101 participants. Even if both products differ in some characteristics, including the price difference, this tax aims at internalizing the non-internalized damage $I_i \times (WTP5_i^P - WTP2_i^P)$ linked to the lack of information about the palm oil product.

Welfare analysis

To perform the welfare analysis, we consider a baseline scenario in which both palm oil and palm oil-free products are available on the market with the "No palm oil" logo identified by consumers. This situation corresponds to round #2, in which participants' knowledge about the palm oil issue is not complete. This baseline welfare is defined by (3) with $t = 0$. Our calculations use the average prices observed in supermarkets, namely $P_P = €1.5, P_{NoP} = €1.3$. Note that these prices are higher than average WTP in Fig. 2, since these average values include WTP equal to zero expressed by non-engaged participants.

Table 4 presents the results of the welfare analysis. We first report the number K of participants who change their purchasing decisions after the implementation of a consumer information campaign ("switchers"). Because of the concerns associates with the production and consumption of both products (including the land use issue linked to the palm oil-free product), the regulatory intervention induces a diversity of reactions among participants. Six possible configurations[14] are inventoried, characterized by opposite behaviors before and after the regulatory intervention. For each configuration with a number K indicated in the previous column, we detail the average welfare variation defined by $\Delta W_K^L = \sum_i^K [W_i^L - W_i(0)]/K$ for the information campaign and $\Delta W_K^t = \sum_i^K [W_i(t^*) - W_i(0)]/K$ for the tax t^*. Table 4 also indicates the average welfare changes over all switchers and all 101 participants, which include the participants who do not change their behavior with ΔW_K^L and ΔW_K^t equal to zero.

Table 4 clearly shows that the implementation of the consumer information campaign on both palm oil and palm oil-free products increases the average welfare of all participants and changes their behavior. The configuration of participants purchasing nothing prior to the campaign and purchasing the palm oil-free product afterward is characterized by the largest number of switchers (equal to 6). The configuration with participants purchasing the palm oil product before the campaign and purchasing nothing afterward is characterized by the largest welfare variation $\Delta W_K^L = €0.8$. This result is explained by a relatively large non-internalized damage $I_i \times (WTP5_i^P - WTP2_i^P)$ linked to the initial palm oil consumption for the four concerned participants compared to the other switchers of Table 4.

Giving consumers full information through a campaign impacts the welfare of 18 participants who change their behavior. This value $\Delta W_K^L = €0.44$ is important because it represents about one third of the price of the palm oil product of €1.5. However, a campaign with complete information is difficult to implement in practice.[15]

Due to the campaign's limits, the analysis suggests turning to an alternative regulatory tool, such as a per-unit tax. The welfare impact of a tax on the palm oil product is weak because of the concerns associated with both products and the diversity of

[14] Recall that consumers can choose between three outcomes before and after the regulatory intervention: the palm oil product, the palm oil-free product and neither.
[15] Field experiments show that imperfect recall, lack of time before purchasing and confusion about complex information characterize many consumers in the supermarket. This makes an information campaign relatively inefficient in a real purchasing context, even if the lab shows a real interest and WTP. The lab context, in eliciting well-informed, thoughtful preferences, is useful for computing an optimal per-unit tax (see Marette et al., 2011).

Table 5
Surplus and profit variations over the 101 participants (€).

	Configuration #1 information campaign	Configuration #2 tax $t^* = €0.01$
Variation in consumer surplus and tax income ($K \times \Delta W_K$)[a]	8.09	0.20
Profit variation for palm oil products' producers	−0.60	−0.15
Profit variation for palm oil-free products' producers	0.65	0.13
Welfare variation[b]	8.14	0.18

Notes:
[a] ΔW_K is ΔW_K^I for the configuration #1 and ΔW_K^t for the configuration #2.
[b] The welfare is the sum of consumer surplus, tax income and profits.

consumers' preferences that the tax does not take into account. Indeed, the tax only modifies the behavior of consumers who initially purchase the palm oil product (and not the behavior of consumers who initially purchase nothing or the palm oil-free product). Furthermore, among the consumers who stop purchasing the palm oil product, some of them exhibit a negative welfare variation, i.e., they make a different decision compared to the one they would have made with the complete information linked to a campaign. ΔW_K^t is negative as shown in the fourth column of Table 4 since the internalization of the non-internalized damage $I_i \times (WTP5_i^P - WTP2_i^P)$ with the complete information campaign would not lead to this decision. This behavior explains the poor welfare impact of the tax (see last line of Table 4).[16]

Results of Table 4 only considered the consumer side via the participants who attended the experiment. One direct extension consists in evaluating the variation in firms' profits based on simplified assumptions, because of difficulties to collect data regarding firms. The profit variation of firms impacted by the policy is given by the number of participants who change their consumption decision times a constant profit margin, arbitrarily set to 10% of market prices that are constant whatever the policy.[17] In the last column, the new optimal tax $t^* = €0.01$ is determined by maximizing the new welfare integrating the firms' profits. Table 5 reports the results and details surpluses and profits over the 101 participants (which is different from Table 4 only presenting means). Although these estimations are imperfect, they show that the losses of palm oil products' producers are close to the benefits of palm oil-free products' producers, even if the ranking between these profits vary with the policy. This closeness results from the fact that the number of participants leaving palm oil products is close to the number of participants turning to the palm oil-free products after the implementation of the policy.

Conclusion

This paper suggests that consumers are concerned by the palm oil issue. Revealed information mainly affects the WTP expressed for the palm oil product. The effect on the WTP expressed for a palm oil-free product is less important though not negligible. Our experiment also highlights consumers' real concern for the environment. Environmental information affects their WTP similar to health information. This environmental interest may explain the intense campaigns of Greenpeace. However, the future public debate should also focus on the oil management of common resources by including some economic evaluations of the palm oil substitutes (e.g., groundnut, cotton, sunflower, and soy or rapeseed oil). The land use issues linked to the production of these alternative oils show the absence of a panacea when the protection of common resources is at stake.

Some extensions could be considered. Information revealed through advertising on TV or additional explanation provided in supermarkets could complete the lab experiment. Consumers' interests emphasized by this experiment could be subject to additional studies regarding their acceptance by Indonesian and Malaysian farmers and citizens directly affected by palm oil production.

This paper also shows that experimental results may help compare various regulatory scenarios. We study the effect of possible regulation by estimating the welfare impact of a per-unit tax and an information campaign. The campaign on the palm oil-free product improves consumer welfare, yet it is hard to implement. The welfare impact of a tax on the palm oil product is weak because of the concerns associated with both products. This result points out the difficulties of going beyond media campaigns aimed at guiding consumers' choices.

Appendix A

Information revealed during the experiment: The messages are translated from the original French.

Timeline of products' introduction: Round #1: Only the pack of milk rolls with palm oil is made available to participants. Round #2: Introduction of the pack without palm oil.

General information before the elicitation of $WTP1^P$ for both groups:

You can buy the pack of milk rolls that is in front of you. For your information, the retail price varies between €0.5 and €2.5 in supermarkets.

General information about both packs before the elicitation of $WTP2^P$ and $WTP2^{NoP}$ for both groups:

Palm oil is an ingredient of the first pack of milk rolls located on the table on your right. There is no palm oil in the new pack of milk rolls that we just put on the table on your left.

Information about the environment before the elicitation of $WTP3^P$ and $WTP3^{NoP}$ for Group I and $WTP4^P$ and $WTP4^{NoP}$ for Group II:

Palm oil, mainly produced in Indonesia and Malaysia, is an ingredient in many products sold in supermarkets. For a whole year, the average caddy of a French family contains 1.5 kg of palm oil.

To produce palm oil on a large scale, palm oil farms and companies are destroying rainforests in Indonesia and Malaysia, with the following consequences:

– The disappearance of animal species, such as the orangutan.
– The disappearance of rare vegetal plants.
– A lower sequestration of greenhouse gases by these rainforests (implying climate change).

Information about land use before the elicitation of $WTP4^P$ and $WTP4^{NoP}$ for Group I and $WTP5^P$ and $WTP5^{NoP}$ for Group II:

[16] The tax on the palm oil product would be more efficient if the non-internalized damage for the palm oil-free product $J_i \times (WTP5_i^{NoP} - WTP2_i^{NoP})$ was equal to zero for all participants.
[17] One extension would consist in evaluating the impact on profits by specifying a supply function allowing price adjustments, while our analysis considered the market prices as constant.

To produce the same quantity of oil as one hectare of palm trees, 10 ha of sunflowers are needed.
Replacing palm oil by sunflower oil in all food products would dramatically change the agricultural practices in Europe (land use intensification, forests changed to arable land, increase in the soil pollution with more pesticides, fertilizers, etc.)
Palm oil is replaced by sunflower oil in the milk rolls on your right.

Information about health before the elicitation of $WTP5^{P}$ and $WTP5^{NoP}$ for Group I and $WTP3^{P}$ and $WTP3^{NoP}$ for Group II.

Oils contain saturated fat harmful to health and that favor cholesterol and cardio-vascular diseases. Oils also contain non-saturated fat beneficial to health.
Palm oil contains fivefold more saturated fat (harmful to health) and six fold less non-saturated fat (beneficial for health) than sunflower oil.
Palm oil is replaced by sunflower oil in the milk rolls on your right.

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