Greenwashing and enforcement

Pre-registration analysis plan

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1 Abstract

Law and enforcement play a crucial role in addressing the issue of firms falsely signalling the environmental performance of their products. Greenwashing, governed by truth-in-advertising laws designed to prevent misleading claims, remains a significant challenge. Despite regulatory measures, the difficulty and scarcity of detecting greenwashing make it a noteworthy concern. In this project, we build on the Beckerian approach in which the probability of detection and the fine size are considered by firms, which then (mis)act accordingly. Going beyond mere enforcement dynamics, our framework integrates a signalling model, refining firm actions based on consumer beliefs and vice versa. Through a laboratory experiment involving real commodities and purchasing decisions, we test partial equilibria. Different treatments manipulate the probability of detection and aim to establish causality in individual decision responses to stimuli. Behaviourally founded results will provide insights for optimal deterrent policy within the realm of green advertising.

2 Research questions

This project aims to investigate the role of enforcement, intended as a combination of sanction size and detection probability, in sellers' and buyers' decision-making. When market conditions allow sellers to benefit from greenwashing, regulation can be adopted to deter misconduct through enforcement. In this work, we investigate the following research questions:

- the role of enforcement in altering profitable conditions to do greenwashing and the consequent behaviour of sellers
- the role of first- and second-order beliefs in the behaviour of sellers and, consequently, the potential existence of psychological costs (i.e., lying costs) or risk aversion
- the role of enforcement in buyer's willingness-to-pay for products with green claims
- the role of enforcement in altering profitable conditions to do greenwashing and the consequent behaviour of buyers conditional on the seller's actions

3 Theoretical framework

3.1 The model

The study is based on a signalling model for goods with credence attributes. The model is characterized by the strategic interaction between sellers and buyers where sellers can sell a product to one single buyer. The product can be green (with green attributes) or conventional (without green attributes) with respectively ρ and $1-\rho$ probabilities. A seller with a conventional product can apply a conventional claim associated with a lower price or a green claim with a higher price, thereby doing "greenwashing". A seller with a green product instead adopts a green claim by default with a higher price. This condition determines truly green and false green products in the market, thus the buyer faces ambiguously green products.
The profitability of greenwashing is altered by the presence of an enforcing authority which verifies the claims adopted by the seller with detection probability ϵ and sanctions the sellers who do greenwashing. Despite that, the enforcement authority cannot verify all the products in the market thereby our focus is to study conditions where the enforcement might (not) rationally deter seller's greenwashing behaviour.
We established formally a threshold level of detection ϵ^* that creates pooling and separating equilibria spaces. This threshold is defined as follows:

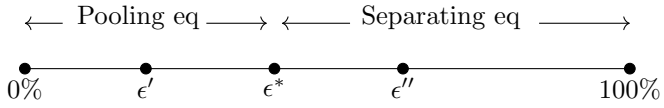
$$\epsilon^* = \frac{\mathcal{F}(\gamma)P_g - \mathcal{H}(\sigma)P_c - D}{\mathcal{F}(\gamma)P_g - \mathcal{H}(\sigma)P_c + f} \tag{1}$$

ϵ^*: threshold enforcement that makes sellers indifferent; $\mathcal{F}(\gamma)$: % of selling g; $\mathcal{H}(\sigma)$: % of selling c; D: adv cost; f: sanction size

This threshold is interpreted as the level of enforcement that makes sellers with conventional products indifferent between adopting a green claim or a conventional claim. The line graph below displays an analytical example of the equilibria spaces. The space is defined between 0 and 1, being the detection probability bounded at these levels. ϵ^* splits the space into two parts:

- a pooling equilibrium space (on the left), where greenwashing is more profitable than truthful conventional claims;
- a separating equilibrium space (on the right), where greenwashing is less profitable than truthful conventional claims.

Under market conditions leading to these equilibria spaces, at ϵ' sellers do greenwashing, while at ϵ'' are deterred and do not greenwash.



First-order beliefs

The buyer possesses information about the market, including prices for both products and enforcement parameters: sanction size (f) and detection probability (ϵ). We assume that buyers can infer from the market conditions whether the sellers have incentives to cheat. In the separating equilibrium, the buyer expects no greenwashing because there is no incentive for the seller to greenwash henceforth the higher the probability of detection (ϵ), the greater the belief that a claimed green product is genuine.

If instead, the enforcement level is small, such as in pooling equilibrium space $\epsilon < \epsilon^*$, the buyer infers incentives for cheating, resulting in ambiguous conditions. In the pooling equilibrium, where enforcement is insufficient, the buyer updates beliefs through Bayes' rule. Therefore:

- In separating equilibrium with $\epsilon \geq \epsilon^*$, cheating is not incentivized, so the updated buyer's willingness-to-pay ($\overline{V_g}$) equals the original willingness-to-pay under certain conditions (V_g')
- In pooling equilibrium with $\epsilon < \epsilon^*$, cheating is incentivized, leading to a lower adjusted willingness-to-pay ($\overline{V_g}$) compared to the original (V_g').

. **Second-order beliefs**

Sellers might anticipate a drop in demand for green products as the result of first-order beliefs' updating. As a consequence of this potential demand reduction, the seller might anticipate smaller profitability for greenwashed products. This can result in two cases:

- The expected demand for green products is so low that there is no profitability of doing greenwashing, even in pooling equilibria space, therefore the sellers do not greenwash.
- The expected demand for green products is smaller but sufficiently high to grant profitability. However, this might be case dependent on expected profitability and as a consequence, this process engenders conditions in the pooling equilibria region conducting alternatively to cheating and non-cheating.

3.2 Extension

The model can have several extensions. We decided to focus on one which can be tested as described in section 5.
Sellers might have ethical reasons not to greenwash even in profitable conditions. To account for that, a random variable ℓ taking values from 0 to the extra profit of greenwashing is added to the model which reduces the profitability of greenwashing.
The parameter ℓ narrows the space of pooling equilibria and enlarges the separating equilibria space. As a consequence, we might expect that in pooling equilibria space, even though the expected demand is large enough to ensure profitability, sellers reveal to have strong ethical reasons not to greenwash.

4 Experimental Design

The experiment is developed in steps. A laboratory experiment is the final result of calibration through an online survey and laboratory auctions held beforehand.
In this section, the design is presented starting from the main laboratory experiment supported by an explanation of the previous work aimed at building the final design.

4.1 The Greenwashing Game

The Greenwashing Game is the reproduction of the theoretical model in practical terms. There are two types of players, a seller and a buyer. The seller sells a good with or without credence attributes. Product type g is a green good, namely a good with the green credence attribute while type c is a conventional good without that attributes. Besides the green attributes, the two products are identical in their other characteristics.
Only the seller possesses the information about the environmental performance of the good, whereas buyers cannot obtain the information on their own through experience or search.
The seller can choose the claim and, as a direct consequence, the price to send to the buyer. The set of possible prices is reduced to two levels for simplicity: the price for a good with green claim P_g and the price of a conventional good

P_c. If the conventional good has a false claim, its price is P_g which is strictly greater than P_c. On top of this, the seller can signal the quality of the product with a claim about the product's sustainability. Adopting a signal costs D which is small and which is identical both for truthful and false claims.
By adopting a false signal, the seller incurs in the probability of being caught by an authority which with ϵ probability verifies the signal truthfulness and applies a fine f of a fixed and known amount.

4.1.1 Game procedure

At the beginning of the study, once the instructions have been read, the seller is exogenously given a product which can have a 50% probability of being green and 50% probability of being conventional. The seller knows the actual characteristics of the product displayed on the screen. In the same page, the seller decides whether to adopt a sustainability claim and incur cost D or not. The seller with the conventional product has a binary choice between "Claim A" and "Claim B" where "Claim B" is the green (false) option. The seller with the green product instead can only choose "Claim B" which is, in practice, true. The choice of the signal influences the price at which the good is sold: a good with the green claim is sold at price P_g; a good with no claim at P_c.
Once the seller has taken the decisions the so-called "market authority" randomly checks some of the product types and the claims adopted. The probability differs across treatments (see section 3. The authority verifies automatically the coincidence between the claim and the product type with ϵ probability and applies a fine f if a green claim has been adopted on a conventional product. Simultaneously, in the case that a false claim is detected, the authority restores the correct price of the good P_c.
In the last stage, the buyer receives the product on his/her screen and elicits two decisions. As a first decision, the buyer has to indicate his/her willingness to pay for the product only by looking at the claim received. Secondly, the buyer is informed about the products' market prices and decides whether to purchase the product or not by paying the relative price.
Once the buyer has taken both decisions, pairs are randomly shuffled and participants are informed that they might be matched with another partner in the next round.
The actual verification is not public knowledge: sellers discover about the sanctions received only at the end of the study, while buyers never discover that.

4.1.2 Preliminary works

This design has been supported by preliminary work to establish a design as fine-tuned as possible considering the multiple factors affecting individual purchasing decisions. Sections 4.1.2 and 4.1.2 report a summary of the goals and outcomes of the online survey held in March 3rd 2023 and the laboratory auctions on products held between October 24th and November 3rd 2023.

Online survey
The initial step in our research involved conducting an online survey (n=178) to assess the willingness-to-pay (WTP) for both conventional and green versions of a diverse set of products. This set included dark chocolate, coffee, avocado, cola, dishwashing liquid, cotton buds, toothpaste, soap, and basmati rice. These products were intentionally chosen for their heterogeneity which allowed me to verify the existence of a WTP gap between green and conventional products but shared characteristics: they possess credence attributes, making them challenging to directly experience or search for, and they are commonly purchased in the market, enhancing the external validity of our results.
The online experiment allowed us to pilot-test the role of image, the potential presence of order effect and, finally, the role of the verification of the products on WTP. Most of the results from this pilot are statistically insignificant since the 2x2x2 design reduced the treatment sample size. However, this online survey helped us to understand the noise and salience of images and the presence of order effect. As a consequence, in the following study products' images were removed and we decided to show one of the two versions of the products to the participants (green or conventional). Moreover, the online survey enabled us to establish the maximum WTP that students would pay for these products, laying the groundwork for the later Becker-Degroot-Marshak analysis during laboratory practices. This step clarified and solidified our understanding of participants' financial thresholds for the products in question.

Laboratory auctions with BDM
After the online survey, a series of laboratory auctions (n=85) have been deployed to elicit in real terms the WTP for green and conventional products in similar conditions as in the main Game.
The methodology adopted is the Becker-Degroot-Marshak following the approach supported by Bohm et al. (1997): participants (as buyers) must elicit a bid for each product without knowing its price which is contained in an envelope. The price has been drawn from a uniform distribution taking values from 0.05€to the maximum WTP elicited during a "previous study" (i.e. the online survey). Bidders are informed of how the upper bound is generated but they do not know the amount.

These auctions had a single treatment where participants were informed that 100% of sustainability claims had been verified and they were correct, providing the upper bound for WTP for such products conditional on verification.
Each participant, endowed with 10€for each round, expresses his/her WTP for the randomly displayed product. Only one round's decision was valid for the payment and the distribution of the product at the end of the study. The payoff is 10€minus the envelope price and the product if the WTP is greater or equal to the product envelope price or 10€otherwise.
The reported table 1 displays the mean and median of the WTP both for conventional and green products. Overall we observe a green premium for most products in both statistics with the single exception of basmati rice which displays only a minor premium among the observed population. As a consequence, basmati rice has been removed from the list of products of the Greenwashing Game given the lack of monetary incentives for sellers to greenwash.
This auction helped to establish the sellers' parameters of the Greenwashing Game. Prices for products with Claim A and Claim B are then fixed at the median level of the auction. This choice enables the examination of partial equilibria because it sets by design the *a priori* expected demand equal to 50%.

Table 1: Comparison of Conventional and Green Products from the BDM auctions

	WTP Conventional				**WTP Green**				**Green premium**	
	Mean	**Median**	**SD**	**Obs**	**Mean**	**Median**	**SD**	**Obs**	Δ_{μ} (%)	Δ_{Q2} (%)
Cotton buds	€1.81	€1.50	1.09	44	€2.24	€2.00	1.58	41	€0.43 (24%)	€0.50 (33%)
Chocolate	€1.94	€1.80	1.26	43	€2.84	€3.00*	1.22	42	€0.90 (47%)	€1.20 (67%)
Coffee	€2.91	€2.00	2.02	47	€3.72	€3.60*	1.81	38	€0.80 (28%)	€1.60 (80%)
Cola	€1.15	€0.95	0.86	44	€1.69	€1.65	0.97	41	€0.54 (47%)	€0.70 (74%)
Dish. liquid	€1.96	€1.60	1.26	46	€2.64	€2.30	1.69	39	€0.68 (34%)	€0.70 (44%)
Basmati rice	€2.37	€2.10	1.48	39	€2.50	€2.17	1.28	46	€0.13 (5%)	€0.07 (3%)
Soap Bar	€2.39	€2.30	1.06	41	€3.04	€2.65	2.11	44	€0.64 (27%)	€0.35 (15%)
Toothpaste	€1.58	€1.50	0.74	45	€2.42	€2.20*	1.56	40	€0.84 (53%)	€0.70 (47%)
Total	€2.01	€1.72	1.38	349	€2.63	€2.45	1.66	331	€0.62 (31%)	€0.73 (42%)

Δ: Difference between WTP_{green} and $\text{WTP}_{conventional}$ for each product type; %: Δ / $\text{WTP}_{conventional}$
* Values are approximated to the upper tenth

4.1.3 Greenwashing game parameters

The parameters chosen for the Greenwashing Game are essential to bring the theoretical predictions to practical terms. In particular, the ϵ^* is computed starting from the knowledge of prices P_g and P_c; $\mathcal{F}(\gamma)$ as the probability of selling g; $\mathcal{H}(\sigma)$ as the probability of selling c; D: the green advertising cost; f: the sanction size.
Prices and probabilities of selling both products are established by design. The prices are set at the median level obtained through BDM auctions so that the probability of selling g and c is also equal to 50%.
For what concerns the green advertising cost, the sanction size we refer to table 2 to show the estimated detection probability ϵ^*, the key element of the study. By fixing the green advertising cost to 0.05€and varying the sanction size I was able to detect a sanction level that creates useful conditions for testing.

Table 2: Each value contained in the table is obtained as the result of Equation 1

Sanction size	**0.10 €**	**0.20 €**	**0.30 €**	**0.40 €**	**0.50 €**	**0.60 €**	**0.70 €**	**0.80 €**	**0.90 €**	**1 €**
Cotton buds	57%	44%	36%	31%	27%	24%	21%	19%	17%	16%
Chocolate	79%	69%	61%	55%	50%	46%	42%	39%	37%	34%
Coffee	83%	75%	68%	63%	58%	54%	50%	47%	44%	42%
Cola	67%	55%	46%	40%	35%	32%	29%	26%	24%	22%
Dish. liquid	67%	55%	46%	40%	35%	32%	29%	26%	24%	22%
Basmati rice	-11%	-6%	-4%	-3%	-3%	-2%	-2%	-2%	-2%	-1%
Soap Bar	45%	33%	26%	22%	19%	16%	14%	13%	12%	11%
Toothpaste	67%	55%	46%	40%	35%	32%	29%	26%	24%	22%
Mean*	66%	55%	47%	41%	37%	33%	30%	28%	26%	24%

The sanction size decided is 60 cents because in this range we obtain heterogeneity of ϵ^* within two boundaries 16% and 54%. The next section displays the treatments chosen to correctly address the research questions and the main hypotheses.

4.2 Treatments

The treatments are focused on the role of detection probability in (not) deterring greenwashing from the sellers' side and in shaping buyers' revealed preferences for green products.
Provided the parameters chosen as displayed in section 4.1.3, the decision taken is to set the detection probability to accomplish two goals: a) examine individuals' behaviour in both equilibria spaces and b) enable participants an undemanding understanding of the condition of enforcement. The resulting levels of ϵ are described in Table 3.

Table 3: Treatment and enforcement levels

Treatment	**SP**	**WP**	**S**
ϵ	1%	20%	50%
Equilibrium space	Pooling	Pooling	Separating

Furthermore, this set of parameters allows us to explore small deviations from the equilibrium level. Indeed, by looking at table 2 we can notice that coffee has an equilibrium threshold ϵ^* equal to 54% which is barely beyond the separating equilibrium threshold. On the contrary, soap bar has a threshold which is below the treatment WP level, namely 16%. These two products' characteristics may highlight slightly different behaviours that can support or weaken the hypotheses in place.

4.3 Session protocol and instructions

The study is held at the Bologna Laboratory for Experiments in Social Sciences (BLESS) with students from the University of Bologna.
Participants are recruited through ORSEE platform with the available population of the students of the University of Bologna. The list of ORSEE is filtered with the following requirements: students, with a participation count smaller than 10 and a no-show count smaller than 2. The resulting available sample is around 3.500 students.
Students are invited through email to take part in the experimental sessions and the email explicitly mentions the possibility to earn money and to buy products. Following the advice of the bioethics committee the email invites participants to avoid registration if they are allergic to chocolate, coffee and cola.
At the session, students are welcomed once they have filled the required consent forms. After that, a random draw assigns participants to each seat. If there are more participants than the number required (an even number), the reserves are sent away after being paid the participation token worth 5 euros. At the same time, playing participants receive printed instructions for Part A (see "Instructions A" in attachments). Once the paid reserves have been turned away, a person among the available staff reads into the microphone the instructions of Part A. After that, the staff fill the prices of the BDM into the envelope and seal it, placing it visibly for all participants. Once all these steps are over the staff starts the oTree session.
At the end of Part A, participants receive a printed copy of Part B instructions (see "Instructions B" in attachments) and one staff member reads them into the microphone. Finally, when the questionnaire is over a member of the staff opens the envelope and reads the prices and the matching product participant which tells which round is valid for buyers.
Finally, participants compile the payment form provided by Playstudies[1]. Once this is concluded, sellers are sent away and, at the end, buyers are called one by one to privately provide them the product (if purchased).

4.3.1 Randomization procedure

Several randomization procedures are adopted. Here is the description:

- Participants are randomly allocated to the seats (or to turned-away reserves) through a visible random draw when they enter the laboratory;
- The software oTree randomly assigns participants to a participant number independently of the seat number they are working;
- The software assigns randomly the roles of sellers and buyers;
- The first product is fixed for econometrics considerations, while from round 2 participants receive a product which is assigned to that participant number. In every session, the product-participant assignment varies randomly;
- The product assigned to sellers can be green or conventional and this is the result of a random draw;
- The prices contained in the envelope are randomly drawn before each session start through Microsoft Excel to facilitate the envelope procedures;

[1] A third-party service provider in charge of paying participants of studies held at the University of Bologna.

- Each buyer can receive a different product which is randomly drawn before the session starts. The software Excel draws a product for each participant number. This is chosen to reduce the number of products brought to the laboratory for every sessions;
- The sellers' two valid rounds are drawn within the software oTree during the session and they are different for each participant.

5 Hypotheses

The hypotheses for this study address both buyers' and sellers' behaviour. This section reports the main hypotheses within the scope of the theoretical framework. Later, section 7 reports actual hypotheses testing procedures.

5.1 Hypotheses for sellers behaviour

1. Greenwashing level in experimental data is compared to theory predictions: the extent of greenwashing behaviour is analysed:
   - **S1**: In the pooling equilibrium space, i.e. the enforcement is not deterrent, we expect the greenwashing to be positive
   - **S2**: In the separating equilibrium space, i.e. the enforcement is deterrent, we expect no greenwashing.
   - **S3**: In general we expect that the the higher the enforcement level, the smaller the greenwashing.
2. The reasons why sellers do (not) greenwash in profitable and non-profitable conditions and given expected demand for products.
   - **S4**: If sellers expect the demand for green and conventional products to be sufficiently high to grant profitability, and they do not greenwash we hypothesize that non-monetary motives (such as ethical reasons or lying aversion) enter the seller's utility function. If instead given profitable conditions, sellers do greenwash, they are expected to be driven by monetary incentives.
   - **S5**: If sellers expect the demand for green and conventional products not to be profitable we identify the presence of second-order beliefs. Sellers expect buyers would react to the potential greenwashing and since the profitability is smaller, the hypothesis is that sellers would not greenwash. If instead given such conditions, small expected demand and reduced profitability, and sellers do greenwashing we hypothesize that sellers are not rational or did not understand the procedures.

5.2 Hypotheses for buyers behaviour

1. Buyers willingness-to-pay for green products is analysed across treatments depending on the enforcement level. The main hypothesis is that buyers are rational and update their WTP depending on the equilibria spaces. We hypothesize that:
   - **B1**: the buyers' WTP with 100% verification of the claim is as high as in the separating equilibrium space
   - **B2**: the buyers' WTP in 100% verification and in the separating equilibrium space to be higher than the buyer's WTP revealed in the pooling equilibrium conditions.
2. Buyers' purchase choice of green products is analysed across treatments depending on the enforcement level. The main hypothesis is that buyers are rational and update their WTP depending on the equilibria spaces. We hypothesize that:
   - **B3**: buyers in separating equilibrium space purchase green products with 50% probability.
   - **B4**: buyers in pooling equilibria spaces purchase green products less than with 50% probability as a consequence of potential greenwashing.
3. Buyers' belief updating given the market conditions:
   - **B5**: in separating space conditions buyers are expected to believe that there is not greenwashing
   - **B6**: in pooling space conditions buyers are expected to believe that there is greenwashing
4. The choice to purchase and the WTP for green product is then compared considering the expected presence of greenwashing for each specific product. We hypothesize that:
   - **B7**: Buyers expecting a sufficiently high level of greenwashing, have a smaller WTP for green products and purchase less green products than buyers without such expectation.

6 Analysis plan

6.1 Data management

The analysis is based on the data sets from the experimental session using oTree software. As previously stated, both the online survey and the auctions have been deployed to parameterize the Greenwashing Game. Without this previous work, a clear pre-registration would not have been possible.
The raw data already obtained during the BDM auctions is uploaded to the registration application on the AEA Social Science Registry together with the present document.

6.2 Main outcome variables

The main outcome variables to test sellers' behaviour are: a) the choice to greenwash while possessing a conventional product; b) the stated expected demand for both conventional and green products.

The first variable is obtained by looking at the variable greenwashing which is gathered directly through oTree (in Part A) when a player with a conventional product decides to opt for a green claim. The variable takes value "Yes"/"No" which can be easily re-constructed as a dummy taking value 1 if there is greenwashing and 0 otherwise.

The second main variable is the expected demand which is generated in Part C of the experimental procedure. Sellers are asked with an economic incentive to reveal what they think is the demand for both the green and conventional versions of each product. The choice is among a set of 10 alternatives with ranges of 10% (0-10%,11%-20%,...,91%-100%), meaning that participants have to pick the range within which they think the demand for that specific product lies.
A variable *eprofit* is generated for the sellers to compute the expected profit from the expected demand. This value is generated for each product seen by each seller and is equal to:

$$eprofit = (\text{expected demand claim B} \times \text{price B} - d)\,(1-\epsilon) + (\text{expected demand claim A} \times \text{price A} - f - d)\,\epsilon$$

This means that the expected demand for a product with claim B is multiplied by the price relative to price B, minus the disclosure cost d, and everything is multiplied by the probability of non-detection $(1-\epsilon)$. This amount is summed with the potential loss (or profitability) of being sanctioned: the expected demand of claim A times the price of product A (because the authority changes the claim of the monitored greenwashing), minus the sanction size f, and the disclosure cost d. This is multiplied by the probability of receiving the sanction ϵ.

Buyers' main outcome variables are the willingness to pay for each product displayed and the actual choice to purchase or not the green product. Both variables are gathered through oTree in Part A. The WTP and choice is filtered through the variable *final_claim* which reports the claim (potentially) after authority intervention. Their nature is very straightforward as is displayed in the summary table 4.
Additionally, buyers reveal what they think is the behaviour of sellers holding a conventional when facing the choice to/not to greenwash. This choice is expressed in Part C, and has two outcome "Yes"/"No" for each product which can be easily converted into a dummy taking value 1 if they believe that a conventional seller does greenwashing in such conditions or 0 otherwise.

Table 4: Main outcome variables

Variable name	**Type**	**Who**	**Level**	**Admitted values**	**Composition**	**Part**
greenwashing	Binary	Sellers	Product	1 and 0	1 if greenwashing or 0	Part A
guess_seller_A	Categorical	Sellers	Product	0-10%;..;91-100%	Guess demand claim A	Part C
guess_seller_B	Categorical	Sellers	Product	0-10%;..;91-100%	Guess demand claim B	Part C
eprofit	Continuous	Sellers	Product	See formula above	Constructed	Mix
product_wtp	Continuous	Buyers	Product	0:10	Revealed WTP	Part A
purchase_choice	Binary	Buyers	Product	1 if "Yes"; 0 if "No"	Revealed purchase of green	Part A
belief_gw	Binary	Buyers	Product	1 and 0	1 if buyer believe there is greenwashing; 0 otherwise	Part C

6.3 Control variables

A list of control variables in included in Appendix. Most of them will be used in the econometric model as discussed in section 8.

7 Hypotheses testing

Each hypothesis in section 5 is here developed describing the main test adopted. A summary is included in table 5 and in table 6 which report the actual test to be adopted.

Sellers hypotheses testing:

S1: In Treatments Weak Pooling (WP) and Strong Pooling (SP) the null hypothesis is that greenwashing is larger than zero. The outcome variable to test this hypothesis is *greenwashing*. This test is run considering all products together and also each product separately to highlight potential heterogeneity between products with high green premium and those with a smaller premium. In particular, we expect that for Soap Bar we should observe less greenwashing because of the parameter chosen which reduces the profitable conditions in Weak Pooling treatment (see 2.

S2: In Treatment Separating (S) the null hypothesis is that greenwashing is equal to zero. The outcome variable to test this hypothesis is *greenwashing*. This test is run considering all products together and also each product separately to highlight potential heterogeneity between products. In particular, we expect that in the case of coffee should reject the null hypothesis due to the parameters chosen (see 2.

S3 analyses a potential ordinal relationship between greenwashing in SP, WP and S conditions.

S4 and **S5** require the analysis of expected profitable conditions. We analyse the case when the expected profit, computed from the expected demand for both conventional and green products, is statistically positive. In this case, the null hypothesis is that greenwashing is positive and larger than 75%. In most of cases, when there is a profitable condition, individuals are rational and driven by monetary incentives. The alternative hypothesis is that greenwashing is smaller than 25% because despite taking advantage of profits, ethical reasons and potentially lying aversion prevent them from exploiting the buyers.

Table 5: Summary of seller's behaviour main hypotheses testing

Hp	Sample	Outcome (X)	Level	Hp_0	Test(s)
S1	SP; WP	*greenwashing*	All products	$X > 0$	χ^2 or Fisher's exact
S1	SP; WP	*greenwashing*	Each product	$X > 0$	χ^2 or Fisher's exact
S2	S	*greenwashing*	All products	$X = 0$	χ^2 or Fisher's exact
S2	S	*greenwashing*	Each product	$X = 0$	χ^2 or Fisher's exact
S3	SP; WP; S	*greenwashing*	All products	$X_{SP} < X_{WP} < X_S$	χ^2 or Fisher's exact
S4	SP; WP; S	[*greenwashing*|*eprofit*>0]	All products	$X > 0.75$	χ^2 or Fisher's exact
S5	SP; WP; S	[*greenwashing*|*eprofit*<0]	All products	$X < 0.25$	χ^2 or Fisher's exact

Buyers hypotheses testing:

B1: The average of the product WTP obtained in the BDM auctions is tested to be equal to the average of the product WTP of the Treatment S.
B2: The average of the product WTP obtained in the BDM auctions and in the S treatment is tested to be greater than the average of the product WTP of the Treatment SP and Treatment WP.
Both **B1** and **B2** are tested for all products together and singularly for each product.

Table 6: Summary of buyer's behaviour main hypotheses testing

Hp	Sample	Outcome (X)	Level	Hp_0	Test(s)
B1	BDM, S	*product_wtp*	All products	$X_{BDM} = X_S$	t-test or Mann-Whitney
B1	BDM, S	*product_wtp*	Each product	$X_{BDM} = X_S$	t-test or Mann-Whitney
B2	All	*product_wtp*	All products	$X_{BDM\ \&\ S} > X_{WP\ \&\ SP}$	t-test or Mann-Whitney
B2	All	*product_wtp*	Each product	$X_{BDM\ \&\ S} > X_{WP\ \&\ SP}$	t-test or Mann-Whitney
B3	S	*purchase_choice*	All products	$X_S = 0.50$	χ^2 or Fisher's exact
B3	SP; WP; S	*purchase_choice*	All products	$X_S > X_{WP} > X_{SP}$	χ^2 or Fisher's exact
B4	SP; WP	*purchase_choice*	All products	X_{WP} & $X_{SP} < 0.50$	χ^2 or Fisher's exact
B5	S	*belief_gw*	All products	$X = 0$	t-test or Mann-Whitney
B6	SP; WP	*belief_gw*	All products	$X > 0$	t-test or Mann-Whitney
B7	S; SP; WP	*product_wtp* & *purchase_choice*	All products	$X_{aware} < X_{unaware}$	t-test or Mann-Whitney

B3: The null hypothesis is that the *purchase choice* of green products in S treatment equals the theoretical prediction of 50% purchase and also that this variable is larger for S treatment compared to Treatment WP and SP.
B4: The null hypothesis is that the *purchase choice* in WP and SP Treatments is smaller than 50% as predicted by the model and by design construction.

B5: For WP and SP Treatments, buyers beliefs on greenwashing are tested. The null hypothesis is that the greenwashing expected is equal to 0%.

B6: Also for S Treatment, buyers beliefs on greenwashing are tested. The null hypothesis is that the greenwashing expected is positive.

B7: At the product level, the sample is divided between those who think there is no or little greenwashing (label: *unaware*), and those who think there is greenwashing high level of greenwashing (label: *aware*). The **B7** null hypothesis is that the WTP for green products of the aware sample is smaller than the WTP for green products of the unaware sample. Similarly, the purchase choice of green products is tested for the two groups and the purchase choice rate for the aware is expected to be smaller than the purchase choice rate of the unaware.

8 Empirical modeling and exploratory analysis

The behaviour of participants is examined not only through treatment testing as described in section 7 but also through econometric modelling which aims to question the results obtained.

For sellers' behaviour of greenwashing, the following model shape the direction of the analysis but it is not meant to be conclusive:
$Y_{\text{greenwashing}} = \alpha T_i + \zeta ED_i + \beta X_i + \gamma R_i + \delta BRET_i + \theta ENV_i + \phi INST_i + \psi DEMO_i + \epsilon_{\text{greenwashing}}$

For buyers' WTP for green products:
$Y_{\text{product\_wtp}} = \alpha T_i + \zeta BELIEF_i + \beta X_i + \gamma R_i + \delta BRET_i + \eta TASTE_{ij} + \theta ENV_i + \phi INST_i + \psi DEMO_i + \epsilon_{\text{prod\_wtp}}$

For buyers' purchase decision of green products:
$Y_{\text{purchase\_choice}} = \alpha T_i + \zeta BELIEF_i + \beta X_i + \gamma R_i + \delta BRET_i + \eta TASTE_{ij} + \theta ENV_i + \phi INST_i + \psi DEMO_i + \epsilon_{\text{pur\_choice}}$

The Dependent Variables are *greenwashing*, *product_wtp* and *purchase_decision*. The independent variables are:

- Treatment variable (T_i): BDM, S, SP, WP;
- Expected demand (only for sellers) (ED_i): The expected demand for each product
- The beliefs about greenwashing (only for buyers) ($BELIEF_i$): the beliefs from *belief_gw*
- Product/claim covariates (X_i): covariates collected in BDM auctions;
- Round indicator (R_i): round in which the decision is taken;
- Risk aversion covariate ($BRET_i$): bombs collected during the Bomb Risk Elicitation Task;
- Taste matrix (only for buyers) ($TASTE_{ij}$): Matrix of covariates indicating the stated preferences for each product in general;
- Environmentalism covariate (ENV_i): indicator of environmentalism;
- Institutional questions covariate ($INST_i$): trust in advertising, trust in institutions and perceived intervention against greenwashing;
- Demographics covariates ($DEMO_i$)

Interaction effects, when possible, are also investigated.

While the treatment effects are based on theoretical predictions, little is known about most of the covariates. Therefore, the formulation of additional hypotheses is not attempted. Nevertheless, we might expect:

1. Individuals with strong environmental attitudes not to greenwash (if sellers) and (if buyers) to have a higher WTP for green products and to purchase more green products than the individuals without such strong environmentalism

2. Individuals with strong trust in green advertising not to greenwash (if sellers) and (if buyers) to have a higher WTP for green products and to purchase more green products than the individuals without such trust.

3. Individuals with high risk aversion to greenwash less (if sellers) and (if buyers) to purchase less green products as well as having a smaller WTP for green products.

9 Power analysis and budgetary limitations

To assess how likely it is that our analyses will identify an effect as statistically significant if it exists, we report results from the possible power analysis available.
Given the uniqueness of the study, the data from BDM auctions and two pilots of the Greenwashing Game have been used. Since it is not possible to have useful data for sellers, the methods employed are solely about buyers' variables. The software employed is G*Power 3 (Faul et al. 2007, 2009) and the technique adopted is a priori to compute the required sample size.

By adopting the a priori power analysis to compute the required sample size, we employed a statistical test from the family of t-test for means to analyse the difference between two independent means. Since BDM and pilots had two different sample sizes, we employed the method with different sample sizes to compute the effect size. The mean of WTP for green products for the BDM is 2.65 (SD 1.70) and for the pilot is 2.42 (SD 1.08). The resulting effect size (opting for the lower bound of SD) is 0.21, which is employed together with $\alpha = 0.05$ and $\beta = 0.80$ to compute the total sample size. The result is 558, meaning that each treatment must have 279 observations. This is mostly aligned with the data gathered for the BDM, which counts 285 observations of product_wtp for green products. The results are similar when employing a Mann-Whitney statistical test, for which the effect size rises to 0.25 and the resulting total sample size required is 424 observations. These results mean that around 280 observations of product_wtp are need to have a statistically valid result, which translated in number of participants means 40 participants seeing a green product. As a consequence, since some participants see conventional products, the number of buyers should be around 80 people per treatment.

Assumptions and Justifications For this power analysis, we had to make some assumptions about the data. Firstly, we employed data of revealed WTP counting each observation as an independent observation. This is chosen for two reasons: firstly, because the design with stranger-matching protocol and the inability for participants to learn throughout the rounds of the game and, secondly, because the main hypotheses are tested considering all products while the potential role of learning is explored secondarily.

Practical Considerations Openly, due to unforeseen budgetary constraints, the plan is to run firstly most of the sessions for SP and S treatments. The absence of any treatment effect in these sessions crucially hinders WP treatment relevance.
At today's date January 6, 2024, sessions with $\sim$20 participants each will be run starting from SP (6 sessions) and S (6 sessions) Treatments. After that, if positive outcomes arise, WP Treatment (6 sessions) will be deployed. Instead, in case of negative outcomes, 2 additional sessions for SP and S treatment will be run to strengthen the (null) results. Any extra session between 18 and 24 is beneficial to the power of the study as previously described. However, we plan not to overcome a maximum of 160 participants per treatment, meaning 24 sessions in total with an average of $\sim$20 participants (10 sellers and 10 buyers).

10 Appendix

10.1 Control variables table

Table 7: Control variables

Variable name	Variable type	Level	Admitted level	Composition	Part	Html page/section
failed_attempts	Count	All	0:infinite	Attempts to complete control questions	Instructions	Comprehension
errors_count	Count	All	0:infinite	Actual errors registered	Instructions	Comprehension
last_failed_attempts	Count	All	0:infinite	Attempts for last control question*	Instructions	LastQuestions.html
last_errors_count	Count	All	0:infinite	Actual errors registered for last question	Instructions	LastQuestions.html
product_type	Categorical	All	List of 7 products	-	Part A	gwg_play
bret_boxes_collected	Continuous	All	0:100	Bomb Risk Elicitation Task: bombs collected	Part B	bret
guess_peak	Categorical	Buyers	0-0.49€;...;9.50-10€	Guess by buyers about maximum wtp in previous study	Part C	Guess_buyer.html
interest_{product]	Categorical	Buyers	1, 2 and 3	1 for “small or no interest”, 2 for “enough”, 3 “a lot”	Part D	Questions_{product.html
experience_{product]	Categorical	Buyers	1, 2 and 3	1 for “small or no experience”, 2 for “enough”, 3 “a lot”	Part D	Questions_{product.html
allergies_{product]	Binary	Buyers	1 and 0	1 for “Yes”; 0 for “No”	Part D	Questions_{product.html
desire_{product	Ordinal; Continuous	Buyers	1, 2, 3	1 for “No”, 2 for “Indifferent”; 3 for “Yes”	Part D	Questions.extra_1.html
difficulty	Ordinal; Continuous	All	1:5	1 for no difficulty; 5 very difficult	Part D	Comments.html
environ_importance	Ordinal; Continuous	All	1:5	“Nothing”; 5 “A lot”	Part D	Questions_extra2
environ_weight1	Ordinal; Continuous	All	1:5	1 for “Nothing”; 5 “A lot”	Part D	Questions_extra2
environ_weight2	Ordinal; Continuous	All	1:5	L1 for “Nothing”; 5 “A lot”	Part D	Questions_extra2
environ_weight3	Ordinal; Continuous	All	1:5	1 for “Never”; 5 “Always”	Part D	Questions_extra2
environ_contribution	Ordinal; Continuous	All	1:5	1 for “Nothing”, 5 for “A lot”	Part D	Questions_extra2
environ_activist	Ordinal; Continuous	All	0:4	Level of activism	Part D	Questions_extra2
environ_knowledge_1	Binary	All	1 or 0	1 if correct (answer: 3); 0 otherwise	Part D	Questions_extra3
environ_knowledge_2	Binary	All	1 or 0	1 if correct (answer: 2); 0 otherwise	Part D	Questions_extra3
environ_knowledge_3	Binary	All	1 or 0	1 if correct (answer: logo_3); 0 otherwise	Part D	Questions_extra3
trust_institution	Ordinal; Continuous	All	1:5	1 “No Trust”; “A lot”	Part D	Questions_extra4
trust_inads	Ordinal; Continuous	All	1:5	1 “No Trust”; “A lot”	Part D	Questions_extra4
gw_outthere	Continuous	All	0:100	Perceived greenwashing in market	Part D	Questions_extra4
perceived_gw	Continuous	All	0:100	Perceived verification in market	Part D	Questions_extra4
perceived_sanction	Continuous	All	0:100	Perceived sanction in market	Part D	Questions_extra4
age	Continuous	All	18:100		Part D	Demographics.html
gender	Categorical	All	M, F, Non binary, NA		Part D	Demographics.html
status	Categorical	All	student, working, seeking working student, neet		Part D	Demographics.html
field_of_study	Categorical	All	List of subjects in orsee		Part D	Demographics.html
sustainance	Categorical	All	Yes, Partially, No, NA	Ability of financial sustainance	Part D	Demographics.html
household_income	Categorical	All	Ranges (see instructions)		Part D	Demographics.html