Carbon Footprint Information, Prices, and Restaurant Wine Choices by Customers: A Natural Field Experiment

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Abstract
There is growing evidence that consumers need to be involved in the solutions to global climate change. To test the responsiveness of wine consumers to carbon footprint stimuli we set a natural field experiment in a restaurant. We modified wine cards to provide different information and price incentives to consumers to test the effects of two types of policy interventions on reducing CO_2 emissions related to wine choices. Specifically, we test the provision of carbon footprint information and an additional price for carbon emissions. We randomly assigned subjects to four different wine cards or menus. Our results show that information about the carbon footprint alone is not enough to affect wine choices, but its effect becomes significant when combined with a price change. A card showing the carbon footprint of wine bottles and proportionally higher wine prices was associated with choices leading to lower carbon emissions. However, when information about the additional price to offset the carbon emissions of the wine was made explicitly visible to consumers on another card, an opposite effect of an increase in the choice of wines with higher carbon-emitting production processes was observed. This finding indicates that how the price increase is presented can affect wine choices, highlighting the importance of careful information policy design.

Keywords: carbon footprint, natural field experiment, sustainability labels, climate change, wine consumers, restaurant

1 Introduction

Agricultural and food production significantly contributes to greenhouse gas (GHG) emissions and climate change (Fesenfeld et al., 2020). Consequently, several policy interventions have been developed in recent decades to promote sustainable behaviour. These include a wide array of different measures that target both producers and consumers. In the food area, the possible policy interventions can be classified into six types: direct command and control interventions, incentive-based structures, information and education, co-regulation, self-regulation, and no intervention (Garcia Martinez et al., 2007). Although all intervention categories may have effects on consumers, the policy measures that are more strongly directed to consumers are price incentives and information interventions.

In regard to price incentive interventions, taxing food products is a particularly complex matter due to the secondary effects on dietary choices that are more difficult to assess and control if the taxation is set based only on social costs and a set of products (Säll and Gren, 2015). One of the main criticisms is related to the potential regressivity of the tax, i.e., the fact that it can pose a greater burden on lower-income groups (Downs et al. 2017; Markandya and Ricci, 2012). However, a careful design can reduce such effects (García-Muros et al. 2017). A number of countries have tried to implement such taxes. For instance, soda taxes have been recently proposed in some European countries, with ongoing discussions about their implementation. Some countries have also introduced food taxes to reduce unhealthy food behaviour. For example, Saudi Arabia introduced a tax on sugar-sweetened beverages in 2017 (Alsukait et al., 2020), and Mexico introduced a tax on non-essential energy-dense food in 2014 (Salgado and Ng, 2019). Recently, there has been increased interest in applying environmental taxes (e.g., carbon taxes) on food products to incentivize consumers to prefer less carbon-intensive products. Economic analyses have been conducted to study the impact of carbon-based taxes, especially in the meat sector (Bonnet et al., 2020; Caillavet et al., 2016), with findings suggesting that these taxes may have a positive effect on consumer choices by reducing their carbon footprint (CF) with a relatively low policy cost (Briggs et al., 2016; Edjabou and Smed, 2013).

Informational interventions like food product labelling are aimed at supporting consumers in making choices that maximize their utility and preferences. Indeed, such schemes do not change the incentive structure of the choice but work on reducing the informational asymmetry between producers and consumers, addressing the related market failures. Consumers can therefore make more conscious choices in relation to their own preferences. In the food sector, it is possible to observe several voluntary information measures to promote environmentally sustainable consumer behaviour (Gadema and Oglethorpe, 2011). Previous studies have shown how labelling can affect food choices (Grunert et al., 2014; Ni Mhurchu et al., 2018) even if issues of comprehension and confusion might arise (Grunert, 2011). This could be particularly relevant for carbon labelling given the difficulty of the topic and the potential lack in transparency in the assessment (Gadema and Oglethorpe, 2011). When considering environmentally friendly labelling, most of the literature has focused on labels such as “organic” or “animal friendly” (Hoek et al., 2017). CF labels are relatively less explored by the empirical literature in the food sector. In general, consumers appear to respond positively to lower carbon-emitting foods, especially when associated with lower-priced items (Canavari and Coderoni, 2020). The value of CF labels seems to be reinforced when these are associated with local origin (Emberger-Klein and Menrad, 2018; Akaichi et al., 2017), health logos (Hoek et al., 2017), or low-fat content (Akaichi et al., 2020). Much also depends on the consumer segment. Past studies have highlighted the effects of cross-cultural differences (Grebitus et al., 2016); human values (Grebitus et al., 2015); and the different attitudes, psychographics, and responses of consumer segments (Steiner et al, 2017).

Given the empirical literature discussed above, it seems that both price incentives and informational interventions have the potential to reduce the CFs of food products that consumers buy.

Understanding consumer behaviour related to these different policy interventions is important for the development of effective institutional interventions that can reduce carbon emissions and to support economic activities and investments in environmentally friendly practices. However, the alternative or joint effectiveness of these two types of food policy interventions has never been investigated within a single comprehensive setting. This study was designed to address this gap. We conducted a natural field experiment to assess how different interventions can affect restaurant customers' choices of wine bottles with different CFs. Specifically, we examined the effect of four restaurant wine cards containing information on the 1) baseline price only; 2) baseline price + CF; 3) CF + total price with carbon tax; and 4) baseline price + CF + additional price based on the CF (i.e., carbon tax) + total price with carbon tax (figure A.1). These cards allowed us to assess the effects of an information policy intervention (CF label) and two price policy interventions on consumer behaviour, namely, a CF contribution policy intervention that adds to the final price a contribution proportional to the CO_2-equivalent emissions related to the production process (CF price) and an out-of-price CF contribution policy intervention that informs the consumer of the part of the price related to offsetting the CO_2-equivalent emissions related to the production process (CF out-price).

Hence, our research questions are as follows:
RQ1: Does providing information on the carbon emissions of a bottle of wine affect wine choices (i.e., result in wine choices with a lower CF)?
RQ2: What is the effect of imposing a carbon content-related increase in price on wine bottles consumed at restaurants? Is there a shift from higher-emitting wines to lower-emitting ones?
RQ3: Of the above alternatives, which is the most effective way of moving choices towards wines with lower carbon-emitting production processes?

Given that hypothetical bias and social desirability bias, among others, can occur in stated preference studies and non-natural settings, we opted to test the effect of these wine cards using a natural field experiment where customers did not know that there was a study being conducted. The natural field experiment was conducted in a full-service, sit-down restaurant in northern Italy. We randomly assigned restaurant customers to the four wine cards described above.

The wine sector offers an interesting case to test our research questions since it is a viable sector to start testing the introduction of CF taxes given that it has a lower potential for tax regressivity effects because wine is a non-essential good. Moreover, the effects of substitution among different types of wine products on diet are limited (Benedetto et al., 2014). The reduced effect on diet also allows us to restrict the research assessment and policy intervention to a limited number of products that could be confined within different wine varieties. This overcomes the complexity of evaluating a broader set of food categories to take into account possible substitution and complementarity effects. As highlighted by Shewmake et al. (2015), any final assessment on the actual effects of a policy that implies a behavioural reaction by consumers depends on the substitution choices. Indeed, potential cross-sector leakage effects could arise from consumers substituting a high-emission targeted product with other high-emitting food categories. This is a limitation of several studies assessing consumer responses to CF information, but it is also a limitation in terms of policy feasibility.Also, the wine sector is highly involved in sustainability initiatives, such that life cycle assessment methodologies are validated and wines with CF information are present in the market (Corbo ed al, 2014). Therefore, this sector offers sufficient elements to test the policy tools of interest in this study in a realistic setting.

Our results indicate that CF information alone is not enough to affect wine choices, but its effect becomes significant when combined with a price change. The wine card or menu showing the CF of wine bottles and proportionally higher wine prices was associated with choices leading to lower carbon emissions. However, when information about the additional price to offset the carbon emissions of the wine was made explicitly visible to consumers in the wine card or menu, an opposite effect of an increase in the choice of wines with higher carbon-emitting production processes was observed.

This paper is organized as follows. A background providing the relevance of CFs in the wine sector is presented in section 2. Section 3 describes the experimental design and procedure. In section 4, information on data collection and model estimations is provided. The results and their discussion are presented in sections 5 and 6, respectively. The paper ends with concluding remarks in section 7.

2. Wine sector, carbon footprint, and wine choices

The CF of the wine sector is estimated to contribute to approximately 0.3% of global human-induced GHG emissions when considering wine bottled at the winery gate (Rugani et al., 2013). This is a non-trivial value if we add it to the relevant GHG emissions related to the distribution system of the wine supply chain (Colman and Päster, 2009). Apart from that of beef production (5.9%), this value is not far from the global GHG emissions of some livestock sectors, such as pig meat (1.2%) and poultry meat (1.3%) (Gerber et al. 2013). In a review by Rugani et al. (2013), the most impactful areas of the wine "system" were found to be the packaging processes (22%), the end-of-life of bottles and co-products (22%), and viticulture activities (17%). Several areas however have a mitigation potential; e.g., reductions in bottle weight, their potential reuse, the use of renewable energy, the longevity of trellis systems, and higher yields (Ponstein et al., 2019).

In recent years, several sustainable wine-growing initiatives have been introduced by the main wine-producing countries worldwide. In 2008, wine industry associations from California, New Zealand, Australia, and South Africa cooperated for the development of the Wine Industry Greenhouse Gas Accounting Protocol and Calculator with the aim of providing a practical guide to actors in the global wine industry to measure the CF of their activities. The principles of this protocol were further enhanced by the International Organisation of Vine and Wine (OIV, 2015). In Europe, many private and voluntary public initiatives have been introduced at the national level (Flores et al., 2018). For example, in Italy, the sustainable development programme VIVA, together with other national initiatives, was introduced by the Italian Ministry for the Environment in 2014 to improve the sustainability of vineyards and wine production using a number of indicators, including GHG emissions, water consumption, the impact on the social and natural environment of companies' actions, and the evaluation of agronomic management practices in vineyards, such as the use of pesticides, soil management, fertility and biodiversity.

While many wine-growing firms have invested in sustainability initiatives, the market response to carbon-related firm strategies towards low-carbon-emission wines is still underexplored. In general, there is a growing awareness of food consumers for climate change issues and on their role in reducing the CF of the food sector (de Boer et al., 2016; Ricci and Banterle, 2020). More specifically, wine consumers seem to show an increasing interest for products with environmentally friendly attributes (Sogari et al., 2016), even if their choices are more complex than those for other food products because of having to jointly consider a wide range of intrinsic and extrinsic product characteristics, such as grape variety, country of origin, price, and brand (Lockshin et al., 2006; Panzone, 2014; Bazzani et al., 2020). Moreover, most of the existing literature deals with organic wine or wine with different levels of labelled pesticide reduction information (Di Vita et al., 2019). Some studies also assessed wine sustainability as a single comprehensive attribute (Sellers-Rubio and Nicolau-

Gonzalbez, 2016), even if consumer awareness of the concept is low (Schäufele and Hamm, 2017). Wine consumers also appear to prefer a no-labelling situation when benefits show trade-offs as, for example, in the case of vineyards using conventional or recycled water (Li et al., 2018).

The assessment of the effect of carbon information on wine choices is still very rare. Tait et al. (2019) used a discrete choice experiment based on an online survey to estimate the willingness to pay (WTP) for different attributes included in sustainability programmes in California. They found that the organic attribute outperforms specific sustainability attributes such as disease management and water management. However, they also found that carbon emissions management is positively valued even if the above attributes show a higher WTP. Using a similar methodology and a multi-country sample, Mueller Loose and Remaud (2013) compared alternative claims in the form of logos that also include a "carbon zero" one. Their results confirm the preference for the organic claim and a higher WTP for environmental claims than social responsibility claims. Glasser (2015) used a similar setting and showed how organic, sustainable, and carbon neutral logos achieve a higher WTP than conventional wines with small differences across the three alternatives. Vecchio (2013) used experimental auctions involving undergraduate students to assess the WTP for a carbon neutral label and other labels addressing social and ethical dimensions. All of these labels resulted in a higher WTP than a conventional label. Pomarici and Vecchio (2014) found similar results by extending the previous study to Italian Millennials in an online hypothetical study. Using a choice experiment targeted to Millennials, Gallenti et al. (2019) compared the presence of carbon emissions and winescape aesthetic attributes, with the former being preferred. None of these studies, however, was conducted using a non-hypothetical experimental design in a natural setting or in a real market context (Schäufele and Hamm, 2017). Moreover, these studies did not examine the effect of both CF information and variants of price information tested in the current study.

3. Experimental design and procedures

3.1. Previous findings of natural field experiments on the effects of food product carbon footprints

In the food literature, some applications of natural field experiments related to the assessment of CF can be found in retail stores or restaurants. Concerning food retail stores, Muller et al. (2019) assessed approximately 300 food items by comparing the no labelling situation with environmental labels applied to a whole set of products. They showed how CF information in isolation or in combination with water eutrophication and air acidity information can lead to the choice of lower carbon-emitting food baskets. A previous study on a smaller number of food items in a retail store was conducted by Vanclay et al. (2011), showing a positive shift towards a less carbon-emitting basket, even if within some product lines, such as fresh milk, no shift was observed. Elofsson et al. (2016) limited the basket to dairy products and assessed the effect of carbon information signs placed close to the lower-emitting milk using a randomized control trial in several stores in Sweden. Their results show an increase in the sales of the signalled milk of 6-8% with no persistent effect when the signs are removed.

With regard to field experiments in cafeterias or restaurants, several empirical investigations based on nudging techniques to reduce carbon emissions have been conducted. For example, default choices (Campbell-Arvai et al., 2014), menu framing (Gravert and Kurz, 2019; Kurz, 2018), reductions in portion size (Reinders et al., 2017), and combinations of the above (Friis et al., 2017) are among the most common techniques explored. Only a few studies, however, have assessed the effect of carbon-related information provision. Brunner et al. (2018) used a field experiment in a university cafeteria to test the effect of labelling dishes in the menu with a CF traffic light label. Their results indicate a reduction of 3.6% of GHG emissions from food sales mainly due to lower beef purchases. No difference was found according to gender, while age groups exhibited inconclusive results.

Spaargaren et al. (2013) used a university canteen to test two alternative carbon labels providing the carbon emissions of each item that could be purchased. Their results show no effects when the label is just placed on the purchased item, while modest positive effects (less than 2%) were found when the labels were supported by other informative campaigns in the canteen. Visschers and Siegrist (2015) also used a university canteen to test the effect of a label called "climate-friendly choice". Among the four dishes offered each day by the canteen, only the two with lower emissions were labelled. The treatment was supported by an informative campaign using posters. The results show an increase in the consumption of the labelled meals. A limitation of this study, however, is that the experiment was not conducted in a real-life setting. Hence, consumers were likely aware of the experiment, as a prior study was conducted by interviewing customers about their meal choices and perceived environmental impacts, and the proposed meals were decided in a way that the differences between high- and low-emitting dishes were high.

3.2 Study experimental procedure and restaurant description

As previously mentioned, we conducted our natural experiment at a full-service, sit-down restaurant in northern Italy. The restaurant "Busatto" is a family-run business specializing in seafood. It provides an upscale service for customers that on average visit the business twice per year. It is located in Treviso, Italy, and attracts both locals and people visiting the area periodically for business trips.

Data were collected from May to September 2018 during regular restaurant work activities, only for dinner. All the participants were unaware of being part of the study. The experiment was run by maintaining the environment as close as possible to the "usual" setting. To this end, we trained the restaurant management team on the data collection procedures. Given the family-run nature of the restaurant, it was possible to ensure that the people supervising and managing the data collection were the same during the whole experiment and that the servers were the same as those the clients were used to. This had several main advantages: (1) the clients would not feel any change in the environment; (2) given the solid experience of the management team and their knowledge of the clients, they were able to ensure that no returning/repeat customers were sampled during the experimental period; and (3) contamination driven by differences in providing information and interacting with clients was minimized.

Usually, the restaurant provides an "a la carte" menu and a special tasting menu called "Carosello della Tradizione", which includes an appetizer of seafood, risotto with seafood, mixed fried fish, and a shot of limoncello. Since our study focuses on wine selections, to minimize the possible biases of pairing wine with food, we sampled only the customers who chose the special tasting menu. Given that this could potentially induce some selection effects, our findings should be interpreted based on an understanding of this context, as every experimental study is context dependent. The "Carosello della Tradizione" was kept the same throughout the whole duration of the experiment to ensure that variations in wine ordering patterns could not be attributed to changes in menu items.

When selecting the menu "Carosello della Tradizione", customers were presented with a wine card randomly selected from four different options (Cards 1-4) that we designed to compare the effect of different interventions, as described in the next subsection. Along with the wine cards, standardized background information was prepared about the wines and the wine producers as well as the meaning of items included on the wine cards (i.e., CO_2 emissions or prices). Information was provided only when asked by the clients. During the whole experimental period, the same person was in charge of providing this extra information. This was conducted by attempting to minimize the risk of the choice being driven by other factors. Customers were not aware or informed that their actions were being observed and registered and that an experiment was being conducted. The wine cards were part of a special offer associated with the choice of the "Carosello della Tradizione" menu.

3.3 Wine card descriptions and the experimental design

Five wines were selected for the natural field experiment. The selection of the products to be included on the wine cards was performed together with the management team of the restaurant by balancing the experimental design requirements with the need to provide consumers with a set of goods that could be coherent with the type of service provided by the restaurant, which specializes in seafood. For the experiment, we tried to select wines in such a way that all options were similar in characteristics but differed in terms of the $CO_{2\text{-eq}}$ emitted[1] during the production process (i.e., CF). Wines were selected from a list of bottles available in the market and certified within the pilot project VIVA "Sustainability and Culture" that was launched by the Italian Ministry for the Environment, Land and Sea. The CFs are therefore certified and publicly available on the project website[2].

The outcome was a set of five wines, all white and not sparkling, with similar price ranges in the market. Moreover, the selected wines were not previously part of the wine list of the restaurant, thus reducing the chance that loyal clients had a reference price for the items on the selection list. Another critical choice was the number of wines listed on the wine card. The choice of listing five wines was made considering that a short selection would facilitate the clients' information screening procedure while ensuring enough variability in the carbon emission levels.

The selected wines, their producers and the related CF per bottle are reported in Table 1. This table also illustrates the information provided on the four different wine cards (Cards 1-4) that were designed to evaluate how different information and pricing policy interventions (CF label, CF price, CF out-price) affect wine choices. All card types included a description of the wine, including the wine type and the name of the producer. Figure A1 in the Appendix shows the visual look of the cards.

Card 1 was the control and reported only the wine type and the baseline price (displaying only column -a- of Table 1 near the wine description). We set all baseline wine prices equal to 10 euros; this was done to eliminate any price effect related to wine selection and to isolate, with the other cards, the effect of treatments or interventions on wine choices. On Card 2, in addition to the wine type and baseline price, we added information about the CF of the production process of the specific wine label (displaying columns -b- and -c- of Table 1 near the wine description). Card 3 displayed, near each wine type, the respective CF and the final price of the wine, calculated as the baseline price of 10 euros plus the CF-based additional price, i.e., an additional amount[3] proportional to the emissions of the wine selected (displaying columns -b - and -d- of Table 1 near the wine description). Card 4 reported all the information displayed on Card 3, but in this case, the client was explicitly informed about the part of the wine price that was related to carbon offsetting in the form of a contribution (displaying columns -a -, -b-, -c- and -d- of Table 1 near the wine description).

On each experimental day and week, the selection of the card type (Cards 1-4) to be used in the restaurant was randomized, as well as the order of the wines listed on each card. This randomization

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[1] $CO_{2\text{-eq}}$ (CO_2-equivalent emissions) includes the full set of GHGs. For simplicity, we referred to CO_2 emissions in the wine cards and to the carbon footprint (CF) of the bottles in the rest of the paper.

[2] The product carbon footprint (PCF) following the VIVA methodology (2016/2.0 specification and 2019/2.1 specification) was used to analyse the CF of a bottle of wine used in the field experiment. The methodology is ISO 14067 standard compliant. It specifies principles, requirements and guidelines for the quantification and reporting of the PCF. An MS Excel workbook designed to facilitate all the processes of calculation, ensuring the repeatability of the measures, accompanies the latest version of the VIVA specification. In summary, the analysis consists of calculating the direct and indirect GHG emissions during the wine life cycle of a 0.75 litre bottle of wine. Further information is available at the official website http://www.viticolturasostenibile.org/.

[3] The monetary amount added to the price for carbon emissions was calculated considering the offset price of 0.50 euro per kg of CO_2 emissions: for example, a bottle of Pinot Grigio emits 0.884 kg of CO_2, so the monetary amount added is of 0.884*0.5= 0.44 euro per bottle. This value was used in the design of both Card 3 and Card 4 (see figure A.1 in appendix).

procedure ensured that the selected card types were different across weekdays in different weeks, meaning, for example, that Card 1 did not always appear on a Monday. We chose not to have different wine cards tested on the same day to avoid the risk of clients noticing differences across tables and thus questioning about it. To ensure the randomization of the wines listed within each card type, we prepared in advance 50 cards of each type (Cards 1-4), where the wine order was randomized; each card was used only once; when an order was placed based on the card received, the card was then discarded and could not be used for the next client. We chose to collect 50 observations to balance data power with the willingness of the restaurant staff, considering the effort required for data collection.

Wine description	*Price*	*CO_2 emissions /bottle**	*Contribution for CO_2*	*Final Price*
	-a-	*-b-*	*-c-*	*-d-*
Pinot Grigio Castello di Porcia DOC, Principi di Porcia	10 euro	0.884kg	0.44 euro	10.44 euro
Gavi DOCG, La Cedraia	10 euro	0.831kg	0.42 euro	10.42 euro
Soave Classico Rocca Sveva, Cantina di Soave	10 euro	1.080kg	0.54 euro	10.54 euro
Sghiras Toscana Bianco IGT, Fattoria Le Sorgenti	10 euro	1.544kg	0.78 euro	10.78 euro
Morabianca, Mastroberardino	10 euro	1.381kg	0.69 euro	10.69 euro
Information displayed by each card type				
Card 1	✓			
Card 2	✓	✓		
Card 3		✓		✓
Card 4	✓	✓	✓	✓

Note: * "Unit of equivalent CO_2 emissions" ($kgCO_{2\text{-}eq}$). Prices are in euro per bottle.
Source: Own elaboration

Table 1: Wine information and card (1-4) composition.

4 Data and model estimation

As explained in the previous section, data were collected from May to September 2018 during the regular work activities of a private full-service, sit-down restaurant in Treviso, Italy. For each table, the managerial team collected data on several variables without directly asking participants, as they needed to remain unaware that a research study was being conducted.

These variables can be grouped into three categories:
G.1) *Context variables:* these variables record the external/outside temperature in three levels (*d_Temp_20*: up to 20°C; *d_Temp_21-29:* from 21°C to 29°C; *d_Temp_30:* from 30°C and up), if it was a rainy day (*d_Rain*), if the data were collected during the weekend (*d_Weekend*), and the month of the data collection (from May to September).
G.2) Characteristics of the table: number of people and where they were from (if from the regional area -*Local*-, from other parts of Italy or from abroad). The party sizes of the tables were also recorded, i.e., if the table was composed of one person (*d_Single*), two people (*d_Couple*) or more. If the party size was more than two people, we recorded whether it was a family (*d_Family*) or a group of friends (*d_Friends*).

G.3) Behavioural characteristics of the table: these variables record whether information was asked about the wine (*d_Wine_info*) or the CF (*d_CF_info*) at the table, if the wine was chosen as a shared decision (*d_Collective*) and if more than one bottle was ordered (*d_bott>1*).

Our final dataset consists of 200 observations: 50 for each type of card/treatment. Each observation corresponds to a table where the menu "Carosello della Tradizione" was chosen together with a bottle of wine on the wine card provided.
Table 2 reports some descriptive statistics of the variables and the behavioural characteristics of the tables included in the sample.

Variable		*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
CF	CO_2_eq content of the wine bottle (or CF)	200	1.11	0.25	0.83	1.55
Card1	Dummy variable indicating that the table received Card 1 as a wine card	200	0.25	-	0	1
Card2	Dummy variable indicating that the table received Card 2 as a wine card	200	0.25	-	0	1
Card3	Dummy variable indicating that the table received Card 3 as a wine card		0.25			
Card4	Dummy variable indicating that the table received Card 4 as a wine card	200	0.25	-	0	1
d_Temp_20	Dummy variable indicating that the external temperature was lower or equal to 20°C	200	0.36	-	0	1
d_Temp_21-29	Dummy variable indicating that the external temperature was between 21°C - 29°C	200	0.39	-	0	1
d_Temp_30	Dummy variable indicating that the external temperature was higher or equal to 30°C	200	0.25	-	0	1
d_Rain	Dummy variable indicating that it was raining during the evening of data collection	200	0.21	-	0	1
d_Weekend	Dummy variable indicating that data was collected during a weekend	200	0.33	-	0	1
d_July_Sept	Dummy variable indicating that data was collected during a July, August or September	200	0.52	-	0	1
d_May-June	Dummy variable indicating that data was collected during a May or June	200	0.48	-	0	1
d_Couple	Dummy variable indicating that the table was composed by a couple	200	0.52	-	0	1
d_Family	Dummy variable indicating that the table was composed by a party identified as a family	200	0.21	-	0	1
d_Friends	Dummy variable indicating that the table was composed by a party identified as a group of friends	200	0.22	-	0	1
d_Local	Dummy variable indicating that customers were locals	200	0.88	-	0	1
d_Wine_info	Dummy variable indicating that the customers asked information about the wines on the wine card	200	0.30	-	0	1
d_CF_info	Dummy variable indicating that the customers asked information about the CF of the wine	200	0.53	-	0	1
d_Collective	Dummy variable indicating that the table companions made the wine choice in a collective manner (as opposed to one person deciding for all).	200	0.16	-	0	1
d_bott>1	Dummy variable indicating that the table ordered more than one bottle of the same wine.	200	0.24	-	0	1

Table 2. Descriptive Statistics

The data were first analysed by means of descriptive statistics to obtain a first idea on the distribution of the variables. Specifically, we computed a set of contingency tables to explore the marginal associations between wine choices and the variables collected during the experiment. Second, we investigated whether the different treatments studied had an effect on the CF, related to wine selection, of the tables. To do so, three robust ordinary least square (OLS) regression models (Models 1a, 1b, and 1c) were run with the bottle's CF, measured in kilograms of equivalent CO_2, as the dependent variable (Model 1). We chose to model the CF of a single bottle, as we are mainly interested in how wine choices are affected by information and/or price interventions and not so much on the exact CF of a single table. We control for tables that ordered more than one bottle of wine. In the experiment, only one type of wine was served at a single table. Indeed, the type of wine is usually chosen first and the number of bottles served then follows according to party size. In a few limited cases, for repeat orders, clients ordered different wine types, and these observations were excluded from the sample.

Specifically, Model (1a) includes as independent variables just the wine card dummies (i.e., the treatment implemented). Model (1b) adds a set of controls that take into account the external conditions of the experiment; that is, we also included the variables listed in category G.1. Finally, Model (1c) includes all variables described above, including the characteristics of the table, thus indicating the card/treatment dummies plus the variables of categories G.1, G.2, and G.3.

Given that the wine card treatments are coded by dummy variables, the same OLS model can be presented in four equivalent specifications, depending on which card is chosen as the reference baseline. All four specifications provide the same results, given that it is the same model, however reporting different specifications allows to compare the effects of each card with all the other cards. Thus, for completeness, in the results, we firstly report the estimated differences between each pair of cards, i.e., the regression coefficients of the card dummy variables in the four specifications of Model 1c. Then, to highlight the effects of the other dummies (G.1, G.2, and G.3) (effects that are identical in each of the four possible model specifications), without loss of generality, to increase the effectiveness of the presentation and for easiness of reading, we show the results of Models 1a, 1b and 1c when Card 3 is taken as the reference.

In its general form, if the *i^th^* card is selected as the reference baseline, the full model (1c) reads as follows:

$$\begin{aligned} CF = \beta_0 + \sum_{j:\, j \neq i} \beta_{ij} * d_{Cardj} + \beta_{Temp_{1-29}} * d_{Temp_{1-29}} + \beta_{Temp_{30}} * d_{Temp_{30}} + \beta_{Rain} \\ * d_{Rain} + \beta_{Weekend} * d_{Weekend} + \beta_{May-June} * d_{May-June} + \beta_{Couple} \\ * d_{Couple} + \beta_{Family} * d_{Family} + \beta_{Friends} * d_{Friends} + \beta_{Local} * d_{Local} \\ + \beta_{Wine\_info} * d_{Wine\_info} + \beta_{CO_2 info} * d_{CO_2 info} + \beta_{Collective} \\ * d_{Collective} + \beta_{bott>1} * d_{bott>1} + \varepsilon \end{aligned} \quad \text{(Eq. 1)}$$

with i=1, …, 4

where β_0 is the reference value (i.e., the expected CF when all dummy variables are switched off), β_{ij} is the effect on the expected CF associated with the activation of the corresponding j^{th} dummy variable when the reference baseline is *card i*, and ε is the table-specific unpredictable random error.

We also took into account possible multicollinearity among the variables using the variance inflation factor. Furthermore, to validate the randomization of the cards with respect to the other covariates, we also performed Fisher's exact tests for each variable against the card treatments to verify the absence of possible confounding effects.

Finally, we also estimated a multinomial logit model (Model 2) to investigate the pairwise preferences among wines characterised by different carbon contents. For this analysis, we consider the full set of independent variables included in Model 1c. In detail, the estimated model reads as follows:

$$log \frac{Prob(wine_k)}{Prob(Gavi)} = \alpha_{0k} + \sum_{j:\, j \neq i} \alpha_{ijk} * d_{Cardj} + \alpha_{Temp_{1-29},k} * d_{Temp_{1-29}} + \alpha_{Temp_{30},k} * d_{Temp_{30}} + \alpha_{Rain,k} * d_{Rain} + \alpha_{Weekend,k} * d_{Weekend} + \alpha_{May-June,k} * d_{May-June} + \alpha_{Couple,k} * d_{Couple} + \alpha_{Family,k} * d_{Family} + \alpha_{Friends,k} * d_{Friends} + \alpha_{Local,k} * d_{Local} + \alpha_{Wine\_info,k} * d_{Wine\_info} + \alpha_{CO_2info,k} * d_{CO_2info} + \alpha_{Collective,k} * d_{Collective} + \alpha_{bott>1,k} * d_{bott>1} \quad \text{(Eq. 2)}$$

with i=1, …, 4

where for each wine k - other than Gavi - α_{0k} is the reference log odds of choosing wine k vs. Gavi and the other regression coeffiencients represent the impact on the same log odds of the relative dummy variables.

The experimental design also allows us to isolate the effects of the single policy interventions: CF label, CF price, and CF out-price. The effect of the information policy intervention CF label can be measured by comparing the results for Card 1 with those for Card 2. Further, we can capture the effect of the pricing policy intervention CF price by comparing the results for Card 2 with those for Card 3. Finally, from a comparison of the results for Card 3 and Card 4, we can measure the effect of the price policy intervention when the extra CF-related expenditure is displayed alone prior to being added to the final price (CF out-price).

5 Results

5.1 Wine choices

Table 3 shows the distribution of choices across the five different types of wine. On the whole, Pinot grigio was the most chosen option among the five choices, followed by Soave and Morabianca. Gavi and Sghiras were overall the least chosen wines. The majority of the tables purchased just one bottle of wine (77%), while two (18%) or more bottles were usually chosen when the party size was larger than three people. In all cases, the wine choice was homogeneous for a given table.

Wine	*Wine cards*				
	Card1	Card2	Card3	Card4	Total
Gavi	8.0%	8.0%	18.0%	10.0%	11.0%
Pinot grigio	38.0%	34.0%	32.0%	22.0%	31.5%
Soave	26.0%	22.0%	28.0%	20.0%	24.0%
Morabianca	14.0%	24.0%	18.0%	40.0%	24.0%
Sghiras	14.0%	12.0%	4.0%	8.0%	9.5%

Table 3. Distribution of wine choices across wine cards

Looking at the distribution of wine choices across wine cards, Pinot grigio was the most chosen option in most cases. This is a relatively low carbon-emitting wine. The lowest-emitting wine – Gavi – was instead the least chosen wine from the control wine card (Card 1), where no policy was tested, but was increasingly preferred by those exposed to Card 3 or Card 4, more so when the price was not explicitly associated with a CF contribution (Card 3). For Sghiras, i.e., the highest-emitting wine included in our wine menu, we find a reduction in the preferences accorded to this wine with every policy intervention. In particular, a CF label combined with a CF implicit price (Card 3) seems to have the highest effect in reducing demand. However, these results are average values that do not take into account the effects of the other variables on wine choices. Thus, they can represent a first insight into the results but need to be further investigated in a multivariate model. For completeness, the univariate effects of all other variables included in the models are reported in Table A1 in the Appendix.

5.2 Effects of treatments on wine-related CF and choice behaviour

To investigate the effects of the treatments implemented with the wine cards on the carbon content of the bottles ordered by the tables, we estimated three robust OLS models (Model 1).

To highlight the differential effects of wine card treatments, as discussed in Section 4, we firstly report the coefficients of the card effects in all four possible specifications of model 1c. This allows us to the test the differences among all treatments. In Table 4, to increase readability, we report only the coefficients of the wine card dummy variables, as being the same model, all other coefficients and model parameters are identical.

Table 5 instead presents the full results of the three robust OLS regressions on the (chosen) bottle CF. In detail, we report the estimates and robust standard errors obtained from the three different specifications of Model 1: 1a) only treatment variables; 1b) adding the context variables (variables in category G.1); and 1c) adding table characteristics (variables in the G.2 and G.3 categories). Without loss of generality, in Table 5 results are reported considering Card 3 as the reference.

Given the significance of some of the context and table variables, from here onwards, we comment on the full model (1c).

	Reference card (i)			
Card effect (j)	Card1	Card2	Card3	Card4
Card1		-0.002	0.092*	-0.060
		(0.057)	(0.052)	(0.057)
Card2	0.002		0.094*	-0.058
	(0.057)		(0.054)	(0.051)
Card3	-0.092*	-0.094*		- 0.152***
	(0.052)	(0.049)		(0.048)
Card4	0.060	0.058	0.152***	
	(0.057)	(0.051)	(0.048)	
Constant	1.229***	1.232***	1.137***	1.290***
	(0.091)	(0.097)	(0.095)	(0.096)
Observations	200	200	200	200
R-squared	0.150	0.150	0.150	0.150

Model specification: Model 1c presented in Eq.1
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4. Card effects with respect to different reference cards

Table 4 indicates that Card 3 is the treatment that more strongly differs from the other treatments. More in detail, the results of the models indicate that there seems to be no difference in the expected wine CF between Card 1 and Card 2. This suggests that just adding information about the CF of the wine does not affect wine choices. However, it needs to be specified, that the absence of a statistically significant different effect between these two cards could be related to power issues, given the limited sample size. Instead, the model shows a reduction in the expected CF of Card 3 with respect to those of Card 1 and Card 2. This highlights the existence of a price effect. Indeed, even if price differences among cards are quite limited, these differences seem to be enough to impact wine choices towards lower-emitting, and thus cheaper, wines.

The expected CF of Card 3 also differs from that of Card 4. Indeed, specifying that the additional price is related to the CF of a bottle tends to increase the CF of the chosen bottles. Indeed, the dummy shows a positive and significant coefficient compared to that of Card 3. This indicates that when consumers are presented with information about a price increase representing the CF, they tend to choose higher-emitting wines. While the reason behind this result is unclear, it is possible that the customers are doing this knowing perhaps that they are paying for their emissions. However, it is also possible that this behaviour is due to a mere limited understanding of how the carbon contribution works and the mistaken evaluation that a higher contribution is associated with a more sustainable choice.

VARIABLES	Model 1a (CF)	Model 1b (CF)	Model 1c (CF)
d_card1	0.049	0.058	0.092*
	(0.048)	(0.048)	(0.052)
d_card2	0.077	0.080	0.094*
	(0.048)	(0.049)	(0.049)
d_card4	0.125***	0.150***	0.152***
	(0.047)	(0.047)	(0.048)
d_Temp_21-29		-0.030	-0.019
		(0.044)	(0.045)
d_Temp_30		-0.052	-0.039
		(0.052)	(0.050)
d_Rain		-0.099**	-0.107**
		(0.047)	(0.048)
d_Weekend		0.089**	0.116***
		(0.040)	(0.040)
d_May-June		-0.036	-0.034
		(0.039)	(0.040)
d_Couple			-0.055
			(0.083)
d_Family			-0.090
			(0.086)
d_Friends			0.028
			(0.089)
d_Local			-0.088
			(0.060)
d_Wine_info			0.104**
			(0.048)
d_CF_info			0.032
			(0.042)
d_Collective			-0.129**
			(0.064)
d_bott>1			-0.026
			(0.055)
Constant	1.046***	1.069***	1.137***
	(0.031)	(0.049)	(0.095)
Observations	200	200	200

R-squared	0.033	0.076	0.150

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5. Model 1 results: OLS regression on bottle CF.

Focusing on the control variables (Table 5), wine choices and their CFs seem to be impacted by weather conditions (rain) and by whether the dining occasion took place on a weekday or on a weekend.
An interesting effect that seems to emerge is that when the choice is made collectively by the customers at a table, the CF tends to be reduced. This might indicate the existence of some form of social pressure directed at promoting more environmentally sustainable choices. On the other hand, customers who asked for specific information about the wines (not regarding their carbon content) are associated with a higher wine CF, possibly indicating that for wine-engaged people, other wine attributes are more important than the CF.

To test for multicollinearity issues, we calculated the variance inflation factor (VIF). This factor did not indicate any strong issues, as the mean value was 2.10, and single values ranged from 1.15 to 5.01, with higher values associated with party type variables. Values remained lower than 10, which is commonly considered the rule of thumb indicator of multicollinearity issues (Hair et al., 1995).
Moreover, to ensure that the actual experimental conditions emerging from the randomization of the wine cards generated balance across the treatments, we performed Fisher's exact test to test the independence between treatments/cards and the covariates. The results are reported in Table 6. What emerges is that in general, the experimental conditions were quite homogeneous across cards. Some heterogeneity in conditions emerges for the variables related to rain and weekend days. However, this is not worrisome given that the variables are already significant in the regression results (Table 4). For the specifications of the models in which some card variables are not significant (Table 5), we tested a model excluding the rain dummy to test if this was masking the effect of the card dummy, finding that this was not the case.

Variables	p-value of Fisher exact test vs. card	
d_Temp_21-29	0.434	
d_Temp_30	0.514	
d_Rain	0.001	***
d_Weekend	0.262	
d_May-June	0.063	*
d_Couple	0.627	
d_Family	0.926	
d_Friends	0.225	
d_Local	0.525	

*** p<0.01, ** p<0.05, * p<0.1

Table 6. Independence tests between policy interventions and context and table-related variables

To further test the effect of the cards on wine choices, we also investigated how preferences moved from different types of wine as the implemented card changed. Table 7 reports the coefficients and standard errors estimated using a multinomial logit model (Model 2). We use a specification that includes policy/card variables, context variables (G.3) and table characteristics (G.1 and G.2). The baseline product is Gavi (0.831 kg $CO_{2\text{-eq}}$/bottle), which is the wine with the lowest CF among the wine list used for the experiment. In the table, the other four wines are ranked by increasing bottle CO_{2-eq} content.

VARIABLES	Pinot Grigio	Soave	Morabianca	Sghiras
Bottle CF ($kgC0_{2-eq}$)	*0.884 kg*	*1,080 kg*	*1,381 kg*	*1,544 kg*
d_card1	0.794	0.949	1.458	3.509**
	(0.881)	(0.910)	(1.009)	(1.511)
d_card2	1.364	1.470*	1.881**	4.879***
	(0.833)	(0.868)	(0.898)	(1.501)
d_card4	0.102	0.520	2.045***	4.149***
	(0.780)	(0.782)	(0.790)	(1.471)
d_Temp_21-29	-0.614	0.746	-0.326	-1.294
	(0.733)	(0.790)	(0.791)	(1.008)
d_Temp_30	-1.411	-0.582	-0.307	-19.072
	(0.886)	(0.945)	(0.932)	(510.026)
d_Rain	-0.121	-0.340	-1.971**	-2.711**
	(0.781)	(0.854)	(0.934)	(1.360)
d_Weekend	-0.990	-0.534	-0.349	3.145***
	(0.614)	(0.620)	(0.655)	(1.100)
d_May-June	-1.318*	-0.998	-0.855	-2.139**
	(0.675)	(0.701)	(0.706)	(0.985)
d_Couple	0.314	1.194	-0.599	0.267
	(1.205)	(1.436)	(1.160)	(1.388)
d_Family	0.801	0.902	-0.618	-0.786
	(1.234)	(1.479)	(1.230)	(1.577)
d_Friends	0.192	-0.400	0.454	1.248
	(1.246)	(1.542)	(1.201)	(1.446)
d_Local	0.577	0.412	-0.138	-1.902*
	(0.905)	(0.996)	(0.841)	(1.150)
d_Wine_info	-0.662	-1.188	0.764	1.259
	(0.727)	(0.786)	(0.722)	(1.189)
d_CF_info	0.014	0.679	0.701	-0.177
	(0.719)	(0.743)	(0.747)	(1.073)
d_Collective	0.491	-0.396	-1.029	-2.223*
	(0.864)	(0.950)	(0.888)	(1.287)
d_bott>1	-0.734	-0.232	-0.925	0.451
	(0.824)	(0.911)	(0.831)	(1.194)
Constant	1.566	-0.378	0.714	-1.059
	(1.576)	(1.809)	(1.587)	(2.090)
Observations	200	200	200	200
Chi-square P-value	0.000			
Pseudo R2	0.200			

Baseline outcome: Gavi. This is the wine that has the lowest CF of our wine list.
Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 7. Model 2 results: Multinomial Logit Model on wine choice.

The results seem to confirm the fact that the price increase on Card 3 generates a shift from wines with a higher carbon content (such as Sghiras and Morabianca) to wines with a lower carbon content (such as Gavi) compared to the other cards. More specifically, Card 3 generates a decrease in the log odds of choosing one of the wines with the highest CF vs. choosing Gavi.

As found in Model 1, Card 4 tends to be associated with an increase in the choice of higher-emitting wines compared to Card 3. In this case, the log odds of choosing either Morabianca or Sghiras (the two wines with the highest-emitting production processes from our list) vs. choosing Gavi are higher.

5.3 Effects of policy interventions on wine-related carbon footprint

Given our experimental design, the results discussed above can be interpreted also in terms of a single policy intervention effect. This is useful when trying to provide some policy implications.

Indeed, the effects of the tested policy interventions can be easily evaluated by comparing the coefficients in Eq. 1. Table 8 shows the coefficient estimates associated with the effects of the singularly isolated different policy interventions.

Policy intervention effect from card effect		
CF label	= Card 2 - Card 1	0.002
CF price	= Card 3 - Card 2	-0.094*
CF out-price	= Card 4 - Card 3	0.152***

*** p<0.01, ** p<0.05, * p<0.1

Table 8. From card/treatment to policy effect, considering model 1c.

The results indicate that adding only information about the CF on wine cards does not seem to be enough to impact the choices of bottles with different levels of carbon content. Indeed, there seems to be no evidence of an effect of the dummy CF label with a change in the table wine-related CF, at least given our sample size. Instead, an increase in price proportional to the bottle CF seems to have an effect on choices. Indeed, in these scenarios, the CF of the chosen wine tends to decrease. More specifically, our results suggest that an increase in price proportional to the CF of the wine is associated with wine choices that have lower levels of emissions. Specifically, the price increase is associated with an average reduction of approximately 0.1 kg of $CO_{2\text{-eq}}$ emitted per purchased wine bottle.

However, when the carbon-related expenditure is made explicit (CF out-price), there is an increase in the wine CF compared to that when the contribution is implicitly included in the final price of the wine.

6 Discussion

The results do not show evidence that providing information on the carbon emissions of wine bottles affects customer wine choices, and therefore, this information has no significant impact on CO_2 emissions (RQ1). Although the empirical literature concerning wine is scarce, these results do not confirm the findings highlighting a positive WTP or consumer preference for lower carbon-emitting wines or, more generally, for wines having sustainability attributes. This could be related to the sample size that could raise power issues in detecting small effects. At the same time, this finding could be related to two novel elements that the paper introduced: the natural field experiment setting and the relative assessment of CF within the wine category.

As underlined in section 2, previous studies on wine labels and information provision were generally based on stated preferences. Even in the few cases where non-hypothetical studies have been conducted (e.g., Vecchio, 2013, Li et al., 2018), the setting was artificial, with participants being aware that a study was going on. List and Levitt (2007) provide a set of arguments underlying the difficulty of generalising the results of laboratory experiments to real-world situations: the awareness of people being scrutinized and the focus on the decision process might alter the way participants behave. In particular, when talking about sustainability attributes, it is likely that participants tend to behave in a socially desirable way, overreacting to these stimuli compared to their behaviour in a natural field experiment. The small effects found in the few carbon studies in restaurants (Brunner et al., 2018; Spaargaren et al., 2013) seem to support this argument. In addition to social desirability bias, there is also the possibility of the existence of experimenter demand effects in studies that are not conducted as a natural experiment.

In the present study, the assessment of CF information is conducted within the labelled wine alternatives (i.e., the level of CO_2 emissions is declared for each wine bottle). This approach is different from other studies that assessed the effect of a carbon label or logo on consumer choices compared to conventional wines. The presence/absence of a logo is likely to show higher responses, especially when presented with visual elements in an easy-to-interpret way. Vlaeminck et al. (2014) used a framed field experiment in a supermarket to show how simple coloured logos providing comprehensive information on environmental sustainability aspects are more effective than complex pieces of information embedded in a logo. This is consistent with the findings of Babakhani et al. (2020), who used eye-tracking techniques to show how little attention is paid to carbon labels in restaurant menus: only 5% of time is spent looking at the label, it is not continually looked at, and it is not looked at first. It is possible that the effectiveness of labels could be improved using a scale in the form of a traffic light (Sharp and Wheeler, 2013). However, we discarded this option, as it would require a normalization process or a scale of reference to be meaningful to consumers (Upham et al., 2011). It is also a challenging issue to define a wine as a "green", "yellow", or "red" carbon emitter, as there is no ideal term of reference. This is different, for example, from health studies where nutritional information can be normalized using dietary guidelines. To our knowledge, Brunner et al. (2018) presents the only field experiment where symbolic CO_2 information was used combined with numeric information to compare a broad range of food products in a restaurant menu. However, even in this case, the thresholds for the choice of colours remained arbitrary.

Imposing a carbon content-related increase in price (RQ2), when controlling for context and table-related variables, seems to induce a choice of wine with a lower CF. This is consistent with the findings by Briggs et al. (2016) and Edjabou and Smed (2013). However, what seems to emerge from our experiment is that when Card 4 is used, CO_2 emissions tend to increase, i.e., consumers tend to choose higher-emitting wines. Card 4 explicitly provides information about the CO_2 emissions and the additional monetary amount for the carbon emissions for each wine bottle. This is an unexpected outcome that could be associated with two possible explanations. On the one hand, this result could be due to the fact that consumers, being informed about the "ecological contribution", felt entitled to order the more impactful wines since they were "paying for emitting more CO_2". This is akin to people not reducing travel via air by offsetting or paying for the CF of their flights. This would suggest advanced environmental economics reasoning by consumers and a preference for a weak sustainability approach. On the other hand, this result could also be due to consumers thinking that they were "helping the environment" by spending more money with a higher CO_2 contribution. This would instead suggest that clients did not fully understand the issue at stake, i.e., that choosing a wine with a higher monetary contribution for the environment was associated with a more impactful behaviour. Given that these results were obtained from a natural field experiment where consumers did not know that their choices were being observed, we cannot disentangle the two explanations. Further research could be directed at trying to shed further light on this.

The results suggest that the most effective way to move towards lower carbon-emitting choices (RQ3) is the use of a price intervention. However, the way in which information is associated with the price intervention is still relevant. It is important to be careful about how the information is delivered to consumers to avoid misunderstandings or misinterpretations when they read the wine lists. The literature has already discussed how the lack of knowledge of consumers about the CF concept limits its success in the food sector (Feucht and Zander, 2018; Hartikainen et al., 2014) and that labels are subject to misinterpretations (Gadema and Oglethorpe, 2011) and would need a substantial amount of supporting information to become meaningful (Upham et al., 2011). However, it seems intuitive for consumers to equate higher carbon emissions with being worse for the environment than lower emission values (Upham et al., 2010). Therefore, the problem of misinterpretation might be an attention issue. According to Babakhani et al. (2020), this situation is worsened in the context of a restaurant where the physical product is not observable compared to a supermarket. This aspect increases the client's search for information or cues signalling the properties of the final product, with an increase in the cognitive burden, thus leading to selective attention and to the adoption of shortcuts in the customer's decision process. Given the large amount of information in a menu, this might limit the attention on carbon labels and their meaning (Babakhani et al., 2020). Customers might simply notice the higher monetary contribution for the environment and opt for that choice assuming they were helping the environment. Supporting information at the point of purchase in the form of displays, fact sheets, etc., could reinforce the understanding and effectiveness of carbon labels (Emberger-Klein and Menrad, 2018; Visschers and Siegrist, 2015; Spaargaren et al., 2013). However, in normal business activities, it is unlikely that restaurants will adopt or persist in such specific communication campaigns. For this reason, in the actual experimental design, no additional information was provided to the customers unless explicitly asked.

7 Conclusions

The aim of this paper was to investigate possible consumer responses to potential carbon-related policies for wine bottles, focusing on both information policies and price policies. The choice of setting analysed in the study is restaurant dining, with the choice of wine bottles. Wine bottles were specifically selected from sustainable certified wines where information about the CF was known and publicly available. Four wine cards were designed, ranging from a card where only wine bottle names and producers were indicated to other cards where the amount of CO_2 emissions of the bottle and, in some cases, a price rise related to the carbon content (resembling a carbon tax) were included. The results suggest that information on the CO_2 content has no significant impact when provided as stand-alone information. However, when this is associated with a price increase, our results suggest that it could help customers focus their attention on carbon emissions. Indeed, price increases are associated with choices characterised by a lower CF. However, when a contribution to offset carbon emissions is made explicitly visible to consumers, we find an opposite effect of an increase in the choice of wines with higher-emitting production processes.

The conducted study has different elements of novelty that relate to the types of policies analysed, the place in which the study was conducted, and the type of experiment implemented. To the best of our knowledge, this study is among the first attempts to assess real consumer choices in relation to the introduction of a potential carbon-related tax on food products. Additionally, no other studies have assessed environmentally friendly consumer behaviour by simultaneously considering different policy instruments for reductions in carbon emissions. Moreover, many past studies conducted their experiments on CO_2 labels in cafeterias or restaurants within university campuses (e.g., Brunner et al., 2018; Visschers and Siegrist, 2015; Spaargaren et al., 2013), which can elicit sample selection bias or non-representative samples (Harrison and List, 2004). Our study also has its own selection issues but we attempted to reduce this problem by selecting a full-service, sit-down restaurant where consumers had time to evaluate the information presented in the menu and to participate in the decision process. Moreover, most of the existing literature used hypothetical approaches to study consumer choices of sustainable food products. The present paper is one of the few attempts to use a natural field experiment to study consumer choices of eco-labelled food products. Such an approach can reveal real purchase behaviour.

The findings suggest different policy implications. Taxing carbon emissions seems to stimulate less carbon-intensive consumer wine choices. However, caution has to be taken in generalising recommendations for such a policy intervention in the agri-food system because of its potential regressivity. Moreover, a policy of this type could imply negative substitution effects in terms of environmentally friendly choices of food products. For example, a carbon tax on food might reduce the consumption of a high-emitting product, but consumers might substitute it with other high-emitting food categories, with a net effect that might be the opposite of the desired one. As a consequence, such policy interventions could be preferred for those products, such as wine, that do not show a high potential for substitution.

Furthermore, the results associated with the out-of-price ecological contribution (Card 4) probably reveal a difficulty for consumers to process information about carbon emissions and environmental economics due to their lack of knowledge about such topics. Investments in educational instruments aimed at improving consumer knowledge and awareness towards carbon emissions and their implications for the planet and about the impacts of different sets of policies could help to guide consumers towards more sustainable food choices. These investments could start with restaurant managers and operators who are directly involved in wine assortment/menu decisions and have a high potential to transfer this knowledge to their clients in everyday service.

The present study has limitations. First, it was conducted using a single restaurant located in a specific geographical area. Therefore, caution should be placed when generalizing these results to other restaurant formats and regions. Moreover, given that we collected real purchase data and not hypothetical data, the sample size is limited, and this might induce some power issues. Thus, non-significant relations may depend on this and we cannot exclude the emergence of a relation in larger samples. However, this also strengthens the relevance of the statistically significant relations found. Second, a comprehensive and long-term evaluation of information provision and price effects would require the assessment of more general equilibrium effects (Ellison et al., 2014). Customers might choose a different menu or a different restaurant in which to dine, but restaurants might also change their wine assortment strategies. Therefore, the impact of carbon policies cannot leave aside considerations concerning the supply side and, more generally, the interaction with the upstream value chain. On the educational side, the use of new labels or the provision of new information on menus can progressively increase awareness about the topic and create new knowledge that could lead to better effectiveness of future information provision and policy instruments. Once gained, this awareness could also generate spillover effects in other sectors over and above wine choices. Third, the adoption of a natural field experimental approach did not provide us with the possibility to infer the motivations that led consumers to make certain choices because we cannot assess variables that can potentially help explain sustainable consumer behaviour, such as knowledge, attitudes, and beliefs, in more depth. Additionally, the anonymous treatment of data did not allow us to collect participants' contact information and conduct ex post interviews.

Future studies could test the external validity of the present findings by replicating the experiment in different contextual situations, such as bars or fast-food restaurants or in alternative geographical locations and cultures. Moreover, further research is needed to test whether the present results can also be confirmed in the long run to test whether the environmental commitment of the restaurant is really appreciated by consumers. Improvements in the experimental setting presented in this case could include careful monitoring of the overall sales of the restaurant, the sales of the fixed menu, and the demographic composition of customers before and after the experimental phase. Finally, future studies could focus on confirming and providing an understanding of the reasons behind the diverging responses to price stimuli provided in this paper as well as on a comparison of different types of carbon emission information provision with price-related interventions.

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Appendix

Figure A.1: Wine Card types (*Card 1-4*)

BUSATTO ristorante

Principi di Porcia	
Pinot Grigio Castello di Porcia DOC	10 €
La Cedraia	
Gavi DOCG	10 €
Cantina di Soave	
Soave Classico Rocca Sveva	10 €
Fattoria Le Sorgenti	
Sghiras Toscana Bianco IGT	10 €
Mastroberardino	
Morabianca	10 €

Card 1: Baseline- wine type+ baseline price

BUSATTO ristorante

	Emissione di CO2	
Principi di Porcia		
Pinot Grigio Castello di Porcia DOC	0,884kg	10 €
La Cedraia		
Gavi DOCG	0,831kg	10 €
Cantina di Soave		
Soave Classico Rocca Sveva	1,080kg	10 €
Fattoria Le Sorgenti		
Sghiras Toscana Bianco IGT	1,550kg	10 €
Mastroberardino		
Morabianca	1,381kg	10 €

Card 2: wine type $+CO_2$ emission+ baseline price

BUSATTO ristorante

	Emissione di CO2	
Principi di Porcia		
Pinot Grigio Castello di Porcia DOC	0,884kg	10,44€
La Cedraia		
Gavi DOCG	0,831kg	10,42€
Cantina di Soave		
Soave Classico Rocca Sveva	1,080kg	10,54€
Fattoria Le Sorgenti		
Sghiras Toscana Bianco IGT	1,550kg	10,78€
Mastroberardino		
Morabianca	1,381kg	10,69€

Card 3: wine type+ CO_2 emission+ taxed price

BUSATTO ristorante

	Emissione di CO2	Prezzo del vino	Contributo ecologico	Prezzo finale
Principi di Porcia				
Pinot Grigio Castello di Porcia DOC	0,884kg	10 €	0,44€	10,44€
La Cedraia				
Gavi DOCG	0,831kg	10 €	0,42€	10,42€
Cantina di Soave				
Soave Classico Rocca Sveva	1,080kg	10 €	0,54€	10,54€
Fattoria Le Sorgenti				
Sghiras Toscana Bianco IGT	1,550kg	10 €	0,78€	10,78€
Mastroberardino				
Morabianca	1,381kg	10 €	0,69€	10,69€

Card 4: wine type+CO_2 emission+ CO_2 contribution+ taxed price

Table A1. Contingency tables testing the association between wine choices and context or table characteristics variables

Wine	*Temperature*		
	<20°C	21-29°C	>30°C
Gavi	11.1%	10.3%	12.0%
Pinot grigio	40.3%	25.6%	28.0%
Soave	13.9%	33.3%	24.0%
Morabianca	18.0%	21.8%	36.0%
Sghiras	17.7%	9.0%	0.0%

Fisher's exact test: p = 0.003

Wine	*Local customers*	
	no	yes
Gavi	12.0%	10.9%
Pinot grigio	20.0%	33.1%
Soave	12.0%	25.7%
Morabianca	40.0%	21.7%
Sghiras	16.0%	8.6%

Fisher's exact test: p = 0.107

Wine	*Rain*	
	no	yes
Gavi	10.7%	12.2%
Pinot grigio	28.3%	43.9%
Soave	25.8%	17.1%
Morabianca	27.0%	12.2%
Sghiras	8.2%	14.6%

Fisher's exact test: p = 0.081

Wine	*Wine information request*	
	no	yes
Gavi	10.0%	13.3%
Pinot grigio	33.6%	26.7%
Soave	28.6%	13.3%
Morabianca	18.5%	36.7%
Sghiras	9.3%	10.0%

Fisher's exact test: p = 0.027

Wine	*Type of day*	
	weekday	weekend
Gavi	9.6%	13.9%
Pinot grigio	36.3%	21.5%
Soave	23.7%	24.6%
Morabianca	25.9%	20.0%
Sghiras	4.5%	20.0%

Fisher's exact test: p = 0.005

Wine	*CF information request*	
	no	yes
Gavi	11.6%	10.5%
Pinot grigio	33.7%	29.5%
Soave	21.0%	26.7%
Morabianca	20.0%	27.6%
Sghiras	13.7%	5.7%

Fisher's exact test: p = 0.242

Wine	*Month*	
	May-June	July-September
Gavi	14.7%	7.6%
Pinot grigio	28.4%	34.3%
Soave	23.2%	24.7%
Morabianca	23.2%	24.8%
Sghiras	10.5%	8.6%

Fisher's exact test: p = 0.538

Wine	*Collective*	
	no	yes
Gavi	10.7%	12.5%
Pinot grigio	30.4%	37.5%
Soave	25.6%	15.6%
Morabianca	23.2%	28.1%
Sghiras	10.1%	6.3%

Fisher's exact test: p = 0.695

Wine	*Couple*	
	no	yes
Gavi	12.4%	9.7%
Pinot grigio	33.0%	30.1%
Soave	16.5%	31.1%
Morabianca	27.8%	20.4%
Sghiras	10.3%	8.7%

Fisher's exact test: p = 0.185

Wine	*Bottle number*	
	1	2+
Gavi	9.1%	17.0%
Pinot grigio	32.7%	27.7%
Soave	26.8%	27.7%
Morabianca	22.9%	12.7%
Sghiras	8.5%	14.9%

Fisher's exact test: p = 0.223

Wine	*Party type*		
	Family	Friends	Other
Gavi	10.0%	13.7%	10.3%
Pinot grigio	40.0%	31.8%	28.5%
Soave	27.5%	9.1%	28.4%
Morabianca	17.5%	31.8%	23.3%
Sghiras	5.0%	13.6%	9.5%

Fisher's exact test: p = 0.191