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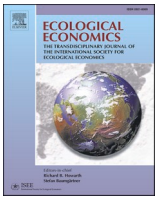

Encouraging sustainable food consumption through nudges: An experiment with menu labels

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ABSTRACT

Finding ways to steer consumers' food choices towards vegetarian and plant-based meals is important to reduce our diets' environmental impact. This paper investigates how nudges in restaurants can be effectively used to increase sales of vegetarian and plant-based dishes. We partnered with two restaurants, which can host up to 130 guests in total and are in the same building, and we tested the effect of three nudge-based interventions on the sales of vegetarian and plant-based dishes. We found that removing the symbols for vegetarian and plant-based dishes increased the sales of those starters by 10.2 pp., and of those mains by 6.2 pp. When a low emissions symbol was added to the menu to replace the symbols for vegetarian and plant-based dishes, it did not affect sales. However, when the same nudge was made transparent through a statement explaining its purpose on the menu, the sales of those starters increased by 14.1 pp. This result suggests that nudges can be used ethically and still be effective. Overall, these findings support the use of nudges as cost-effective interventions to tackle the issue of unsustainable food consumption in the hospitality sector.

1. Overview

In recent years, research on sustainable food consumption has focused on understanding which kind of diet has the least impact on the environment. Many studies have found that reducing our consumption of meat products, and eating vegetarian or plant-based more often, can help reduce our diet's footprint. The present research investigates ways to encourage consumers to make this change in a real-world setting.

We delivered an intervention aimed at testing the effect of different labels applied to a restaurant's menu on the sales of their vegetarian and plant-based dishes. Additionally, we compared the impact of the same nudge when hidden and when made transparent. Two similar restaurants in London partnered with us on this research: One restaurant was used for our interventions, and the other one acted as a control. Alterations were made, and nudges in the form of labels were applied, to the treated restaurant's menu. Firstly, the symbols "v" and "pb", which respectively indicated a vegetarian and a plant-based dish, were removed from the menu. Secondly, the symbol "LE", which stood for "Low Emissions", was placed next to vegetarian and plant-based dishes, replacing the old "v" and "pb" labels. The meaning of the labels "v", "pb", and "LE" was explained with simple statements such as "LE: Low Emissions" at the bottom of the menu. Thirdly, a disclosure of the latter nudge's purpose was added to the menu, making it transparent to the consumers. We found that removing the vegetarian and plant-based symbols from the menu increased sales of both starters and mains in those categories (by 10.2 pp. and 6.2 pp. respectively). Additionally, the transparent version of the low-emission nudge successfully increased sales of the recommended starters (by 14.1 pp).

This study is innovative in three ways. Firstly, it supports, in a real-world setting rather than through an online experiment, the finding that labelling vegetarian and plant-based dishes as such is detrimental for the sales of those dishes. Secondly, we found that making a nudge transparent can increase its efficacy rather than decreasing it. In the current experiment, when the symbol "LE" was first added to the menu with a simple explanation about its meaning, it did not have an impact on sales. However, when a transparency statement was added to the menu to explain the purpose of the nudge, sales of vegetarian and plant-based starters increased. This is an important result which shows that nudges can be used effectively whilst making consumers aware that they are being nudged, thus addressing the ethical issues concerning these interventions. Thirdly, this experiment was run with a counterfactual despite being a real-world study. We collaborated with two similar

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restaurants, where one received the treatments, and the other provided us with sales data from the same time frame. Overall, our findings provide cost-effective recommendations for the hospitality sector on how to increase sales of the more environmentally friendly dishes.

2. Literature review

2.1. Environmentally friendly diets

Sustainable development can be thought of as having three dimensions: economic, environmental, and social (United Nations, n.d.). The focus of this work will be on the environmental one of food production and consumption.

The food system is responsible for about a third (34%) of total greenhouse gas emissions (Crippa et al., 2021). The environmental impact of food items can be evaluated across different metrics (carbon footprint, water use or scarcity-weighted water use, eutrophication, and land use) and with reference to either 1 kg, 100 g of protein, or 1000 kcal. As an example, we will be using 1000 kcal as a reference, and we will make comparisons between some of the foods with greater impact and some of those with smaller impact. Beef (beef herd) has the highest impact in terms of greenhouse gas emissions, and requires the most land. On the other hand, farmed prawns require the most amount of freshwater, and have the greatest impact on water eutrophication. Eating less meat, fish and cheese can help reduce one's diet's environmental footprint. These foods may be replaced with vegetables-based meals, together with legumes and whole grains (Behavioural Insights Team, 2020), as growing vegetables produces much lower GHG emissions, requires less water and land, and has a much smaller impact on water eutrophication. Fruits can also be consumed more: For example, apples, bananas, berries and grapes account for much lower GHG emissions per 1000 kcal than meat and fish (Richie et al., 2022).

Chai et al. (2019) conducted a systematic review of vegan, vegetarian and omnivorous diets, analysing their impact on the environment in terms of greenhouse gas emissions, land use, and water footprint. They came to the general result that the more plant-based a diet is, the lower these three impacts are. Takacs et al. (2022) assessed the environmental impact (global warming, freshwater eutrophication, terrestrial acidification, and water depletion potential) of 13 meals belonging to different cuisines. They found that the plant-based version of these meals was more environmentally friendly in terms of all the criteria compared to the vegetarian and meat-based versions of the dishes. In particular, the meat-based meal had 14 times higher environmental impact than the plant-based meal, whereas the vegetarian version had 3 times higher environmental impact. Similarly, the Planetary Health Diet by the EAT-Lancet Commission recommends a "plant-forward diet" that is healthy for both people and the planet, and where meat and dairy make up a smaller proportion of what we should eat than whole grains, fruits, vegetables, nuts and legumes (EAT, n.d.).

2.2. Policies and nudges

Given the negative impact that eating meat and animal-derived products can have on the environment, it is important to understand how diets may be changed.

The introduction of taxes and subsidies to tackle unsustainable food consumption could present both benefits and drawbacks. If a single country was to impose a tax on emissions on the production side, it may put local producers at a competitive disadvantage, with production increasing in exporting countries, thus obtaining the opposite result: an increase in GHG emissions (Abadie et al., 2016). Introducing a tax on the consumption side of €60 per ton of CO_2e, for example, could reduce greenhouse gas emissions by 7% in the EU27 (Wirsenius et al., 2011). A target of a 10% reduction of 10% reduction in emissions could be achieved through a set of taxes and subsidies in Norway, such as 40% tax on ruminants and a 40% subsidy on fish (Abadie et al., 2016).

On the other hand, there is a chance that a tax on red meat may lead to a suboptimal use of land resources and a foregone opportunity to occupy non-fertile soils and produce essential nutrients (Lee et al., 2021), therefore affecting food security (Golub et al., 2013). In fact, the livestock industry provides livelihoods for 1.3 billion people (FAO, n.d.). However, some argue that the health benefits from reductions in obesity that would come from these taxes would outweigh the health losses from increased people being underweight (Springmann et al., 2017). A fine balanced between optimal levels of nutrition, rural economy and climate change mitigation should be sought (Lee et al., 2021).

As an alternative to policies, behavioural interventions have often been successful at steering people's choices towards the greener alternative. A useful tool used in behavioural interventions is a nudge. As defined by Thaler and Sunstein (2008, p. 8), it is "any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid. Nudges are not mandates. Putting fruit at eye level counts as a nudge. Banning junk food does not."

Nudges have been used successfully in various contexts, such as to increase vaccination rates (Milkman et al., 2011). In the context of food consumption, healthier food choices were successfully encouraged by increasing their visibility and accessibility (Wansink and Hanks, 2013). In the context of sustainable food consumption, nudges may provide a useful tool to achieve a reduction in meat consumption, and lead to an increase in consumption of vegetarian and plant-based dishes.

As argued by Ammann et al. (2023), although market-based and regulatory interventions are more effective, they are also more intrusive instruments. On the other hand, information-based interventions and nudges are less intrusive, more widespread, more likely to be well-received by the public, and can be combined with each other. Mertens et al. (2022) found that choice architecture interventions, on average, promote behaviour change with a small to medium effect. Additionally, such interventions seem to be particularly effective on impacting food choices, delivering effects up to 2.5 times larger than in other contexts.

Although most studies will deliver the desired outcomes, about 15% of nudging interventions are likely to backfire, meaning the desired behaviour is either reduced or reversed (Mertens et al., 2022). For example, text message reminders to encourage people to save actually discouraged those who set high saving goals (Andrieş and Walker, 2023).

2.3. The argument for transparent nudges

Despite their effectiveness, nudges are sometimes criticised for being unethical: Some see them as manipulative, threatening people's freedom of choice, and paternalistic, pushing others to choose the option preferred by the nudger (Michaelsen et al., 2021).

Lemken (2021) defines six characteristics which can be used to make an ethical assessment of an intervention: the initial state of the choice architecture; the invasiveness of the nudge, the psychological mechanism it relies on; the visibility of the decision; whether it is the same for everyone or is individually customized; and the disclosure of the intent behind the intervention.

Some argue that nudges could be made more transparent through the disclosure of the intent, but there are two factors to consider: One, their covert nature may be what makes nudges effective (Bovens, 2009); and two, letting people know that they are being "nudged" may lead to psychological reactance (Brunner et al., 2018). Psychological reactance refers to a state of distress, anxiety and resistance that follows the loss of or perceived threat of loss of behavioural freedom, whereby the individual will try to regain that freedom (Brehm, 1966). Psychological reactance may make the nudge ineffective, or even produce the opposite effect whereby people refuse to make the recommended choice even though they would have been happy to do that had there not been a behavioural intervention in place (Arad and Rubinstein, 2018).

However, no evidence has been found that making a nudge transparent has a negative impact on the effect of the nudge (Kroese et al., 2016; Loewenstein et al., 2015; Steffel et al., 2016, Brunner et al., 2018). For example, Brunner et al. (2018) found that neither disclosing the possible influence of a default nudge on decision-making nor its purpose negatively affected contributions to climate protection. Moreover, transparency does not seem to create psychological reactance (Brunner et al., 2018) or to affect the experiences of autonomy and choice satisfaction (Wachner et al., 2020).

2.4. How nudges can drive sustainable choices

According to Münscher et al. (2016), choice architecture interventions can be classified into three categories: decision information, decision structure, and decision assistance. Decision information nudges are those that translate information, make information visible, or provide a reference point. Decision structure nudges may change the default option, the effort to pursue the desired action, the composition of the available options, or the consequences of choosing the desired action. Decision assistance nudges may work as reminders or to facilitate commitment (Ytreberg et al., 2023).

Different nudges belonging to each of these categories have been trialled in the general context of influencing green behaviours. For example, a decision information nudge was applied to a restaurant menu to encourage the consumption of a veal dish. It was found that neither providing information on animal welfare nor on the organic quality of the product significantly affected its sales (Schjøll and Alfnes, 2017). On the other hand, a decision structure nudge which made the purchasing choice of the participant public increased willingness-to-pay for the organic alternative by 90% (Kim et al., 2018). Finally, combining exposure to an advertisement with a prediction request was successful at increasing consumers' preference for environmentally friendly cleaning products (Bodur et al., 2015).

In the specific context of influencing pro-environmental eating behaviour, different labels and graphics have been tested as decision information nudges. For example, a traffic-light coloured label was instrumental in changing students' eating decisions at a university restaurant: Sales of green labelled meat dishes (indicating low greenhouse gas emissions) increased by 11.5%, whereas sales of red labelled meat dishes decreased by 4.8% (Brunner et al., 2018). In a workplace lunch restaurant in Finland, nudging reduced meat consumption of those people who were already looking to switch to more plant-based and fish-based eating. Moreover, customers appreciated vegetarian dishes which were familiar to the Finnish culinary culture, and the use of sustainably sourced fish. Meanwhile, the climate label was seen as a restriction to the menu by some (Kaljonen et al., 2020).

The use of the label “vegetarian”, or “v” for short, next to dish names in menus is a controversial issue. It could be argued that labelling dishes as “vegetarian”, or segregating vegetarian dishes from the rest, reinforces the idea that they are different (Behavioural Insights Team, 2020). In fact, vegetarians are a minority group and their behaviour may be seen as “deviant” from the norm (Romo and Donovan-Kicken, 2012). In practice, previous research found that it either had a negative impact on sales of vegetarian dishes (Bacon and Krpan, 2018) or had no significant effect on consumer choice (Parkin and Attwood, 2022). Some argue that any alternative framing to “vegetarian” is better than “vegetarian” itself: Krpan and Houtsma (2020) found that a pro-environmental label (“Environmentally friendly main course for a happy planet”), a social label (“Refreshing main courses for relaxing conversations”), and a neutral frame (no distinction between vegetarian and non-vegetarian dishes) all led to the vegetarian choice being selected more compared to when it was described as vegetarian. However, all three studies were conducted online, with participants being asked to make hypothetical choices from a mock menu. One study set in a living laboratory found that promoting vegetable-rich dishes as “dish of the day” can make them more popular compared to the neutral frame without affecting consumer satisfaction (Saulais et al., 2019). However, this research did not test the dishes' popularity when signposted as vegetarian.

The way a dish is described or offered can also have an impact on consumers' choices. When meat-related labels were used to describe vegetarian dishes (e.g. “cauliflower steak” instead of “cauliflower slice”) in an online study, consumers reported higher willingness to eat those dishes, and reported to perceive them as more filling and containing more protein (Marshall et al., 2022). In another study, the likelihood of picking a vegetarian dish increased when participants were given the option of adding meat to the dish (De Vaan et al., 2019). This could be seen as an example of a default nudge, that is a decision structure nudge, being successful. A real-world restaurant study investigated what could influence customers to pick either the richest or the lightest version of the same dessert. It was found that a dessert would get chosen more frequently when it was presented as the default option, irrespectively of whether it was the richest or lightest version (Bergeron et al., 2019). This result suggests a strong status quo bias, and the efficacy of default framing as a nudge.

Other visual nudges such as signs and posters have also been shown to be effective. Signs placed in grocery carts successfully increased the sales of fruits and vegetables in supermarkets in New Mexico, U.S.A, and Denmark (Payne et al., 2015; Bauer et al., 2022). These studies relied on the concepts of salience, social norms, and simplification: The posters were attention-grabbing and strategically placed so that they would be easy to see; They informed customers of other clients' consumption of fruits and vegetables; They simplified customers' decision-making by suggesting recipes to make with fruits and vegetables. Similarly, letting customers know that asking for a doggy bag to take their leftovers home is common, and therefore socially acceptable, led to a significant increase in the number of diners who did so (Giaccherini et al., 2021). These nudges could be considered a mix of decision information, structure and assistance nudges.

The position and availability of a dish is also important. Sales of vegetarian products increased when these were placed in the meat aisles in supermarkets, however this did not decrease the sales of meat products (Piernas et al., 2021). When vegetarian dishes made up most of the menu, more participants selected them, compared to when they were scarce (Parkin and Attwood, 2022). These are examples of decision structure nudges.

As illustrated, nudges can be used to guide eating choices. This does not apply only to environmentally friendly diets: For example, similar strategies have been adopted to encourage healthier eating choices as well (Ensaff, 2021). It therefore comes within the power of restaurants and stores to design menus and shops' layouts in a way that promotes healthy and sustainable diets.

2.5. Overview of the study and hypotheses

This study aims at testing whether making use of decision information nudges in the form of different labels on selected dishes in a restaurant menu can have an impact on customers' choices. This intervention examines:

1. Whether removing the symbols “v” and “pb”, respectively indicating a vegetarian and a plant-based dish, will make those dishes more or less popular;
2. Whether adding a low-emission label (“LE”) to make consumers aware that some dishes are responsible for creating less emissions than others will make those dishes more or less popular;
3. Whether being transparent about the intentions behind the low-emission nudge above described will make it more effective.

Based on past experimental findings, it is hypothesised that:

H1. Removing the symbols “v” and “pb” associated with those dishes will increase the sales of those products compared to control.

Table 1
Ratios of vegetarian (v) and plant-based (pb) dishes over total number of dishes in each category in each menu.

Menu	Starters		Mains		Desserts	
	$\frac{v}{total}$	$\frac{pb}{total}$	$\frac{v}{total}$	$\frac{pb}{total}$	$\frac{v}{total}$	$\frac{pb}{total}$
Restaurant A	$\frac{1}{6}$	$\frac{0}{6}$	$\frac{1}{5}$	$\frac{0}{5}$	$\frac{4}{6}$	$\frac{2}{6}$
Restaurant B lunch	$\frac{1}{6}$	$\frac{5}{6}$	$\frac{0}{13}$	$\frac{4}{13}$	$\frac{4}{4}$	$\frac{0}{4}$
Restaurant B dinner	$\frac{3}{12}$	$\frac{6}{12}$	$\frac{3}{17}$	$\frac{2}{17}$	$\frac{4}{4}$	$\frac{0}{4}$

H2. Introducing the symbol "LE" (standing for Low Emissions) next to the vegetarian or plant-based options will increase their sales compared to control.

H3. Making the "LE" nudge transparent will increase the sales of those products compared to control.

It is left as an exploratory question to investigate which treatment would be the most effective.

3. Method

3.1. Restaurants

The two restaurants which collaborated with us on this research project will thereafter be called Restaurant A and Restaurant B. The nudges were implemented at Restaurant A, whereas Restaurant B acted as control for the experiment.

The restaurants are both part of a five-star hotel in central London, and are in the same building but on different floors. Both restaurants offer dishes from British and European cuisines. Restaurant A can host up to 70 guests, whereas Restaurant B up to 60 guests. Restaurant A's prices range from £6 to £20 for starters, from £25 to £45 for mains, and from £6.50 to £28 for desserts. Restaurant B's prices range from £4.50 to £16 for starters, from £12 to £45 for mains, and from £6.50 to £22 for desserts. Although the restaurants are associated with a hotel, the majority of their clients are not hotel guests. The clients are mostly in the 30–50 age range, with around 65% of them being male and 35% being female. Clients are often couples, or bigger groups visiting the restaurants for a work meal.

3.2. Materials

The menus from Restaurant A and Restaurant B were used. The former restaurant had an à la carte menu which did not differ between lunch and dinner. The latter restaurant had two menus, one for lunch and one for dinner. The vegetarian and plant-based dishes were those selected for treatment. The ratios of vegetarian and plant-based dishes in each category in each restaurant are reported in Table 1. Examples of the restaurants' dishes from the study period and from a different period of the year can be found in the appendices.

3.3. Study design

Variations of Restaurant A's menu were presented to the restaurant's clients during the period from June 21st to September 20th, 2022 (see Table 2). A control menu, with no variations, was used from the 21st of June to the 7th of July. During the baseline period, the symbols "v" and "pb" appeared as plain text and looked the same on both menus. The first treated menu, on which the symbols "v" and "pb" were not present, was used between the 8th of July and the 8th of August. The second treated menu, with the symbol "LE" written as plain text next to the vegetarian and plant-based dishes, was used between the 9th of August and the 6th of September. The third treated menu, where the intentions behind the symbol "LE" were explained to make the nudge transparent, was used between the 7th and the 20th of September.

The second and third treated menus differed in the following way. The second menu only explained the meaning of the symbol "LE" as "Low Emissions". The third menu also included the following statement: "A selection of dishes we would like you not only to taste for the amazing flavour but also for the environment". This disclosed the purpose of the nudge, making it transparent.

As previously illustrated, the vegetarian and plant-based dishes in the menu were chosen as the sustainable dishes to be treated during this study. However, because all dishes in the dessert category of Restaurant A's menu were at least vegetarian, and plant-based can be often considered more environmentally-friend than vegetarian, only the plant-based desserts from that category were treated with the addition of the "LE" symbol.

3.4. Measures

Both restaurants collected their sales data as per usual and shared them with us at the end of the study. The following pieces of information were also used for the purpose of this study: the location of sale (Restaurant A or Restaurant B); the category of the dish (starters, mains, desserts); the time of day (lunch or dinner); whether it was during the weekend (Saturday and Sunday) or not; and which menu was used (original, treatment 1, treatment 2, treatment 3).

Two dependent variables were used. The first dependent variable was "sustainable sales ratios". *SustainableSalesRatios* ($M = 0.18$, $SD = 0.18$) was calculated as the ratio of sales of the sustainable items over total sales. This was computed separately for starters, mains, and desserts, and separately for lunch and dinner, each day for each restaurant. This was considered a more appropriate measure than the absolute number of sales because ratios illustrate how much of the customer's choice is sustainable in comparative terms. Additionally, analysing ratios means that fluctuations in absolute number of sales have no impact on the trends of interest. It is important to note, however, that *SustainableSalesRatios* was obtained by transforming the original data, and is bounded between 0 and 1. The second dependent variable, *binarySales*, was calculated by recoding *SustainableSalesRatios* as a dummy variable with values 0 for any *SustainableSalesRatios* $= 0$, and 1 for any other value. By definition, *SustainableSalesRatios* $= 0$ whenever a sustainable sale was not made, and any value above 0 tells us what proportion of the revenue comes from sustainable dishes. On the other hand, *binarySales* simply tells us whether the revenue comes from sustainable dishes or not.

The other following variables were used in the model: *restaurantA* is a dummy variable which takes value of 1 if the restaurant is Restaurant A (treated), and 0 if the restaurant is Restaurant B (control); the variable *days* indicate which day the sale is from (days were numbered from 1, indicating June 21st, to 92, indicating September 20th); *dinner* is a dummy variable which indicated whether it was lunch (0) or dinner (1); *weekend* is a dummy variable which took the value 1 if the sale happened either on a Saturday or Sunday; *mains* is a dummy variable which took the value 1 if the dish was a main; the variables *experimentalPeriod1*,

Table 2
Treatments and timeline explained.

	Baseline	Treatment 1	Treatment 2	Treatment 3
Menu	Original menu	Symbols "v" and "pb" removed	"LE" symbol added	"LE" symbol plus transparency statement
Timeline	June 21st – July 7th	July 8th – August 8th	August 9th – September 6th	September 7th – September 20th

experimentalPeriod2, and *experimentalPeriod3* were dummy variables indicating respectively which, if any, of the treatments was present at the time of sale.

3.5. Models

We created three linear models with *SustainableSalesRatios* as dependent variable. Because our dataset provided information on each restaurant's sales for both lunch and dinner for each day, and because we were interested in understanding how much of those sales came from vegetarian and plant-based dishes rather than other dishes depending on the treatment, the following models seemed fit to conduct our analyses.

The first model, *Model 1*, concerns only Restaurant A:

$$\begin{aligned} SustainableSalesRatios = {} & b0 + b1{*}dinner + b2{*}weekend \\ & + b3{*}experimentalPeriod1 \\ & + b4{*}experimentalPeriod2 \\ & + b5{*}experimentalPeriod3 \end{aligned}$$

The second and third models, *Model 2* and *Model 3*, look at the comparison between the treated restaurant and the control restaurant. *Model 2* gives an overall picture by looking at all the experimental periods and categories of dishes together.

Model 2:

$$\begin{aligned} SustainableSalesRatios = {} & b0 + b1{*}restaurantA + b2{*}days + b3{*}dinner \\ & + b4{*}weekend + b5{*}mains + b6{*}experimentalPeriod1 \\ & + b7{*}experimentalPeriod2 + b8{*}experimentalPeriod3 \\ & + b9{*}restaurantA{*}experimentalPeriod1 \\ & + b10{*}restaurantA{*}experimentalPeriod2 \\ & + b11{*}restaurantA{*}experimentalPeriod3 \end{aligned}$$

On the other hand, *Model 3* is used whilst isolating treatment periods and categories of dishes.

Model 3:

$$\begin{aligned} SustainableSalesRatios = {} & b0 + b1{*}days + b2{*}dinner \\ & + b3{*}weekend + b4{*}restaurantA \\ & + b5{*}restaurantA{*}experimentalPeriod \\ & + b6{*}experimentalPeriod \end{aligned}$$

In both models, the interactions between restaurant and experimental period represent the relevant treatment.

Finally, a robustness check analysis was performed by using *binarySales* as a dependent variable, and by conducting a logistic regression with the same predictors used in *Model 2*.

We decided to use both linear and logit models because both present their advantages and disadvantages. The linear models presented above allow us to give a more intuitive interpretation of our results, facilitating a discussion on their magnitudes and implications. However, our first dependent variable, *SustainableSalesRatios*, is bounded between 0 and 1, making the use of linear models debatable. On the other hand, using a logit model with *binarySales* as a dependent variable can be considered more statistically sound, and it therefore provides us with useful information to be able to support the results of the linear models. However, conducting an analysis with *binarySales* implies losing important information about the magnitude of sustainable sales over total sales. We therefore present the results from both approaches in section 4.

3.6. Data analysis

Firstly, the sustainable sales at Restaurant A were analysed through *Model 1*. Secondly, a comparison between Restaurant A and Restaurant B is made, and the results from the analyses of *Model 2* and *Model 3* are reported. A robustness check was then performed by conducting a binary logistic regression with *binarySales* as dependent variable. Finally, graphs were created to show the sales of starters and mains for each treatment period in comparison to the baseline period.

The period between July 18th and July 26th was excluded from the analysis of comparison between Restaurant A and Restaurant B, as the latter restaurant was closed for refurbishment during that period of time. As Restaurant B did not offer any plant-based desserts, therefore not providing a counterfactual, this category of dishes was also excluded from the analysis which compared the two restaurants. Thus, the effects of the interventions on Restaurant A's plant-based desserts were only evaluated in comparison to that restaurant's sales during the baseline period (*Model 1*).

4. Results

4.1. Restaurant A only

When analysing the sales of Restaurant A through *Model 1*, it was found that the sales of starters were only influenced by the first treatment ($t(178) = 2.02$, $p = .045$), which was correlated to an 8 pp. increase in *SustainableSalesRatios*. On the other hand, no significant correlation was found between the treatments and the *SustainableSalesRatios* of mains and desserts.

4.2. Restaurant A vs. restaurant B

4.2.1. Model testing

4.2.1.1. Model 2. *Model 2* can explain 31.6% of the variance in ratios of sales ($F(11, 652) = 27.38$, $p < .001$). The variables *restaurantA*, *dinner*, *mains*, *restaurant*experimentalPeriod1* were found to be significantly related to *SustainableSalesRatios* (see Table 3). In particular: Treatment 1 brought an increase of 8.2 pp. in *SustainableSalesRatios* at Restaurant A ($t(652) = 2.54$, $p = .011$); vegetarian and plant-based options were more popular at dinner time by 3 pp. ($t(652) = 2.74$, $p = .006$); vegetarian and plant-based mains were less popular compared to starters by 15.5 pp. ($t(652) = -14.04$, $p < .001$).

4.2.2. Model 3

Model 3 was then tested by analysing the sales of starters and mains separately, and by isolating treatment periods, comparing each of them to the baseline period (see Table 4). As far as starters are concerned, treatment 1 ($t(153) = 1.97$, $p = .050$) and treatment 3 ($t(117) = 2.41$, $p = .017$) were found to be effective; on the other hand, treatment 1 ($t(153) = 2.68$, $p = .008$) was the only treatment to significantly affect sales of mains at Restaurant A. Treatment 1 increased the ratio of sustainable sales by 10.2 pp. for starters and by 6.2 pp. for mains. Treatment 3 increased the ratio of sustainable sales by 14.1 pp. for starters.

4.2.3. Robustness check

A binary logistic regression was conducted by using *binarySales* as

Table 3
Model 2. Significance levels: ****p < .001, ***p < .01, **p < .05, *p < .1.

Model 2		B	S.E.
	constant	0.297****	0.020
Control variables	*restaurantA*	0.067***	0.024
	days	−0.001	0.001
	dinner	0.030***	0.011
	weekend	0.016	0.012
	mains	−0.155****	0.011
Periods	*experimentalPeriod1*	−0.020	0.029
	experimentalPeriod2	0.026	0.044
	experimentalPeriod3	0.007	0.059
Treatments (Difference-in-Difference)	*restaurantAXexperimentalPeriod1*	0.082**	0.032
	restaurantAXexperiemntalPeriod2	−0.001	0.031
	restaurantAXexperimentalPeriod3	0.047	0.036

Table 4
Model 3. Significance levels: ****$p < .001$, ***$p < .01$, **$p < .05$, *$p < .1$. Other variables in the model: days, time, weekend, restaurant, treatment.

Model 3		B	S.E.
Treatment 1	Starters	0.102*	0.052
	Mains	0.062**	0.023
Treatment 2	Starters	−0.009	0.056
	Mains	0.006	0.024
Treatment 3	Starters	0.141**	0.058
	Mains	−0.048	0.031

Table 5
Robustness check. Significance levels: ****$p < .001$, ***$p < .01$, **$p < .05$, *$p < .1$.

Robustness check		Odds Ratio
	constant	3.320
Control variables	*restaurantA*	3.193
	days	0.958*
	dinner	5.168****
	weekend	2.014*
	mains	3.338***
Periods	*experimentalPeriod1*	0.280
	experimentalPeriod2	2.753
	experimentalPeriod3	1.670
Treatments (Difference-in-Difference)	*restaurantAXexperimentalPeriod1*	45.735**
	restaurantAXexperiemntalPeriod2	2.006
	restaurantAXexperimentalPeriod3	18.904**

dependent variable (see Table 5). Treatments 1 and 3 were again found to be effective as they both increased the probability of vegetarian and plant-based dishes being picked. The odds of a vegetarian or plant-based dish being ordered were 45.735, 95% CI [2.007, 1042.048] when treatment 1 was in place, and 18.904, 95% CI [1.113, 321.183] when treatment 3 was in place. These results therefore support what we previously found through our linear models.

4.2.4. Parallel trends

Fig. 1 illustrates 6 parallel trends, each showing a comparison between Restaurant A's sales (maroon line) and Restaurant B's sales (blue line), and between the baseline period and each treatment period (separated by a red vertical line). As shown in the trends, treatment 1, the removal of the symbols "v" and "pb" from the menu, had a positive impact on the sales of both sustainable starters and sustainable mains at Restaurant A. Treatment 2, the inclusion of the symbol "LE" next to the treated dishes on the menu, did not have an impact on the sales of those. Treatment 3, the inclusion of the symbol "LE" together with a message to make the nudge transparent, successfully increased sales of the starters at Restaurant A.

5. Discussion

This study tested whether removing the "vegetarian" and "plant-based" labels from restaurant menus, and subsequently adding a decision information nudge in the form of a "low emissions label", could increase the sales of those dishes. It was found that both removing the "v" and "pb" labels and adding a "LE" label plus a transparency disclaimer were successful strategies. When the vegetarian and plant-based labels were taken off the menu, the sales of sustainable starters increased by 10.2 pp., and those of sustainable mains increased by 6.2 pp. When the "LE" label was added next to the sustainable dishes on the menu, together with the statement "LE means Low Emissions. A selection of dishes we would like you not only to taste for the amazing flavour but also for the environment" at the bottom of the menu, the sales of sustainable starters increased by 14.1 pp. Therefore, these interventions can be effective instruments to decrease the environmental impact of our diets.

Although there are currently not many published studies that have tested the impact of different labels on menus, the magnitudes of our results can be compared to previous research as follows. We found that removing the vegetarian and plant-based labels increased the sales of the sustainable dishes by 10.2 pp. for starters and by 6.2 pp. for mains; adding a transparent low-emissions label increased sales of sustainable starters by 14.1 pp. In their online study, Krpan and Houtsma (2020) had found that a pro-environmental label increased the percentage of participants who selected the dish by 9.3 pp. compared to the vegetarian label, and that a social label was more effective than the vegetarian label by 5.9 pp. Saulais et al. (2019) reported that, in their study set in a living laboratory, labelling the vegetarian dish as "dish of the day" increased the percentage of customers who chose it by 25.2 pp. when only one alternative dish was available, and by 30 pp. when two alternatives were available. In an online research, Marshall et al. (2022) found that labelling a cauliflower slice as "steak" increased participants' willingness to consume by 5.4 pp. Considering that the current study was conducted in a real-life setting and that most of the dishes on the treated menu were not vegetarian, the present results can be considered significant.

The first experimental treatment, removing the symbols indicating a vegetarian or plant-based option ("v" and "pb"), was conceptually built on what had been suggested by Bacon and Krpan (2018), and Krpan and Houtsma (2020), which is that signposting vegetarian and plant-based options as such is detrimental for sales, and a neutral frame is better. Our results indeed show that removing the symbols indicating a vegetarian or plant-based option ("v" and "pb") successfully increased the sales of both starters and main dishes at Restaurant A. The current study brings a significant novel contribution to this field of research as it is the first piece of research that finds this result in a real-world setting. Given how common it is for restaurants and cafes to include symbols such as "v" and "pb" on their menus, this study's result gives an important insight: Those symbols may conveniently suggest suitable dishes for those who identify as vegetarian but may not be helpful to encourage the majority to go for the vegetarian and plant-based option.

Including a "Low Emissions" logo ("LE") next to the sustainable alternatives on the menu was not successful at increasing sales of those items. Making the addition of the logo "LE" a transparent nudge was successful at increasing the sales of the starters, but not of the main dishes. These two results together give us important insights into how nudges can be used to create interventions that are both transparent and effective. Previous literature argued that transparent nudges may dissuade consumers to act in the desired way, which would have otherwise happened had the nudge been hidden (Arad and Rubinstein, 2018). However, we found the opposite: Our hidden nudge was not effective, but its transparent alternative was. Including only the symbol "LE" may have not been enough to prompt behaviour change due to the value-action gap (Behavioural Insights Team, 2020): Consumers may be concerned about the planet but may still not act on this worry for economic reasons, such as cost, and psychological reasons, such as lack of willpower (De Haen and Réquillart, 2014). Making the nudge transparent may have prompted behaviour change by creating social pressure, signalling that eating vegetarian or plant-based was the socially desirable or normal thing to do (Evans et al., 2012). Moreover, as people tend to prefer "conscious decisional enhancements" (Felsen et al., 2013), customers may have appreciated the nudge's purpose being transparent, and may have therefore felt more willing to pick the suggested dishes.

As for how the current study was run at a practical level, this is also the first piece of research to test the impact of such nudges whilst also providing a control: Restaurant B provided a useful counterfactual for our analysis. The two restaurants are quite similar as they are situated in the same building and are part of the same hotel, whilst being also highly frequented by visitors other than the hotel guests. This meant that we were able to compare sales data from the two, isolating the impact of our treatments on the choice of sustainable dishes whilst accounting for possible external shocks to their business.

The low emissions label that was used in this research was simply

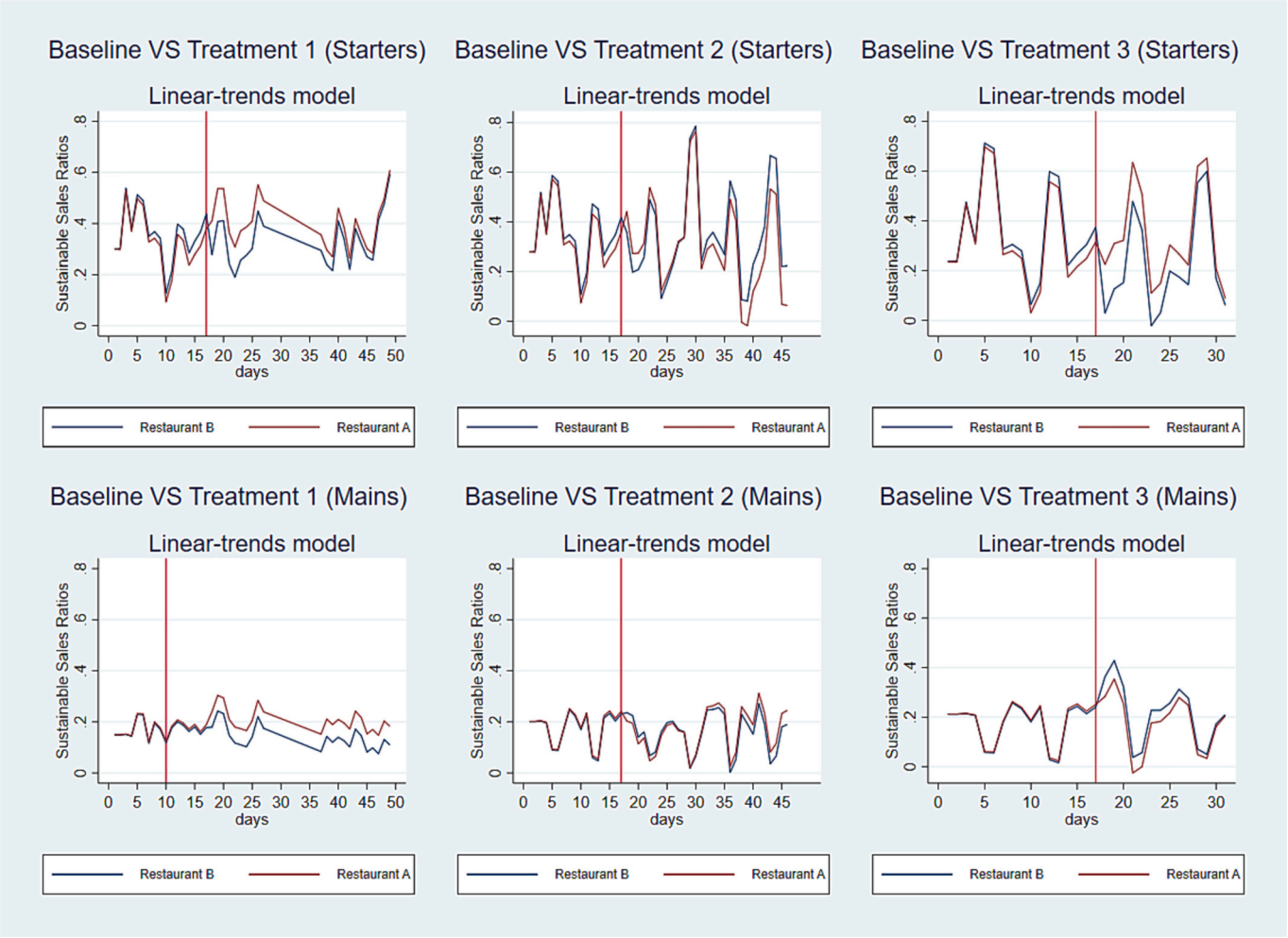

Fig. 1. Parallel trends. Each of them illustrates a comparison between baseline and a treatment period which are separated by the red vertical line. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

added to the menu as "LE" written in plain text. Previous research had trialled different graphics for similar interventions, such as a traffic-light coloured label (Brunner et al., 2018), and colourful posters (Bauer et al., 2022). Although the simple labels from this study and these colourful nudges (Brunner et al., 2018; Bauer et al., 2022) were all found to be effective, it is reasonable to assume that choosing the right type of nudge and the right type of graphics for the specific place of interest is essential. For example, it sounds sensible to assume that a small label written in plain text would be more difficult to spot if it was placed somewhere in a supermarket aisle compared to a restaurant menu. On the other hand, very colourful and/or big labels may not be considered appropriate for a restaurant menu for being too invasive. Different wording and graphics may be tested by businesses and future research to find out how to best market vegetarian and plant-based products depending on the context.

Adding or removing labels on a menu may or may not be seen as helpful strategies by restaurant managers. One of the concerns expressed to us during the preparation of this research was that changing the menu may result in the non-sustainable dishes being perceived as less appealing. Another possible concern is that the consumer may become overwhelmed while reading the labels and decide not to purchase at all. However, if a business was interested in reducing its emissions, removing the vegetarian and plant-based labels, and possibly adding simple symbols signalling that a product is low-emission, would be cost-effective strategies to implement. These suggestions imply that businesses would need to be prepared to reduce their sales of meat-base dishes, which might or might be acceptable depending on the nature of the store/restaurant, and on how big the portion of profits coming from those sales is.

6. Limitations

Restaurant B did not offer any plant-based desserts; hence it was not possible to make a comparison between the two restaurants and test the effect of the treatments on the sales of Restaurant A's desserts using Restaurant B as a counterfactual.

We could not collect detailed information on the socio-demographic characteristics of the restaurants' clientele. Therefore, it was not possible to keep this into account in our models and analysis. This study was conducted in London, and it is therefore likely that those who participated in this research (i.e., the restaurants' clients) had various cultural backgrounds and attitudes towards eating vegetarian and plant-based dishes. Nevertheless, the United Kingdom is a country where the average daily consumption of meat is still too high and needs to decrease both for health and environmental sustainability reasons (Stewart et al., 2021). Further research may replicate this study in different locations, whilst accounting for the customers' socio-economic status and attitudes towards eating meat-based dishes. Similar nudges may be tested in other countries, either with higher or lower average meat consumption, and in different cities, either bigger or smaller than London, and with different cultural backgrounds.

Party sizes could also not be collected. Because of the impact that

social pressure can have on eating behaviours, it is possible that diners could influence each other whilst choosing what to order. It would therefore be interesting to run a similar study and collect this piece of information to test whether the number of people sitting together moderates the effect of the nudges on sales of the recommended dishes.

It was not feasible to check whether the same guests went to both restaurants. In particular, if a guest had eaten at Restaurant A first, and subsequently at Restaurant B, a spillover effect may have been created: The nudges in the first restaurant may have had an impact on the selection of dishes at the second restaurant. However, this would have made the difference between the sales of Restaurant A and Restaurant B smaller, therefore reducing the chances of finding significant effects through a difference-in-difference analysis. Because significant effects were found nevertheless, it is likely that a spillover effect either did not present itself or was small enough not to cancel out the differences in sales between the two restaurants.

This study was conducted mostly during the summer period, and this determined what dishes were available on the menu. Dishes can be considered inherently more or less appealing depending on one's personal taste and preferences. For example, it could be that the non-vegetarian and non-plant-based dishes in the mains category were seen as more appealing by the customers, hence treatment 3 only worked for the starters. Moreover, vegetarian and plant-based dishes were the minority in our treated restaurant's menu. In order to provide further support to our results, future research may replicate this study with different menus containing more or less sustainable dishes.

7. Conclusions

This study was innovative in its application of behavioural interventions, including a transparent nudge, in a real-world dining setting with the use of a counterfactual. Our aim was to find ways to encourage the consumption of more sustainable dishes, which would in turn reduce the carbon footprint of our diets. We found that two strategies may be effective in encouraging the consumption of vegetarian and plant-based dishes: removing any symbols or labels that define a dish as “vegetarian” or “plant-based”; and including a symbol such as “LE” (Low Emission) to signpost which dishes are most sustainable on the menu, whilst being transparent about the reasons behind the intervention. These results contribute to the so far limited but emerging literature on interventions designed to reduce the environmental impact of our diets through nudges. We showed how adding labels to menus is an easy yet cost-effective strategy to encourage individuals to eat vegetarian and plant-based meals. Meat consumption needs to decrease both for health and environmental sustainability reasons. For this to happen, restaurants and food shops may need to be prepared to rely less on sales coming from foods such as beef. Nudges like the ones used in this research can be useful tools to tackle unsustainable food consumption in the hospitality sector whilst leaving the consumer free to make the final choice.

Author contributions

A.B.: conception and design of the work, data collection and curation, data analysis and interpretation, writing, manuscript preparation and editing. L.L.: conception and design of the work, support on data collection and curation, data analysis and interpretation, support on writing and manuscript preparation. All authors have approved the final version of this manuscript, and agree to be accountable for all aspects of this paper.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Examples of dishes from the menus from the study period (Summer)

Restaurant A's menu

Vegetarian starter: Truffle burrata, English heritage tomatoes, pane carasau.

Other starter: Beef tartare, whipped hen's yolk, mustard, grissini.

Vegetarian main: Courgette tortelloni, shaved truffle, roast radicchio, horseradish.

Other main: Wild Cornish turbot on-the-bone, butter sauce, sesame asparagus.

Dessert: Strawberry, marshmallow, meringue.

Restaurant B's menu.

Plant-based starter: Beetroot and heritage tomatoes, tofu mayo, sourdough.

Other starter: Spicy chicken wings.

Plant-based main: Roast cauliflower and sweet potato, spinach pancake, walnuts, harissa aioli.

Other main: Salmon fillet, Puy lentils, spinach, salsa verde.

Dessert: Sticky toffee pudding, salted caramel ice cream.

Appendix B. Examples of dishes from the menus from a different period (Winter)

Restaurant A's menu.

Vegetarian starter: Burrata, pumpkin relish, pumpkin seed granola.

Other starter: Pressed Barbary duck terrine, smoked duck breast, cranberry relish, sourdough crisps.

Plant-based main: Roast celeriac, wild mushrooms, cavolo nero, chestnut sauce.

Other main: Slow cooked Welsh lamb shoulder, creamed mashed potatoes, braised red cabbage, minted lamb jus.

Dessert: Chocolate & orange tart, vanilla ice cream.

Restaurant B's menu.

Vegetarian starter: Artisan goat's cheese, pumpkin relish & crumb.

Other starter: Cured sea trout, pickled cucumber, wholegrain mustard dressing.

Plant-based main: Roast celeriac, wild mushrooms, cavolo nero, chestnut sauce.

Other main: Slow braised beef cheeks, creamed mashed potatoes, Savoy cabbage, red wine jus.

Dessert: Sticky toffee pudding, salted caramel sauce, Chantilly cream Cashel Blue, chutney, walnut & raisin toast.

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