# Price of change: does a small alteration to the price of meat and vegetarian options affect their sales?

Emma E. Garnett[a,b,1], Andrew Balmford[a], Theresa M. Marteau[c], Mark A. Pilling[c], Chris Sandbrook[d]

[a] Department of Zoology, University of Cambridge, CB2 3EJ, UK; [b] Cambridge Institute for Sustainability Leadership, University of Cambridge, CB2 1QA, UK; [c] Behaviour and Health Research Unit, University of Cambridge, Institute of Public Health, CB2 0SR, UK; [d] Department of Geography, University of Cambridge, CB2 1QB, UK

[1] To whom correspondence may be addressed: Emma E. Garnett, ee.garnett@gmail.com

## Abstract

Reducing meat and fish consumption in wealthier countries would help mitigate climate change, raising the question of the most effective ways to achieve this. Price influences the food people buy, but to our knowledge no published field study has assessed the impact on sales of experimentally altering the price of meat and vegetarian meal options. We ran an experiment across 106 mealtimes with 13,840 meal selections at a college cafeteria in the University of Cambridge (UK), introducing a small change to the price of vegetarian meals (decreased by 20p from £2.05 to £1.85) and meat meals (increased by 20p from £2.52 to £2.72). Total meal sales did not differ significantly before and after the price change. When controlling for other variables, changing price significantly increased the proportion of vegetarian sales by 3.2 percentage points ($p=0.036$). However, there was no significant change in meat sales before and after the price change, although fish sales did decline by 2.8 percentage points ($p=0.010$). When analysed by individual diners' pre-experimental meal choices ($N=325$), the price intervention significantly affected only the quartile of diners with the highest prior rates of vegetarian and vegan meal selection ("MostVeg" quartile), who increased their vegetarian meal selection by 13.7 percentage points ($p=0.011$). Students mainly pay for meals on their university cards and rarely pay with cash, which may lessen the impact of a price intervention in this context. Our results suggest price changes may be one lever for increasing vegetarian meal consumption. Further field studies are needed to test different price changes, and in non-university populations.

## Key Words
price; meat; vegetarian; climate change; cafeterias

## Highlights

- We conducted a field-experiment with 13,840 meal selections over a nine-week period, 91% of which could be linked to individual diners.
- In week five we introduced a small price change to vegetarian (£0.20 cheaper) and meat meals (£0.20 more expensive).
- This increased vegetarian meal selection by 3.2 percentage points overall and by 13.7 percentage points in the quartile of diners (“MostVeg”) with the highest prior likelihood of selecting a vegetarian meal.
- There was no significant change in meat sales, even for the MostVeg quartile of diners.
- However, when meat and fish sales were analysed together, the MostVeg quartile’s selection of meat and fish meals decreased by 13.1 percentage points.

## 1 Introduction

### 1.1 Livestock farming and the environment

Livestock farming produces an estimated 14.5% of anthropogenic greenhouse gas emissions (GHGE) and is a leading cause of deforestation, biodiversity loss, water-use and pollution (Machovina, Feeley, & Ripple, 2015; Poore & Nemecek, 2018). Intensive factory farming is also a leading cause of novel diseases and pandemics in people (Dhingra et al., 2018; Jones et al., 2013) and the widespread use of antibiotics in livestock farming is contributing to antimicrobial resistance (Van Boeckel et al., 2015). Reducing meat production and consumption in high-income countries such as the UK is almost universally advocated as a necessary strategy to reach net and absolute zero GHGE (Allwood et al., 2019; Committee on Climate Change, 2020; Energy Systems Catapult, 2019; Shukla et al., 2019). Ruminants (cows, buffalo, sheep, goats) have particularly high GHGE due to both their generation of methane (Dangal et al., 2017) and the disproportionately large area of land used to meet current demand, much of which could potentially be restored to $CO_2$-sequestering woodland or wetland (Balmford et al., 2018; Committee on Climate Change, 2018; Searchinger, Wirsenius, Beringer, & Dumas, 2018).

To feed 10 billion people (the projected population for 2050) a healthy and sustainable diet, approximately 16kg of meat and 10kg of seafood consumption per person per year is recommended (the equivalent of 3 and 2 quarter pounder burgers per week respectively)(Willett et al., 2019). However, mean global consumption (including food waste) is currently 43kg and 19kg per person per year respectively, and averages 81kg and 23kg in the EU (7, 3, 14 and 4 burgers per week respectively)(FAO, 2017). It is estimated for the United Kingdom that GHGE from food are 47% lower in a vegetarian diet compared to a high meat diet (>100 g per day; Scarborough et al., 2014).

How best to encourage lower meat consumption is a key question for environmental psychology. Among other interventions, fiscal measures such as reforming taxes, subsidies and prices are likely to be vital for bringing about healthy and sustainable diets. British citizens self-report price as the most important influence on their food purchases; taste, quality, familiarity and healthy options were also important influences on choice (DEFRA, 2016).

### 1.2 Meat taxes and subsidies

Many academic papers and reports have proposed the introduction of meat taxes (Park, 2020; Springmann et al., 2017; The Danish Council on Ethics, 2016; True Animal Price Protein Coalition, 2020; Wellesley, Happer, & Froggatt, 2015). However, taxes are generally politically unpopular due to their lack of public support (Diepeveen, Ling, Suhrcke, Roland, & Marteau, 2013) and no specific meat taxes have yet been introduced. In 2011 Denmark introduced a tax on foods with high levels of saturated fat. This tax predominantly affected meat and dairy products and it is estimated that it did result in a modest decrease in saturated fat consumption (Jorgen Dejgaard Jensen, Smed, Aarup, & Nielsen, 2016). However, due to government concerns about the tax's administrative costs and the disproportionate effects on low-income households, this tax was removed a little over a year later in 2012 (Vallgårda, Holm, & Jensen, 2015). A more acceptable alternative to taxing meat could be to reduce its subsidies. Industrial-scale livestock farms in the UK received an estimated £70 million in government subsidies in 2016 and 2017 (Wasley, Heal, & Snaith, 2018). Wellesley et al. (2015) found in focus-group discussions that subsidy removal was more popular than a tax, even though it led to the same effect (i.e. increased consumer prices on individual products).

Due to a lack of empirical experimental data, estimates for the effects of price changes on meat consumption have generally been modelled based on assumptions of price elasticities for different products. Price elasticity is the change in demand for a product (%) for a given increase in price (%) (Andreyeva, Long, & Brownell, 2010). In five published modelling studies meat taxes were based on GHGE and other environmental metrics, and therefore beef received a higher price change (12-33% price increases) than pork (5-11%) and poultry (3-11%) (Edjabou & Smed, 2013; Kehlbacher, Tiffin, Briggs, Berners-Lee, & Scarborough, 2016; Säll & Gren, 2015; Springmann et al., 2017; Wirsenius, Hedenus, & Mohlin, 2011). In three of the five studies, price increases were predicted to decrease consumption of all meat types (Kehlbacher, Tiffin, Briggs, Berners-Lee, & Scarborough, 2016; Säll & Gren, 2015; Springmann et al., 2017). However, in the other two studies the large increase in the price of beef, and the modest increase to pork and poultry prices, led to a decrease in beef but an increase in poultry (Edjabou & Smed, 2013; Wirsenius et al., 2011) and pork consumption (Wirsenius et al., 2011). Another possible unintended consequence of meat taxes is increased purchases from discount supermarkets, rather than dietary shifts away from meat (Jørgen Dejgård Jensen & Smed, 2013).

### 1.3 Studies on price and changes in food selections

Several reviews on the effects of price on food choices conclude that taxes and subsidies have great potential to bring about healthier diets (Andreyeva et al., 2010; Epstein et al., 2012; Thow, Downs, & Jan, 2014). One review found that in 23 out of 24 studies, subsidising healthier foods significantly increased their purchase and consumption (An, 2013). In a Belgian university cafeteria, decreasing students' meal price by 10% and 20% if fruit was chosen as a dessert increased fruit purchases by 25.1% and 42.4% respectively (Deliens, Deforche, Annemans, De Bourdeaudhuij, & Clarys, 2016). Increasing the cost of unhealthy food is also effective: increasing the students' meal price by 10% and 20% when they selected fries as a side led to a 10.9% and 21.8% reduction in fries purchased (Deliens et al., 2016). In contrast to health, there are relatively few studies on how price affects selection of more sustainable food options (Hoek, Pearson, James, Lawrence, & Friel, 2017).

Turning to meat, a systematic review on interventions to reduce meat consumption (Bianchi, Garnett, Dorsel, Aveyard, & Jebb, 2018) found only one experimental study on price (Vermeer, Alting, Steenhuis, & Seidell, 2010). Changing the price structure of chicken nuggets from a value system (decreasing price/gram across "small", "medium" and "large" portions) to a proportional system (same price/gram for all three portion sizes) did not increase selection of smaller portions of chicken nuggets (Vermeer et al., 2010). Although this was a field study, the questionnaire measured behavioural intention rather than actual behaviour. Since the systematic review, an online study has been published which used three-option menus (one meat, two vegetarian options) and found that the presence of a "decoy" vegetarian option, priced 30% higher than the other two options, did not increase selection of the cheaper "target" vegetarian option (Attwood, Chesworth, & Parkin, 2020). However, neither of these studies tested the effects of price changes on vegetarian and meat meal consumption through measuring actual rather than hypothetical behaviour.

### 1.4 Aims of the study

The current study contributes to this gap in evidence. We conducted a field experiment in a University of Cambridge college cafeteria to test the hypothesis that a small change in the price of meat and vegetarian options would affect their sales. Halfway through a nine-week university term the price of a vegetarian option was lowered by 20p from £2.05 to £1.85 (-9.8%), and the price of the two meat options was increased by 20p from £2.52 to £2.72 (+7.9%). As well as quantifying meat and vegetarian meal sales before and after the intervention we tested whether the price change affected total meal sales, and sales of fish and vegan meals (whose prices were not manipulated). Importantly we also used anonymized individual-level data to analyse whether changing price had different effects depending on prior levels of vegetarian and vegan meal consumption of individual diners.

## 2 Methods

### 2.1 Study Setting

The study was conducted during autumn term 2018 (1st October to 30th November 2018) in a University of Cambridge (UK) college (the university's colleges are broadly equivalent to halls of residence). The studied college admits students of any gender identity, as well as both undergraduate and graduate students. Students who are members of the college can pay for meals by swiping their university cards, which are pre-loaded with credit throughout the academic year. Students can view their spending history online. Approximately 91% of meals are paid for on such university cards, the remaining 9% are paid with cash or a debit card. Meals are not included in tuition or accommodation fees, though students pay a compulsory "Kitchen Fixed Charge" which subsidises the college cafeteria's overheads. The Kitchen Fixed Charge is approximately £50 per term for graduates, £165 for undergraduates who live on the same site as the cafeteria, and £100 for undergraduates who live on a different site. Although many students eat at least some meals in the cafeteria, students can also cook their own meals or eat elsewhere.

This research was approved by the University of Cambridge Psychology Research Ethics Committee. We obtained signed consent forms from the college catering managers. In keeping with research governance for interventions that target environments rather than individuals, college diners were not informed of the study per se, though the price change was advertised (see below).

### 2.2 Study Design

The study had a simple clustered A/B design in which meal selections by individuals were observed for four weeks before a price change was introduced and then observed for five weeks after this. We collected data from lunches and dinners, Mondays to Saturdays across the approximately 9 weeks of autumn term 2018. This comprised 106 mealtimes involving 13,840 hot meal selections, with purchases of sides, sandwiches and salads excluded from these analyses. Students who choose a hot meal (hereafter simply "meals") can also buy accompanying vegetables sides (£1 per vegetable), desserts (£1.19) and other items. The college served two meat options, one vegetarian, one fish and one vegan option at all mealtimes, except on Friday lunchtimes where one meat option was replaced with an additional fish option and Saturday lunchtimes where the vegan option was not included

(Supplementary Online Material (SOM) Table S1). The first four weeks of term were the baseline period (original prices) and the final five weeks of term were the intervention period (altered prices). Four weeks into term (from Monday 29th October 2018) the college decreased the price of the vegetarian option by 20p (from £2.05 to £1.85, a 9.8% decrease) and increased the price of meat options by 20p (from £2.52 to £2.72, a 7.9% increase, Table 1). The price of the vegan option (£2.39) and the fish option(s) (£2.85) were not changed. The price difference between the meat and vegetarian option increased from 47p to 87p (85% increase). In absolute terms the price changes were fairly small. According to one review a 20% change in price for a single item is standard in the literature, and our price changes (9.8% price decrease and a 7.9% increase) are of this magnitude, albeit summed for price changes across two items (Zizzo, Parravano, Nakamura, Forwood, & Suhrcke, 2016). We also chose a 20p change as this led to both meat and vegetarian meals having an 80p margin between the customer price and the ingredient costs during the intervention period (Discussion 4.2).

We chose to make a modest change to prices to avoid criticism by the students using the college cafeteria and to not leave the more carnivorous students substantially less well-off. The change may also better reflect what is currently feasible to introduce in other outlets. The price changes were advertised throughout the whole study period on a screen outside the dining hall (which students walk through to reach the cafeteria and where they eat their purchased meals) and on the paper menus posted outside the cafeteria. The notification was worded: "As of Monday 29th October, the meal prices are changing a small amount to reflect the cost of ingredients" (SOM Figure S1 and S2). The price change did result in the meal option prices better reflecting the cost of ingredients (Discussion 4.2).

*Table 1: Raw data summaries from the study. Mean values reported with standard deviations (SD) in square brackets, and median values reported with interquartile range (IQR) in square brackets.*

| | **Baseline** | | | **Intervention** | | |
|---|---|---|---|---|---|---|
| Dates | 1/10/2020 to 27/10/2020 | | | 29/10/2020 to 30/10/2020 | | |
| Mealtimes | 48 | | | 58 | | |
| Total Meals | 6587 | | | 7253 | | |
| Meals/Mealtime | 137.2 | | | 125.1 | | |
| **Option (number available)** | **Price (£)** | **Mean sales per mealtime (%) [SD]** | **Median sales per mealtime (%) [IQR]** | **Price (£)** | **Mean sales per mealtime (%) [SD]** | **Median sales per mealtime (%) [IQR]** |
| Vegetarian (1) | 2.05 | 21.0 [9.9] | 21.0 [15.7] | 1.85 | 21.8 [9.2] | 20.7 [13.6] |
| Meat (2) | 2.52 | 61.7 [13.7] | 62.0 [15.1] | 2.72 | 61.2 [11.6] | 65.0 [16.9] |
| Fish (1) | 2.85 | 12.7 [10.6] | 8.8 [8.9] | 2.85 | 11.1 [10.4] | 7.3 [6.9] |
| Vegan (1) | 2.39 | 4.5 [5.0] | 3.6 [7.3] | 2.39 | 5.9 [5.6] | 5.1 [9.1] |

### 2.3 Data Collection and Preparation

We downloaded sales data from Uniware (“Uniware,” n.d.), an online catering platform. Identifiable data were stored on a secure online server at the University. We summarised the sales data into 1) aggregate data, with the total meat, vegetarian, vegan and fish purchases at each mealtime, based on all sales by college members and their guests; and 2) anonymised individual-level data, with which meal option (meat, vegetarian, vegan, fish) each individual diner selected at each mealtime, based on purchases made by college members using university cards (with the 9% of meal purchases made with cash or debit cards excluded). We used the total number of meals bought to analyse if the price intervention affected overall cafeteria sales.

To model individual-level vegetarian sales, a diner who bought no vegetarian meals at a single mealtime was coded as 0 for that mealtime, and a diner who bought only vegetarian meals (one or more) at a single mealtime was coded as 1. Meal choices by diners who bought both vegetarian and another meal type (meat, fish or vegan) at a single mealtime were categorised as NA and excluded (<2.5%, SOM Table S2). The same approach was applied to model individual-level meat sales.

We wanted to test if response to price changes varied with background levels of meat consumption. We used data from the preceding term (summer 2018) to calculate the percentage of meals that were vegetarian or vegan for each diner who had bought 10 or more meals and used these values to estimate quartiles for Most, More, Less and Least vegetarian (MostVeg, MoreVeg, LessVeg and LeastVeg). To increase sample sizes, we also applied these quartile thresholds (Q1=7.6%, median=18.8%, Q3=33.3%, SOM Table S3) to those diners who chose ≤9 meals during the summer term, and so were able to assign each diner in autumn 2018 who had eaten at the cafeteria at least once during summer 2018 to our quartile groups. The mean values of vegan and vegetarian meals selected per individual within each quartile from the summer term were: MostVeg = 70.7%, MoreVeg = 21.2%, LessVeg = 10.7% and LeastVeg = 0.9%, SOM Table S4).

We also combined the data for vegetarian and vegan (veg&vegan) meals, and for meat and fish meals (meat&fish) to investigate the effect of the intervention on meat&fish-free and meat&fish-containing sales. These are meaningful categories to compare (i.e. vegetarian and non-vegetarian) and collapsing meal types into these broader categories has been carried out in previous studies (Garnett et al., 2019; Jalil, Tasoff, & Bustamante, 2020). Furthermore, this results in models which are simpler to interpret as we can investigate the effect of the intervention on two categories instead of four (i.e. as a binary contrast).

### 2.4 Analytical approach

For this study the primary outcomes were the effects of the price change on total sales, vegetarian sales (%) and meat sales (%). The secondary outcomes were the effects of the price change to fish sales (%), vegan sales (%), vegetarian and vegan sales (%) and meat and fish sales (%). To avoid repetition, here we describe the analytical approach used for the primary outcomes, the same methods were applied for the secondary outcomes. We carried out analyses in R 3.6.3 using packages lme4, visreg and effects (Bates, Bolker, Maechler, & Walker, 2015; Breheny & Burchett, 2016; Fox & Weisberg, 2018; R Core Team, 2020). Following the recommendations of Simmons et al. (2011) we estimated the effects of the price change on total sales, meat sales and vegetarian sales using both univariate and multivariate analyses (Table 2 shows the independent variables included in our analyses). To make our experiment feasible for the cafeteria to implement, we could only introduce a one-time change between the baseline and intervention periods, instead of multiple alternations during the term. Therefore, controlling for any potentially confounding time effects is particularly important for our analyses. We considered two time variables, days since the start of the baseline (with an invariant value for the intervention days), and days since the start of the intervention (with an invariant value for the baseline days, Table 2).

We estimated the effect of the price change on vegetarian sales (% of total sales) and meat sales (% of total sales) using binomial generalised linear models (GLMs) for the aggregate data. These data were coded using the binomial distribution. For example for vegetarian sales (%), each observation (mealtime) was a composite of two numbers: the total vegetarian meals and the total non-vegetarian meals (meat, fish, vegan) sold at one mealtime. For these analyses, where data were not disaggregated by individual diners, each meal selection was treated as independent. This adds uncertainty to p-value estimates so we focused on effect sizes and 95% confidence intervals. We used linear models (LMs) to model the total meal sales (meat, vegetarian, vegan and fish). For individual-level data, we used binomial generalised linear mixed models (GLMMs) with each diner as a random (rather than fixed) effect, so meal selections were not treated as independent but were grouped longitudinally by diner. The GLMMs allowed each individual to have a different likelihood of selecting a vegetarian or meat meal. For these data, each individual at each mealtime was one observation, coded as 0, 1 or NA.

Conditional regression was used to generate lines of best fit and confidence intervals, with conditions selected to most closely match the raw data means (Figure 1). A 95% confidence level was used to calculate confidence intervals and the exponential of the model estimate was used to generate effect sizes. Model diagnostics were run for each model and the models were acceptable, with no models reporting a variance inflation factor (VIF) over 10, with the exception of the individual-level model for fish.

*Table 2: Independent variables included in the multi-variate models*

| **Model** | **Variable** | **Description and notes** |
|---|---|---|
| All models | Price condition | Baseline or Intervention |
| | Days Since Baseline | Time variable for the baseline period. First day of the baseline has a value of -27 and the final baseline day, -1; all days of the intervention period are invariant with a value of 0. |
| | Days Since Intervention | Time variable for the intervention period. First day of the intervention has a value of 1 and the final intervention day, 32; all days of the baseline period are invariant with a value of 0. |
| | Mealtime | Lunch or dinner |
| | Day | Monday, Tuesday, Wednesday, Thursday, Friday, Saturday |
| | Ambient temperature (centigrade) | Mean outside temperature on that date (“Cambridge Daily Weather Graphs,” 2018). Previous studies have found that temperature can correlate with food and drink selections (Garnett, Balmford, Sandbrook, Pilling, & Marteau, 2019; Pechey et al., 2016). |
| For individual-level models only | Prior level of vegetarian meal consumption | Individual diners were divided into least, less, more and most vegetarian quartiles in order to test for interaction effects with the price change |

# 3 Results

## 3.1 Total sales: aggregate data

A mean of 137 meals were sold per mealtime during the baseline period, and 125 meals per mealtime during the intervention period. In a univariate analysis, total meal sales were significantly lower during the intervention period (LM, p=0.048), but when adjusting for other variables in the multivariate analysis there was no significant difference (LM, p=0.783, Table 3, SOM Table S5), with a predicted 133 meals [CI= 112, 153] sold during the baseline period and 131 [CI= 111, 148] sold during the intervention period.

## 3.2 Vegetarian and meat sales: aggregate data

The mean proportion of vegetarian sales were 21.0% during the baseline period and 21.8% during the intervention; mean meat sales were 61.7% and 61.2% respectively. In the univariate analysis there was no significant difference in vegetarian sales between the baseline and intervention periods (GLM, p=0.654). In the multivariate analysis, vegetarian sales were significantly higher during the intervention period (GLM, p=0.036, SOM Table S6) by an estimated 3.2 percentage points (from 20.6% [CI= 18.0%, 23.5%] to 23.8% [CI= 21.1%, 26.7%], a 15.5% increase from baseline sales, Table 3). For meat sales, the price change made no significant difference to sales in the univariate analysis (GLM, p=0.490, SOM Table S7) nor the multi-variate analysis (GLM, p=0.298, Table 3).

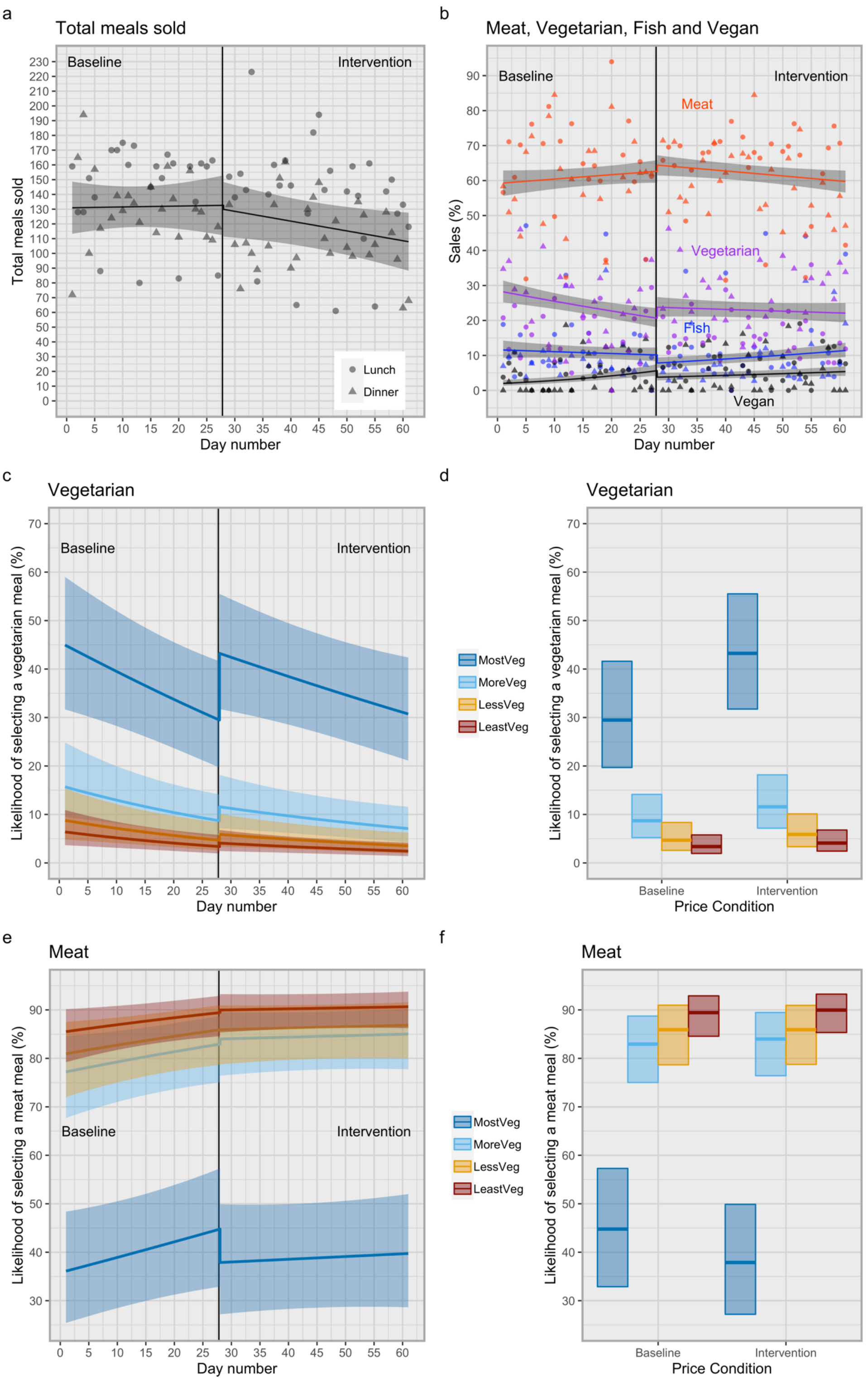


*Figure 1: Results from the baseline and intervention periods.*
*Raw data: a) Total meals sold. b) Aggregate sales of meat, vegetarian, fish and vegan meals for all diners, including cash sales. Modelled data: c) Likelihood of selecting a vegetarian meal for quartiles of diners over time and d) in the baseline and intervention periods. e) Likelihood of selecting a meat meal for quartiles of diners over time and d) in the baseline and intervention periods. For c) to f), individual diners are divided into MostVeg to LeastVeg quartiles, based on data from a previous term. Lines are modelled estimates and the error bars are 95% confidence regions.*

*Table 3: Modelled results from aggregate data analyses (univariate and multivariate) for total meal, vegetarian (%) and meat (%) sales. 95% confidence intervals reported. [a]Model estimates for sales under baseline prices; [b]Model estimates for sales under intervention prices; [c]Effect size of the price intervention (odds ratio (OR)) compared to the baseline (the reference category).*

| **Model** | **Sales** | **[a]Baseline period sales [CIs]** | **[b]Intervention period sales [CIs]** | **Difference between Intervention and Baseline periods** | **[c]Price change effect size OR [CIs]** | **Price change p-value** |
|---|---|---|---|---|---|---|
| Univariate | Total meals | 137 [128, 146] | 125 [117, 133] | -12 | 0.91 [0.81, 1.00] | 0.048 * |
| Multivariate | Total meals | 133 [112, 153] | 130 [111, 148] | -3 | 0.98 [0.83 1.10] | 0.783 |
| Univariate | Vegetarian (%) | 21.1 [20.1, 22.1] | 20.8 [19.9, 21.7] | -0.3 | 0.98 [0.90, 1.06] | 0.654 |
| Multivariate | Vegetarian (%) | 20.6[18.0, 23.5] | 23.8 [21.1, 26.7] | 3.2 | 1.20 [1.01, 1.42] | 0.036 * |
| Univariate | Meat (%) | 60.9 [59.7, 62.0] | 61.5 [60.3, 62.6] | 0.6 | 1.02 [0.96, 1.10] | 0.490 |
| Multivariate | Meat (%) | 62.7 [59.4, 65.8] | 64.4 [61.5, 67.3] | 1.7 | 1.08 [0.94, 1.24] | 0.298 |
| Univariate | Fish (%) | 13.2 [12.4, 14.1] | 11.7 [10.9, 12.4] | -1.5 | 0.86 [0.78, 0.95] | 0.004 ** |
| Multivariate | Fish (%) | 12.5 [10.2, 15.3] | 9.7 [7.8, 12.0] | -2.8 | 0.75 [0.60, 0.94] | 0.010 * |
| Univariate | Vegan (%) | 4.8 [4.3, 5.3] | 6.1 [5.6, 6.7] | 1.3 | 1.30 [1.12, 1.51] | <0.001 *** |
| Multivariate | Vegan (%) | 6.4 [4.8, 8.5] | 4.3 [3.2, 5.7] | -2.1 | 0.66 [0.49, 0.89] | 0.006 ** |

### 3.3 Vegetarian and meat sales: individual-level data

During the study period in the individual-level analysis dataset, 626 identifiable diners bought a meal at the college cafeteria. Of these, 325 diners (52%) had bought at least one meal during the previous term (summer 2018) and were therefore assigned a quartile based on their level of vegetarian and vegan meal consumption during that time. These 325 diners visited the cafeteria a mean of 16.4 times during the term (number of visits: min =1, Q1=4, median=13, Q3=25, max=75), making 5,330 meal selections which we analyse here (SOM Table S2). Of these 325 individuals, 296 dined during the baseline period and 270 (91%) of these diners were also present during the intervention period. Within the MostVeg quartile, diners who came to the cafeteria less frequently selected a higher proportion of vegetarian (and vegan) meals, and therefore the mean vegetarian sales (%) aggregated across all individuals was substantially lower than the mean vegetarian selection per individual (Table 4).

For both meat and vegetarian sales the MostVeg quartile had the strongest response to the price intervention (Figure 1c-f). The likelihood of individuals in the MostVeg selecting a vegetarian meal increased by 13.7 percentage points (from 29.5% [CI= 19.7, 41.6] to 43.2% [CI= 31.7, 55.5], a 46.4% increase from the baseline, GLMM, p=0.011, Table 4, SOM Table S8). Vegetarian purchases by diners from the other three quartiles (LeastVeg, LessVeg and MoreVeg) did not significantly change under the intervention (Table 4, Figure 1c and 2d). We found a similar pattern when we divided diners into deciles based on their prior vegetarian and vegan meal consumption (SOM Figure S3 and Table S9). However, none of the quartiles showed significant differences in meat purchases following the intervention (GLMM, p values >0.1, Table 4, Figure 1e and 2f, SOM Table S10).

*Table 4: Raw means and modelled results from multivariate analyses for individual-diner vegetarian (%) and meat (%) selections. Standard deviation (SD) and 95% confidence intervals (CIs) reported. For vegetarian analyses, if a diner selected both a vegetarian meal and a meat/fish/vegan meal at the same mealtime, this was designated NA and excluded from analyses. The raw mean for overall selections is weighted towards individuals who visited the cafeteria more frequently; for the raw mean per individual, each individual is weighted equally.*

| **Meal option** | **Quartile** | **Number of individuals (excluding NAs)** | **Meal selections (excluding NAs)** | **Raw mean (overall selections) (%)** | **Raw mean (per individual) (%)** | **Baseline period selection (%) [CIs]** | **Intervention period selection (%) [CIs]** | **Difference between Intervention and Baseline periods (percentage points)** |
|---|---|---|---|---|---|---|---|---|
| Vegetarian | Most vegetarian | 76 | 924 | 33.5 | 44.2 | 29.5 [19.7, 41.6] | 43.2 [31.7, 55.5] | 13.7 |
| Vegetarian | More vegetarian | 68 | 1270 | 12.4 | 14.8 | 8.7 [5.2, 14.1] | 11.6 [7.2, 18.2] | 2.9 |
| Vegetarian | Less vegetarian | 69 | 1168 | 8.0 | 7.2 | 4.7 [2.6, 8.4] | 5.9 [3.4, 10.1] | 1.2 |
| Vegetarian | Least vegetarian | 111 | 1863 | 5.6 | 6.4 | 3.4 [2.0, 5.8] | 4.1 [2.4, 6.8] | 0.7 |
| *Vegetarian* | *Total* | *324* | *5225* | *20.5* | *17.2* | *NA* | *NA* | *NA* |
| Meat | Most vegetarian | 76 | 925 | 46.2 | 34.2 | 44.8 [32.9, 57.3] | 37.8 [27.2, 49.8] | -7.0 |
| Meat | More vegetarian | 68 | 1266 | 73.2 | 70.3 | 82.9 [75.0, 88.7] | 84.0 [76.4, 89.5] | 1.1 |
| Meat | Less vegetarian | 69 | 1160 | 75.0 | 70.8 | 85.9 [78.7, 91.0] | 85.9 [78.7, 90.9] | 0.0 |
| Meat | Least vegetarian | 110 | 1855 | 80.4 | 77.0 | 89.4 [84.6, 92.9] | 90.0 [85.3, 93.2] | 0.6 |
| *Meat* | *Total* | *323* | *5206* | *62.2* | *64.2* | *NA* | *NA* | *NA* |

### 3.4 Price change and meal displacement

If the price change led to increased vegetarian meal selection but correspondingly lower vegan sales there is a risk that there would be no additional environmental benefit or greenhouse gas savings. Similarly, lower meat sales but higher fish sales could also compromise sustainability objectives. We ran further models to estimate the overall effects of our intervention.

For the aggregate data, the intervention period corresponded with a significant decrease in both fish (GLM, p=0.010) and vegan sales (GLM, p=0.006), by 2.8 and 2.1 percentage points respectively (multivariate analyses, Table 3, SOM Tables S11 and S12). However, no significant differences in selection for any of the four quartiles were detected in the individual analysis for vegan and fish selections (GLMMs, p values>0.050, SOM Tables S13 and S14) indicating that it was the sales from guests and diners without a prior quartile (included in the aggregate but not individual analyses) that contributed to a significant reduction in vegan and fish sales.

We combined the data for vegetarian and vegan (veg&vegan) meals, and for meat and fish meals (meat&fish). For the aggregate sales, the price change made no difference to veg&vegan sales (GLM, p=0.555) nor meat&fish sales (GLM, p=0.555). In the individual-level analyses, the difference in selections for diners from the LeastVeg, LessVeg and MoreVeg quartiles, for both veg&vegan and meat&fish sales, were non-significant and no greater than 1 percentage point before and after the price change (GLMMs, p values >0.100, Figure 2). However, for diners from the MostVeg quartile the models estimated that the price change led to a 12.2 percentage point increase in veg&vegan selections (from 44.3% [CI=31.4%, 57.9%] to 56.5% [CI=43.3%, 68.8%], GLMM, p=0.035, SOM Table S15), and a 13.1 percentage point decrease in meat&fish selections (from 57.1% [CI= 43.4%, 69.7%] to 44.0% [CI=31.6%, 57.2%]; GLMM, p=0.020, Figure 2, SOM Table S16).

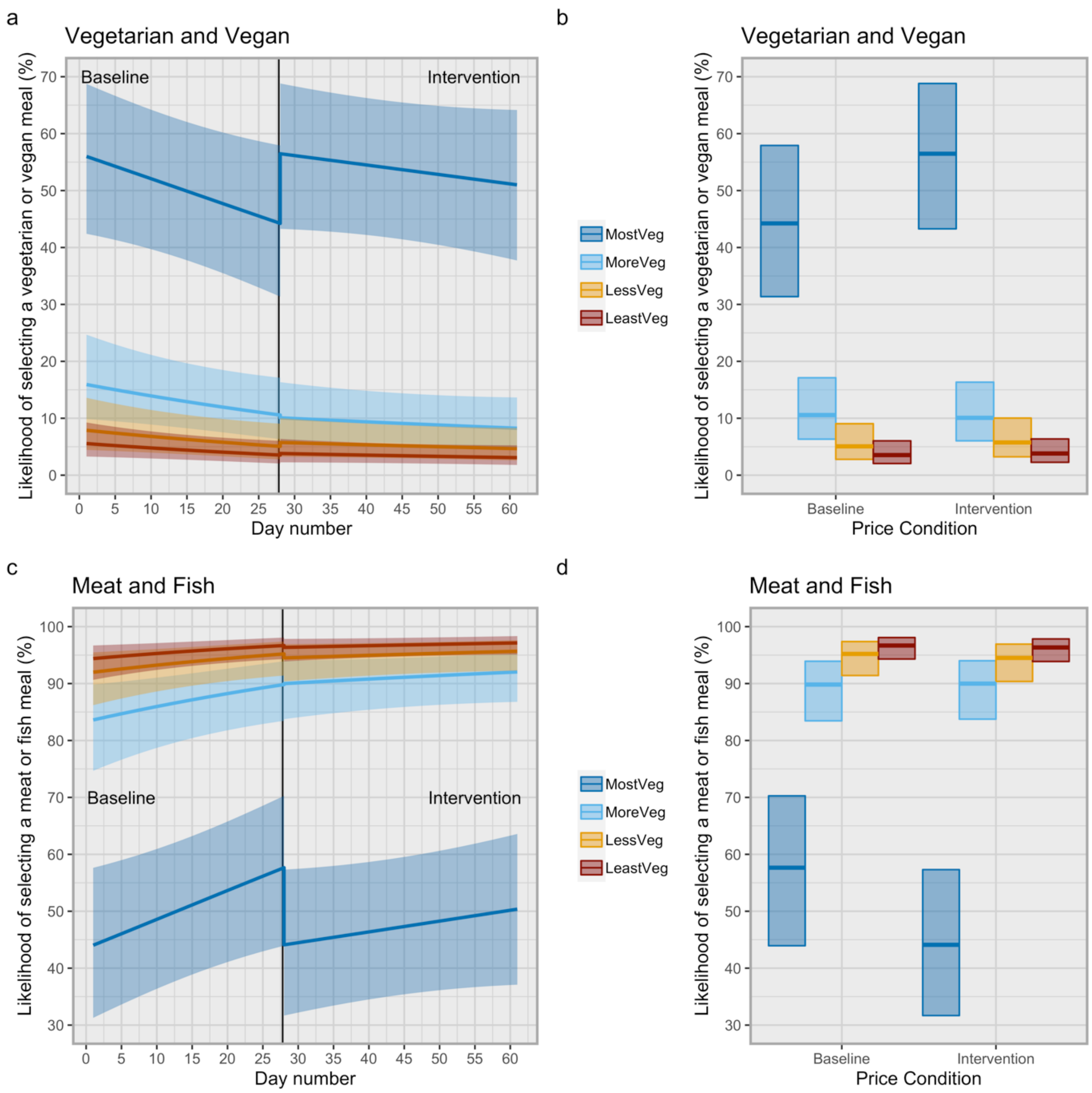


*Figure 2: Results from the baseline and intervention periods. a) Likelihood of selecting a vegetarian or vegan meal for quartiles of diners over time and b) in the baseline and intervention periods. c) Likelihood of selecting a meat or fish meal for quartiles of diners over time and d) in the baseline and intervention periods. Individual diners are divided into MostVeg to LeastVeg quartiles, based on data from a previous term. Lines are modelled estimates and the error bars are 95% confidence intervals.*

## 4. Discussion

Our results show that even a small change in the price of meat and vegetarian options can increase overall vegetarian sales, but did not lead to significantly lower overall meat sales. Individual-level analysis indicates that the increase in vegetarian sales was driven by individuals with a prior disposition to selecting vegetarian food. Meat selections did not decrease significantly for the MostVeg quartile of individuals, but meat&fish selections did decrease significantly by 13.1 percentage points for this quartile. This indicates that the increase in vegetarian selection for the MostVeg quartile was not primarily driven by reductions in vegan meal selection.

### 4.1 Study strengths and limitations

To our knowledge this is the first field study to use individual-level data to test if a small price change to meat and vegetarian options can increase vegetarian meal consumption. Although many reports have called for reductions in meat consumption, there are still relatively few field studies testing strategies that might achieve this (Bianchi, Dorsel, Garnett, Aveyard, & Jebb, 2018; Bianchi, Garnett, et al., 2018). Furthermore, very few studies in cafeterias and restaurants have individual-level data (Epstein et al., 2012). We conducted a field study that tracked hundreds of individuals across 106 cafeteria mealtimes and we were able to look separately at people with varying prior levels of vegetarian and vegan consumption. Our results provide important evidence on how the effects of small economic incentives differ across subgroups: this knowledge is key for designing effective interventions at the population level. A previous study found that dietary behaviour change from a motivated population subgroup can lead to important environmental benefits (Willits-Smith, Aranda, Heller, & Rose, 2020). The modest change to the price of options, and our finding that this did not significantly affect total meal purchases, indicates that an intervention of the magnitude tested here could be safe for caterers to implement without impinging negatively on sales.

However, our study also has several limitations. It was conducted in one cafeteria in a university. We therefore do not know the extent to which the results generalise beyond that one cafeteria or to other populations. We do not know if the change in price of the vegetarian option, the meat options, the increase of the price differential or a combination of all three led to our results. Due to the design of our study, we did not collect information on students' views of the price change or to what extent they had noticed it. The price change was not heavily advertised (Figures S1 and S2) and although this might have resulted in a smaller effect size, this may better reflect how price changes are brought about in real-world contexts. We were unable to extend the study beyond nine weeks thereby limiting our ability to test the sustainability of the effects observed for a relatively short period of time: there is therefore a chance that our study is underpowered to detect changes in sales. Vegetarian sales were lower than meat sales and therefore our analyses for aggregate vegetarian sales have higher power than the analyses for aggregate meat sales, with the same absolute change easier to detect for vegetarian than for meat sales. In the individual-level analyses, the MostVeg quartile showed a significant increase in vegetarian sales after the price change (Table S9), but no significant decrease in meat or fish sales when these were analysed separately (Tables S10 and S13). However, when meat and fish sales were analysed together, the MostVeg quartile's selection of meat&fish meals decreased by 13.1 percentage points (p=0.020, Table S16). This perhaps suggests that the increase in vegetarian selections for the MostVeg quartile were due to a decrease in both meat and fish selections and that there was not enough statistical power to detect a decrease when meat and fish were analysed separately.

### 4.2 Interpretation and implications

Price changes which are more salient – i.e. more noticeable – have a greater influence on demand for those products (Chetty, Looney, & Kroft, 2009). Various factors are likely to have lowered the salience of our intervention to diners. Although the price change was advertised it would still have been easy for students – especially those paying with cards (Greenacre & Akbar, 2019) – to miss, and the meat and vegetarian options in the baseline period already had different rather than identical prices. Students generally buy additional items such as vegetable sides, drinks and desserts which might further have masked the price change to the main meal options. Some factors are likely to have increased the salience and effectiveness of our intervention. The vegetarian option price change resulted in the first numeral changing from £2 to £1: consumers pay less attention to the digits after the decimal point, and associate £1.99 with £1 rather than £2 purchases (Bizer & Schindler, 2005). We might also expect students to be more price sensitive than other groups in the UK. However, students on a small budget tend to avoid college cafeterias and prepare their own meals instead (E.G. pers. obs.). Our sample of students choosing to dine in the cafeteria is therefore likely to be biased towards less price-sensitive students. These factors are idiosyncratic to the study setting and all might have affected the results.

This research presents opportunities for further studies. Our work was conducted in one cafeteria in one UK university, with only one small change in price. The MostVeg quartile of diners in our study may have had a more elastic demand for meat and vegetarian options, and therefore were more sensitive to price changes than other diners who might be more fixed in their preference for meat. Future research could involve staggered field studies with different magnitudes of price changes and initial price parity between options, to ascertain if greater price changes persuade more carnivorous diners to change their behaviour and consequently lead to larger changes in meat and vegetarian consumption, or affect overall sales and revenue. Universities are useful locations to run trials, but further studies in non-student populations and in medium and low-income countries are also clearly needed to test if our findings are generalisable.

Besides the arguments for changing the price of meal options to encourage more sustainable diets, the new prices also better reflected the costs of the meal ingredients. During the intervention period both meat and vegetarian meals had an 80p margin between the customer price and the ingredient costs, though the vegetarian meals still had a higher percentage mark up (~76%) than meat (~43%, SOM Table S17). In the absence of fiscal measures which align the market price of food with its environmental cost, institutions could introduce differential pricing on meals to better reflect both environmental and ingredient costs. However, changes in price whilst potentially effective at changing behaviour in the short term, perhaps risk reinforcing the notion of meat as a status symbol and vegetarian options as inferior (Hayley, Zinkiewicz, & Hardiman, 2015; Rogers, 2015; Ruby & Heine, 2011). This could potentially increase the demand for meat in the long-term.

### 4.3 Effectiveness of price compared to other interventions

Compared to other studies conducted in the University of Cambridge, a small change in price may be more effective than changing the order in which meal options are presented in the cafeteria (Garnett, Marteau, Sandbrook, Pilling, & Balmford, 2020). However, it does not appear to be as effective at reducing meat consumption as increasing the proportion of vegetarian options available. A 25% to 50% increase in vegetarian availability led to increases in vegetarian sales of between seven and 15 percentage points in three different colleges (Garnett et al., 2019). The diners with the lowest prior levels of vegetarian consumption responded most strongly to this intervention (Garnett et al., 2019), a finding which was replicated in an online study on vegetarian availability (Raghoebar, Kleef, & Vet, 2020). Our result that only the MostVeg quartile of diners responded to the price change is perhaps unsurprising given that price elasticity depends on individuals' preferences (Andreyeva et al., 2010), but it is interesting that other studies on increasing vegetarian meal selection found an effect in the opposite direction.

Currently there is insufficient evidence on the effects of price on meat consumption. In other contexts, depending on the product and the price, price interventions can be very effective at changing behaviour (An, 2013; Andreyeva et al., 2010; Bloomberg et al., 2019).

## 4.4 Conclusion

This study provides promising evidence that even small price changes can increase sales of vegetarian and vegan meals and decrease sales of meat and fish meals, but only for diners with the highest prior levels of vegetarian and vegan meal selection. Further field studies are needed to investigate more generally how far shifting prices could reduce meat consumption and thereby mitigate climate change and biodiversity loss.

## Data Availability

The aggregate data, a summary of the individual-level data and model predictions from this study is available at https://doi.org/10.17863/CAM.52898.


## Acknowledgements

We thank Rob and Martin for generously contributing their time and data, Benno Simmons for help with coding in R, and Sarah Warren and Ned Garnett for feedback on the manuscript. E.E.G is funded by a Natural Environment Research Council Studentship (Grant NE/L002507/1). A.B. is supported by a Royal Society Wolfson Research Merit Award.

## 5. References


Allwood, J. M., Dunant, C. F., Lupton, R. C., Cleaver, C. J., Serrenho, A. C. H., Azevedo, J. M. C., … Hawkins, W. (2019). Absolute Zero. Delivering the UK's climate change commitment with incremental changes to today's technologies. https://doi.org/10.17863/CAM.46075

An, R. (2013). Effectiveness of subsidies in promoting healthy food purchases and consumption: A review of field experiments. *Public Health Nutrition*, *16*(7), 1215–1228. https://doi.org/10.1017/S1368980012004715

Andreyeva, T., Long, M. W., & Brownell, K. D. (2010). The impact of food prices on consumption: A systematic review of research on the price elasticity of demand for food. *American Journal of Public Health*, *100*(2), 216–222. https://doi.org/10.2105/AJPH.2008.151415

Attwood, S., Chesworth, S. J., & Parkin, B. L. (2020). Menu engineering to encourage sustainable food choices when dining out: An online trial of priced-based decoys. *Appetite*, *149*(June 2019), 104601. https://doi.org/10.1016/j.appet.2020.104601

Balmford, A., Amano, T., Bartlett, H., Chadwick, D., Collins, A., Edwards, D., … Eisner, R. (2018). The environmental costs and benefits of high-yield farming. *Nature Sustainability*, *1*(9), 477–485. https://doi.org/10.1038/s41893-018-0138-5

Bates, D., Bolker, B. M., Maechler, M., & Walker, S. C. (2015). Fitting linear mixed effects models using lme4. *Journal of Statistical Software*, *67*(1), 251–264. https://doi.org/10.18637/jss.v067.i01

Bianchi, F., Dorsel, C., Garnett, E., Aveyard, P., & Jebb, S. A. (2018). Interventions targeting conscious determinants of human behaviour to reduce the demand for meat: A systematic review with qualitative comparative analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *15*(102), 1–25. https://doi.org/10.1186/s12966-018-0729-6

Bianchi, F., Garnett, E., Dorsel, C., Aveyard, P., & Jebb, S. A. (2018). Restructuring physical micro-environments to reduce the demand for meat: A systematic review with qualitative comparative analysis. *Lancet Planetary Health*, *2*(9), e384–e397.

https://doi.org/10.1016/S2542-5196(18)30188-8

Bizer, G. Y., & Schindler, R. M. (2005). Direct evidence of ending-digit drop-off in price information processing. *Psychology and Marketing*, *22*(10), 771–783. https://doi.org/10.1002/mar.20084

Bloomberg, M. R., Summers, L. H., Ahmed, M., Aziz, Z., Basu, K., Cárdenas, M., … Vázquez, T. (2019). *Health taxes to save lives*.

Breheny, P., & Burchett, W. (2016). Visualization of Regression Models Using visreg. *The R Journal*, *9*(December), 56–71. Retrieved from https://cran.r-project.org/web/packages/visreg/citation.html

Cambridge Daily Weather Graphs. (2018). Retrieved from http://www.cl.cam.ac.uk/research/dtg/weather/index-daily-graph.html

Chetty, R., Looney, A., & Kroft, K. (2009). Salience and taxation: Theory and evidence. *American Economic Review*, *99*(4), 1145–1177. https://doi.org/10.1257/aer.99.4.1145

Committee on Climate Change. (2018). *Land use: Reducing emissions and preparing for climate change*. Retrieved from www.theccc.org.uk/publications

Committee on Climate Change. (2020). *Land use: Policies for a net zero UK*. Retrieved from https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/

Dangal, S. R. S., Tian, H., Zhang, B., Pan, S., Lu, C., & Yang, J. (2017). Methane emission from global livestock sector during 1890–2014: Magnitude, trends and spatiotemporal patterns. *Global Change Biology*, *23*(10), 4147–4161. https://doi.org/10.1111/gcb.13709

DEFRA. (2016). *Food statistics pocketbook 2016*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/423616/foodpocketbook-2014report-23apr15.pdf

Deliens, T., Deforche, B., Annemans, L., De Bourdeaudhuij, I., & Clarys, P. (2016). Effectiveness of Pricing strategies on French fries and fruit purchases among university students: Results from an on-campus restaurant experiment. *PLoS ONE*, *11*(11), 1–16. https://doi.org/10.1371/journal.pone.0165298

Dhingra, M. S., Artois, J., Dellicour, S., Lemey, P., Dauphin, G., Von Dobschuetz, S., … Gilbert, M. (2018). Geographical and historical patterns in the emergences of novel highly pathogenic avian influenza (HPAI) H5 and H7 viruses in poultry. *Frontiers in Veterinary Science*, *5*(JUN), 1–14. https://doi.org/10.3389/fvets.2018.00084

Diepeveen, S., Ling, T., Suhrcke, M., Roland, M., & Marteau, T. M. (2013). Public acceptability of government intervention to change health-related behaviours: a systematic review and narrative synthesis. *BMC Public Health*, *13*(756), 1–11. https://doi.org/10.1186/1471-2458-13-756

Edjabou, L. D., & Smed, S. (2013). The effect of using consumption taxes on foods to promote climate friendly diets - The case of Denmark. *Food Policy*, *39*, 84–96. https://doi.org/10.1016/j.foodpol.2012.12.004

Energy Systems Catapult. (2019). *Innovating to Net Zero*. Birmingham, UK. Retrieved from es.catapult.org.uk

Epstein, L. H., Jankowiak, N., Nederkoorn, C., Raynor, H. A., French, S. A., & Finkelstein, E. (2012). Experimental research on the relation between food price changes and food purchasing patterns: a targeted review. *American Journal of Clinical Nutrition*, *95*, 789–809. https://doi.org/10.3945/ajcn.111.024380.1

FAO. (2017). Food Supply: Livestock and fish primary equivalent. Retrieved September 6, 2019, from http://www.fao.org/faostat/en/?#data/CL/visualize

Fox, J., & Weisberg, S. (2018). Visualizing fit and lack of fit in complex regression models with predictor effect plots and partial residuals. *Journal of Statistical Software*, *87*(9). https://doi.org/10.18637/jss.v087.i09

Garnett, E. E., Balmford, A., Sandbrook, C., Pilling, M. A., & Marteau, T. M. (2019). Impact of increasing vegetarian availability on meal selection and sales in cafeterias. *Proceedings of the National Academy of Sciences*, *116*(42), 201907207. https://doi.org/10.1073/pnas.1907207116

Garnett, E. E., Marteau, T. M., Sandbrook, C., Pilling, M. A., & Balmford, A. (2020). Order of meals at the counter and distance between options affect student cafeteria vegetarian sales. *Nature Food*, *1*(August), 485–488. https://doi.org/10.1038/s43016-020-0132-8

Greenacre, L., & Akbar, S. (2019). The impact of payment method on shopping behaviour among low income consumers. *Journal of Retailing and Consumer Services*, *47*(November 2018), 87–93. https://doi.org/10.1016/j.jretconser.2018.11.004

Hayley, A., Zinkiewicz, L., & Hardiman, K. (2015). Values, attitudes, and frequency of meat consumption. Predicting meat-reduced diet in Australians. *Appetite*, *84*, 98–106. https://doi.org/10.1016/j.appet.2014.10.002

Hoek, A. C., Pearson, D., James, S. W., Lawrence, M. A., & Friel, S. (2017). Healthy and environmentally sustainable food choices: Consumer responses to point-of-purchase actions. *Food Quality and Preference*, *58*, 94–106. https://doi.org/10.1016/j.foodqual.2016.12.008

Jalil, A. J., Tasoff, J., & Bustamante, A. V. (2020). Eating to save the planet: Evidence from a randomized controlled trial using individual-level food purchase data. *Food Policy*, (June), 101950. https://doi.org/10.1016/j.foodpol.2020.101950

Jensen, Jorgen Dejgaard, Smed, S., Aarup, L., & Nielsen, E. (2016). Effects of the Danish saturated fat tax on the demand for meat and dairy products. *Public Health Nutrition*, *19*(17), 3085–3094. https://doi.org/10.1017/S1368980015002360

Jensen, Jørgen Dejgård, & Smed, S. (2013). The Danish tax on saturated fat - Short run effects on consumption, substitution patterns and consumer prices of fats. *Food Policy*, *42*, 18–31. https://doi.org/10.1016/j.foodpol.2013.06.004

Jones, B. A., Grace, D., Kock, R., Alonso, S., Rushton, J., Said, M. Y., … Pfeiffer, D. U. (2013). Zoonosis emergence linked to agricultural intensification and environmental change. *Proceedings of the National Academy of Sciences*, *110*(21), 8399–8404. https://doi.org/10.1073/pnas.1208059110

Kehlbacher, A., Tiffin, R., Briggs, A., Berners-Lee, M., & Scarborough, P. (2016). The distributional and nutritional impacts and mitigation potential of emission-based food taxes in the UK. *Climatic Change*, *137*(1–2), 121–141. https://doi.org/10.1007/s10584-016-1673-6

Machovina, B., Feeley, K. J., & Ripple, W. J. (2015). Biodiversity conservation: The key is reducing meat consumption. *Science of the Total Environment*, *536*, 419–431.

https://doi.org/10.1016/j.scitotenv.2015.07.022

Park, T. (2020). *A menu for change: Using behavioural science to promote sustainable diets around the world*. London, UK. Retrieved from www.bi.team

Pechey, R., Couturier, D. L., Hollands, G. J., Mantzari, E., Munafò, M. R., & Marteau, T. M. (2016). Does wine glass size influence sales for on-site consumption? A multiple treatment reversal design. *BMC Public Health*, *16*(1), 1–6. https://doi.org/10.1186/s12889-016-3068-z

Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science*, *992*(6392), 987–992. https://doi.org/10.1126/SCIENCE.AAQ0216

R Core Team. (2020). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.r-project.org/

Raghoebar, S., Kleef, E. Van, & Vet, E. De. (2020). Increasing the proportion of plant-based foods available to shift social consumption norms and food choice among non-vegetarians. *Sustainability*, *12*(5371), 1–23. https://doi.org/10.3390/su12135371

Rogers, R. A. (2015). Beasts, burgers, and hummers: Meat and the crisis of masculinity in contemporary television advertisements. *Environmental Communications*, *2*(3), 281–301. https://doi.org/10.1080/17524030802390250

Ruby, M. B., & Heine, S. J. (2011). Meat, morals, and masculinity. *Appetite*, *56*(2), 447–450. https://doi.org/10.1016/j.appet.2011.01.018

Säll, S., & Gren, I.-M. (2015). Effects of an environmental tax on meat and dairy consumption in Sweden. *Food Policy*, *55*, 41–53. https://doi.org/10.1016/j.foodpol.2015.05.008

Scarborough, P., Appleby, P. N., Mizdrak, A., Briggs, A. D. M., Travis, R. C., Bradbury, K. E., & Key, T. J. (2014). Dietary greenhouse gas emissions of meat-eaters, fish-eaters, vegetarians and vegans in the UK. *Climatic Change*, *125*(2), 179–192. https://doi.org/10.1007/s10584-014-1169-1

Searchinger, T. D., Wirsenius, S., Beringer, T., & Dumas, P. (2018). Assessing the efficiency of changes in land use for mitigating climate change. *Nature*, *564*, 249–253. https://doi.org/10.1038/s41586-018-0757-z

Shukla, P. R., Skea, J., Slade, R., Diemen, R. van, Haughey, E., Malley, J., … Pereira, J. P. (2019). *IPCC Special Report on Climate Change and Land - Technical Summary*. *Climate Change and Land*. Retrieved from https://www.ipcc.ch/srccl/chapter/technical-summary/

Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2011). False-positive psychology: Undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological Science*, *22*(11), 1359–1366. https://doi.org/10.1177/0956797611417632

Springmann, M., Mason-D'Croz, D., Robinson, S., Wiebe, K., Godfray, H. C. J., Rayner, M., & Scarborough, P. (2017). Mitigation potential and global health impacts from emissions pricing of food commodities. *Nature Climate Change*, (7), 69–74. https://doi.org/10.1038/nclimate3155

The Danish Council on Ethics. (2016). *The Ethical Consumer: Climate Damaging Foods*.

Thow, A. M., Downs, S., & Jan, S. (2014). A systematic review of the effectiveness of food taxes and subsidies to improve diets: Understanding the recent evidence. *Nutrition Reviews*, *72*(9), 551–565. https://doi.org/10.1111/nure.12123

True Animal Price Protein Coalition. (2020). *Aligning food pricing policies with the European Green Deal*. Retrieved from www.tappcalition.eu

Uniware. (n.d.). Retrieved January 8, 2019, from http://www.uniware.co.uk/

Vallgårda, S., Holm, L., & Jensen, J. D. (2015). The Danish tax on saturated fat: Why it did not survive. *European Journal of Clinical Nutrition*, *69*(2), 223–226. https://doi.org/10.1038/ejcn.2014.224

Van Boeckel, T. P., Brower, C., Gilbert, M., Grenfell, B. T., Levin, S. A., Robinson, T. P., … Laxminarayan, R. (2015). Global trends in antimicrobial use in food animals. *Proceedings of the National Academy of Sciences*, *112*(18), 5649–5654. https://doi.org/10.1073/pnas.1503141112

Vermeer, W. M., Alting, E., Steenhuis, I. H. M., & Seidell, J. C. (2010). Value for money or making the healthy choice: The impact of proportional pricing on consumers' portion size choices. *European Journal of Public Health*, *20*(1), 65–69. https://doi.org/10.1093/eurpub/ckp092

Wasley, A., Heal, A., & Snaith, E. (2018, December 28). Intensive farmers get £70M in government subsidies in two years. *Burea of Investigative Journalism and The Guardian*. Retrieved from https://www.thebureauinvestigates.com/stories/2018-12-28/intensive-farms-get-70m-subsidies

Wellesley, L., Happer, C., & Froggatt, A. (2015). *Changing climate, changing diets: Pathways to lower meat consumption*. *Chatham House Report*. Retrieved from https://www.chathamhouse.org/publication/changing-climate-changing-diets

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., … Murray, C. J. L. (2019). Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet*, *393*(10170), 447–492. https://doi.org/10.1016/S0140-6736(18)31788-4

Willits-Smith, A., Aranda, R., Heller, M. C., & Rose, D. (2020). Addressing the carbon footprint, healthfulness, and costs of self-selected diets in the USA: a population-based cross-sectional study. *The Lancet Planetary Health*, *4*(3), e98–e106. https://doi.org/10.1016/S2542-5196(20)30055-3

Wirsenius, S., Hedenus, F., & Mohlin, K. (2011). Greenhouse gas taxes on animal food products: Rationale, tax scheme and climate mitigation effects. *Climatic Change*, *108*(1), 159–184. https://doi.org/10.1007/s10584-010-9971-x

Zizzo, D. J., Parravano, M., Nakamura, P., Forwood, S., & Suhrcke, M. (2016). *The impact of taxation and signposting on diet: An online field study with breakfast cereals and soft drinks* (CHE Research Paper No. 131). *Centre for Health Economics*.