Got Beef with Beef? Evidence from a Large-Scale Carbon Labeling Experiment*

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Food systems account for approximately one-third of total greenhouse gas emissions, and simple shifts across food choices can yield large cuts in emissions. In a randomized field experiment with over 200,000 meal kit customers in the US, we find that carbon footprint labels cause customers to choose lower-emission meals, and that the introduction of labels has positive effects on customer retention and company profits. Both the reduction in emissions and the increase in profits are driven by customers with high baseline beef consumption. We find evidence that the labels act through salience rather than knowledge, and that the effects on meal choices depend on whether customers' values are aligned with the mission to address climate change through behavioral change.

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1 Introduction

Anthropogenic climate change has already increased global average temperatures by approximately 1.1 $^\circ$C from pre-industrial levels, with much larger increases projected without urgent efforts to cut greenhouse gas emissions (IPCC, 2023). Globally, food systems account for 25-35% of total greenhouse gas (GHG) emissions, so limiting climate change will likely require major shifts in food consumption and production (Crippa et al., 2021; Lamb et al., 2021).

Large changes in dietary carbon footprints can be achieved through simple shifts across food products (Weber and Matthews, 2008; Poore and Nemecek, 2018; Sandström et al., 2018). Animal products – and beef in particular – account for a large fraction of the GHG emissions involved in food consumption. In total, producing a kilogram of beef emits about 10 times the CO_2-equivalent emissions for a kilogram of pork or chicken and about 20 times the emissions for a kilogram of tofu (Poore and Nemecek, 2018). Shifting a fraction of average beef consumption in high-income countries towards plant-based proteins, or towards meats other than beef, could substantially reduce emissions (Bajželj et al., 2014; Clark et al., 2020; Ripple et al., 2014; Springmann et al., 2016; Hedenus et al., 2014). Despite the potential value of shifting consumers to more sustainable diets, there have been no coordinated policy efforts to achieve these demand-side behavioral changes at scale in the US.

In the absence of carbon pricing or other policy intervention to shift diets, one way to promote consumers' voluntary dietary change is to give them information about the carbon footprints of different products at their point of purchase (Taufique et al., 2022). While a policy to standardize product carbon labeling has been proposed in the EU, carbon labeling in the US will likely remain at the discretion of companies (European Commission, 2023). Some US companies have voluntarily done so, to varying extents: Panera Bread identifies its climate-friendly options as "Cool Food" meals, for example, while some companies that offer predominantly low-emission options (e.g. Oatly, Quorn, and JustSalad) label their products with numeric carbon-footprint estimates.

In this project, we collaborate with HelloFresh, the largest meal-kit company in the US, to answer two questions. First, does carbon labeling in a commercial, realistic setting effectively reduce dietary GHG emissions? Second, if dietary carbon labels will continue to be primarily implemented at the discretion of profit-maximizing companies, under what circumstances is it profitable for companies to do so? In a randomized experiment over eight weeks and including over 200,000 customers, HelloFresh added climate labels to all meals on the HelloFresh menu. To implement these labels,

HelloFresh estimated the carbon footprint of each meal on their menu and then categorized them into one of three footprint tiers (<2 kg CO2/meal; 2-7 kg CO2/meal; >7 kg CO2/meal). Customers were then randomized to see either control group menus with no carbon labels or one of three labelling schemes: (1) *Letters*, in which meals in the lowest through highest carbon footprint tiers were labeled as A, B, or C, respectively, (2) *Abstract*, in which the footprint tiers were labeled with color-varying globes and the words "Climate Superstar," "Good," and "Fair," and (3) *Climate Superstar*, in which only the meals in the lowest carbon footprint group were labelled with their *Abstract* symbol and text. We use administrative data to study the impacts of the labels on meal choices, customer retention, and profits. We then combine this administrative data with a baseline survey completed by 5,592 participants to shed light on dimensions of heterogeneity in the effects of the climate labels.

All three labelling schemes reduced customers' carbon footprints by a small amount. The treatment effects across different label formats are statistically indistinguishable, so we pool these treatments throughout most of our analysis. Across the full period during which the labels were visible on menus (fiscal Weeks 21-28), seeing menus with any carbon label reduced the carbon emissions of customers' meal choices by 0.6% ($p < 0.01$). However, likely because many customers choose their meals several weeks in advance, the treatment effects increased over the first few weeks of the labels, to a maximum of 1.2% during Week 24. We define Week 23 through Week 28 as the experimental period for our main analysis, but we show that our results are robust to an experimental period starting in Week 21.

The reduction in carbon emissions is driven by customers with relatively high beef consumption in HelloFresh meals before the start of the intervention. Customers in the top 25th percentile of beef consumption before the introduction of climate labels select 3.7% more *Climate Superstar* meals and 1.9% fewer *Fair* meals if assigned to one of the treatment groups. This heterogeneity is not driven by floor effects: customers in the lowest 25th percentile of beef consumption during the pre-period did not change their meal choices on average, still consuming 8.7% *Fair* meals during the intervention period despite the availability of lower-emission meals. This pattern matches Lohmann et al. (2022)'s findings that carbon labels had the largest effects on those with the highest baseline carbon footprints in UK dining halls. In contrast, Bilén (2023) finds that while the combination of labels, social benchmarking, and low-carbon substitution suggestions in a Swedish grocery store initially reduced carbon footprints both among those with above- and below-median baseline consumption in the first six weeks of the intervention, the effects faded over time among consumers with high baseline footprints.

Introducing climate-related labels was profitable for HelloFresh overall, and the company is now scaling up the labels across all regions. The labels increased customer retention by 0.7%, translating into an increase in profit at the customer-week level of 0.8%. These increases in retention and profits were driven by customers with at least one meal box ordered before the start of the experimental period, so it appears to have reduced customer drop-off rather than attracting new customers. The profit and retention effects are also much larger among those with high baseline beef consumption; these customers were 4.2% more likely to order a HelloFresh box in a given week, translating into a 3.9% increase in profits. Given that customers who ate more beef in the pre-period also show the largest changes in meal choices, these patterns suggest that many customers with high beef consumption valued the carbon footprint reminders as tools to help them reduce their carbon footprints. Although suggestive, heterogeneous treatment effects among high beef consumers support this hypothesis: the positive effects on retention and profits are driven by customers who are well-informed about the climate impacts of different types of proteins, and who believe that individuals and companies have a moral duty to address climate change at baseline. Note that the labels were intentionally designed to be relatively positive, as labels implemented voluntarily by companies would typically be: even the highest-footprint meals were labeled as "Fair" or graded at a C. Harsher labels may have had less positive effects overall among customers with high baseline footprints.

Nevertheless, even this labeling scheme generated substantial backlash effects among customers who disagree with its intention: those who state below-median beliefs that individuals or companies have a moral duty to combat climate change increase their carbon footprints by 4.4% and 4.1%, respectively, in response to labels. Customers in these groups were also less likely to agree at baseline that companies should nudge customers to make climate-friendly choices.

Our paper makes three main contributions. First, to our knowledge, our study is the first randomized field experiment to examine the impacts of carbon labeling on company profits, a perspective made possible by our direct collaboration with HelloFresh. If climate labels increase profits, then companies may have an incentive to add these labels even in the absence of government regulation. However, if the labels do not effectively reduce emissions as companies implement them, then climate labels could become a form of greenwashing that does not meaningfully contribute to food-system sustainability. We find that introducing climate labels increases customer retention and company profits while also reducing the average carbon footprint per customer. However, the change in carbon footprint is small. Furthermore, the labels' impacts on meal choices may attenuate somewhat by the end of the 8-week experimental period, while the retention impacts

show no sign of dissipating. Most closely related to our focus on profit, Bilén (2023) uses a natural experiment to find that implementing a bundle of pushes towards sustainable food purchases in a Swedish grocery store, including carbon labels, reduced customer visits, especially among those with high baseline carbon footprints. We find opposite effects in a randomized experiment among US mealkit consumers.[1] An important caveat to this analysis is that we can only estimate the partial-equilibrium profit and retention effects of adding carbon labels; we might expect these gains to dissipate as other companies add carbon labels as well.

Second, this experiment is the largest real-world evaluation of food-based carbon labeling globally to date and the first such field evaluation in the US, which has one of the highest per capita climate footprints in the world (Global Carbon Project 2023).[2] Like most of the existing literature, we find that carbon labels shift consumers to lower-carbon meals. A sizeable literature of lab-based studies and small-scale experiments on individual products (e.g. Muller et al., 2019; Vlaeminck et al., 2014; Osman and Thornton, 2019; Elofsson et al., 2016), along with two larger, real-world evaluations (Lohmann et al., 2022; Bilén, 2023) find that carbon labels may generate consistent shifts towards lower-footprint consumption (for reviews, see Potter et al., 2021; Taufique et al., 2022). However, we find much smaller-magnitude shifts than those estimated in prior label evaluations, underscoring the importance of well-powered field experiments with real-world implementation (DellaVigna and Linos, 2022). This discrepancy could also reflect that the HelloFresh customer audience may be less climate-conscious than the participants in previous experiments. Americans express less support for climate action than do Europeans (Dechezleprêtre et al., 2022), and HelloFresh primarily advertises its meal kits' cost and time savings, not their environmental benefits. Thus, our study may be a more realistic benchmark for the treatment effects that policymakers should expect from climate-related labels in the US.

Third, we add to knowledge about climate label targeting . By combining administrative data of customers' meal choices with baseline survey responses from a subset of customers, we find that some customers (e.g. those with higher baseline beef consumption) show larger shifts in meal-choices and retention in response to climate labels. On the other hand, we find suggestive evidence

[1]This research question is broadly related to the literature on companies' incentives to disclose quality information or ethical signals to customers. A large literature has examined firms' incentives to reveal absolute, verifiable data to customers (Dranove and Jin, 2010; Loewenstein et al., 2014; Bederson et al., 2018; Jin, 2005; Jin et al., 2021; Mathios, 2000). Among restaurants, for example, recent work suggests that voluntarily disclosing meals' calorie contents may leave revenue unchanged and improve customers' perceptions of the company (Bollinger et al., 2011; Avery et al., 2023; Berry et al., 2018). Other work in marketing studies companies' incentives to introduce green products or otherwise signal corporate-social responsibility to customers (Olsen et al., 2014; Sen and Bhattacharya, 2001). Our paper is the first to examine companies' incentives to disclose information about the carbon footprints of their products. Note that HelloFresh only reveals the relative footprints of various meals in our setting, while much of the disclosure literature has focused on disclosure of absolute, verifiable data (Dranove and Jin, 2010).

[2]https://globalcarbonbudget.org/archive/

that labels may actually have a backlash effect on some groups of customers (e.g. those who do not believe individuals and companies have a moral responsibility to combat climate change). This pattern suggests caution in rolling out climate labels in settings where some of the target audience does not support action against climate change. The labels' efficacy for some groups – and the backlash in other subgroups – suggests that it may be best to deploy climate labels so that people can opt in and out of seeing climate-related information. The climate labels had positive retention effects on high baseline-beef customers who reduced their carbon footprint in response to the labels, so an opt-in program could be feasible.

Finally, we add suggestive evidence to the small but growing literature on whether climate labels change choices by providing new information or by increasing the salience of climate change or norms around footprint reductions. Most recently, Imai et al. (2022) show that cleanly correcting consumers' misperceptions about the carbon emissions from beef has no effect on demand, suggesting that labels may primarily function through non-informational mechanisms. We find mixed evidence for the role of information provision in the carbon labels' impacts in this setting. In our full baseline sample, we find no gap in the labels' impacts on meal choices by baseline carbon-footprint knowledge. We also find that all of the label formats reduce consumption of Fair meals versus Good meals, including the labeling scheme that only labels Climate Superstars. Together, these patterns suggest that the labels work at least in large part through salience effects. However, we also find some suggestive evidence that information plays a role as well: in our baseline sample, the labels' positive effects on retention and profit are driven by those with low baseline footprint knowledge.

The rest of the paper proceeds as follows. Section 2 describes the experimental design. Section 3 reports the effects of treatment on meal choices and carbon footprints, and Section 4 reports the treatment effects on customer retention and profits. Section 5 concludes.

2 Experimental Design

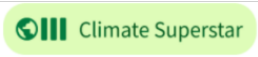
We ran an experiment with HelloFresh, the largest meal-kit company in the United States, for eight weeks in May through July 2022 on their online meal choice platform.

2.1 Treatment variations

The experimental intervention added carbon-footprint labels to the HelloFresh menus from which customers choose meals each week. This menu includes an array of meal cards, each with a photo, name, and a series of labels describing the meal (e.g. low-calorie, vegetarian, spicy). The new labels

introduced in the experiment are shown in Table 1. On average, each meal was labeled with 1.2 non-climate labels. From this main menu page, participants can click on each meal to pull up a more detailed meal card including nutritional content and larger renditions of the labels on each meal.

Table 1: Label variations

Treatment group	N	Labels on main menu	Labels on menu cards
Control	58,645	None	None
Letters Score	58,441		
Abstract Score	58,385		
Climate Superstar	59,040		

The experimental sample is randomized across four arms: a control arm with no carbon footprint information and three treatment arms with different carbon labeling schemes. To develop these labeling schemes, HelloFresh first used the Agribalyse dataset[3] to estimate the carbon footprints of each meal on a given week's menu, using the ingredients required for each meal recipe. Meals were then categorized into three tiers based on their estimated footprints: (1) "Climate Superstar," with an estimated footprint below 2 kg CO_2, (2) "Good," with estimated footprints between 2 kg CO_2 and 7 kg CO_2, and (3) "Fair," with estimated footprints above 7 kg CO_2.

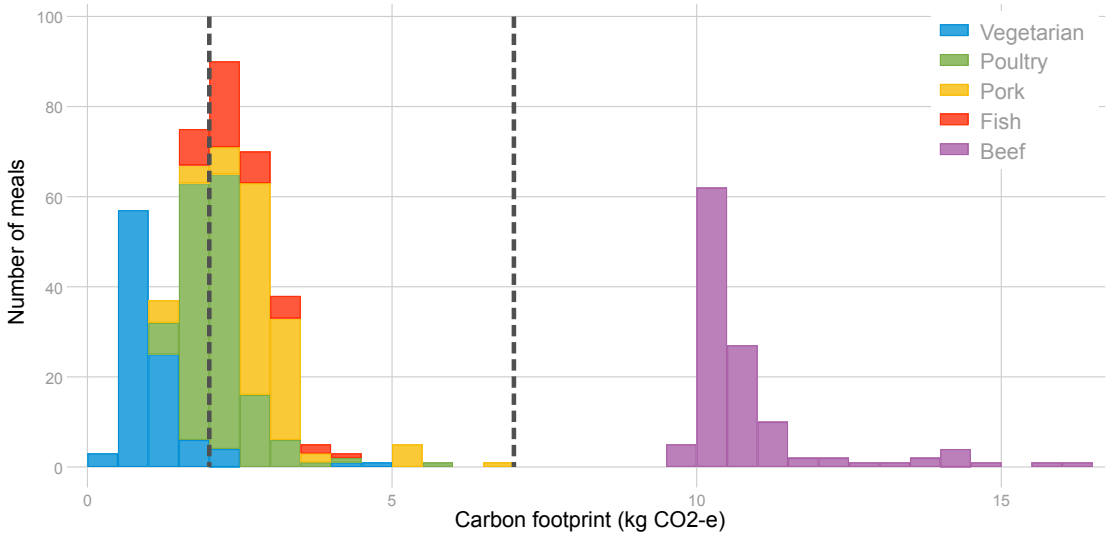
The meal categories were communicated in different ways across the three treatment groups (Table 1). The *Letters* group saw menus on which meals in the Climate Superstar, Good, or Fair footprint categories were labeled as A, B, or C, respectively. The *Abstract* group saw menus on which meals were labeled with abstract globe symbols and the text of their carbon-footprint category. Finally, the *Climate Superstar* group saw menus on which only top-tier meals were labeled with an abstract globe symbol and category name. In each of the labeling arms, menu cards also included short descriptions of what the climate labels meant. For example, the menu card for the Cherry Balsamic Bavette Steak stated, "This meal is rated **Fair** because it's among the least carbon-efficient options on this week's menu." Other pre-existing labels do not have an explanation. Appendix Figure A1 shows examples of the HelloFresh menu as it appeared to the *Abstract* group.

Baseline meal categorization:

[3]Agribalyse estimates the impact of products using the Life Cycle Assessment (LCA) method, which takes into account each stage in food production (i.e. from field to plate). Agribalyse is widely cited, including by the EU and the UN. Because the data are based on products in France, the carbon footprint estimates for HelloFresh US are likely to have some errors, although the meals would likely largely be categorized the same way. For more information, see https://doc.agribalyse.fr/documentation-en/agribalyse-data/documentation.

Figure 1 plots the distribution of carbon footprints across the 505 meals offered by HelloFresh from fiscal Weeks 17 through 28, along with vertical lines at 2 kg CO_2e and 7 kg CO_2e, the cutoff thresholds between Climate Superstar, Good, and Fair meals.[4] While vegetarian meals tend to have lower carbon footprints than poultry meals, followed by pork and fish, this distribution reveals the primary importance of beef as a source of greenhouse gas emissions. All meals with a primary protein other than beef have an estimated carbon footprint below 7 kg CO_2e, thus falling in the Superstar and Good categories, while all meals with beef as a primary protein have estimated carbon footprints well above the cutoff for the Fair category. This distribution underscores the central role for reducing beef consumption in cutting dietary emissions.

Figure 1: Distribution of meal carbon footprints



Note: This figure gives the distribution of carbon footprints for the 505 meals HelloFresh offered from fiscal Week 21 through Week 28, separating the distributions for meals with different proteins. When a meal had multiple proteins, we categorized the meal as belonging to the category with the higher-emissions protein. Minor protein additions (i.e. a sprinkle of bacon or a slice of proscuitto) were disregarded. The two black dashed vertical lines denote the thresholds separating Fair vs Good meals (2 kg CO_2e) and Good vs Superstar meals (7 kg CO_2e).

2.2 Experiment timing

HelloFresh assigned customers to the experimental sample if they visited the HelloFresh website in fiscal Weeks 18, 19, or 20 of 2022. Labels were randomly added to the menu for Weeks 21 through 28, first appearing on future menus midway through Week 20. Customers select meals a week in advance of delivery, so the addition of these labels could not have affected meal choices from the

[4]Note that here we classify each meal as falling in a single protein category, while some meals actually contain multiple proteins. For example, we classify any meal that contains beef as falling in the beef category, and we classify any meal that contains bacon or prosciutto as a minor ingredient alongside another protein as falling in the other protein's category.

Week 20 menu. Customers can preview menus 5 weeks in advance of delivery. Throughout our main analysis, we will define the pre-experimental period as Weeks 8 through 20 and the experimental period as Weeks 23 through 28. However, we show that our main results are entirely robust to alternative definitions. All heterogeneity results remain similarly unchanged and are available upon request.

2.3 Sample data and characteristics

2.3.1 Full experimental sample

A total of 234,511 customers were assigned to the experimental sample. Using administrative data, we observe participants' meal choices from Weeks 8 through 28, the end of the experimental period, as well as the ingredients in each available meal and their costs. We observe additional administrative data for each customer, including week-level revenue and costs, beginning in the week (18, 19, or 20) during which they were assigned to the experimental sample. Finally, we also observe HelloFresh's estimates for the carbon footprint of each meal for Weeks 17 through 28. While we observe detailed customer behavior, the only customer characteristic that we observe for the full experimental sample is zip code. We merge these data with zipcode-level voteshare data from the 2020 presidential election and with 2020 5-year summary data from the American Community Survey (ACS) at the level of Zip Code Tabulation Areas.

Table 2 presents baseline summary statistics and balance regressions for the main experimental survey, split across the four treatment groups. Several facts bear noting. First, the HelloFresh customer population live in areas that are somewhat whiter, more educated, and wealthier than the national population. In particular, customers live in zip codes where 67% of residents are non-hispanic whites on average, compared to 60% nationally, where on average 40% of residents 25 and over have a bachelor's degree or more, compared to 33% nationally, and where on average 11% live below the US poverty level, compared to 13% nationally. Studies have found robust evidence that environmental concern rises with education, so we expect HelloFresh's pool of customers to be somewhat more responsive to carbon labels than the average US population (Angrist et al., 2023; Dechezleprêtre et al., 2022).

Second, our sample is largely balanced on observable baseline characteristics, such as longevity as customers at HelloFresh, baseline meal choices, and zipcode-level demographics. To adjust for the small differences that remain, we control for baseline meal choices, demographics, and customer longevity in our main specifications. We also show that our results are robust to excluding the

demographic and longevity controls..

2.3.2 Baseline survey sample

We pair administrative data for the full sample with detailed baseline survey data collected from a subset of this sample. Before the experimental period began, HelloFresh emailed all customers allocated to the experiment with an invitation to complete a short survey, for which all participants would be entered into lotteries to win a $100 or $200 gift card. The survey elicited participants' beliefs about climate change, their self-perceptions on traits like altruism and environmental consciousness, their political affiliation, and their baseline knowledge about the carbon footprints of different foods. The full text of the survey is available at this link.

Table 2: Summary statistics and balance: Main experimental sample

	N	Control Mean	Letters Score	Abstract Score	Climate Superstar
	(1)	(2)	(3)	(4)	(5)
Longevity at HelloFresh					
Had any pre-period meal	234511	0.813	-0.001	0.002	0.000
			(0.002)	(0.002)	(0.002)
Week of first pre meal	190730	11.930	0.018	0.051*	0.066**
			(0.028)	(0.028)	(0.028)
# Pre weeks with meals	234511	4.449	-0.015	-0.017	-0.028
			(0.024)	(0.024)	(0.024)
Total # pre-period meals	234511	13.917	-0.048	-0.027	-0.062
			(0.080)	(0.080)	(0.080)
Baseline meal choices					
Avg box carbon footprint	160958	12.966	0.020	0.062	-0.010
			(0.044)	(0.044)	(0.044)
Share of baseline meals:					
Vegetarian	190730	0.149	-0.002**	-0.001	0.000
			(0.001)	(0.001)	(0.001)
Poultry	190730	0.365	0.000	-0.000	-0.000
			(0.001)	(0.001)	(0.001)
Pork	190730	0.232	0.000	0.001	0.000
			(0.001)	(0.001)	(0.001)
Fish	190730	0.052	0.001	-0.000	0.000
			(0.001)	(0.001)	(0.001)
Beef	190730	0.216	0.001	0.001	0.000
			(0.001)	(0.001)	(0.001)
Demographics by zipcode					
Share below US poverty line	229084	0.108	0.001	0.000	0.000
			(0.000)	(0.000)	(0.000)
Share adults 25+ with bachelor's	229103	0.395	-0.001	0.001	0.001
			(0.001)	(0.001)	(0.001)
Shares by race or ethnicity:					
White, non-hispanic	229106	0.670	-0.002**	-0.000	-0.001
			(0.001)	(0.001)	(0.001)
Black	229106	0.101	0.000	-0.000	-0.001
			(0.001)	(0.001)	(0.001)
Hispanic	229106	0.138	0.001	-0.000	0.001
			(0.001)	(0.001)	(0.001)
2020 Democratic vote share	229805	0.530	0.000	-0.000	0.000
			(0.001)	(0.001)	(0.001)

Note: This table compares average characteristics of the study participants by treatment arm. Column 1 presents the number of participants in the study for whom we have information on the given characteristic. Column (2) is the average for the characteristic in the control group. Columns 3-5 present the difference in means between participants in the three labelled treatment arms (*Letters*, *Abstract*, and *Climate Superstar*) and the control group. Standard errors for the estimated difference from the control group are in parentheses. The variables shown in the table are: (i) whether or not the participant ordered any HelloFresh meals during the pre-period we observe in the administrative data before the start of the experiment (Week 8 to Week 20), (ii) the week in which the participant ordered their first HelloFresh meal (for participants who ordered at least one meal during the pre-period), (iii) the number of weeks during the pre-period in which the participant ordered at least one HelloFresh meal, (iv) the total number of meals that the participant ordered during the pre-period from HelloFresh, (v) the average carbon footprint of a HelloFresh box ordered by the participant in the pre-period for which we observe carbon footprints (Week 17 to Week 20), (vi) the share of meals ordered during the pre-period which had a main protein which was vegetarian, poultry, pork, fish, or beef, (vii) the share of people in the participant's county below the US poverty line (according to 2020 5-year summary data from the American Community Survey (ACS), for HelloFresh customers with zipcodes that matched to an ACS zipcode), (viii) the share of adults aged 25 or over in the participant's county who have earned at least a bachelor's degree (according to the ACS), (ix) the share of people in the participant's county who are classified as non-hispanic white, black, or hispanic (according to the ACS), and (x) the share of people in the participant's county who voted for the Democratic party candidate in the 2020 US presidential election.

In total, 7,259 customers completed the baseline survey, and 5,592 provided email addresses that successfully merged with administrative data from HelloFresh. We use this merged sample to test for heterogeneous treatment effects of carbon labels by baseline carbon-footprint knowledge and beliefs about climate change. While this baseline sample comprises only about 2.4% of the full experimental sample, it is quite similar to the full experimental sample on most observable traits (Appendix Table A1). Two exceptions warrant mention. First, customers in the baseline sample are longer-standing customers of HelloFresh on average: 97% of the baseline sample ordered at least one meal box during the 13-week pre-experimental period, compared to 81% of the full experimental sample. Second, the average box-level carbon footprint of customers in the baseline sample is about 3% (0.4 kg) lower than among customers in the full experimental sample.

Despite selection into the baseline sample, it still allows us to test how treatment effects differ by important dimensions of customer beliefs and knowledge. The baseline sample is broadly balanced across treatment arms (Appendix Table A2), except that those assigned to any carbon-labeling arm state that they consider the environment in their food somewhat less than do those in the control group. We will control for these self-perceptions throughout our analysis of the baseline sample.

2.4 Empirical strategy

Our primary analysis uses the following simple regression model:

$$Y_{it} = \sum_{j=1}^{4} \beta_j LabelTreat_{ij} + \sum_{w=18}^{20} \gamma_{1,w} Y_{iw} + \sum_{w=18}^{20} \gamma_{2,w} \mathbb{1}(MiY_{iw}) + \delta_t + \Phi X_i + \epsilon_{it} \quad (1)$$

where Y_{it} is an outcome variable for customer i in week t, $\{LabelTreat_j\}_{j=1}^{4}$ are indicators for being in the control group or each of the three label groups and $\{\beta_j\}_{j=1}^{4}$ are our primary coefficients of interest. We control for lagged outcomes in Weeks 18, 19, and 20, represented as $\{Y_{iw}\}_{w=18}^{20}$, and indicators that these values are missing, $\{\mathbb{1}(MiY_{iw})\}_{w=18}^{20}$. For some outcomes, these lagged controls are missing because that customer did not order a meal box in that week (e.g. baseline meal choices). For other administrative variables, such as customer revenue, these values are missing because we observe the variables for a given customer only after they were allocated to the experimental sample; customers were allocated across Weeks 18 through 20.

The variables δ_t are week fixed effects, and X_i is a vector of other customer control variables. In our main specifications, these additional controls include indicators for customers' meal plan with HelloFresh (i.e. veggie, chef's choice, premium, etc.), zipcode-level demographics, and customers' longevity at HelloFresh. We also show robustness to specifications in which we drop some of these

controls in the Appendix. Due to small imbalances in the baseline sample (Appendix Table A2), we control in all baseline-sample regressions for customers' self reports of environmentalism and how much they consider environmental impacts in their food choices.

We also estimate regressions in which we pool all of the label treatments together to construct a binary treatment variable, as follows:

$$Y_{it} = \beta AnyLabel_i + \sum_{w=18}^{20} \gamma_{1,w} Y_{iw} + \sum_{w=18}^{20} \gamma_{2,w} \mathbb{1}(MiY_{iw}) + \delta_t + \Phi X_i + \epsilon_{it} \quad (2)$$

Finally, we estimate regressions in which we test for heterogeneous treatment effects, both in the main experimental sample and the baseline sample. In most cases, we estimate heterogeneous treatment effects by fully stratifying the sample by baseline variables, but we also show robustness in some cases to regressions in which we simultaneously interact the treatment indicators with multiple baseline traits.

3 Effects on meal choices

Adding carbon footprint labels to the HelloFresh menu induced small but robust shifts towards more sustainable diets. This section details the impacts on the main sample and then explores how they vary by customer traits.

Table 3 presents results for the impacts of carbon footprint labels on customers' meal choices, restricting the regression sample to customers with a meal box in a given week. Panel A presents regressions separately estimating the effects of each of the three label variations, while Panel B pools these variations into a single binary variable for seeing menus with any carbon footprint label. Each of the three labeling schemes reduces the total carbon footprint of meals a customer ordered by about 0.075 kg, or about 0.6% of the control mean of 11.775 kg per box. All three label treatments reduce the number of Fair meals ordered by about 0.009, or about 1.5% of the control mean of 0.59 Fair meals per box. When pooled, the three labeling treatments marginally increase the number of Climate Superstar meals by about 0.007, or about 0.8%. As expected, these shifts reflect a substitutions from beef meals to vegetarian, poultry, and pork meals.[5],[6] Our main

[5]While the meal choice outcome in our main specifications combine the extensive and intensive margins (choosing *any* meal with a given protein combined with the number of meals with that protein conditional on choosing any), we find similar results when the outcome is an indicator for whether customers chose any meal with a given protein (Appendix Table A3).

[6]This treatment effect of climate labels on carbon footprint is not explained by the positive treatment effects of climate labels on customer retention (Table 4). The customers driving the positive effects on retention had higher carbon footprints at baseline, and so we would expect the estimated treatment effect of climate labels on carbon footprints to underestimate the treatment effect holding customer composition fixed.

estimates are robust to removing the controls for zipcode-level demographics and for customers' longevity at HelloFresh (Appendix Table A4).

Table 3: Impacts on meal choices: Including demographic and longevity controls, Week 23+

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total CO2	# Meals by footprint category			# Meals by protein				
	footprint	Superstar	Good	Fair	Veggie	Poultry	Pork	Fish	Beef
Unpooled treatments:									
Letters Score	-0.076**	0.005	0.003	-0.009***	0.007*	0.000	0.005	-0.003	-0.009***
	(0.035)	(0.004)	(0.005)	(0.003)	(0.004)	(0.004)	(0.004)	(0.002)	(0.003)
Abstract Score	-0.075**	0.012***	-0.001	-0.008***	0.005	0.007*	0.001	-0.001	-0.008***
	(0.035)	(0.004)	(0.005)	(0.003)	(0.004)	(0.004)	(0.004)	(0.002)	(0.003)
Superstar	-0.075**	0.004	0.003	-0.009***	0.003	0.001	0.002	0.000	-0.009***
	(0.034)	(0.004)	(0.005)	(0.003)	(0.004)	(0.004)	(0.004)	(0.002)	(0.003)
Pooled treatments:									
Any label	-0.075***	0.007*	0.002	-0.009***	0.005*	0.003	0.003	-0.001	-0.009***
	(0.028)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)	(0.002)	(0.003)
Control mean	11.775	0.856	1.635	0.589	0.439	1.070	0.851	0.167	0.589
N: Customers	130618	130618	130618	130618	130618	130618	130618	130618	130618
N: Customer-weeks	396271	396271	396271	396271	396271	396271	396271	396271	396271

Note: This table reports the treatment effects of the climate labels on HelloFresh customer meal choices. In the first panel (Unpooled treatments), each column shows the OLS estimates of equation 1, in which there are dummies for each treatment arm. In the second panel (Pooled treatments), each column shows the OLS estimates of equation 2, which includes one dummy variable equal to one if the participant is assigned to any of the three climate label treatment arms. All of the regressions include controls for (i) lagged outcomes in Weeks 18, 19, and 20 (as well as missing indicators if those values are missing), (ii) the customer's meal plan with HelloFresh (which may be set to options such as veggie or chief's choice, and which determine the default meals for each week if the customer does not check the menu and select their meals themselves), (iii) zip-code level demographics (the share that voted for the Democratic presidential candidate in 2020 , the share below the US poverty line, the share of adults over 25 with at least a bachelor's degree, and the share of non-hispanic whites), (iv) customer longevity at HelloFresh (number of weeks the customer had ordered HelloFresh meals in the pre-period), and (v) week fixed effects. Standard errors are clustered at the customer level. Stars next to coefficients reflect unadjusted p-values (* significant at 10%; ** at 5%; *** at 1%).

While the sign of our results in a realistic commercial setting match those in previous studies (e.g. Lohmann et al. 2022 at a university cafeteria and Bilén 2023 in a Swedish grocery store), the magnitudes of our estimates are notably smaller. However, although the impacts of the carbon labels per customer are small, they are large when summed across HelloFresh customers. Our estimates suggest that adding carbon labels to menus for all 234,511 customers in the experimental sample would reduce emissions by 17,588 kg CO_2e per week. To benchmark this reduction in emissions, this is equivalent to the GHG emissions from burning 19,701 pounds of coal or from the weekly energy use of 114.4 homes.[7]

[7]Calculated using the Environmental Protection Agency (EPA) greenhouse gas equivalencies calculator: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

Notably, all three of the labeling schemes had very similar impacts on consumption of Fair meals and total carbon footprint. This speaks to the mechanisms by which environmental labeling alters meal choices: does it primarily work by providing new information on the environmental impacts of different foods or by increasing the salience of customers' baseline environmental knowledge at the point of decision-making? Here, the Climate Superstar labeling arm only provides information to distinguish the Climate Superstar meals from all others, and yet it substantially reduces consumption of Fair meals relative to Good meals. This result suggests that the labels function in part by making salient customers' existing knowledge of beef's high environmental costs.

The labels' impacts on meal choices are only slightly attenuated when we define the experimental period as beginning in Week 21 instead of Week 23 (Appendix Table A5). Appendix Figure A2 plots the treatment effects on total carbon footprint and number of Fair meals across the treatment period from Weeks 21 through 28. As expected, the treatment effects are about zero in Weeks 21 and 22; recall that since many customers choose their meals several weeks in advance, many customers made their meal choices for these weeks without seeing the carbon labels, which were first introduced in Week 20 on menus for Weeks 21 and beyond. The treatment effects rise to a maximum in Week 24 of a 1.2% drop in total carbon footprints before attenuating.

3.1 Heterogeneous treatment effects on meal choices

The impacts of carbon labeling vary significantly with several key customer traits or behaviors: baseline meal choices, beliefs about climate action, and carbon-footprint knowledge.

3.1.1 By baseline meal choices

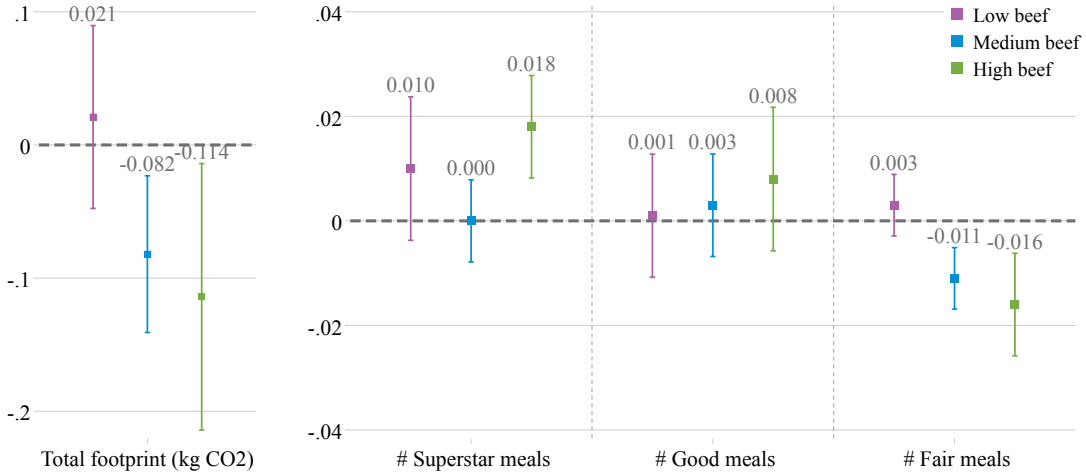
First, we test for heterogeneous treatment effects by customers' baseline consumption of beef, which we calculate as the share of customers' pre-experimental meals that contained beef.[8] Figure 2 presents separate treatment effects among those below the 25th percentile, between the 25th and 75th percentiles, and above the 75th percentile of baseline beef consumption. Appendix Table A6 presents these results in regression form, along with p-values for tests of equality between these coefficients.

Only customers with medium or high baseline beef consumption significantly decrease their box-level carbon footprints and consumption of Fair meals, with signficantly different treatment effects

[8] We examine heterogeneity by baseline beef consumption instead of baseline carbon footprint because we observe baseline meal choices for pre-experimental Weeks 8 through 20, while we observe carbon footprint values only for pre-experimental Weeks 17 through 20. Thus, we measure baseline beef consumption with less error. Customers with no baseline meal consumption data are excluded from these regressions.

from those with low baseline beef consumption. Notably, the null treatment effects among those in the bottom 25 percentiles of baseline beef consumption do not just arise from floor effects; this group consumed an average of 0.25 Fair meals per week during the experimental period, compared to means of 0.64 and 0.83 among the medium and high beef consumers, respectively.

Figure 2: Heterogeneous effects by baseline beef consumption



Note: This figure shows the treatment effects of climate labels on customers' meal choices and the total carbon footprint of their meals differentially by baseline beef consumption. Baseline meal consumption is measured by the share of customers' HelloFresh meals ordered during the pre-treatment period (Weeks 8 through 20) that contained beef. Customers who did not order at least one meal during the pre-treatment period are excluded from these regressions. "Low beef" customers ordered a share of meals with beef that put them in the 25th percentile or lower out of all customers who ordered a pre-treatment period meal, "Medium beef" customers ordered meals such that they were in the 25th-75th percentile, and "High beef" customers were in the 75th percentile or higher. The estimates shown in this figure are obtained from OLS estimates of equation 2 on separate subsamples for the low, medium, and high beef eaters. The total footprint measure (left panel) is the kg CO_2e per customer per week. The numbers of Superstar meals, Good meals, and Fair meals (right panel) are the number of meals falling into each of those three categories (<2 kg CO_2e , 2-7 kg CO_2e , >7 kg CO_2e) that participants ordered in a given week. The results of the regressions are presented in table form, and coefficients are tested for equality, in Table A6. Whiskers represent 95% confidence intervals.

3.1.2 By climate beliefs

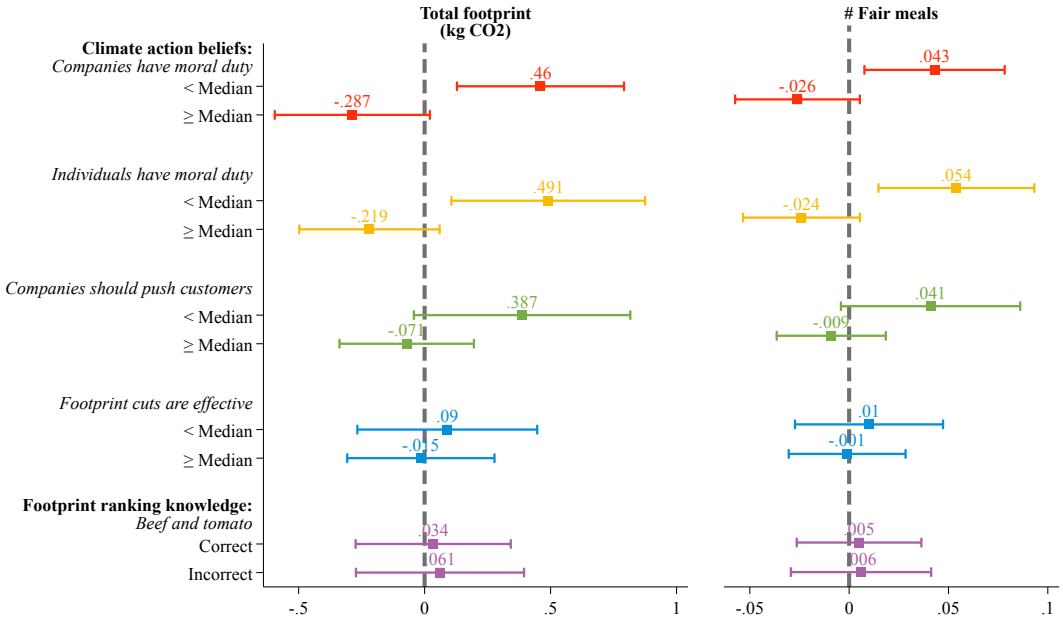
Next, we test for heterogeneous treatment effects by key climate attitudes and knowledge that we observe in the baseline sample.[9]

We first use the baseline sample to test for heterogeneous treatment effects by beliefs about climate action, finding that the labeling intervention may generate opposite treatment effects for those who do and do not agree with its purpose. We elicited baseline participants' beliefs on 7-point scales for whether companies and individuals have moral duties to help address climate change, whether companies should push their customers to make more climate-friendly choices, and whether

[9]We replicate the labels' heterogeneous impacts on meal choices by baseline beef consumption in the baseline survey sample in Appendix Figure A3. Our point estimates for these heterogeneous effects match those estimated in the full experimental sample, though they are less precisely estimated due to the smaller sample size.

individual efforts to reduce carbon footprints are effective in addressing climate change. (See the full text of the baseline survey at this link, including these questions.) For each question, we define binary variables for whether customers answer below or above the median response. Figure 3 plots the impacts of being assigned to any carbon labeling treatment on total carbon footprint and number of Fair meals consumed, separately by each of these binary variables. We present these results in regression form in Appendix Table A7.

Figure 3: Heterogeneous effects on total carbon footprint by climate beliefs: Baseline sample



Note: This figure shows the treatment effects of climate labels on the carbon footprint of customers' meals differentially by characteristics captured by our baseline survey. We test heterogeneity along five dimensions: (i) whether or not companies have a moral duty to help combat climate change, (ii) whether or not individuals have a moral duty to help combat climate change, (iii) whether or not companies should push their customers to make climate-friendly choices, (iv) whether or not individual efforts to reduce personal carbon footprints could be effective in addressing climate change, and (v) knowledge of the carbon footprints of different foods (in this case, whether or not the customer correctly selected that beef had the highest carbon footprint and tomatoes the lowest out of the foods they were asked to rank). The full text of the survey is available at this link. For characteristics (i)-(iv), equation 2 is estimated separately on baseline survey respondents whose opinions were below or above the median baseline survey participant. In the total footprint panel (left), the outcome is the kg CO_2e per customer per week. In the right panel, the outcome is the number of Fair meals that customers selected in a given week (Fair meals are the least climate-friendly category of meals, with footprints of over 7 kg CO_2e.) The results of the regressions are presented in table form, and coefficients are tested for equality, in Tables A7-??. Whiskers represent 95% confidence intervals.

We find stark treatment differences by some of these climate beliefs. In particular, being assigned to any carbon labeling treatment actually increases carbon footprints among survey-takers with below-median agreement that companies and individuals have a moral duty to address climate change and that companies should push customers to make more climate-friendly choices, while decreasing carbon footprint among those with at- or above-median beliefs on each dimension. While

our baseline sample is not fully representative of HelloFresh customers overall, these results suggest that carbon-footprint interventions may generate substantial backlash among those who disagree with their purpose.

3.1.3 By baseline knowledge: Salience or learning?

Next, we attempt to further explore the role of salience effects versus new information in the labels' impacts on meals by testing how those impacts vary with customers' baseline knowledge about the carbon footprints of different foods.

To elicit participants' baseline carbon-footprint knowledge, we asked them to rank six foods from that which generates the most to the least emissions per pound on average: beef, cheese, farmed shrimp, pork, chicken, and tomatoes, listed here in the correct order by median emissions.[10] Our main analysis uses two definitions of baseline knowledge: whether participants correctly answer that beef and tomatoes have the highest and lowest carbon footprints, respectively, and whether participants both correctly identify these ranking endpoints and answer that pork has a higher carbon footprint than chicken. About 51% of the baseline sample correctly places beef and tomato on the footprint scale, and about 41% also know the relative footprints of pork and chicken. Only about 1% of the sample correctly produces the full scale, including farmed shrimp and cheese.

Figure 3 above presents treatment effects on meal choices by knowledge about beef and tomato, with regression results in Appendix Table A8. We find no gap in the labels' treatment effects on the number of fair meals and total carbon footprint that participants order by these knowledge variables, though our point estimates are noisy. Appendix Figure A3 shows very similar patterns by our more stringent measure of footprint knowledge. While we are cautious to treat these results as definitive, the fact that impacts are not stronger among those with low baseline knowledge provides additional evidence that the labels function at least in part through salience effects among the already informed.

[10] Our estimates of the "truth" here come from data on greenhouse gas emissions per kilogram of food product estimated by Poore and Nemecek (2018) and compiled by Ritchie (2020). These estimates include emissions from land use change associated with food production, on-farm emissions from crop production and processing into livestock feed, emissions from cow digestion, fertilizer, and farm machinery, emissions from the conversion of raw agricultural products info final food items, emissions from transporting food in-country and internationally, retail emissions, and emissions from the production and disposal of packaging materials. Our main measures of baseline knowledge are derived from simple rankings of emissions from proteins like beef and chicken and robust to error in these emissions estimates.

3.1.4 Summary and joint heterogeneity

We find several striking patterns of heterogeneity in how carbon-footprint labeling affects customers' meal choices. The labels only significantly reduce total carbon footprint among customers with moderate or high baseline beef consumption, and they may generate substantial backlash among customers with weak beliefs that companies or individuals have moral duties to address climate change. There is no detectable difference in the labels' impacts on meal choices between those with and without baseline carbon-footprint knowledge, so the labels appear to affect meal choices at least in part by making customers' existing knowledge salient at the time of decision-making.

One concern in interpreting the heterogeneity patterns we present here is that the dimensions of heterogeneity we test are themselves correlated: customers who report stronger beliefs in companies' and individuals' moral obligations for climate action consume less beef at baseline (Appendix Figure A4), as do customers who correctly answer baseline carbon-footprint questions (Appendix Figure A5). In Appendix Table A9, we estimate regressions of our key meal-choice outcomes (columns 1 and 2) on simultaneous interactions of the treatment indicator with the baseline beef categories, baseline knowledge, and an indicator for scoring above or below the median on an index of climate-action morality beliefs.[11] While our estimates are noisy, all of the point estimates on the treatment interactions have the same sign and similar magnitudes as in our separate heterogeneity regressions.

The heterogeneous results by beef consumption, climate beliefs, and knowledge raise a puzzle. In the cross-section, customers who ate more beef at baseline are less likely to believe that it is a moral imperative to take action on climate change, and yet on average the treatment effects of the climate labels go in opposite directions for customers who eat more beef on average (reduce carbon footprint) and customers who do not think there is a moral imperative to take action on climate change (increase carbon footprint). To resolve this puzzle, we examine treatment effects in subsamples crossing baseline beef consumption with climate beliefs and carbon footprint knowledge. We find that one subgroup drives the reduction in carbon footprint due to climate labels: customers who (a) had high baseline beef consumption and also (b) believe individuals and/or companies have a moral duty to address climate change, Customers who score below the median in believing there is a moral imperative to address climate change have positive point estimates (i.e. increased their carbon footprint) in response to climate labels across all baseline beef consumption habits. Also, even among customers who score above the median in believing there is a moral imperative to

[11] We construct this index by standardizing the sum of the standardized variables for customers' beliefs that companies have a moral duty to address climate change, that individuals have a moral duty to address climate change, and that companies should push customers to make greener choices.

address climate change, those who ate medium or low amounts of beef at baseline do not appear to change their meal choices in response to the labels.

We see a similar pattern in heterogeneous treatment effects crossing baseline beef consumption and carbon-footprint knowledge. There is one subgroup driving the reduction in carbon footprints: customers who (a) have high baseline beef consumption and (b) already knew about the high carbon footprint of beef at baseline. This suggests that the mechanism for treatment effects may be salience rather than information. Combining this with the heterogeneous treatment effects by climate beliefs, it seems that the climate labels may be most effective in reducing the carbon footprints for customers who believe they should be eating less beef due to its effect on the climate, but are currently eating high levels of beef.

See Table A7 for the full set of regression results testing heterogeneous treatment effects by baseline beef consumption crossed with beliefs about climate change on meal choices.

4 Effects on retention and profit

Firms deciding whether to roll out information about the climate impacts of their customers' product choices will consider the effects of any changes in customer behavior on profit. For a firm such as HelloFresh, one of the first-order concerns is customer retention from week to week. In addition, since ingredients vary in cost and HelloFresh prices some proteins, such as beef and shrimp, at markups, the labels could affect average profit by shifting customers' meal choices.

Columns 1 and 2 of Table 4 report the impacts of the carbon labels on two retention measures: whether customers order a box in a given week and the number of meals per week. Across the three label formats, carbon labels increase customers' likelihood of ordering a meal box in a given week by about 0.3 pp, or about 1.1% of the control mean of 28.1%. The labels do not significantly alter the average number of meals per box, conditional on ordering a box.

Table 4: Impacts of climate labels on retention and profit

	(1)	(2)	(3)	(4)	(5)	(6)
		# Meals	Net rev.	Direct cost	Profit (Euros)	
	Has box	/ box	(Euros)	(Euros)	All	If box
Unpooled treatments:						
Letters Score	0.003	-0.001	0.173	0.106	0.067	-0.003
	(0.002)	(0.005)	(0.130)	(0.080)	(0.051)	(0.026)
Abstract Score	0.003	0.003	0.215*	0.130	0.092*	0.012
	(0.002)	(0.005)	(0.130)	(0.080)	(0.051)	(0.026)
Superstar	0.003	0.002	0.202	0.135*	0.075	0.020
	(0.002)	(0.005)	(0.129)	(0.080)	(0.050)	(0.026)
Pooled treatments:						
Any label	0.003***	0.001	0.197*	0.124*	0.078*	0.010
	(0.001)	(0.004)	(0.106)	(0.065)	(0.041)	(0.021)
Control mean	0.281	3.078	20.874	12.898	7.954	13.606
N: Customers	229083	130646	229083	229083	229083	130618
N: Customer-weeks	1374498	396315	1374498	1374498	1374498	396271

Note: This table presents the treatment effects of climate labels on outcomes related to profit and customer retention. In the first panel (Unpooled treatments), each column shows the OLS estimates of equation 1, in which there are dummies for each treatment arm. In the second panel (Pooled treatments), each column shows the OLS estimates of equation 2, which includes one dummy variable equal to one if the participant is assigned to any of the three climate label treatment arms. Columns (1) and (2) display the results for outcomes related to customer retention: column (1) is a dummy variable for whether or not a given customer ordered a box from HelloFresh in the given week, and column (2) is a numerical variable for the number of meals per box the customer ordered (HelloFresh allows customers to choose 3, 4, or 5 meals per box.) Columns (3)-(6) display the results for outcomes related to costs and revenue: column (3) is the net revenue for HelloFresh from a given customer in a given week (in Euros, excluding any discounts, which are common for HelloFresh), column (4) is the cost to HelloFresh of the meals for a given customer in a given week, column (5) is the profit HelloFresh made from a given customer in a given week (in Euros, with zeros for customers who did not order a box in that week), and column (6) is the profit HelloFresh made from a given customer in a given week (in Euros, only including customers who ordered a box that week). All of the regressions include controls for (i) lagged outcomes in Weeks 18, 19, and 20 (as well as missing indicators if those values are missing), (ii) the customer's meal plan with HelloFresh (which may be set to options such as veggie or chief's choice, and which determine the default meals for each week if the customer does not check the menu and select their meals themselves), (iii) zip-code level demographics (the share that voted for the Democratic presidential candidate in 2020 , the share below the US poverty line, the share of adults over 25 with at least a bachelor's degree, and the share of non-hispanic whites), (iv) customer longevity at HelloFresh (number of weeks the customer had ordered HelloFresh meals in the pre-period), and (v) week fixed effects. Standard errors are clustered at the customer level. Stars next to coefficients reflect unadjusted p-values (* significant at 10%; ** at 5%; *** at 1%).

Columns 3 through 6 of Table 4 estimate the impacts of the carbon-labeling intervention on HelloFresh's financial outcomes, which are of primary importance to understanding companies' incentives to implement nudges moving their customers to greener choices: revenue net of any customer discounts (column 3), total direct costs (column 4), and profits (column 5 and 6). Collaborating directly with HelloFresh allows us the unique opportunity to observe these back-end costs and revenues, which are crucial to evaluating the promise of interventions that will be implemented, at least in the near term, at the discretion of profit-maximizing companies.

The labels could affect the company's finances via two mechanisms. First, the labels could affect profit through changes in customer retention. We set the measures of net revenue, direct costs, and profits in columns 3, 4, and 5 to zero for weeks in which customers did not order a meal box, so these estimates capture the financial implications of reduced attrition. Next, the labels could affect profit by shifting customers towards more or less profitable meals, conditional on ordering a box in a given week. Appendix Table A10 regresses HelloFresh's weekly net revenue, direct costs, and profit from a given customer on the number of meals they order in each protein category that week, conditional on ordering a box. The direct costs of an additional meal vary across proteins: vegetarian and pork meals are the cheapest to produce, followed by poultry, beef, and fish. HelloFresh more than recoups these additional costs by adding surcharges to some high-cost meals, however, especially those including beef or fish, so beef and fish meals ultimately are more profitable than vegetarian or poultry meals. Then, shifting customers from beef to vegetarian or poultry meals might reduce profit on the boxes ordered. To test this mechanism, column 6 of Table A11 tests the labels' impacts on profits among customers who ordered a box in a given week.

In the full sample, our point estimates suggest that the carbon-footprint labels increased net revenue per customer-week by about 0.14 Euros and raised direct costs by about 0.09 Euros, thus increasing profit per customer by about 0.06 Euros. At face value, our point estimates imply that assigning the entire experimental sample of 234,511 customers would have increased HelloFresh's profits by 14,071 Euros per week. Note that these treatment estimates fall slightly and the profit results become statistically insignificant when we remove controls for demographics and customer longevity (Appendix Table A11).

Our estimates remain similar when we define the experimental period as beginning in Week 21 (Appendix Table A12). Appendix Figure A7 shows that these effects gradually rose over the first few weeks of the treatment, before remaining between 0.8% to 1.3% for weeks 25 through 28. Unlike the labels' impacts on meal choices, then, their impacts on retention show no signs of dissipating by the end of the experimental period.

4.1 Heterogeneous treatment effects on retention and profit

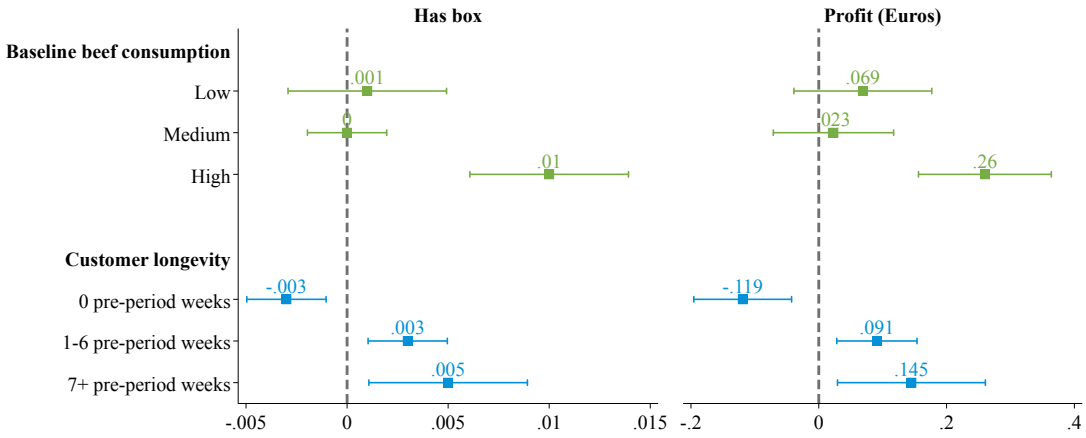
4.1.1 By customer longevity at HelloFresh

As with meal choices, we find substantial heterogeneity in the labels' retention and profit effects by baseline customer traits.

First, the labels' impacts on retention and profit vary strongly with customers' longevity at

HelloFresh. We split customers into three longevity groups: those with 0 meals in the 13-week pre-experimental period, those with 1 through 6 meals, and those with 7 or more meals. While customers with at least 1 pre-period meal show strong positive effects on retention and profit, the labels actually reduce retention and profit among those with no-period meals (Figure 4 and Appendix Table A13).[12] Thus, while the carbon labels allowed HelloFresh to better retain existing customers, they may have increased drop-off among new customers.

Figure 4: Heterogeneous effects on total carbon footprint by climate beliefs: Baseline sample



Note: This figure shows the treatment effects of climate labels on customer retention and profits, differentially by pre-intervention beef consumption and customer longevity at HelloFresh. We test heterogeneity along two dimensions: (i) the share of meals the customer ordered from HelloFresh during the pre-intervention period (Week 8 - Week 20) that contained beef (Low: 25th percentile, Medium: 25th-7th percentile, High: >75th percentile), and (ii) how many weeks before the intervention began we observe the customer order their first meal from HelloFresh. Customers who did not order any HelloFresh meals before the beginning of the intervention are excluded from the regressions examining heterogeneous treatment effects by baseline beef consumption. The estimates plotted are obtained from equation 2, estimated separately on each category of participants. In the left panel (Has box), the outcome is a dummy for whether or not the customer ordered a box in a given week. In the right panel (Profit), the outcome is the profit HelloFresh made from a customer in a given week (in Euros). The results of these regressions, along with results of other retention- and profit-related regressions, are presented in table form with coefficients tested for equality in Tables **??** (baseline beef consumption) and A13 (longevity). Whiskers represent 95% confidence intervals.

4.1.2 By baseline meal choices

Next, the carbon labels' retention and profit impacts vary starkly with baseline beef consumption (Figure 4 and Appendix Table A14). These effects are much larger for those in the top 25 percentiles of baseline beef consumption; these customers are 1 percentage point more likely to order a meal box in a given week, a 3.8% increase over a control mean of 26%. Given these large retention effects, the impacts of the carbon labels on profits are also much higher among those with high baseline beef consumption. Putting these results together with those from Section 3.1 suggest that

[12]Note that Appendix Figure A9 presents heterogeneous effects on meal choices by customer longevity groups. These estimates are quite imprecise for new customers, since they only order a meal box for 12% of the experimental-period weeks, on average.

customers with high carbon footprints at baseline both react to and value the labels' information about the carbon footprint of meals, on average.

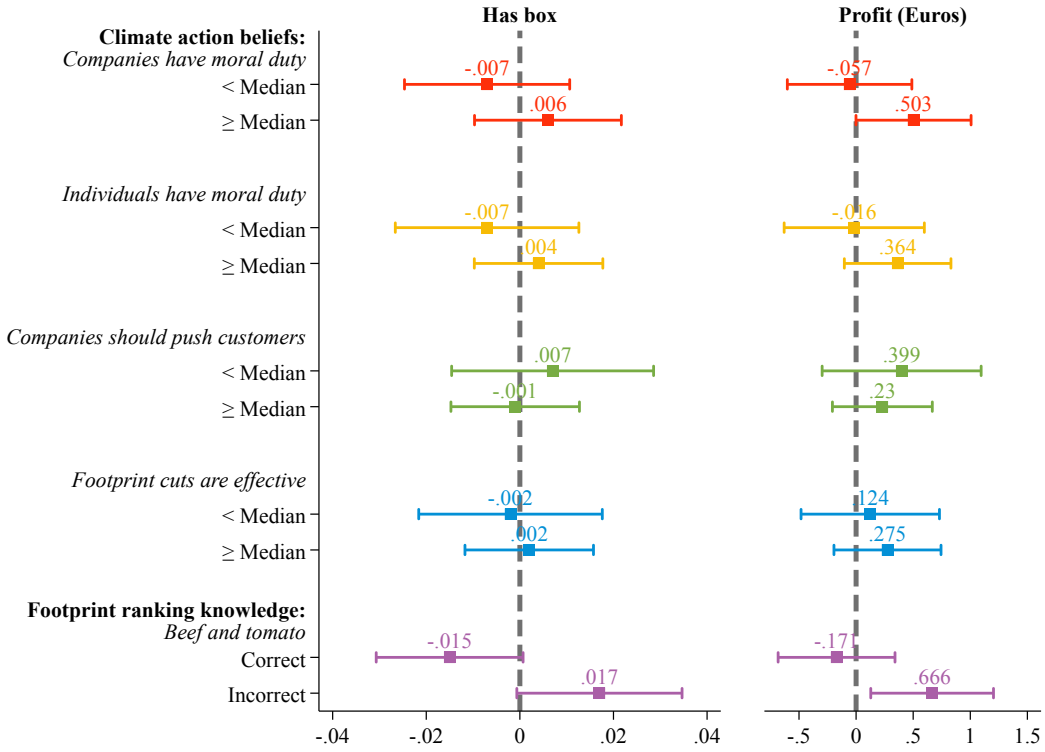
These results contrast notably with Bilén (2023), who finds that customers with above-median baseline carbon footprints both reduced their shopping frequency and dollars spent per visit after a grocery store introduced a bundled intervention aimed at reducing customers' carbon footprints, including carbon footprint labels. He finds no spending or retention effects among those with below-median baseline footprints.

4.1.3 By baseline knowledge and beliefs

Just as for meal choices, we use the baseline survey sample to test for heterogeneous retention by customers' climate beliefs and baseline carbon-footprint knowledge (Figure 5).[13] While our results are imprecise, we find no detectable differences in the the impacts of the carbon labels on retention by customers' beliefs about the morality of climate action or the effectiveness of cutting individual carbon footprints. This pattern contrasts with our findings for the labels' impacts on meal choices, where those with below- versus above-median beliefs about individuals' and companies' moral climate duties show opposite reactions to the labels.

[13] To check the comparability of the baseline sample and full experimental sample, we estimate heterogeneous retention effects by baseline beef consumption and customer longevity in the baseline sample in Appendix Figure A8. As in the main experimental sample, these point estimates suggest that the carbon labels differentially increased retention among those with high baseline beef consumption. However, unlike in the full experimental sample, our point estimates suggest negative retention effects for the highest-longevity customers among baseline survey respondents, although these are not precisely estimated.

Figure 5: Heterogeneous effects by climate beliefs and baseline knowledge



Note: This figure shows the treatment effects of climate labels on customer retention and profits, differentially by beliefs and knowledge elicited on our baseline survey. We test heterogeneity along five dimensions: (i) whether or not companies have a moral duty to help combat climate change, (ii) whether or not individuals have a moral duty to help combat climate change, (iii) whether or not companies should push their customers to make climate-friendly choices, (iv) whether or not individual efforts to reduce personal carbon footprints could be effective in addressing climate change, and (v) knowledge of the carbon footprints of different foods (in this case, whether or not the customer correctly selected that beef had the highest carbon footprint and tomatoes the lowest out of the foods they were asked to rank). The full text of the survey is available at this link. For characteristics (i)-(iv), equation 2 is estimated separately on baseline survey respondents whose opinions were below or above the median baseline survey participant. In the left panel, the outcome is a dummy for whether or not a given customer ordered at least one box from HelloFresh in a given week. In the right panel, the outcome is the profit that HelloFresh made from a given customer in a given week. For other dimensions of heterogeneity elicited from the baseline survey, see Figure A8. Whiskers represent 95% confidence intervals.

Again in contrast to our results for the labels' impacts on meal choices, we find substantial gaps in the labels' effects on retention by baseline carbon-footprint knowledge. In particular, our point estimates suggest that the labels increase customer retention entirely through customers with low baseline knowledge. The labels increased retention by 1.7pp among those who do not correctly place beef and tomatoes as having the highest and lowest carbon footprints in the list of six products, respectively, while reducing retention among those with correct answers. Appendix Figure A8 shows that the same pattern is visible for other measures of baseline knowledge (e.g. for our measure of knowledge based on correctly ranking all of beef, pork, chicken, and tomatoes.)

4.1.4 Summary and joint heterogeneity

As with meal choices, the carbon labels' impacts on customer retention and profit vary with key customer traits. First, we find opposite retention effects among new customers, who ordered no meal boxes in the pre-experimental period, and customers with at least one pre-experimental meal: the labels may have decreased new customers' likelihood of ordering a box, while increasing retention among existing customers. Next, the labels have large positive effects on retention and profit among customers with high baseline beef consumption, while having no such effects on others. Together, our results suggest that customers with high baseline beef consumption on average both react to and value the carbon footprint labels the most. Finally, we use the baseline survey to estimate that while there are no detectable differences in retention effects by customers' beliefs about the morality of climate action, the labels' retention effects are significantly larger among those without baseline carbon-footprint knowledge.

While these underlying dimensions of heterogeneity are correlated (Appendix Figures A5 and A4), we again find that none of these heterogeneity patterns explains the others. In columns 3 and 4 of Appendix Table A9, we use the baseline sample estimate regressions of our key profit and retention outcomes on simultaneous interactions of the treatment indicator with the baseline beef categories, baseline knowledge, and an indicator for scoring above or below the median on an index of climate-action morality beliefs. In Appendix Table A15, we use the main sample to estimate similar regressions where we simultaneously interact treatment with categories of baseline beef consumption and customer longevity.[14] In both sets of regressions, we find that the approximate magnitude and sign of heterogeneous treatment effects are unchanged.

To better understand the heterogeneous results by beef consumption, climate beliefs, and knowledge, we take the same approach that we took with meal choices, examining the treatment effects of climate labels crossing baseline beef consumption with climate beliefs and knowledge. The pattern we find for effects on retention and profit is similar to what we found for meal choices. We find that one subgroup drives the climate label's effect of increasing retention and profits for HelloFresh: customers who (a) had high baseline beef consumption and also(b) believe individuals and/or com-

[14] In the main sample data, a natural concern is that we measure the share of beef in past meal choices for customers with fewer pre-period meal weeks with differential error, perhaps inducing a spurious correlation between customer longevity and categories of baseline beef consumption that could underlie heterogeneous treatment effects with respect to both longevity and baseline beef consumption. However, since we can only define baseline beef consumption for customers with at least one pre-period meal, heterogeneity by baseline beef consumption cannot be explained by the large gap in retention effects between those with no pre-period meals and at least one pre-period meal. Moreover, we find no correlation between longevity and the prevalence of beef in pre-period meals among customers where we can define both measure. Nonetheless, we simultaneously estimate both patterns of heterogeneity for completeness.

panies have a moral duty to address climate change. We also see the same pattern in heterogeneous treatment effects crossing baseline beef consumption and carbon-footprint knowledge, where the positive effect on profits is driven by customers who (a) have high baseline beef consumption and (b) already knew about the high carbon footprint of beef at baseline. This provides additional evidence that the climate label treatment effect mechanism is salience rather than information. This subgroup of customers that responds to the climate labels by reducing their carbon footprints is also more likely to continue ordering from HelloFresh, which suggests that they might be grateful for the climate labels as a commitment device to achieve their desired lower-emissions diet.

See Table A7 for the full set of regression results testing heterogeneous treatment effects by baseline beef consumption crossed with beliefs about climate change on meal choices.

5 Discussion and conclusion

Food systems contribute a substantial fraction (between 25-35%) of total annual greenhouse gas emissions. The proteins that people choose to eat make a substantial difference in the carbon footprint of their diets, and beef consumption in particular has a larger impact on the environment than other types of protein per unit weight. This paper shows that firm-proposed labels that provide information on the environmental impacts of different food products can reduce the carbon footprint of their customers' diets, and that these labels can be profitable to the firm by increasing customer retention. Perhaps surprisingly, we find evidence that the customers who change their meal choices most are those who were eating more higher-emissions meals before the introduction of the climate labels, and that these higher-emission customers are also more likely to continue ordering from HelloFresh as a result of the labels. Baseline survey responses suggest that this could operate through a salience mechanism: the customers who change their meal choices and who are more likely to continue ordering from HelloFresh as a result of the labels are those who (a) eat a lot of beef before the introduction of the labels, but (b) know that beef production has a large carbon footprint, and (c) believe that individuals have a moral duty to address climate change.

We find that the climate labels are effective in reducing the carbon footprints of a subset of customers who already believe that climate change is happening and that it is our moral imperative to address it. However, it appears that the labels can generate backlash among those who do not believe that they should be nudged to make climate-friendly choices, and these customers may even increase their carbon footprint when faced with climate-related labels. This suggests caution in proceeding – at least in the United States – with rolling out any mandatory carbon labelling, given

the substantial fraction of Americans who are not supportive of climate action. Our results suggest that some form of self-targeting could be effective: the customers whose meal choices change also seem to be those who are more likely to continue ordering HelloFresh meals, which suggests that customers who reduce their carbon footprints may choose to see the climate-related information. Therefore a voluntary system that allows customers to opt out of seeing climate-related information could be an effective initial step.

Although the carbon labels do significantly reduce the carbon footprint of HelloFresh meals chosen by the treatment group, the adjustments are small in face of the changes necessary to reach global emissions targets and warming limits. For slowing down climate change, it may be welcome news that companies can profitably opt in to effectively nudging customers to choose lower-emission products, even when those lower-emission products have a smaller profit margin. However, this experiment also makes clear that labelling products with carbon footprints and allowing customers to choose is unlikely to contribute a substantial fraction of the carbon emissions reductions required.

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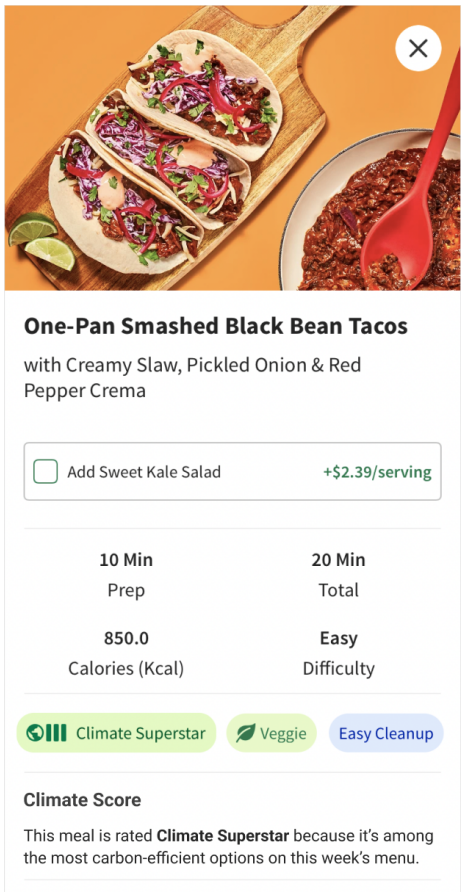
A Appendices

A.1 Figures

Figure A1: HelloFresh Menu with Abstract Score

(a) Example Menu Excerpt

(b) Menu Card Example 1



(c) Menu Card Example 2

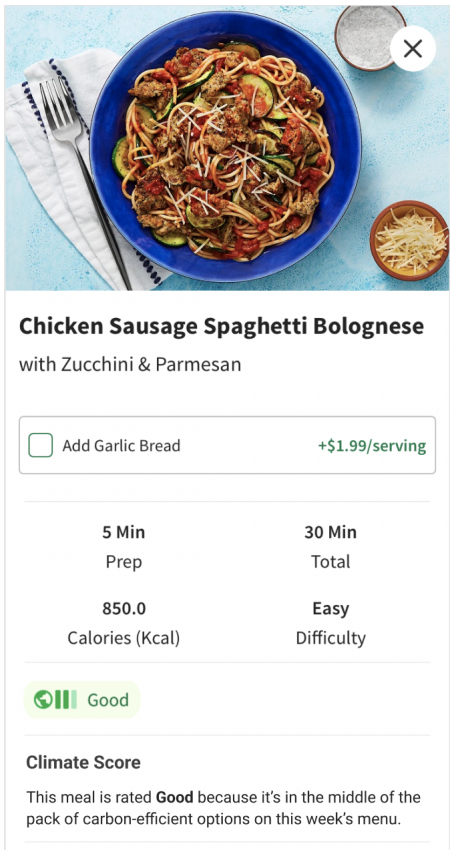


Figure A2: Treatment effects on meal choices over time

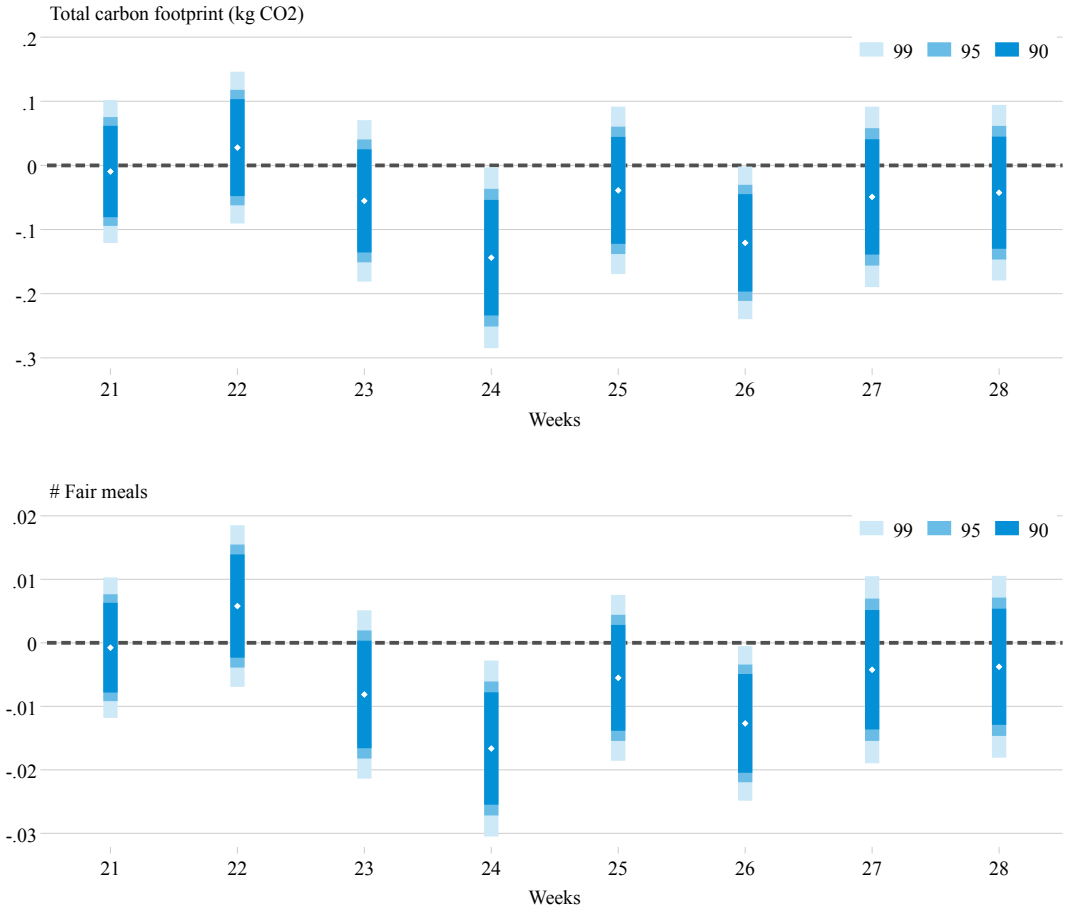


Figure A3: Baseline sample: Full heterogeneous treatment effects on meal choices

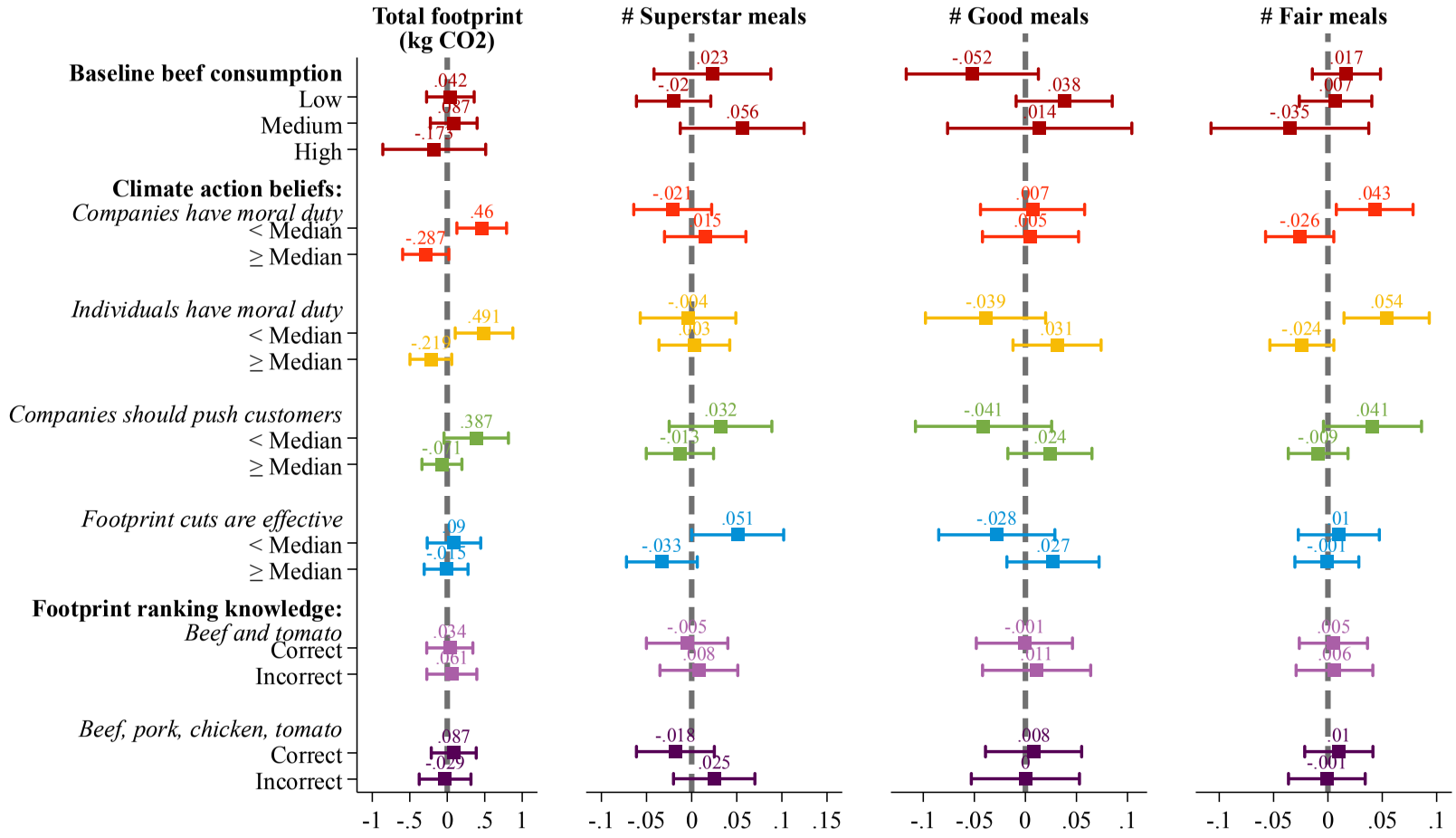
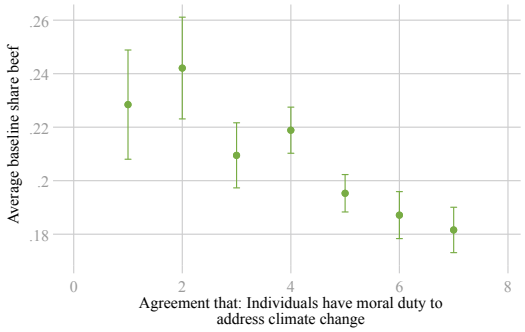
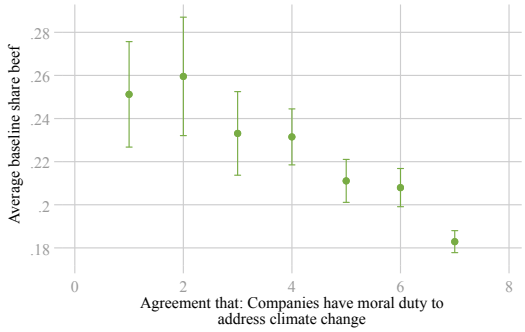


Figure A4: Correlation of baseline climate beliefs and beef consumption





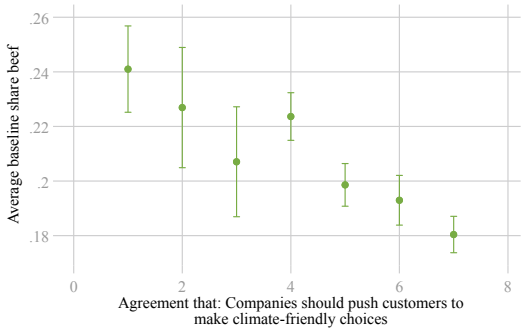
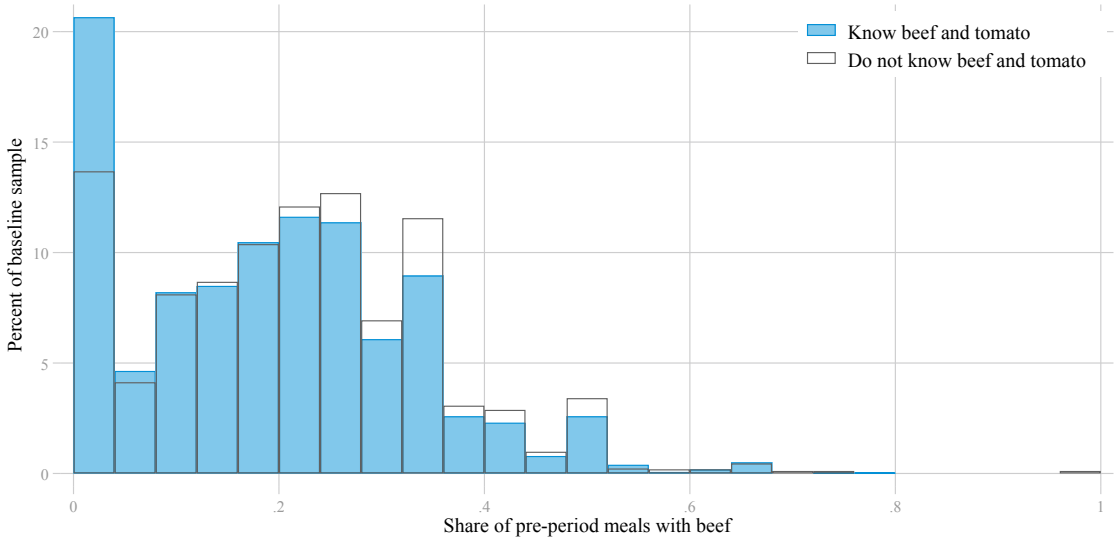


Figure A5: Correlations between baseline beef consumption and carbon footprint knowledge

(a) Distribution of baseline eef share by knowledge of beef and tomatoes



(b) Baseline beef categories by knowledge of beef and tomatoes

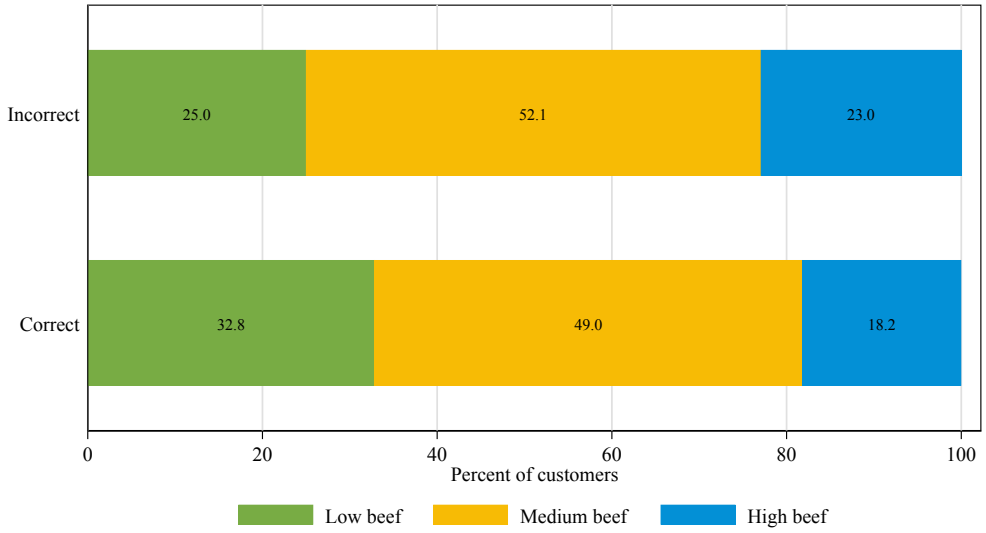


Figure A6: Ingredient costs by meal protein type

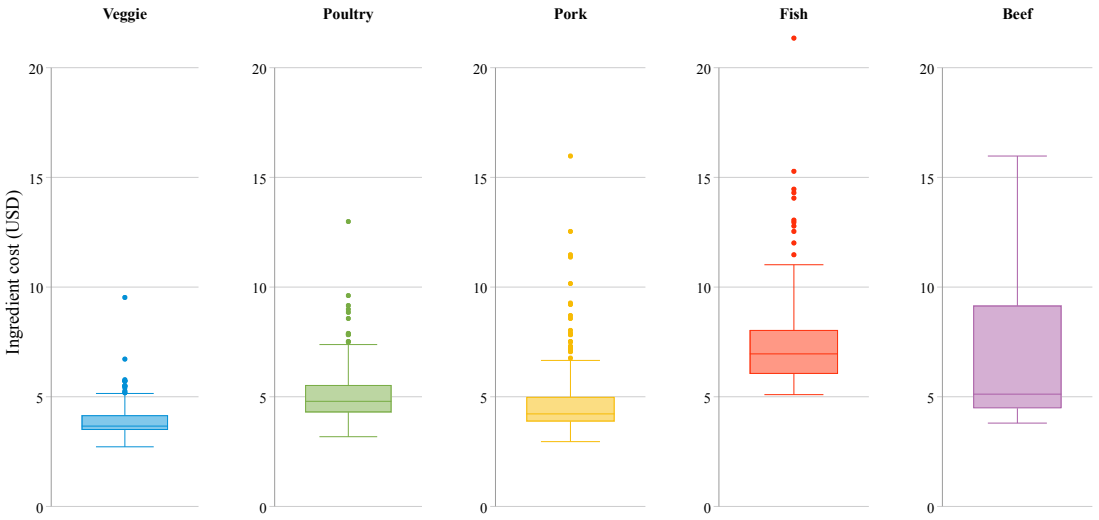


Figure A7: Treatment effects on retention and profit over time

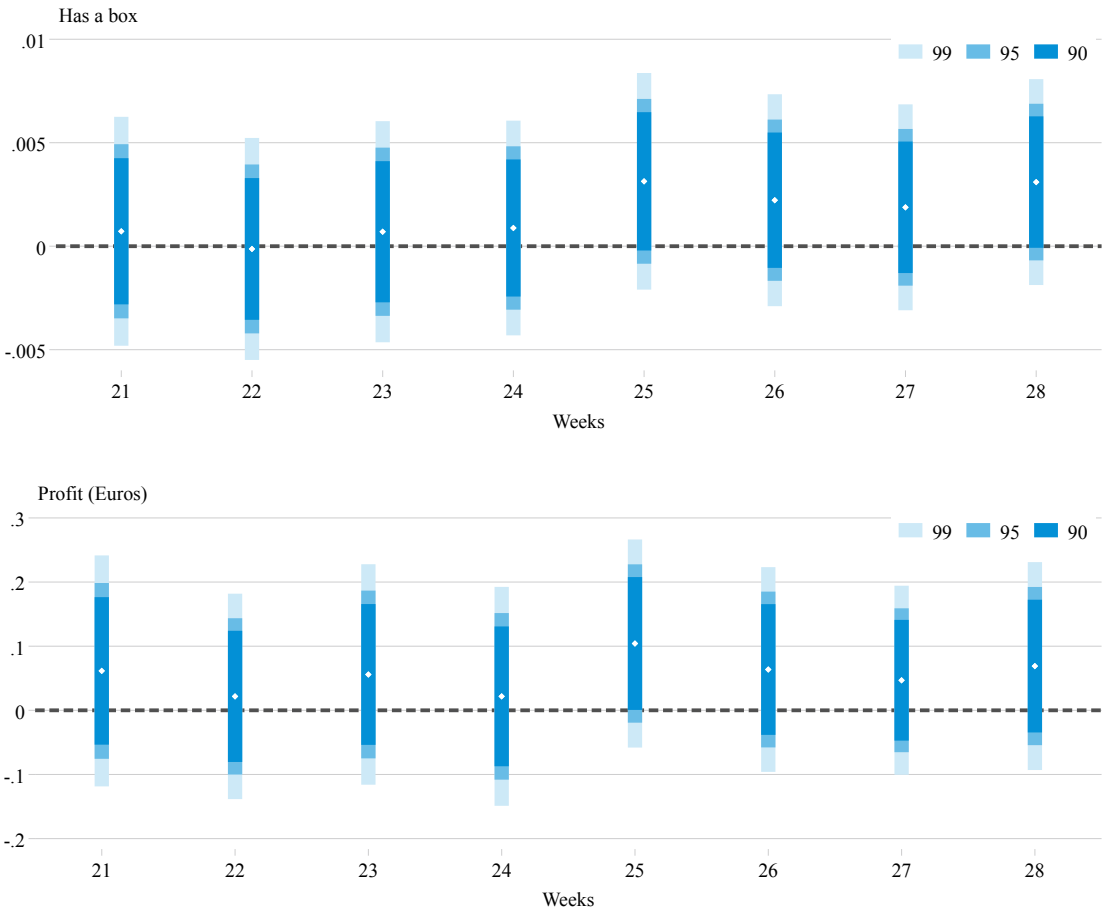
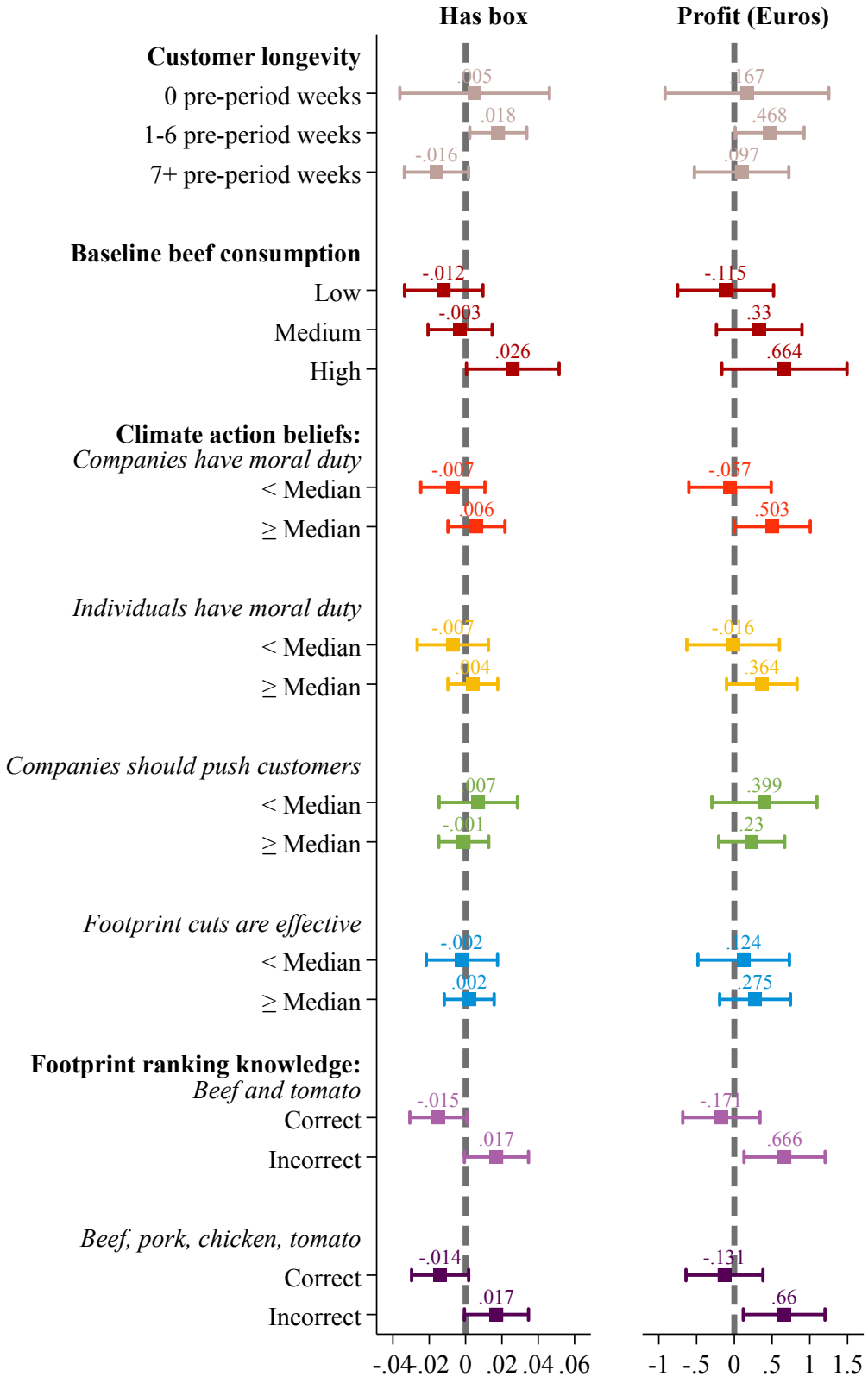


Figure A8: Baseline sample: Full heterogeneous treatment effects on profit and retention



A.2 Tables

Table A1: Comparing baseline sample and main experimental sample

	In baseline sample?				
	No		Yes		
	Mean	N	Mean	N	Δ Means
Longevity at HelloFresh					
Had any pre-period meal	0.810	228919	0.969	5592	0.159***
Week of first pre meal	11.964	185312	11.970	5418	0.006
# Pre weeks with meals	4.394	228919	6.063	5592	1.670***
Total # pre-period meals	13.745	228919	19.519	5592	5.774***
Baseline meal choices					
Avg box carbon footprint	12.997	155899	12.582	5059	-0.415***
Share of baseline meals:					
Vegetarian	0.148	185312	0.174	5418	0.026***
Poultry	0.366	185312	0.352	5418	-0.014***
Pork	0.233	185312	0.226	5418	-0.007***
Fish	0.052	185312	0.064	5418	0.012***
Beef	0.217	185312	0.200	5418	-0.017***
Demographics by zipcode					
Share below US poverty line	0.108	223514	0.108	5570	-0.000
Share adults 25+ with bachelor's	0.395	223532	0.406	5571	0.011***
Shares by race or ethnicity:					
White, non-hispanic	0.669	223535	0.679	5571	0.011***
Black	0.101	223535	0.096	5571	-0.005**
Hispanic	0.139	223535	0.132	5571	-0.007***
2020 Democratic vote share	0.530	224219	0.541	5586	0.011***

Table A2: Baseline sample summary statistics and balance

	(1) Total		(2) Control		(3) Treatment		(2)-(3) Pairwise t-test	
Variable	N	Mean/(SE)	N	Mean/(SE)	N	Mean/(SE)	N	P-value
CO2 Footprint	3627	11.885	911	11.605	2716	11.979	3627	0.158
		(0.114)		(0.230)		(0.132)		
Female (=1)	5511	0.842	1357	0.839	4154	0.843	5511	0.731
		(0.005)		(0.010)		(0.006)		
Democrat (=1)	5592	0.406	1377	0.395	4215	0.409	5592	0.359
		(0.007)		(0.013)		(0.008)		
Indiviual CO2 = Effective (1-7)	5592	4.082	1377	4.111	4215	4.073	5592	0.438
		(0.021)		(0.043)		(0.025)		
Individual CO2 = Moral Resp. (1-7)	5592	4.940	1377	4.934	4215	4.942	5592	0.869
		(0.021)		(0.042)		(0.024)		
Environmentalist (Self-Perception, 1-4)	5592	2.880	1377	2.898	4215	2.874	5592	0.339
		(0.010)		(0.021)		(0.012)		
Envi. in Food Choices	5592	2.211	1377	2.253	4215	2.197	5592	0.042**
		(0.012)		(0.024)		(0.014)		
Envi. in Policy Issues	5592	0.354	1377	0.371	4215	0.349	5592	0.131
		(0.006)		(0.013)		(0.007)		
Ate Beef Recently (=1)	5565	0.615	1372	0.618	4193	0.614	5565	0.781
		(0.007)		(0.013)		(0.008)		
Climate Worry (1-4)	5592	2.933	1377	2.954	4215	2.926	5592	0.351
		(0.013)		(0.026)		(0.015)		
F-test of joint significance (F-stat)								0.943
F-test, number of observations								3561

Table A3: Impacts on extensive-margin meal choices

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	By footprint category			By protein type				
	Superstar	Good	Fair	Veggie	Poultry	Pork	Fish	Beef
Unpooled treatments:								
Letters Score	0.001	0.001	-0.005**	0.003	0.002	-0.003	0.003	-0.005**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
Abstract Score	0.003	-0.002	-0.007***	0.002	0.004**	-0.002	-0.001	-0.007***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
Superstar	0.001	0.001	-0.006***	0.001	0.001	-0.000	0.003	-0.006***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Pooled treatments:								
Any label	0.002	0.000	-0.006***	0.002	0.002	-0.002	0.002	-0.006***
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Control mean	0.554	0.863	0.508	0.283	0.743	0.155	0.616	0.508
N	397514	397514	397514	397514	397514	397514	397514	397514

Table A5: Impacts on meal choices: Defining experimental period as weeks 21-28

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total CO2	# Meals by footprint category			# Meals by protein				
	footprint	Superstar	Good	Fair	Veggie	Poultry	Pork	Fish	Beef
Unpooled treatments:									
Letters Score	-0.058*	0.007*	0.000	-0.006**	0.006**	0.000	0.003	-0.001	-0.006**
	(0.031)	(0.004)	(0.005)	(0.003)	(0.003)	(0.004)	(0.004)	(0.002)	(0.003)
Abstract Score	-0.039	0.009**	-0.004	-0.004	0.003	0.004	-0.000	-0.001	-0.004
	(0.031)	(0.004)	(0.005)	(0.003)	(0.003)	(0.004)	(0.004)	(0.002)	(0.003)
Superstar	-0.054*	0.004	0.000	-0.006**	0.003	-0.001	0.001	0.001	-0.006**
	(0.031)	(0.004)	(0.005)	(0.003)	(0.003)	(0.004)	(0.004)	(0.002)	(0.003)
Pooled treatments:									
Any label	-0.050**	0.007**	-0.001	-0.005**	0.004	0.001	0.001	-0.001	-0.005**
	(0.025)	(0.003)	(0.004)	(0.002)	(0.003)	(0.003)	(0.003)	(0.001)	(0.002)
Control mean	11.968	0.786	1.717	0.600	0.432	1.060	0.892	0.158	0.600
N	572732	572732	572732	572732	572732	572732	572732	572732	572732

Table A4: Impacts on meal choices: Not controlling for demographics or longevity, Weeks 23+

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total CO2	# Meals by footprint category			# Meals by protein				
	footprint	Superstar	Good	Fair	Veggie	Poultry	Pork	Fish	Beef
Unpooled treatments:									
Letters Score	-0.073**	0.005	0.004	-0.008***	0.006	0.001	0.006	-0.003	-0.008***
	(0.035)	(0.004)	(0.005)	(0.003)	(0.004)	(0.004)	(0.004)	(0.002)	(0.003)
Abstract Score	-0.078**	0.012***	-0.001	-0.009***	0.005	0.007*	0.000	-0.001	-0.009***
	(0.035)	(0.004)	(0.005)	(0.003)	(0.004)	(0.004)	(0.004)	(0.002)	(0.003)
Superstar	-0.075**	0.004	0.003	-0.009***	0.003	0.001	0.002	0.000	-0.009***
	(0.035)	(0.004)	(0.005)	(0.003)	(0.004)	(0.004)	(0.004)	(0.002)	(0.003)
Pooled treatments:									
Any label	-0.075***	0.007*	0.002	-0.009***	0.005*	0.003	0.003	-0.001	-0.009***
	(0.028)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)	(0.002)	(0.003)
Control mean	11.775	0.856	1.635	0.589	0.439	1.070	0.851	0.167	0.589
N: Customers	131017	131017	131017	131017	131017	131017	131017	131017	131017
N: Customer-weeks	397514	397514	397514	397514	397514	397514	397514	397514	397514

Table A6: Impacts on meal choices: Heterogeneity by baseline beef consumption

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total CO2	# Meals by footprint category			# Meals by protein				
	footprint	Superstar	Good	Fair	Veggie	Poultry	Pork	Fish	Beef
Low baseline beef:									
Any label	0.021	0.010	0.001	0.003	0.014*	-0.000	-0.001	-0.001	0.003
	(0.046)	(0.009)	(0.008)	(0.004)	(0.008)	(0.007)	(0.006)	(0.004)	(0.004)
Control mean	7.949	1.433	1.309	0.254	0.957	0.973	0.622	0.211	0.254
N: Customers	30452	30452	30452	30452	30452	30452	30452	30452	30452
N: Customer-weeks	90518	90518	90518	90518	90518	90518	90518	90518	90518
Medium baseline beef:									
Any label	-0.082**	-0.000	0.003	-0.011***	-0.003	0.002	0.007	-0.002	-0.011***
	(0.040)	(0.005)	(0.006)	(0.004)	(0.004)	(0.005)	(0.005)	(0.002)	(0.004)
Control mean	12.679	0.735	1.801	0.643	0.313	1.123	0.971	0.168	0.643
N: Customers	61412	61412	61412	61412	61412	61412	61412	61412	61412
N: Customer-weeks	201764	201764	201764	201764	201764	201764	201764	201764	201764
High baseline beef:									
Any label	-0.114*	0.018***	0.008	-0.016**	0.009*	0.015**	0.001	0.002	-0.016**
	(0.067)	(0.006)	(0.009)	(0.007)	(0.005)	(0.007)	(0.007)	(0.003)	(0.007)
Control mean	13.575	0.486	1.524	0.828	0.169	1.019	0.759	0.111	0.828
N: Customers	27005	27005	27005	27005	27005	27005	27005	27005	27005
N: Customer-weeks	74369	74369	74369	74369	74369	74369	74369	74369	74369
Comparison p-values:									
Group 1 = Group 2	0.093	0.308	0.802	0.020	0.063	0.782	0.355	0.844	0.020
Group 1 = Group 3	0.099	0.434	0.515	0.015	0.604	0.120	0.820	0.563	0.015
Group 2 = Group 3	0.681	0.021	0.621	0.437	0.042	0.115	0.555	0.349	0.437

Table A7: Impacts on meal choices: Heterogeneity by beliefs about moral duties on climate change

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total CO2	# Meals by footprint category			# Meals by protein				
	footprint	Superstar	Good	Fair	Veggie	Poultry	Pork	Fish	Beef
Companies have a moral duty to address climate change:									
< Median belief:									
Any label	0.460**	-0.021	0.007	0.043*	-0.009	-0.018	0.019	0.002	0.043*
	(0.233)	(0.028)	(0.035)	(0.022)	(0.022)	(0.030)	(0.028)	(0.014)	(0.022)
Control mean	11.638	0.875	1.695	0.552	0.406	1.148	0.861	0.194	0.552
N: Customers	2007	2007	2007	2007	2007	2007	2007	2007	2007
N: Customer-weeks	6677	6677	6677	6677	6677	6677	6677	6677	6677
≥ Median belief:									
Any label	-0.287	0.015	0.005	-0.026	0.012	-0.019	0.006	0.037***	-0.026
	(0.203)	(0.028)	(0.031)	(0.019)	(0.024)	(0.029)	(0.024)	(0.013)	(0.019)
Control mean	11.112	1.121	1.572	0.513	0.667	1.088	0.783	0.190	0.513
N: Customers	2221	2221	2221	2221	2221	2221	2221	2221	2221
N: Customer-weeks	7431	7431	7431	7431	7431	7431	7431	7431	7431
Comparison p-values:									
Group 1 = Group 2	0.016	0.360	0.966	0.018	0.527	0.980	0.723	0.073	0.018
Individuals have a moral duty to address climate change:									
< Median belief:									
Any label	0.491*	-0.004	-0.039	0.054**	-0.006	-0.041	0.000	0.007	0.054**
	(0.261)	(0.034)	(0.039)	(0.024)	(0.027)	(0.033)	(0.031)	(0.016)	(0.024)
Control mean	11.633	0.921	1.694	0.544	0.458	1.140	0.859	0.198	0.544
N: Customers	1524	1524	1524	1524	1524	1524	1524	1524	1524
N: Customer-weeks	5090	5090	5090	5090	5090	5090	5090	5090	5090
≥ Median belief:									
Any label	-0.219	0.003	0.031	-0.024	0.010	-0.006	0.022	0.026**	-0.024
	(0.191)	(0.025)	(0.029)	(0.018)	(0.020)	(0.026)	(0.023)	(0.012)	(0.018)
Control mean	11.219	1.047	1.597	0.525	0.586	1.105	0.800	0.188	0.525
N: Customers	2704	2704	2704	2704	2704	2704	2704	2704	2704
N: Customer-weeks	9018	9018	9018	9018	9018	9018	9018	9018	9018
Comparison p-values:									
Group 1 = Group 2	0.028	0.860	0.146	0.010	0.633	0.405	0.569	0.328	0.010
Companies should push customers to make greener choice:									
< Median belief:									
Any label	0.387	0.032	-0.041	0.041	0.032	-0.034	0.017	0.001	0.041
	(0.291)	(0.037)	(0.044)	(0.028)	(0.029)	(0.037)	(0.035)	(0.019)	(0.028)
Control mean	11.891	0.854	1.732	0.571	0.399	1.151	0.873	0.203	0.571
N: Customers	1245	1245	1245	1245	1245	1245	1245	1245	1245
N: Customer-weeks	4139	4139	4139	4139	4139	4139	4139	4139	4139
≥ Median belief:									
Any label	-0.071	-0.013	0.024	-0.009	-0.005	-0.014	0.009	0.029***	-0.009
	(0.182)	(0.024)	(0.027)	(0.017)	(0.020)	(0.025)	(0.021)	(0.011)	(0.017)
Control mean	11.169	1.057	1.594	0.517	0.594	1.105	0.801	0.188	0.517
N: Customers	2983	2983	2983	2983	2983	2983	2983	2983	2983
N: Customer-weeks	9969	9969	9969	9969	9969	9969	9969	9969	9969
Comparison p-values:									
Group 1 = Group 2	0.181	0.303	0.212	0.127	0.293	0.649	0.858	0.205	0.127

Table A8: Impacts on meal choices: Heterogeneity by beliefs about effectiveness of footprint reductions and footprint knowledge

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total CO2	# Meals by footprint category			# Meals by protein				
	footprint	Superstar	Good	Fair	Veggie	Poultry	Pork	Fish	Beef
Footprint reductions are effective:									
< Median belief:									
Any label	0.090	0.051	-0.028	0.010	0.020	-0.007	-0.008	0.030**	0.010
	(0.238)	(0.032)	(0.038)	(0.023)	(0.026)	(0.034)	(0.030)	(0.015)	(0.023)
Control mean	11.275	0.963	1.638	0.526	0.516	1.124	0.812	0.179	0.526
N: Customers	1614	1614	1614	1614	1614	1614	1614	1614	1614
N: Customer-weeks	5427	5427	5427	5427	5427	5427	5427	5427	5427
≥ Median belief:									
Any label	-0.015	-0.033	0.027	-0.001	-0.005	-0.025	0.023	0.012	-0.001
	(0.202)	(0.025)	(0.029)	(0.019)	(0.021)	(0.026)	(0.023)	(0.013)	(0.019)
Control mean	11.423	1.027	1.628	0.535	0.556	1.113	0.826	0.200	0.535
N: Customers	2614	2614	2614	2614	2614	2614	2614	2614	2614
N: Customer-weeks	8681	8681	8681	8681	8681	8681	8681	8681	8681
Comparison p-values:									
Group 1 = Group 2	0.735	0.038	0.248	0.699	0.450	0.689	0.414	0.355	0.699
Knowledge about beef and tomato footprints:									
Incorrect footprint ranking:									
Any label	0.061	0.008	0.011	0.006	0.015	-0.039	0.032	0.017	0.006
	(0.226)	(0.028)	(0.035)	(0.021)	(0.024)	(0.029)	(0.028)	(0.014)	(0.021)
Control mean	11.983	0.862	1.725	0.578	0.413	1.151	0.873	0.194	0.578
N: Customers	2056	2056	2056	2056	2056	2056	2056	2056	2056
N: Customer-weeks	6850	6850	6850	6850	6850	6850	6850	6850	6850
Correct footprint ranking:									
Any label	0.034	-0.005	-0.001	0.005	-0.003	-0.002	-0.008	0.023	0.005
	(0.212)	(0.028)	(0.031)	(0.020)	(0.022)	(0.029)	(0.024)	(0.014)	(0.020)
Control mean	10.820	1.126	1.549	0.491	0.654	1.088	0.774	0.190	0.491
N: Customers	2172	2172	2172	2172	2172	2172	2172	2172	2172
N: Customer-weeks	7258	7258	7258	7258	7258	7258	7258	7258	7258
Comparison p-values:									
Group 1 = Group 2	0.931	0.754	0.780	0.974	0.572	0.366	0.274	0.773	0.974

Table A9: Joint heterogeneity regressions in the baseline sample

	(1)	(2)	(3)	(4)
	Meal-choice outcomes		Retention outcomes	
	Total CO2 footprint	# Fair meals	Has box	Profit (Euros)
Any label	0.326	0.043	-0.001	0.158
	(0.352)	(0.032)	(0.023)	(0.690)
Baseline beef heterogeneity:				
Medium base beef	0.617**	0.138***	0.032	0.867
	(0.285)	(0.027)	(0.020)	(0.607)
Any label * Medium base beef	-0.011	-0.014	0.009	0.413
	(0.315)	(0.028)	(0.023)	(0.692)
High base beef	0.157	0.210***	-0.061**	-1.245
	(0.481)	(0.049)	(0.025)	(0.760)
Any label * High base beef	-0.229	-0.053	0.042	0.887
	(0.533)	(0.052)	(0.028)	(0.855)
Moral belief heterogeneity:				
$\geq$ Median moral index	0.369	0.026	0.010	0.270
	(0.275)	(0.026)	(0.018)	(0.545)
Any label * $\geq$ Median moral index	-0.478	-0.037	0.013	0.373
	(0.314)	(0.029)	(0.020)	(0.612)
Knowledge heterogeneity:				
Correct footprint rank	-0.236	-0.019	0.025	0.877*
	(0.276)	(0.026)	(0.017)	(0.533)
Any label * Correct footprint rank	0.024	-0.008	-0.034*	-0.921
	(0.316)	(0.030)	(0.020)	(0.614)
Control means	11.366	0.532	0.423	11.691
N	14108	14108	33552	33552

Table A10: Revenue, costs, and profits by box composition

	(1) Net revenue (Euros)	(2) Direct costs (Euros)	(3) Profit (Euros)
Number of meals:			
Vegetarian	11.457***	7.750***	2.989***
	(0.462)	(0.294)	(0.254)
Poultry	12.668***	8.620***	3.181***
	(0.359)	(0.221)	(0.184)
Pork	11.418***	7.320***	3.438***
	(0.535)	(0.258)	(0.331)
Fish	17.850***	10.919***	5.055***
	(1.088)	(0.813)	(0.654)
Beef	14.458***	9.471***	3.831***
	(0.656)	(0.400)	(0.324)
Box means	71.752	44.372	27.331
N	779744	779744	779744

Table A11: Impacts on retention and profit: Not controlling for demographics or longetivity, Weeks 23+

	(1)	(2)	(3)	(4)	(5)	(6)
		# Meals	Net rev.	Direct cost	Profit (Euros)	
	Has box	/ box	(Euros)	(Euros)	All	If box
Unpooled treatments:						
Letters Score	0.002	-0.001	0.142	0.089	0.054	-0.006
	(0.002)	(0.005)	(0.135)	(0.084)	(0.053)	(0.026)
Abstract Score	0.002	0.002	0.150	0.085	0.072	0.009
	(0.002)	(0.005)	(0.135)	(0.084)	(0.053)	(0.027)
Superstar	0.002	0.001	0.141	0.087	0.056	0.015
	(0.002)	(0.005)	(0.134)	(0.083)	(0.052)	(0.026)
Pooled treatments:						
Any label	0.002**	0.001	0.144	0.087	0.061	0.006
	(0.001)	(0.004)	(0.110)	(0.068)	(0.043)	(0.022)
Control mean	0.281	3.078	20.874	12.898	7.954	13.606
N: Customers	234511	131049	234511	234511	234511	131017
N: Customer-weeks	1407066	397565	1407066	1407066	1407066	397514

Table A12: Impacts on retention and profit: Defining experimental period as weeks 21-28

	(1)	(2)	(3)	(4)	(5)	(6)
		# Meals	Net rev.	Direct cost	Profit (Euros)	
	Has box	/ box	(Euros)	(Euros)	All	If box
Unpooled treatments:						
Letters Score	0.002	-0.001	0.097	0.063	0.037	-0.004
	(0.002)	(0.005)	(0.127)	(0.079)	(0.050)	(0.024)
Abstract Score	0.002	0.002	0.142	0.070	0.075	0.006
	(0.002)	(0.005)	(0.127)	(0.079)	(0.050)	(0.024)
Superstar	0.001	-0.000	0.122	0.067	0.055	0.007
	(0.002)	(0.005)	(0.126)	(0.078)	(0.050)	(0.024)
Pooled treatments:						
Any label	0.002**	0.000	0.120	0.067	0.056	0.003
	(0.001)	(0.004)	(0.103)	(0.064)	(0.041)	(0.020)
Control mean	0.304	3.101	22.145	13.744	8.389	13.728
N	1876088	572695	1876088	1876088	1876088	572732

Table A13: Impacts on profit and retention: Heterogeneity by customer longevity

	(1)	(2)	(3)	(4)	(5)	(6)
		# Meals	Net rev.	Direct cost	Profit (Euros)	
	Has box	/ box	(Euros)	(Euros)	All	If box
0 pre-period weeks:						
Any label	-0.003	-0.002	-0.317	-0.181	-0.119*	-0.020
	(0.003)	(0.024)	(0.195)	(0.126)	(0.070)	(0.115)
Control mean	0.120	3.242	8.072	5.388	2.746	14.333
N: Customers	43781	12160	43781	43781	43781	12148
N: Customer-weeks	262686	30908	262686	262686	262686	30863
1-6 pre-period weeks:						
Any label	0.003	0.011	0.258**	0.166**	0.091*	0.078**
	(0.002)	(0.007)	(0.131)	(0.081)	(0.051)	(0.036)
Control mean	0.199	3.079	14.415	9.005	5.409	13.565
N: Customers	122006	62143	122006	122006	122006	62125
N: Customer-weeks	732036	147872	732036	732036	732036	147826
7 or more pre-period weeks:						
Any label	0.005*	-0.004	0.316	0.202	0.145	-0.030
	(0.003)	(0.005)	(0.242)	(0.147)	(0.097)	(0.026)
Control mean	0.528	3.054	40.353	24.510	15.734	13.529
N: Customers	68724	56746	68724	68724	68724	56744
N: Customer-weeks	412344	218785	412344	412344	412344	218825
Comparison p-values:						
Group 1 = Group 2	0.060	0.591	0.015	0.020	0.015	0.413
Group 1 = Group 3	0.043	0.947	0.042	0.048	0.027	0.935
Group 2 = Group 3	0.530	0.086	0.831	0.832	0.623	0.013

Table A14: Impacts on profit and retention: Heterogeneity by baseline beef consumption

	(1)	(2)	(3)	(4)	(5)	(6)
		# Meals	Net rev.	Direct cost	Profit (Euros)	
	Has box	/ box	(Euros)	(Euros)	All	If box
Low baseline beef:						
Any label	0.001	0.014*	0.197	0.123	0.069	0.051
	(0.003)	(0.008)	(0.223)	(0.139)	(0.088)	(0.039)
Control mean	0.303	2.993	21.351	13.186	8.176	12.935
N: Customers	49811	30454	49811	49811	49811	30452
N: Customer-weeks	298866	90519	298866	298866	298866	90518
Medium baseline beef:						
Any label	0.000	-0.008	0.002	-0.011	0.023	-0.017
	(0.002)	(0.006)	(0.201)	(0.123)	(0.079)	(0.029)
Control mean	0.370	3.178	28.702	17.560	11.059	14.096
N: Customers	90884	61419	90884	90884	90884	61412
N: Customer-weeks	545304	201757	545304	545304	545304	201764
High baseline beef:						
Any label	0.010***	0.014	0.694***	0.425***	0.260***	0.059
	(0.003)	(0.009)	(0.222)	(0.137)	(0.087)	(0.046)
Control mean	0.239	2.835	17.508	10.791	6.699	12.779
N: Customers	50035	27016	50035	50035	50035	27005
N: Customer-weeks	300210	74381	300210	300210	300210	74369
Comparison p-values:						
Group 1 = Group 2	0.872	0.029	0.516	0.469	0.698	0.160
Group 1 = Group 3	0.036	0.996	0.114	0.122	0.125	0.899
Group 2 = Group 3	0.013	0.042	0.021	0.018	0.045	0.165

Table A15: Joint heterogeneity regressions by customer longevity and baseline beef consumption in the full sample

	(1)	(2)	(3)	(4)
	Meal-choice outcomes		Retention outcomes	
	Total CO2 footprint	# Fair meals	Has box	Profit (Euros)
Any label	-0.108	-0.011	-0.002	-0.109
	(0.129)	(0.010)	(0.003)	(0.070)
Baseline beef heterogeneity:				
Medium base beef	0.659***	0.132***	0.012***	0.552***
	(0.060)	(0.005)	(0.003)	(0.102)
Any label * Medium base beef	-0.080	-0.012**	-0.001	-0.072
	(0.064)	(0.006)	(0.004)	(0.116)
High base beef	0.211***	0.192***	-0.019***	-0.361***
	(0.078)	(0.008)	(0.003)	(0.107)
Any label * High base beef	-0.153*	-0.020**	0.008**	0.162
	(0.085)	(0.008)	(0.004)	(0.121)
Longevity heterogeneity:				
1-6 pre weeks	-1.525***	-0.174***	-0.000	0.876***
	(0.126)	(0.010)	(0.003)	(0.099)
Any label * 1-6 pre weeks	0.165	0.016	0.003	0.171
	(0.143)	(0.012)	(0.004)	(0.112)
7+ pre weeks	-1.642***	-0.191***	0.231***	6.607***
	(0.128)	(0.011)	(0.004)	(0.132)
Any label * 7+ pre weeks	0.079	0.011	0.006	0.287**
	(0.140)	(0.011)	(0.005)	(0.143)
Control means	11.775	0.589	0.281	7.954
N	397514	397514	1407066	1407066

Figure A9: Full sample: Heterogeneous treatment effects on meal choices by longevity

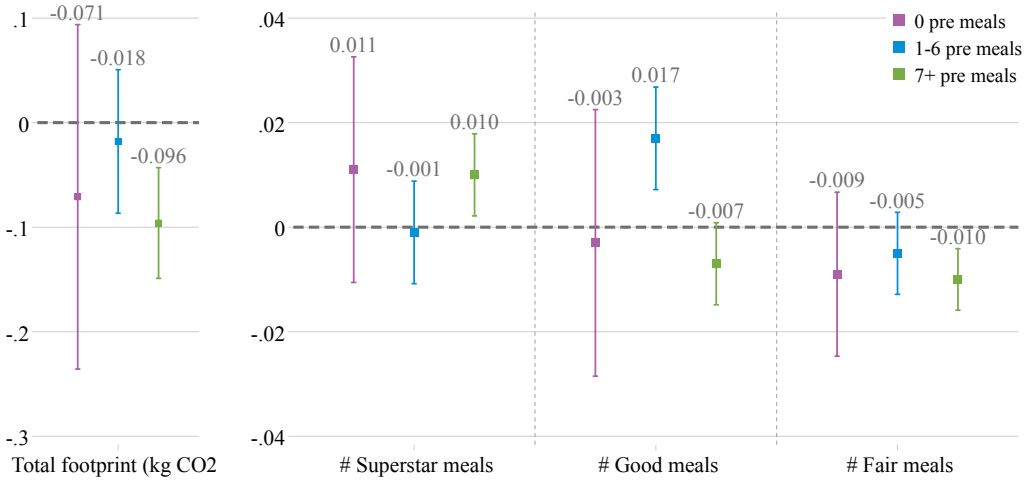


Table A16: Crossed heterogeneity by baseline beef consumption and climate-morality beliefs

	(1)	(2)	(3)	(4)
	Meal-choice outcomes		Retention outcomes	
	Total CO2 footprint	# Fair meals	Has box	Profit (Euros)
Baseline beef: Low				
< Median morality belief				
Any label	0.542	0.024	-0.004	0.265
	(0.501)	(0.036)	(0.031)	(0.919)
Control means	8.139	0.246	0.397	9.926
N	1520	1520	3858	3858
≥ Median morality belief				
Any label	0.396	0.041	-0.010	-0.287
	(0.361)	(0.025)	(0.027)	(0.832)
Control means	7.148	0.174	0.416	11.076
N	2273	2273	5568	5568
Baseline beef: Medium				
< Median morality belief				
Any label	0.429	0.030	0.006	0.558
	(0.382)	(0.031)	(0.022)	(0.739)
Control means	12.428	0.597	0.463	13.035
N	3873	3873	8292	8292
≥ Median morality belief				
Any label	0.238	-0.005	-0.016	-0.295
	(0.371)	(0.031)	(0.022)	(0.778)
Control means	12.439	0.615	0.502	14.633
N	3978	3978	8124	8124
Baseline beef: High				
< Median morality belief				
Any label	0.193	-0.014	-0.009	-0.330
	(0.738)	(0.069)	(0.033)	(1.076)
Control means	13.988	0.851	0.356	9.986
N	1296	1296	3714	3714
≥ Median morality belief				
Any label	-1.405	-0.093	0.052	1.440
	(0.983)	(0.084)	(0.036)	(1.136)
Control means	14.734	0.874	0.323	8.427
N	1069	1069	2952	2952

Table A17: Crossed heterogeneity by baseline beef consumption and carbon-footprint knowledge

	(1)	(2)	(3)	(4)
	Meal-choice outcomes		Retention outcomes	
	Total CO2 footprint	# Fair meals	Has box	Profit (Euros)
Baseline beef: Low				
Incorrect footprint ranking				
Any label	0.246	0.036	0.014	0.932
	(0.489)	(0.037)	(0.031)	(0.898)
Control means	8.275	0.246	0.385	9.416
N	1566	1566	3954	3954
Correct footprint ranking				
Any label	0.411	0.020	-0.019	-0.580
	(0.375)	(0.025)	(0.027)	(0.828)
Control means	7.176	0.181	0.421	11.284
N	2227	2227	5472	5472
Baseline beef: Medium				
Incorrect footprint ranking				
Any label	0.251	0.015	0.018	0.868
	(0.375)	(0.030)	(0.022)	(0.743)
Control means	12.613	0.609	0.466	13.198
N	3954	3954	8244	8244
Correct footprint ranking				
Any label	0.406	0.010	-0.028	-0.598
	(0.377)	(0.031)	(0.022)	(0.775)
Control means	12.259	0.603	0.499	14.458
N	3897	3897	8172	8172
Baseline beef: High				
Incorrect footprint ranking				
Any label	0.026	-0.023	-0.027	-0.581
	(0.752)	(0.066)	(0.033)	(1.071)
Control means	14.230	0.864	0.373	9.962
N	1276	1276	3636	3636
Correct footprint ranking				
Any label	-1.134	-0.078	0.072**	1.685
	(0.973)	(0.090)	(0.035)	(1.146)
Control means	14.407	0.856	0.304	8.510
N	1089	1089	3030	3030