Optimal Green Retailing: Theory and Evidence*

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Abstract

We lay out a simple framework for optimal green retailing and use it to evaluate a heavily publicized "true cost" campaign in which a large German grocer added the estimated uninternalized externality costs to a selection of products and donated the proceeds to climate change mitigation projects. When the campaign increased prices, demand decreased less than would be predicted by responses to standard short-term price changes, suggesting that warm glow from the donations increased demand. Surveys show that the campaign did not substantially affect beliefs about externality magnitudes, but consumers expressed concerns about greenwashing and viewed true cost pricing more skeptically after the campaign. Using a structural model and home scanner data, we evaluate alternatives such as a cross-subsidy from high- to low-externality foods and the first-best system of externality taxes.

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1 Introduction

In addition to selling goods and services, many companies around the world take other actions to benefit consumers, local communities, and the environment. Indeed, there is a longstanding debate about whether and why firms might purely maximize profits versus consider their shareholders' non-financial objectives and their impacts on other stakeholders (Friedman 1970; The British Academy 2018). Within this debate, a growing focus area is environmental externalities, and climate change in particular. Many companies have voluntary net-zero carbon emissions pledges, and at least a few may be devoting significant effort to voluntary decarbonization (e.g., Rathi 2022).

This discussion raises a series of questions. To what extent can firms both help the environment and increase profits? For retailers specifically, what are the merits of different environmental strategies, such as decarbonizing supply chains, green marketing campaigns, and even cross-subsidizing environmentally friendly goods? To what extent is voluntary corporate action a substitute for government regulation?

This paper studies these questions in one of the largest product markets in one of the world's largest economies: grocery retail in Germany. To fix ideas, we begin with a model of imperfectly competitive retailers that place some non-negative weight on reducing environmental externalities. We then evaluate a widely publicized nationwide "true cost" campaign that we implemented with Penny, a large German grocery chain, in which they posted and charged consumers the additional uninternalized environmental externalities on certain products for one week. Finally, we estimate a structural model of German grocery demand and simulate the effects of alternative green retailing approaches as well as nationwide environmental taxation.

In our theoretical framework, consumers buy a set of goods with different externalities from imperfectly competitive retailers. At least some consumers are altruistic: due to pure altruism and/or warm glow, they prefer goods with less negative externalities. Retailers set the price of each good and can also take costly abatement actions to reduce marginal externalities—for example, by decarbonizing supply chains or buying offsets. Retailers maximize profits net of negative environmental externalities, with some non-negative weight ω on reducing externalities. If ω is at least slightly positive, a retailer's optimal pricing depends not only on its market power but also how its pricing affects substitution to lower-externality products. In that case, both costly externality reductions and cross-subsidies can be optimal. For example, the retailer might increase the price of products to buy externality offsets or raise the price of beef while reducing the price of plant-based meat substitutes. The retailer's optimal abatement levels depend on the extent to which abatement increases demand and, if $\omega > 0$, the direct benefits and costs of abatement plus the indirect effects through substitution to other goods.

We apply this framework to studying Penny's "true cost" campaign. For one week in summer 2023, Penny posted and charged consumers the uninternalized externalities on nine products in the yogurt, cheese, meat, and meat substitute categories. We calculated the externalities following Michalke et al. (2023), by monetizing 14 categories of environmental harms and subtracting already-internalized European and

German carbon prices. Penny donated the proceeds from the true cost surcharge to agricultural energy efficiency efforts. The campaign was widely publicized: there were at least 762 media articles, and it headlined all three German nightly news channels on the first day of the campaign. About 64 percent of Germans reported hearing about Penny's campaign.

Penny's campaign could have affected demand through two channels: the price increase should reduce quantity demanded, but the warm glow from the donations could shift demand outward. To separate these effects, we compare the demand response to the true cost campaign versus the demand response to standard temporary promotional price reductions for the same products. We find that the decrease in log demand is less than half of the predicted price effect for the average campaign product. If demand is roughly iso-elastic both above and below the usual price, this implies that the warm glow effect shifted demand significantly outward.

To go beyond the purchase data, we fielded a nationally representative panel study with an oversample of Penny shoppers, with baseline and endline waves just before and just after the campaign. Strikingly, consumers' (incentivized) average beliefs about the magnitude of uninternalized externalities were almost constant across products, meaning that people have limited awareness of what products impose the highest damages. In addition, there was very little change in beliefs after the campaign, making it unlikely that the campaign's effects operated through changing factual beliefs about the magnitude of externalities. Instead, large majorities of people who reported buying a campaign product reported that donations and sustainability were important reasons for doing so. This suggests that warm glow played an important role. The most notable post-pre difference is a strong *decrease* in support for true cost information and pricing. Perhaps consistent with this, only 19 percent of people agreed that the campaign directly helped the environment, and almost half believed that the campaign was greenwashing without positive impact. Also consistent with concerns about greenwashing, our media analysis shows that negative coverage outweighed positive coverage.

We then use our theoretical framework to evaluate the welfare effects of Penny's true cost campaign. We assume that the donation led to warm glow utility, to explain the lower-than-expected demand response. We estimate that the price increase reduced consumption utility by about €274,000 but increased warm glow utility by €279,000. The change in purchases reduced externalities by €241,000, in addition to the €316,000 in donations to agricultural energy efficiency.[1] Penny's profits dropped by €91,000 during the campaign. Overall, we estimate that the marginal value of profit reduction (MVPR) from the campaign—that is, the ratio of consumer and environmental gains to profit reductions—is 6.19.

Of course, a true cost pricing campaign on a subset of products is only one possible strategy that retailers might consider. To evaluate alternative possible strategies, we estimate a structural model of grocery demand and simulate counterfactuals. Consumers in our model make two decisions. First, they make a discrete choice of what grocery retailer to shop at, preferring lower prices and and shorter travel times. Second,

[1] This represents our estimate of the donations generated through purchases of the campaign products. Penny did its own calculation, including rounding the figure up, and added a further €50,000, as announced at the start of the campaign. In total, they donated €375,000.

once at a retailer, they make a continuous choice of how much to buy in each grocery product category. We identify travel costs using cross-sectional variation in distances between consumers and retailers—i.e., the extent to which people in practice shop at retailers that are closest to them, conditional on demographic characteristics that might affect retailer choice. We identify grocery product substitution patterns from time series price variation from retailer promotions, following Allcott et al. (2019a), DellaVigna and Gentzkow (2019), and many others.

We consider three counterfactual scenarios. First, we consider a unilateral revenue-neutral cross-subsidy: if Penny were to re-price goods so that relative prices change by the relative uninternalized externalities, but the total cross-subsidy amounts sum to zero. In our model, this has very limited effects on consumer surplus and profits, because consumers generally substitute within a retailer. The predicted negative externality reductions are large relative to profit or consumer surplus losses, implying that at least in our model, retailers can generate large environmental benefits at relatively limited cost. Second, we consider the effect of nationwide environmental taxes: a carbon tax that increases each good's price by its uninternalized externality, as well as the first-best Pigouvian tax. Because these affect all retailers, the overall total surplus gains dwarf the effects of Penny's 2023 campaign or counterfactual cross-subsidy. This underscores that unilateral voluntary action by firms is not a substitute for efficient government policy. Third, we consider the effects of a voluntary policy in which Penny implemented the true cost campaign for one year, instead of one week. Welfare effects of this campaign are between those for the cross-subsidy and taxes, with consumer surplus gains from warm glow being a main driver of the results.

Our work builds on several literatures. First, we contribute to the literature on corporate social responsibility and stakeholder capitalism,[2] as well as theoretical work on private provision of public goods (e.g., Kotchen 2006). Second, we contribute to the literature on consumer demand for contributions to environmental public goods.[3] Third, we contribute to a recently growing literature on food CO2 labeling and information provision by providing new empirical evidence plus an economically grounded welfare evaluation.[4] Fourth, our counterfactual simulations provide new evidence on the effects of food carbon taxes, building on Springmann et al. (2017) and Funke et al. (2022). Finally, we extend a large body of previous work on grocery demand estimation[5] and spatial competition in grocery retail.[6] Our focus on food systems is particularly important given that food systems account for one-third of global human-caused greenhouse gas emissions (Crippa et al., 2021), and climate externalities are only part of food's total environmental externalities.

[2]This includes Friedman (1970), Besley and Ghatak (2005), Heal (2005), Reinhardt, Stavins and Vietor (2008), Bénabou and Tirole (2010), Kitzmueller and Shimshack (2012), Stout (2012), Magill, Quinzii and Rochet (2015), Hart and Zingales (2017a, 2017b), Mayer (2018), Morgan and Tumlinson (2019), Cheng, Hong and Shue (2020), Edmans (2021), and Fama (2021).

[3]This includes Kotchen and Moore (2007), Semken (2024), Rodemeier (2024), and others.

[4]This includes Lohmann et al. (2022), Bilén (2023), Ho and Page (2023), Imai et al. (2023), and Tilling (2023); see Potter et al. (2023) and Taufique et al. (2022) for reviews.

[5]This includes Nevo (2003), Hendel and Nevo (2006), Mehta (2007), Song and Chintagunta (2007), Dubois et al. (2014), Allcott et al. (2019b), and others.

[6]This includes Bell et al. (1998), Smith (2004), Thomassen et al. (2017), Eizenberg et al. (2021), Arcidiacono et al. (2020), Ellickson et al. (2020), and Ozhegova (2023).

Sections 3–8, respectively, present background information, the theoretical framework, data, campaign evaluation, structural model, counterfactual results, and conclusion.

2 Background

2.1 Green Retailing

Several factors motivate our work. First, many companies have non-profit objectives, including environmental targets. For instance, among the 2,000 largest global companies by revenue, 48 percent have incorporated a net zero emissions target into their corporate strategies, while an additional 10 percent have pledged to adopt such a target (Lang et al., 2024). A robust literature explores the motives behind corporate social responsibility (CSR) targets (Bénabou and Tirole, 2010; Kitzmueller and Shimshack, 2012). On one hand, these targets may reflect the demands of employees or customers, or improve long-term profitability in other ways (e.g., Friedman, 1970; Porter and van der Linde, 1995). On the other hand, CSR objectives may stem from the prosocial motives of shareholders or management (e.g., Hart and Zingales, 2017a). Empirical evidence suggests that both motives play a role (e.g., Kitzmueller and Shimshack, 2012; Fioretti, 2022). Regardless of the underlying drivers of green objectives, a critical question is how to achieve them efficiently.

The retail sector, and grocery retail specifically, is of particular interest for several reasons. First, retail policies targeting consumption changes can be highly impactful. A significant share of global emissions come from products sold in retail stores, with agricultural products alone accounting for 26 percent of global emissions (Poore and Nemecek, 2018). Second, because grocers sell a wide array of products, they may be able to induce consumers to switch from high-carbon to low-carbon products without significantly decreasing their profits. For instance, producing one gram of beef protein emits 100 times more carbon than producing a gram of pea protein (Poore and Nemecek, 2018). Grocers can earn a markup on either product, but inducing consumers to switch from one to the other could significantly reduce emissions. Of course, this would only affect the grocer's Scope 3 emissions.[7] Third, as consumer-facing entities, retailers are well-positioned to gain reputational benefits from implementing green policies.

Finally, despite their significant environmental externalities, agricultural products are largely excluded from carbon pricing. For example, the European Emissions Trading System (ETS) does not cover agriculture, except for select inputs such as energy and chemicals. Most other environmental externalities remain completely untaxed. As a result, green policies in the retail sector can nudge consumption closer to the social optimum in cases where first-best policies are politically infeasible.

[7] In carbon accounting, Scope 1, 2, and 3 emissions refer to direct emissions, indirect emissions from purchased energy, and all other value chain emissions, respectively.

2.2 Campaign

2.2.1 Context

The true cost campaign took place in the context of the German retail sector. The sector is divided between traditional retail stores and discounters. Discounters like Penny are characterized by low prices, self-service and a reduced product selection (Wortmann, 2004; Steenkamp and Sloot, 2018). Unlike large U.S. discount stores such as Costco, German discounters often have small stores and only offer one or two brands of the same product. The German food retail sector is very competitive, as evidenced by "pricing wars" between retail chains, which in turn exert strong price pressure on suppliers and farmers (BVE, 2023; Lebensmittelpraxis, 2023). For a large number of consumers in Germany, price plays an important role when buying groceries (Zielke and Komor, 2015; BMEL, 2023). Germans of all income levels (including high incomes) shop at discounters (Schramm-Klein, 2018).

German food retailing is dominated by four large companies: (1) Edeka Group (traditional retailer EDEKA and discounter Netto Marken-Discount) with a market share of 25 percent, (2) REWE Group (traditional retailer REWE and discounter Penny) with 21 percent, (3) Schwarz Group (traditional retailer Kaufland and discounter Lidl) with 18 percent, and (4) Aldi Group (discounter only) with 11 percent (BVE, 2023). Discounters hold a market share of around 33 percent (BMEL, 2023). The main discounters by market share are Aldi, Lidl, Netto Markendiscount, Penny, and Norma (Aygün, 2012; Hahn Gruppe, 2023). Penny had a 3.3 percent market share and generated €8.8 billion in revenues in 2022 (Rewe Group, 2023).

2.2.2 Intervention

During the true cost campaign, all 2,119 Penny stores charged an environmental surcharge on nine private label products: two meat sausages, six diary products, and one plant-based meat alternative. Except for the latter, the products always included the conventional and organic version of the same product. The campaign included only private label products, because Penny's supplier contracts did not allow it to change prices on non-store brands. The campaign took place for one week from July 31 to August 6, 2023.[8] Table 1 presents the nine products and their pre-campaign prices and surcharges.

The additional revenue (the sum of the surcharges) was donated to the "Future Farmer" (Zukunftsbauer) project, which improves energy efficiency at small-scale dairy farms that sell to Penny. Penny and its customers donated a total of €375,000 through the campaign, and this amount was also matched by the dairy supplier.[9] Any customer who purchased one or more campaign products received a shopping voucher of €3, which could be redeemed in Penny stores between August 7 and 31 on purchases of €20 or more. The voucher was printed on the receipt at checkout but was not advertised or promoted in the store, and

[8] The campaign was advertised as running until Saturday, August 5. Only 22 Penny stores were open on Sunday. The campaign price was still charged in these stores on Sunday.

[9] The donation includes the surcharges paid by customers plus an additional €50,000 donation from Penny, which they had announced at the start of the campaign.

Penny staff suggest that it was unlikely that customers were aware of it when shopping.[10]

2.2.3 Media and Advertising Campaign

The campaign was widely advertised through a media and advertising campaign. Starting on Saturday July 29, Penny distributed information about the campaign in their weekly advertising brochure. Additionally, they published a landing page about the campaign and placed an advertisement in a nationwide tabloid newspaper. The German Press Agency (dpa) released a press report about Penny's true cost campaign on Sunday. At the start of the campaign on Monday, Penny and the authors of this paper held a joint press conference and issued press releases.

The University of Greifswald and Nuremberg Institute of Technology published their own website with information about the campaign and the underlying calculations as well as a detailed press kit. In addition, it links to the research project pages of the University of Greifswald and Nuremberg Institute of Technology, which contain further information like simple explanatory videos about the campaign and the true cost accounting approach in general.

2.3 True Cost Estimates

Our research team computed the uninternalized externalities for each campaign product that Penny used. Of course, such calculations require many assumptions and significant discussion of uncertainty and robustness. We provide that discussion in a separate paper (Michalke et al. 2025) and consider the externality assumptions as exogenous to this paper. In that separate paper, we used an approach called True Cost Accounting (TCA), which combines Life Cycle Assessment (LCA) with social cost estimates to get a broad measure of environmental externalities (Pieper et al., 2020; De Adelhart Toorop et al., 2021). Following Michalke et al. (2023), our analysis consisted of three steps. First, we used existing databases, ingredient lists, and adjustments for farming practices to create a Life Cycle Inventory (LCI) for each product. The inventory comprises resource, energy and water flows of all processes needed for the production and processing of that product. Second, we used Life Cycle Impact Assessment (LCIA) to aggregate related damages into one environmental impact with a standardized unit (e.g, tCO_2eq for climate change damages). Third, we monetized the environmental impacts by multiplying them with estimates of the social costs per unit of environmental impact. We derived the uninternalized externalties by subtracting climate change externalities that are already internalized through the EU ETS carbon price and Germany's carbon tax.

Figure 2 presents the uninternalized externality estimates for the nine campaign products. Externalities are 0.69–12.12€/kg, or 5–95 percent of the sales price. Meat has the highest externalities (7.05–12.12€/kg), dairy has medium externalities (0.92–7.94€/kg), and the vegan product has the lowest externalities (0.69€/kg). On average, the true costs are composed of 32 percent climate, 27 percent health, 5

[10]The receipt said: "Thank you for joining us! You have chosen 'true cost' products and thus made a contribution to the environment. 3€ discount on your purchase from 20 € - valid from 8/7 - 8/31/2023."

percent water, and 37 percent soil impacts. The organic sausages have higher externalities (12.12€/kg) than the conventional sausages (7.05€/kg), due to the difference in ingredients: the organic sausage box contains 33 percent beef sausages with very high externalities (26.35€/kg), while the conventional sausages are always pork sausages with externalities of 7.05€/kg. Otherwise, organic products generally have slightly lower externalities than conventional products.

2.4 Media Coverage

The campaign was widely publicized. Figure 4a shows the number of media articles mentioning Penny and the true cost campaign specifically over time. A total of 762 articles mentioned the campaign through August 12. The number of articles mentioning Penny increased 9-fold, from 13 per day the week before the campaign to 122 per day during the campaign week.[11] In most of these articles and unlike before the campaign, Penny was the main topic; see Figure A2. The campaign also led to 31 percent and 19-fold increases in Google searches about Penny and true costs, respectively; see Figure 4b. Finally, the campaign led to a 136-fold increase in the usage of the hashtag Penny on twitter and the emergence of tweets about true costs.

3 Theoretical Framework

3.1 Model

We present a simple theoretical framework to organize our analysis. Competing multi-product retailers (such as supermarkets and department stores) sell products with heterogeneous production externalities. Retailers maximize profits adjusted for some concern about externalities, for example due to corporate net-zero emissions commitments or pressure from regulators, workers, or other stakeholders. Retailers choose the price of their products and can also decrease the externalities associated with each product at a cost, for example by working with suppliers to reduce their carbon footprints.

Retailers indexed by r sell J "inside goods" indexed by j or k. Vectors are in boldface type. Vectors $\boldsymbol{q}_r$, $\boldsymbol{p}_r$, $\boldsymbol{c}_r$, and $\boldsymbol{\phi}_r$ are the quantities, prices, marginal costs, and externalities at retailer r. $\boldsymbol{q}_{\setminus r}$, $\boldsymbol{p}_{\setminus r}$, $\boldsymbol{c}_{\setminus r}$, and $\boldsymbol{\phi}_{\setminus r}$ are the analogous vectors at all retailers other than r, and $\boldsymbol{q}$, $\boldsymbol{p}$, $\boldsymbol{c}$, and $\boldsymbol{\phi}$ are the vectors across all retailers. We sign $\boldsymbol{\phi}$ so that $\boldsymbol{\phi} > 0$ is a negative externality.

Consumers choose inside good consumption $\boldsymbol{q}$ plus the quantity of a numeraire good n. Consumers maximize utility $u(\boldsymbol{q}, n; \boldsymbol{\phi}, \phi_n)$ subject to their budget constraint, where ϕ_n is the negative externality of the numeraire. The inclusion of the terms $\boldsymbol{\phi}$ and ϕ_n captures altruism, and we assume weakly higher demand for products with lower negative externalities: $dq_j/d\phi_j \leq 0$. We assume for simplicity that consumers perceive

[11] Since the media campaign started on Sunday, we define a week as Sunday to Saturday in the context of the media coverage. Thus the campaign week includes 07/30 – 08/05 and the week before includes 07/23 – 07/29. The coding of the media articles is explained in Section 4.4.

the externalities correctly. As we show in Section 5.3, consumers have misperceptions but do not update their beliefs about externalities much.

Retailer r sets $\boldsymbol{p}_r$ and $\boldsymbol{\phi}_r$ to maximize a weighted sum of profits and externalities. We allow marginal cost to be a a weakly decreasing function of negative externalities: $c'_j(\phi_j) \leq 0$. ω is the weight the retailer places on production externalities. In practice, we might expect $0 \leq \omega \ll 1$. The retailer's objective function is

$$\max_{\{\boldsymbol{p}_r, \boldsymbol{\phi}_r\}} \boldsymbol{q}_r \cdot (\boldsymbol{p}_r - \boldsymbol{c}_r) - \omega \left(\boldsymbol{q}_r \cdot \boldsymbol{\phi}_r + \boldsymbol{q}_{\setminus r} \cdot \boldsymbol{\phi}_{\setminus r} + n\phi_n \right). \tag{1}$$

As written, the retailer cares about externalities from the numeraire as well as from products sold by other retailers. Without these terms, the retailer would ignore "leakage" from its actions to externalities at other retailers. Ignoring leakage encourages retailers to reduce sales to reduce externalities, because they would ignore how substitution to other retailers still generates externalities. Thus, a retailer that ignores leakage would be more willing to increase costs and prices by decarbonizing its supply chain, even though those higher prices push some consumers to competitors. This would be an especially perverse incentive if the competing retailers sold higher-carbon substitute products because they had not worked to decarbonize their own supply chains.

3.2 Optimal Policy

Taking the first-order condition (FOC) for the price of good j and rearranging gives

$$p_{jr} - c_{jr} = \overbrace{\frac{-q_{jr}}{\frac{\partial q_{jr}}{\partial p_{jr}}}}^{\text{standard markup}} \overbrace{- \sum_{k \setminus j} \frac{dq_{kr}}{dq_{jr}} (p_{kr} - c_{kr})}^{\text{diversion to other products}} + \omega \overbrace{\left(\left(\frac{d\boldsymbol{q}_r}{dq_{jr}} \cdot \boldsymbol{\phi}_r + \frac{d\boldsymbol{q}_{\setminus r}}{dq_{jr}} \cdot \boldsymbol{\phi}_{\setminus r} \right) + \frac{dn}{dq_{jr}} \phi_n \right)}^{\text{indirect externality effects}}, \tag{2}$$

where $\frac{dq_k}{dq_j} = \frac{dq_k/dp_j}{dq_j/dp_j}$ is the diversion ratio between two goods. This is a modified version of the familiar inverse elasticity markup rule. For a single-product retailer with $\omega = 0$, the optimal markup (in \$/unit) is the standard inverse semi-elasticity. For a multi-product retailer with $\omega = 0$, the second term on the right-hand side adjusts for the effects of diversion on profits. With $\omega > 0$, the three components of the final term respectively adjust for the effects of diversion on externalities within the retailer, from other retailers, and from the numeraire.

Taking the FOC for the externality of good j and rearranging gives

$$\overbrace{-c'_{jr} q_{jr}}^{\text{marginal cost}} = \overbrace{-\frac{d\boldsymbol{q}_r}{d\phi_{jr}} \cdot (\boldsymbol{p}_r - \boldsymbol{c}_r)}^{\text{profit}} + \omega \overbrace{q_{jr}}^{\text{direct effect}} + \omega \overbrace{\left(\frac{d\boldsymbol{q}_r}{d\phi_{jr}} \cdot \boldsymbol{\phi}_r + \frac{d\boldsymbol{q}_{\setminus r}}{d\phi_{jr}} \cdot \boldsymbol{\phi}_{\setminus r} + \frac{dn}{d\phi_{jr}} \phi_n \right)}^{\text{indirect externality effects}}. \tag{3}$$

When interpreting this equation, recall that $c'_{jr} < 0$ and $\frac{d\boldsymbol{q}_r}{d\phi_{jr}} < 0$. The equation shows that the optimal

externality reduction trades off the marginal cost increase with the profits from increased demand due to consumer altruism (taking account of effects on sales of the full vector of the retailer's products), the direct externality effect, and the indirect externality effects through changes in purchasing patterns.

Equations (2) and (3) show the importance of considering substitution. We can think of two types of substitution: within and between retailers. Ignoring within-retailer substitution would make retailers insufficiently willing to reduce their own emissions, because they ignore how demand shifts to their lower externality products when they decarbonize. On the other hand, ignoring leakage to other retailers and to the numeraire will make retailers too willing to raise prices on relatively low-externality products, because they ignore how higher prices will drive consumers to other retailers.

To understand the quantities that affect the retailer's decision problem, we decompose the effect of a marginal change in price and emissions into components relevant to our study. First, the effect of marginal decrease in price p_{jr} on the retailer's objective function is

$$\overbrace{\overbrace{\underbrace{q_j}_{\text{direct effect}} + \overbrace{\frac{dq_{jr}}{dp_{jr}}(p_{jr}-c_{jr})}^{\text{own demand}} + \overbrace{\sum_{k\setminus j}\frac{dq_{kr}}{dp_{kr}}(p_{kr}-c_{kr})}^{\text{product substitution}}}^{\text{profit}} - \omega\overbrace{\left(\overbrace{\frac{d\boldsymbol{q}_r}{dp_j}\cdot\boldsymbol{\phi}_r}^{\text{product substitution}} + \overbrace{\frac{d\boldsymbol{q}_{\setminus r}}{dp_j}\cdot\boldsymbol{\phi}_{\setminus r}}^{\text{retailer substitution}} + \overbrace{\frac{dn}{dp_j}\phi_n}^{\text{outside good}}\right)}^{\text{externalities}}. \quad (4)$$

Second, the effect of a marginal decrease in emissions ϕ_{jr} on the retailer's objective function is

$$\overbrace{\overbrace{\underbrace{-\frac{dq_{jr}}{d\phi_{jr}}\cdot(p_{jr}-c_{jr})}_{\text{own demand}} + \overbrace{\sum_{k\setminus j}-\frac{dq_{kr}}{d\phi_{jr}}\cdot(p_{kr}-c_{kr})}^{\text{product substitution}} + \overbrace{c'_{jr}\cdot q_{jr}}^{\text{cost}}}^{\text{profit}}}$$

$$+\omega\overbrace{\left(\underbrace{q_{jr}}_{\text{direct effect}} - \overbrace{\frac{d\boldsymbol{q}_r}{d\phi_j}\cdot\boldsymbol{\phi}_r}^{\text{product substitution}} + \overbrace{\frac{d\boldsymbol{q}_{\setminus r}}{d\phi_j}\cdot\boldsymbol{\phi}_{\setminus r}}^{\text{retailer substitution}} + \overbrace{\frac{dn}{d\phi_j}\phi_n}^{\text{outside good}}\right)}^{\text{externalities}}. \quad (5)$$

In this paper, we estimate several of the relevant derivatives above.

While reducing negative externalities can increase marginal cost, this may be optimal for two reasons. First, when consumers care about environmental externalities, a reduction in externalities will lead to an increase in demand ($dq_{jr}/d\phi_{jr} < 0$). Second, if the retailer cares about externalities ($\omega > 0$), an externality reduction will create non-financial benefits. Moreover, a retailer that begins from a purely profit-maximizing outcome (from maximizing equation (1) with $\omega = 0$) can initially generate first-order environmental gains with only second-order profit losses. To see this, notice that setting $\omega = 0$ in the FOCs in equations (2) and

(3) implies that the profit terms in equations (4) and (5) sum to zero. Intuitively, starting from the purely profit maximizing outcome, a marginal change in p_{jr} or ϕ_{jr} must have zero effect on profits. However, that marginal change can reduce emissions. In practical terms, this means that otherwise profit-maximizing retailers can potentially generate meaningful environmental benefits from small pro-environmental initiatives, with only small profit losses.

3.3 Policy Welfare Implications

We use our framework to analyze several green retailing policies. We assume that in the short-run retailers cannot change the consumption externalities of products. However, they can freely set prices. Price changes can be used to buy mandatory offsets or to cross-subsidize low-externality products. We compare these policies to a Pigouvian tax.

Let ΔCS, ΔE, $\Delta\Pi$ and ΔGS be the changes in consumer surplus, uninternalized externalities, profits and government surplus, respectively. With altruistic consumers, price and externality changes will both have effects on consumer surplus, which we call price and warm glow effect, respectively. Green retailing policies may affect externalities through changes in the composition of goods purchased or the per-product externalities.

We define two measures for the overall welfare effects. First, the change in total surplus is

$$\Delta TS = \Delta CS - \Delta E + \Delta\Pi + \Delta GS.$$

Second, the marginal value of profit reductions (MVPR) is the total social value created per € of forgone profit of firm i:

$$MVPR = \frac{\Delta CS - \Delta E + \Delta GS + \sum_{k \neq i} \Delta\Pi_k}{-\Delta\Pi_i}.$$

The MVPR is analogous to the marginal value of public funds (MVPF) proposed by Hendren and Sprung-Keyser (2022). It allows the firm to compare the benefits of its policies to others with their effect own its own profits. Unlike the change in total surplus, this measure avoids any assumptions about how the firm weights its own profits relative to the surplus of others. This is analogous to how the MVPF allows government policies to be compared without making any assumption about the marginal cost of public funds. As with the MVPF, the different terms in the numerator (consumer surplus, externalities, etc.) can be weighted differently. For example, a firm might weight consumer surplus or negative externality reduction more heavily than effects on competitors' profits. Indeed, equation (1) assumes that the weights to on the consumer surplus, government surplus, and other firms profits to be zero. A final advantage of the MVPR compared to the change in total surplus is that it normalizes the benefits to others by the change in profits to the firm, so that corporate policies of different magnitudes can be compared.

3.4 Offsets

The first policy we analyze is a campaign in which consumers pay for a mandatory offset or donation to reduce externalities. To illustrate the welfare effects of this policy, we focus on a monopolist selling a single product. For simplicity, we assume that one dollar spent on offsets reduces externalities by one dollar, and analyze the case in which the monopolists offsets the entire externality ϕ. In this case the product and retailer substitution terms of equation (5) are equal to zero. The baseline price and marginal costs of the good are p^b and c^b, respectively. The price and marginal costs during the campaign are $p^c = p^b + \phi$ and $c^b = c^c + \phi$. Consumers know about the donation and experience increased warm glow. Government revenues are unaffected.

The welfare implications of this policy are illustrated in Figure 4. The effect of the price change on consumer surplus is the area under the baseline demand curve D^b between the baseline price p^b and the campaign price $p^c = p^b + \phi$. We call the former the baseline scenario and the latter the hypothetical scenario, with equilibrium quantities q^b and q^h, respectively. We assume the demand curve shifts outwards due to warm glow. The effect of this "warm glow" on consumer surplus is the difference in the area under the baseline demand curve D^b and the campaign demand curve D^c at the campaign price p^c. Let CS^c, CS^b and CS^h be consumer surplus for the campaign, baseline and hypothetical scenarios, respectively. Then,

$$\Delta CS = \underbrace{CS^c - CS^h}_{\text{warm glow effect}} + \underbrace{CS^h - CS^b}_{\text{price effect}}.$$

We also decompose the change in externalities into a consumption effect and a donation effect. The consumption effect on externalities for inside goods is the difference between the campaign quantity q^c and the baseline quantity q^b times the externality ϕ. The donation effect are the campaign quantity q^c times the difference in the price $p^c - p^b = \phi$. The change in externalities for the numeraire good is the change in n times its externalities ϕ_n (not shown). The change in retailer profits $\Delta\Pi$ is the difference between the campaign quantity q^c and the baseline quantity q^b times marginal costs c.

3.5 Cross-subsidy

The second policy we consider is a cross-subsidy. Equation (4) shows that if $\omega > 0$, it can be optimal to cross-subsidize high-ϕ and low-ϕ goods. Assume that quantities are measured in calories and that consumers have a fixed calorie constraint—e.g., they consume a certain number of calories per day. Then the diversion ratios must sum to zero: $\sum_r \sum_k \frac{dq_{kr}}{dq_j} = 0$. Define ϕ^{max} and ϕ^{min} as the highest- and lowest-externality goods, and assume that $\phi^{min} < \phi_n < \phi^{max}$. Then p_{jr} is increasing in ω if $\phi_{jr} = \phi^{max}$, and p_{jr} is decreasing in ω if $\phi_{jr} = \phi^{min}$. For goods with intermediate externalities, the optimal price depends on substitution patterns. As a simple example, retailers with $\omega > 0$ may find it optimal to raise the price of beef, which has very large negative environmental externalities, and reduce the price of plant-based meat substitutes, which have relatively small externalities. We investigate this policy in our model counterfactuals.

4 Data

4.1 Penny Store Scanner Data

Penny provided extensive scanner data to facilitate evaluation of the true cost campaign. The data run from June 1, 2019 until November 5, 2023. The item-level scanner data cover the campaign products, all products in the same product category, all products in categories that may contain substitutes according to Penny's own analysis, and all products in control categories. The control categories (bananas, tomatoes, fruit vegetables, butter, fresh milk, and UHT milk) contain some of the most frequently bought items.

Variables in the item-level scanner data include the product ID, receipt ID, current price, taxes, and quantity bought. Penny also gave us receipt-level data (e.g., total transaction amount, store, anonymized customer loyalty card ID, date, time of day, and cashier number). We match these records with data from Penny on store-level information (e.g., location) and product-level information (e.g., brand, name, size, and whether the product is organic).

The 2.8bn item-level scans cover 14 percent of revenues in 2022. Thanks to the relatively high demand for control group products, the 1.1bn observations in the receipt data cover 77 percent of revenues (in 2022). Loyalty card customers, whom we can track over time, account for 50 percent of revenues, though we do not use the customer identifiers in our analyses.

For our analysis, we first sum quantities and average prices at the market level. We then take the average over all markets where a given product was sold. We exclude returns and Sundays from all our analyses.[12]

Figure 5 shows the price and average quantity sold for the average campaign product. The downward spikes in the price come from weekly sales events. The upward spike in August 2023 is the true cost campaign.

4.2 AiMark Home Scanner Data

We purchased household-level grocery transaction data for calendar year 2022 from AiMark, which licenses the original data from GfK. GfK is analogous to the Nielsen Homescan data often used in the U.S. The data include item-level quantities and prices paid for all packaged goods purchased by a nationally representative sample of German households. The panel consists of at least 30,000 at any given time. Our data includes 31,057 households in the first quarter of 2022 and 39,852 households in total. We observe the retailer and date for each transaction. We also purchased a dataset of the driving time from each household to each retailer's nearest store.[13]

We limit the analysis to standard grocery items, excluding alcohol, beverages, baby food, and non-food items. We define 21 categories of goods based on our assessment of (i) product homogeneity (elastic

[12] Only a handful of stores are open on Sundays.

[13] AiMark uses their own methodology when calculating driving distances. They assume there is no traffic. As a result, the estimates are independent of the time of day.

substitution within a category and less elastic substitution across categories) and (ii) similar uninternalized externalities.

We create two datasets using the AiMark data. The "transaction dataset" includes the date, total amount, and retailer for each transaction made by each household. The "purchase dataset" includes the prices and total quantity of calories purchased at the consumer group-category-retailer-week level. We use two consumer groups: above and below median income. Prices vary at the category-retailer-week level. There are two price variables: *average price* is the observed average price per calorie across all observed purchases in the category. *Price deviation* is the average observed price per calorie across all observed purchases, but instead weighting UPCs by their annual average market shares.

4.3 Survey Data

To understand customers' reactions to the campaign, we ran a nationally representative survey before and after the campaign. The baseline survey took place from July 25 until July 28 (Friday before the campaign). The endline survey took place from August 7 (Monday after the campaign) until August 9.

The survey elicited a number of beliefs, attitudes, and characteristics. In both surveys, we asked about general brand favorability (Holbrook and Batra, 1987), brand favorability on environmental issues (Chen, 2010), retailer decision factors, product decision factors, support for true cost policies, true cost beliefs, and campaign awareness. We ask the brand favorability questions for Penny, four other grocers (to test for spillovers), and two non-food retailers (as controls).[14] Adding several other retailers also served to obfuscate the purpose of the survey. The policies assessed were: in-store information about true costs, a surcharge by retails that is donated to reduce environmental damages (as in the campaign), and a government tax. The campaign reach question asked which retailers, if any, had a true cost campaign (same retailers as above). All answer choices were randomized.

In the true cost belief estimation, participants selected the externalities in percent of the regular sales price using a slider going from 0 percent to 90 percent for 10 products. The products covered five campaign products, four other food items (to test for spillovers), and one non-food item (as a control). We estimated the average true costs of these products to be the mid-point of the scale (45 percent), so that any central tendency effect would bias the average result towards our estimate of the correct value. For each item, participants were shown the name, production method, package size, and baseline price. Participants were incentivized to give an answer that matched our estimate. We randomized the reward to be either €0.05 or €0.20 per correct answer.

In the baseline survey, we also elicited baseline characteristics. At the beginning of the survey, we asked who made the shopping decisions in the participant's household, how often the participant shopped at the above retailers, and about their state, gender, and age. These questions were used to screen out participants (see below). At the end, we elicited environmentalism UBA (2020), education (UNESCO and UIS, 2012;

[14] The four other grocers were two other discounters (ALDI and Lidl) and two traditional supermarkets (REWE and Edeka). The two non-food retailers were Bauhaus and MediaMarkt.

Destatis, 2021), number of household members, and household income (Beckmann et al., 2016). The full baseline questionnaire is shown in Appendix C.1.

In the endline survey, we further elicited beliefs and views about the campaign. We ask about the perceived effectiveness of the donation, perceived effectiveness of the campaign, whether the participant shopped at Penny during the campaign week, whether the participant bought any campaign products, as well as reason for buying or not buying any campaign products. The full endline questionnaire is shown in Appendix C.2.

We used two samples: (i) a general population sample that was representative in terms of age, gender, and region, and (ii) a sample of Penny customers who were the main decision-maker in the household and shopped at Penny at least once in the month before the baseline survey. Both samples came from panels recruited by the survey company Cint. The baseline sample was completed by 1516 and 1500 participants from the general population and Penny customer pool, respectively. Of those, 1119 (general population) and 1141 (Penny customers) also completed the endline survey. We pool both samples for our analyses. We use entropy weighting to make the survey representative Hainmueller (2012). The weighted means match the population means for gender, age, years of education, and shopping at Penny, see Table A1.

4.4 Media Data

We obtained media articles about Penny from Factiva and coded their content. We retrieved all 1,473 articles matching the search query "Penny" in German media articles in the period from July 22 to August 18, 2023. Two coders manually coded these articles. We assessed whether the articles were about the discounter Penny (as opposed to, for example, the British politician Penny Mordaunt) and the true cost campaign, as well as whether they were the main topic. If the article was about the campaign we additionally assessed the articles narrative and sentiment. We coded whether the article explained the true cost concept and methodology, mentioned any of five possible aims/effects (scientific research, provide information, encourage debate, greenwash Penny's image, patronize consumers), and discussed any of two critiques (price hikes, methodological problems). We also assessed sentiments towards both Penny and the true cost campaign as either positive, negative, neutral, or "ambivalent" (providing a mix of positive and negative arguments/views with high tonality). The full coding instructions are provided in Appendix D. A pilot in which both showed high inter-coder agreement of at least 82 percent on all questions, except sentiments toward Penny where the agreement was 69 percent, see Table A2.

5 Campaign Evaluation

In this section we evaluate the effect of the campaign on beliefs, consumption and preferences; media coverage; as well as the campaign's welfare implications. First, we show that the campaign had no significant effect on beliefs about externalities. Second, we show that consumers responded less strongly to the change

in prices than under other week-long price changes. We attribute the difference to warm glow from the donation. Third, we look at various survey outcomes, including perceptions of Penny and policy preferences. Forth, we show that the polarizing view of the campaign is in line with media coverage at the time. Finally, we estimate the effect of the campaign on total welfare.

5.1 Beliefs

With altruistic consumers, preferences may depend on the (possibly biased) perceived externalities of products. Since the true costs were very salient in the campaign, customers may have updated their beliefs. To test this, we elicited true cost beliefs both before and after the campaign in our survey for five campaign products, four substitute food products, and one non-food product.

Figure 6 plots baseline and endline externality beliefs against the value estimated by us (see Section 2.3). The average baseline belief is close to the middle of the scale and actual average true cost (45 percent of the sales price). However, beliefs for individual products are very compressed around this average, consistent with cognitive uncertainty (Enke and Graeber, 2023). Moreover, baseline beliefs are mostly uncorrelated with true externalities, even though participants were incentivized to match them.

After the campaign, the average estimate increases slightly. However, estimates increase for both products where participants underestimated and overestimated the externalities at baseline. As a result, beliefs do not improve on average. We conclude that it is unlikely the campaign effect operated through changing factual beliefs about the magnitude of externalities.

5.2 Price and Warm Glow Effect

In this subsection, we estimate the effect of the campaign on demand and decompose it into a price effect and a warm glow effect. As in the rest of the paper, we assume that consumers maximize a constant elasticity of substitution (CES) utility function that is linear in the numeraire good. As shown in Appendix E, Demand for product j in category c on day t is:

$$q_{jt} = \left(\frac{\alpha_{jt}}{p_{jt}}\right)^{\sigma_c} C_{ct}, \tag{6}$$

where q_{jt} is the quantity demanded, α_{jt} is a taste parameter, p_{jt} is the price, σ_c is the elasticity of substitution, and C_{ct} captures substitution between products, between categories, and between inside goods and the numeraire.

Consistent with the belief results above, we assume that the campaign had a temporary – but not permanent – effect on preferences:

$$\alpha_{jt} = \begin{cases} \alpha_j^c \cdot \bar{\alpha}_{jt} & \text{during the campaign} \\ \bar{\alpha}_{jt} & \text{otherwise.} \end{cases} \tag{7}$$

To identify the elasticity parameter σ_c and the warm glow parameter α_j^c, we use an event study design.

Specifically, we identify σ_c using sales events and α_j^c using the campaign event.[15] We motivate this approach with event study graphs. Figure 7 shows the price and quantity demanded for the average campaign product around the campaign, normalized by the value two weeks before the start of the campaign. Figure 8 shows the normalized price and quantity around sales events. Comparing the two figures shows that demand is significantly less elastic during the campaign than during sales events, suggesting a positive warm glow effect.

We run an event study regression to estimate the price effect and warm glow effect. To only use sales events for the identification of σ_c, we include a fixed effect for each price window w of product j, that starts when the price of good j changes, except during the campaign and during sales events. We also include fixed effects for the 5 week windows around the campaign and each sales event, to control for changes in demand unrelated to the event. Our regression model is

$$\ln q_{jt} = -\sigma_c \ln p_{jt} + \mathbb{1}_{jt}^{c} \tau_j + \mathbb{1}_{jt}^{cw} \delta_j^{cw} + \sum_{e \in E_j} \mathbb{1}_t^{ew} \delta^{ew} + \delta_{jw} + \delta_{ct} + \varepsilon_{jt}, \tag{8}$$

where $\mathbb{1}_{jt}^{c}$ is one if j is a campaign product and t is in the campaign week, $\mathbb{1}_{jt}^{cw}$ is one if j is a campaign product and t is in the campaign window, E_j is the set of sales events for product j, $\mathbb{1}_t^{ew}$ is one if t is in the event window for sales event e, $\tau_j := \sigma_c \ln \alpha_j^c$ is the warm glow effect, $\delta_{ct} := \ln C_{ct}$ captures substitution and income effects, and ε_{jt} is a mean-zero error. In Appendix F.1 we microfound this regression equation using a nested CES utility function. We cluster standard errors by product and week of sample.

To illustrate the results of our regression, we decompose the campaign effect into a price effect and a warm glow effect. Let $\Delta \ln q_j$ be the change in log demand of the campaign compared to a baseline without the campaign price change and donation. By equations (6) and (7), we have that

$$\underbrace{\Delta \ln q_j}_{\text{campaign effect}} \approx \underbrace{-\sigma_c \Delta \ln p_j}_{\text{price effect}} + \underbrace{\sigma_c \ln \alpha_j^c}_{\text{warm glow}}. \tag{9}$$

The relationship is approximate, since we are abstracting from substitution and income effects captured by C_{ct} in (6).[16] We will estimate substitution effects in Section 7. We also calculate the simple average of the price and warm glow effects across campaign products.

The results are shown in Figure 9. The first bar for each product is the price effect, while the second bar is the approximate campaign effect. The warm glow effect is the difference between the two bars. For the average campaign product, the change in log demand is less than half what it would be without warm glow. Indeed, for several products, the warm glow effect more than offsets the price effect, leading to a slight increase in consumption, compared to the baseline scenario. Table A3 shows the full regression results. Column (3) is our main specification. The results are robust to a different selection of fixed effects (columns

[15] Sales events are events where the median price paid is constant for one week and lower than the median price paid on each day of the previous and following four weeks.

[16] Using analogous regression specifications, we did not find a statistically significant effect on substitution toward other products.

1-2), and to different standard error specifications (Tables A4).

We attribute the difference between the campaign and sales elasticities to warm glow. Our interpretation relies on the following assumptions and motivating facts. First, the result is not driven by differences in salience. Salience is arguably comparable since the price change is highlighted at the point of sale in both events. If anything, the campaign is more salient due to the cardboard explainer and media campaign, so that we would expect a stronger (more negative) price effect during the campaign event. Second, the results are not driven by stockpiling, which could inflate the demand response in sales events. This assumption is in line with the event study in Figures 7 and 8, which show no significant increase in sales before and decrease after the event, respectively. Third, the results are not driven by a change in the composition of customers. Fourth, the demand elasticity is iso-elastic around the current price. Assuming consumers are loss averse, we would again expect a stronger (more negative) price effect during the campaign week, making the warm glow estimate conservative.[17]

5.3 Survey Results

The sales data results raise additional questions. To answer these, we fielded a nationally representative survey before and after the campaign. Of the 2,260 participants who completed the endline survey, 760 had shopped at Penny during the campaign week. We calculate the mean difference between all outcome variables that were elicited in the baseline and endline surveys and divide them by their baseline standard deviation to calculate the pre-post difference. Additionally, we report other variables, including baseline beliefs and reasons to buy/not to buy campaign products, as means. The percentage figures below refer to the weighted sample average.

The campaign was well known. At endline, 58 percent of participants knew that Penny had a true cost campaign. Surprisingly, this number was similar for people who had shopped at Penny (74 percent) and those who had not (54 percent). However, participants did not understand the details well. Only 37 percent remembered that the true costs were calculated by scientists.

Instead of externality beliefs, the survey results suggest that the lower-than-expected reduction in externalities comes from the donation. Participants who bought at least one campaign product (n=119) agreed that important factors were the donation (67 percent) and their interest in sustainability generally (69 percent).

After the campaign, there was a strong reduction in the support for true cost information, true cost pricing, and environmental taxation, see Figure 10. There was no effect on which factors are most important in retailer and product choice. There was also no effect on Penny's general or environmental image, when compared to control retailers. Perhaps consistent with these findings, while 51 percent of participants agreed that the campaign raised awareness about the true cost issue, only 20 percent agreed that it directly helped the environment. By contrast, almost half (46 percent) believed that the campaign was greenwashing without

[17] Ideally, we would compare the campaign effect to similar temporary price increase. However, these do not exist. We only observe temporary price decreases (sales) and permanent price increases.

any positive impact.

5.4 Media Analysis

To understand the driver of the change in support for true cost policies and the results about the effectiveness of the campaign, we coded the sentiments and narratives of media articles mentioning Penny. Consistent with the polarized opinion in the survey, more media articles exhibited negative than positive sentiments towards Penny, while most included strong positive and negative views (see Figure A7). Interestingly, sentiments towards the campaign itself were more likely to be positive (see Figure A8). Early articles were most likely to explain the campaign and mention positive aim, such as informing consumers about externalities, while later articles were more likely to mention negative aims, such as greenwashing, or point to the fact that the campaign was badly timed with a recent increase in inflation (see Figure A9).

5.5 Welfare

In this section, we estimate the welfare implications of the true cost campaign. We only consider the price and warm glow effects and do not account for product or retailer substitution. Thus, the welfare implications for each campaign product are the same as in the case of the single-product monopolist introduced in Section 3.4. We calculate the change in consumer surplus, externalities, and profits by summing over all campaign products. We decompose the change in consumer surplus into a price and warm glow effect, and the change in externalities into a donation and consumption change effect. Formal definitions are provided in Appendix F.2. We return to and quantify product and retailer substitution effects in Section 7.

We estimate quantities and consumer surplus in the baseline and hypothetical scenarios using our regression estimates. Recall that in the hypothetical scenario the price for product j is the campaign price p^c_j, but there is no warm glow. We use equation (6), our estimates of the campaign effect α^c_j and the price elasticity σ_c for product j in category c, the campaign price p^c_{jt}, and the observed quantity q^c_{jt} on day t of the campaign week to calculate $\bar{\alpha}^{\sigma_c}_{jt} C_{ct}$. We then assume that baseline and hypothetical quantities are

$$q^b_{jt} = \bar{\alpha}^{\sigma_c}_{jt} C_{ct} \left(p^b_{jt}\right)^{-\sigma_c} \qquad q^h_{jt} = \bar{\alpha}^{\sigma_c}_{jt} C_{ct} \left(p^c_{jt}\right)^{-\sigma_c}.$$

In Appendix F.3, we show that the consumer surplus for all three scenarios can be calculated using the same variables. Note that by keeping C_{ct} constant, we are abstracting from substitution and income effects.

The remaining parameters are estimated as follows. For ϕ_n (externalities of €1 spent outside the grocery market), we use the social damages from all German carbon emission divided by German consumption expenditure, multiplied by the ratio of true costs to carbon costs in nationwide grocery shopping. For the marginal cost, we assume that average costs were the same for all products: $c_{jt}/p_{jt} = \kappa$. We estimate κ as one minus the profit margin of Penny's parent company. Finally, we assume that donations are efficient (i.e., a 1€ donation offsets externalities by 1€) .

Figure 11 presents results. We estimate that the price increase reduced consumer surplus by about €274,000, while the increased warm glow effect increased consumer surplus by €279,000. The change in purchases reduced externalities by €241,000, in addition to the €316,000 in donations to agricultural energy efficiency. Penny's profits decreased by €91,000 due to the campaign. As a result, total surplus increased by €471,000. Moreover, we estimate that the marginal value of profit reduction (MVPR) from the campaign – that is, the ratio of consumer and environmental gains to profit reductions – is 6.19.

6 Grocery Demand Model

The model-free analysis in Section 5 above allows us to evaluate the particular campaign that Penny ran in 2023. We now introduce a structural model of grocery demand that allows us to consider alternative prices and campaigns that Penny or other retailers might run. In the model, consumers choose in two stages. In the first stage, consumers choose which retailers to shop at, given logit taste shocks. In the second stage, consumers choose products within a store, given constant elasticity of substitution (CES) preferences across products. These two stages allow our model to make realistic predictions of how consumers substitute across stores and products in response to price changes.

6.1 Second Stage

6.1.1 Model

In the second stage, after consumers have arrived at the retailer, consumers choose how much of each product category to consume to maximize CES preferences. As shown by Anderson et al. (1992), we can think of CES as an aggregation of individual discrete choices to the customer group level.

We model consumer preferences in a triple nest CES structure. This framework allows us to flexibly model different substitution patterns across products in a tractable way. In the outermost nest, consumers have preferences over groups of products (protein foods, non-protein foods, and beverages), and a numeraire outside good. In the intermediate nest, consumers have preferences over product categories within a group (e.g. red meats and poultry are categories of protein foods). In the innermost nest, consumers have preferences over individual products (individual UPCs, for example, different types of sausages).

Let g index product groups, c index product categories, and j index individual products. Let i, k, r, and w index consumers (i.e., households), consumer groups (i.e., above- and below- median income), retailers, and weeks, respectively. p_{jrw} is the price of product j in retailer r in week w. q_{jkrw} is the quantity purchased by consumer group k, in units of calories. Boldface type indicates vectors; e.g., $\boldsymbol{q}_{ckrw}$ is the vector of product-level quantities chosen by group k in retailer r in week w across all products in category c.

The consumers in group k who are observed in the data shopping products from category c at retailer r in week w maximize category-level utility

$$\mu_c\left(\boldsymbol{q}_{ckrw};\boldsymbol{\alpha}^c_{krw}\right)=\left(\sum_j \alpha_{jkrw} q_{jkrw}^{\frac{\sigma_c-1}{\sigma_c}}\right)^{\frac{\sigma_c}{\sigma_c-1}} \tag{10}$$

subject to budget constraint $y_{ckrw}=\boldsymbol{\mu}_{ckrw}\cdot\boldsymbol{p}_{crw}$. The α_{jkrt} are taste parameters for individual products j, the vector $\boldsymbol{\alpha}^c_{krw}$ collects the taste parameters for all products in category c. σ_c will be the elasticity of substitution between products in category c.

By properties of the CES model, consumer utility over product categories and groups also has the CES form. Denote by $\boldsymbol{P}_{ckrw}$ ($\boldsymbol{P}_{gkrw}$) the price index faced by consumer group k in retailer r and week w for products in category c (group g). Consumers choose consumption across categories within a product group to maximize product group-level utility

$$\nu_g\left(\boldsymbol{\mu}_{ckrw};\boldsymbol{\alpha}^g_{krw}\right)=\left(\sum_d \alpha_{dkrw}\mu_{dkrw}^{\frac{\sigma_g-1}{\sigma_g}}\right)^{\frac{\sigma_g}{\sigma_g-1}} \tag{11}$$

subject to the budget constraint $y_{gkrw}=\boldsymbol{\mu}_{ckrw}\cdot\boldsymbol{P}_{ckrw}$.

At the product group level, consumers choose expenditure between product groups and a numeraire outside good n_{krw} to maximize utility

$$u\left(\boldsymbol{\nu}_{gkrw},n_{krw};\boldsymbol{\alpha}_{krw},m\right)=n_{krw}+\left(\sum_h \alpha_{hkrw}\nu_{hkrw}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{m\sigma}{\sigma-1}} \tag{12}$$

where $0<m<1$ controls total demand for inside goods relative to the numeraire, subject to the budget constraint $y_{krw}=n_{krw}+\boldsymbol{\nu}_{gkrw}\cdot\boldsymbol{P}_{gkrw}$.

Define $I_{krw}=y_{krw}-n_{krw}$ as total expenditures on the inside goods, and define $D_{krw}\coloneqq\sum_h \alpha^\sigma_{hkrw}P^{1-\sigma}_{hkrw}$. Following ten Raa (ten Raa (2015)), utility maximization gives consumer group k's demand function for product j at retailer r in week w:

$$q_{jkrw}=\left(\frac{\alpha_{jkrw}}{p_{jrw}}\right)^{\sigma_c}\left(\frac{\alpha_{ckrw}}{P_{ckrw}}\right)^{\sigma_g}\left(\frac{\alpha_{gkrw}}{P_{gkrw}}\right)^{\sigma}\frac{y_{krw}}{D_{krw}}P^{\sigma_g}_{gkrw}P^{\sigma_c}_{ckrw}, \tag{13}$$

as well as total expenditure on the inside goods:

$$I_{krw}=m^{\frac{1}{1-m}}D_{krw}^{\frac{1}{(1/m-1)(\sigma-1)}}. \tag{14}$$

Demand functions at the product category and group levels take analogous expressions to equation (13).

6.1.2 Estimation

We identify the σ parameters using price variation within retailers across weeks. Logging equation (13) gives

$$\ln q_{jkrw} = \sigma_c \ln \alpha_{jkrw} - \sigma_c \ln p_{jrw} + \sigma_g \ln \alpha_{ckrw} + (\sigma_c - \sigma_g) \ln P_{ckrw} + \sigma \ln \alpha_{gkrw} + (\sigma - \sigma_c) \ln P_{gkrw} + \ln \left(\frac{y_{krw}}{D_{krw}} \right). \tag{15}$$

Let λ_x denote fixed effects varying by index x; e.g. λ_{jkr} are kjr fixed effects. Our estimating equation for σ_c is

$$\ln q_{jkrw} = (1 - \sigma_c) \ln p_{jrw} + \lambda_{jkr} + \lambda_{krw} + \lambda_{jkw} + \varepsilon_{jkrw}, \tag{16}$$

We estimate equation (16) in the purchase dataset.

With the estimated σ_c in hand, we back out the unique α_{jkrw} that rationalize consumption given average prices p_{jrw}, using the system of J equations given by equation (13). Given the α_{jkrw}, we construct category-level price indices $\boldsymbol{P}_{ckrw}$ and repeat the procedure at the category level to back out category-level to obtain group-level elasticities of substitution σ_g and category-level taste parameters α_{ckrw}. We proceed in the same fashion to estimate group-level demands, obtaining the outermost elasticity of substitution σ and the group-level taste parameters α_{gkrw}. Finally, we back out the m that rationalizes total inside good expenditures, using equation (14). For $\sigma > 1$, m and I are monotonically positively related when $0 < m < 1$.

6.1.3 Results

We first graphically illustrate the parameter identification strategy. Figure 12 illustrates an example of the variation used to identify σ in equation (16), using the meat substitutes category as an example. The figure is a heat map of prices across retailers and time, with weeks on the x-axis and retail chains on the y-axis. The variation in color intensity conditional on retailer and week is the price variation that identifies σ. Figure 13 is a binned scatterplot of the identification of σ in equation (16).

Table 2 presents the second stage parameter estimates, including elasticities of substitution σ and σ_g, scaling parameters ϕ and ϕ', and relative taste for the numeraire good m.

6.2 First Stage

6.2.1 Model

In the first stage, consumers choose which retailer to shop at, given prices and their preferences. We define I_{irw} as grocery expenditures in transaction made at retailer $r$in week w. In each transaction, household i has the preferences $\boldsymbol{\alpha}_{irw} \coloneqq (\boldsymbol{\alpha}_{jkrw}, \boldsymbol{\alpha}_{ckrw}, \boldsymbol{\alpha}_{gkrw})$ associated with the retailer it actually shopped at for that transaction in the week of the transaction.

Let $v_{irw}(\boldsymbol{p}_{rw}, I_{irw}; \boldsymbol{\alpha}_{irw})$ be the indirect utility that consumer i would get from their optimal consumption choice if they decide to shop at retailer $r$in week w. d_{ir} is the drive time from household i to retailer r's nearest store, in minutes. l_{ir} is an indicator for whether household i is below-median income and r is a discount

retailer. Consumer i's utility from carrying out a transaction in week w at retailer r is $U_{irw} = V_{irw} + \varepsilon_{irw}$, where ε_{irw} is a type 1 extreme value idiosyncratic preference, and the representative utility V_{irw} is

$$V_{irw} = \theta_1 v_{irw}(\boldsymbol{p}_{rw}, I_{irw}; \boldsymbol{\alpha}_{irw}) - \theta_2 d_{ir} + \theta_3 l_{ir} + \xi_r. \tag{17}$$

θ_1 is the marginal utility of money, θ_2 is the marginal disutility of travel, θ_3 is lower-income consumers' additional preference for discounters, and ξ_r is a retailer fixed effect. We arbitrarily normalize $\xi_r = 0$ for online grocers.

6.2.2 Estimation

Define $\mathscr{R}_i$ as household i's choice set of retail chains within a 30 minute drive of their home. Letting s also index retail chains, the choice probabilities are:

$$Pr_{irt}(\boldsymbol{\theta}, \boldsymbol{\xi}) = \frac{e^{V_{irt}}}{\sum_{s \in \mathscr{R}_i} e^{V_{ist}}}. \tag{18}$$

The likelihood function is then

$$L(\boldsymbol{\theta}; \boldsymbol{\xi}) = \prod_i \prod_t Pr_{irt}(\boldsymbol{\theta}, \boldsymbol{\xi}). \tag{19}$$

We estimate the $\{\boldsymbol{\theta}, \boldsymbol{\xi}\}$ parameters using maximum likelihood.

6.2.3 Estimation Results

Figure 14 presents the variation that identifies the travel time disutility parameter θ_2. The x-axis is distance to the store in distance bins. The y-axis presents the share of grocery shopping trips to stores in that distance bin. Online grocers are plotted in grey at distance of zero. The downward-sloping line illustrates that households are more likely to shop at a retail chain if the closest store is closer to them; the slope of this line is what identifies the travel time disutility θ_2.

Panel (b) of Table 3 presents the first stage parameter estimates $\boldsymbol{\theta}$ and $\boldsymbol{\xi}$.

7 Counterfactuals

With the parameter estimates in hand, we turn to simulating three counterfactual scenarios. First, we consider what would happen if Penny, instead of the true cost campaign, implemented an ongoing revenue neutral cross-subsidy from high-carbon to low-carbon foods. Second, we consider the effects of nationwide externality taxes on all grocery sales. Third, we consider what would happen if Penny implemented the campaign for the whole year, instead of only one week, while assessing substitution effects and leakage to other retailers through the lens of our structural model.

The total surplus effect is the sum of changes in consumer surplus (both from price and warm glow effects), negative externalities, donations, profits, and government revenues:

$$\Delta TS = \Delta CS + \Delta WG - \Delta CE + \nu \Delta D + \Delta GS. \tag{20}$$

Consumer surplus over consumers i and transactions t can be written using the standard Small and Rosen (1981) log-sum formula:

$$CS = \sum_i \sum_t \frac{1}{\theta_1} \ln \left(\sum_r \exp\left(V_{irt}\right) \right) + K, \tag{21}$$

where V_{irt} is from equation (17) and K is an unknown constant that is differenced out when comparing counterfactuals.

The negative externality is

$$E = \sum_i \sum_t \left[\sum_r Pr_{irt}\left(\boldsymbol{\theta}, \boldsymbol{\xi}\right) \cdot \boldsymbol{q}_{irt}\left(\boldsymbol{p}_{rw(t)}\right) \right] \cdot \boldsymbol{\phi}, \tag{22}$$

where the term inside brackets is i's expected quantities purchased in transaction t, summing over the choice probabilities for each retailer r.

Define $\boldsymbol{\tau}$ as the vector of taxes across all product categories j. For example, a full externality tax is $\boldsymbol{\tau} = \boldsymbol{\phi}$. The government revenue from a tax is

$$GS = \sum_i \sum_t \left[\sum_r Pr_{irt}\left(\boldsymbol{\theta}, \boldsymbol{\xi}\right) \cdot \boldsymbol{q}_{irt}\left(\boldsymbol{p}_{rw(t)}\right) \right] \cdot \boldsymbol{\tau}. \tag{23}$$

Table 4 presents results in monetary terms. The first row presents the effects of the cross subsidy. In our model, the cross-subsidy has very limited effects on consumer surplus and profits, because consumers generally substitute within a retailer. The predicted negative externality reductions are large relative to profit or consumer surplus losses, implying that at least in our model, retailers can generate large environmental benefits at relatively limited cost. The second and third rows present the effect of a carbon tax (setting price = social marginal cost) and a Pigouvian tax (setting tax = externalitty net of markup). Because these taxes affect all retailers, the overall total surplus gains dwarf the effects of Penny's 2023 campaign or counterfactual cross-subsidy or true cost campaigns. This underscores that unilateral voluntary action by firms is not a substitute for efficient government policy. The bottom rows present the effect of a counterfactual true cost campaign implemented by Penny for the whole year and for all products in the treated product categories (dairy white, dairy yellow, red meats, and meat substitutes). Estimated total surplus gains are between those for the cross-subsidy and taxes, with warm glow being a main driver of the welfare increases.

8 Conclusion

This paper lays out a simple framework for optimal green retailing and uses it to evaluate Penny's heavily publicized true cost campaign. We find that the implied demand elasticity with respect to the campaign price increase was half of the elasticity with respect to standard short-term promotional price decreases, suggesting that demand may have shifted out significantly due to warm glow from the donations. Our surveys show that the campaign did not substantially affect beliefs about externality magnitudes, but consumers expressed concerns about greenwashing and viewed true cost pricing more skeptically after the campaign. These results speak to both the challenges and opportunities with unilateral corporate environmental action: in practice, a campaign may or may not increase brand equity and profits, but our model suggests that alternatives such as a cross-subsidy could generate high environmental benefits at a relatively small profit loss. Our model also speaks to the large societal gains from economists' favorite policy: taxing uninternalized externalities.

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Table 1: **Campaign Products**

Product	**Type**	**Size (g)**	**Regular price (€)**	**Campaign price (€)**	**Price increase (%)**
Fruit yogurt	organic	400	1.19	1.56	31
Sliced cheese	organic	180-200[1]	2.19	3.70	69
Mozzarella	organic	200	1.29	1.92	49
Sausages	organic	160-200[1]	3.29	5.36	63
Fruit yogurt	conventional	450	1.19[2]	1.64	38
Sliced cheese	conventional	300	2.49	4.84	95
Mozzarella	conventional	200	0.89	1.55	74
Sausages	conventional	400	3.19	6.01	88
Vegan schnitzel	conventional	200	2.69	2.83	5

Notes: This table shows products included in the true cost campaign. Uninternalized environmental externalities ("true costs") were calculated as described in Section 2.3. [1]Product comes in different varieties that have the same name and price. True costs represent a weighted average over all varieties, see Section 2.3. [2]Price varied by region.

Table 2: **Structural Demand Model Estimates**: **Second Stage**

Parameter	Estimated
σ	1.10^{***}
	(3.6e-03)
$\sigma_{Beverages}$	1.09^{***}
	(0.01)
$\sigma_{Non-proteinfood}$	1.11^{***}
	(0.01)
$\sigma_{Protein}$	1.04^{***}
	(0.02)
$\sigma_{Alcoholic\ Beverages}$	1.58^{***}
	(0.02)
$\sigma_{Chocolate\ Goods}$	1.54^{***}
	(0.01)
$\sigma_{Dairy\ White}$	1.31^{***}
	(7.9e-03)
$\sigma_{Dairy\ Yellow}$	1.42^{***}
	(0.01)
$\sigma_{Deli/seasonings}$	0.74^{***}
	(0.02)
$\sigma_{Fats\ Non-veggie}$	1.99^{***}
	(0.04)
$\sigma_{Fats\ Veggie}$	1.89^{***}
	(0.04)
σ_{Fish}	1.00^{***}
	(0.02)
σ_{Fruit}	1.23^{***}
	(9.9e-03)
σ_{Juices}	1.28^{***}
	(0.03)
$\sigma_{Meat\ Poultry}$	0.84^{***}
	(0.02)
$\sigma_{Meat\ Substitutes}$	1.17^{***}
	(0.04)
$\sigma_{Ready\ Meals}$	1.20^{***}
	(0.01)
$\sigma_{Red\ Meats}$	1.02^{***}
	(7.6e-03)
σ_{Sauces}	1.19^{***}
	(0.01)
σ_{Sodas}	1.48^{***}
	(0.02)
$\sigma_{Staples\ Cereals}$	1.08^{***}
	(8.9e-03)
$\sigma_{Staples\ Potatoes}$	1.44^{***}
	(0.02)
$\sigma_{Staples\ Rest}$	0.52^{***}

Table 3: **Structural Demand Model Estimates: First Stage**

Parameter	Estimated
θ_1	2.7e-04***
	(1e-04)
θ_2	0.06***
	(2.4e-04)
θ_3	0.15***
	(3e-03)
$\xi_{Internet}$	0
ξ_{aldi}	0.78***
	(8.6e-03)
$\xi_{edeka\ eh}$	0.83***
	(8.5e-03)
ξ_{famila}	-0.55***
	(0.01)
$\xi_{globus\ st.\ wendel}$	0.31***
	(0.01)
ξ_{hit}	-0.62***
	(0.01)
$\xi_{kaufland}$	1.04***
	(8.8e-03)
ξ_{lidl}	0.79***
	(8.7e-03)
$\xi_{marktkauf}$	-0.14***
	(0.01)
$\xi_{netto\ marken-discount}$	0.72***
	(8.7e-03)
ξ_{norma}	0.28***
	(9.4e-03)
$\xi_{other\ discounters}$	-0.61***
	(0.01)
$\xi_{other\ non-discounters}$	0.29***
	(8.5e-03)
ξ_{penny}	0.55***
	(8.9e-03)
ξ_{real}	-0.11***
	(0.01)
ξ_{rewe}	0.85***
	(8.5e-03)
ξ_{tegut}	-0.61***
	(0.01)

Notes: This table presents estimates of the first stage of the structural demand model parameters, using the estimation strategy described in Section 6.

Table 4: **Counterfactual Simulations**

Counterfactual	Δ CU	Δ WG	Δ GS	Δ EX	ΔΠ	Δ DO	Δ TS
Cross-subsidy (€2.12)	€-4.98	€0	€0	€-5.49	€-0.110	€0	€0.404
Carbon tax ($\tau = \phi_j$)	€-429	€0	€326	€-256	€-79	€0	€74
Pigouvian tax ($\tau = \phi_j - (p_j - c_j)$)	€-255	€0	€191	€-203	€-46	€0	€92
Whole-year true cost campaign	€-0.332	€0	€0	€-0.282	€-0.057	€0.233	€0.126
Whole-year true cost campaign, with warm glow	€-0.332	€10	€0	€0.292	€0.140	€0.349	€10

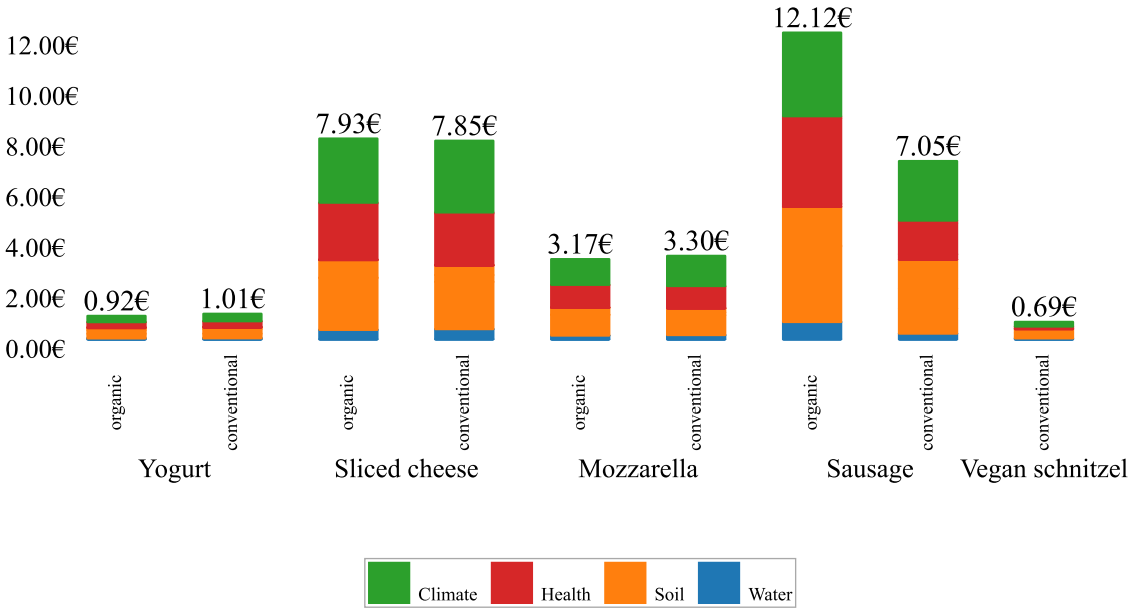
Notes: This table presents the effects of counterfactual policies on components of total surplus. "Cross-subsidy" means that Penny implements a revenue-neutral cross-subsidy, where the price differences between goods are increased by the differences in their uninternalized externalities. "Carbon tax" means a nationwide tax on each product category equal to its uninternalized externality. "Pigouvian tax" means a nationwide Pigouvian tax on each product category. "Whole-year true cost campaign" means that Penny implements the true cost campaign for the whole year, and consumers do not derive warm glow from purchasing the campaign products. "Whole-year true cost campaign, with warm glow" means that Penny implements the true cost campaign for the whole year, and consumers derive warm glow from purchasing the campaign products.

Figure 1: **Example of True Cost Labels**



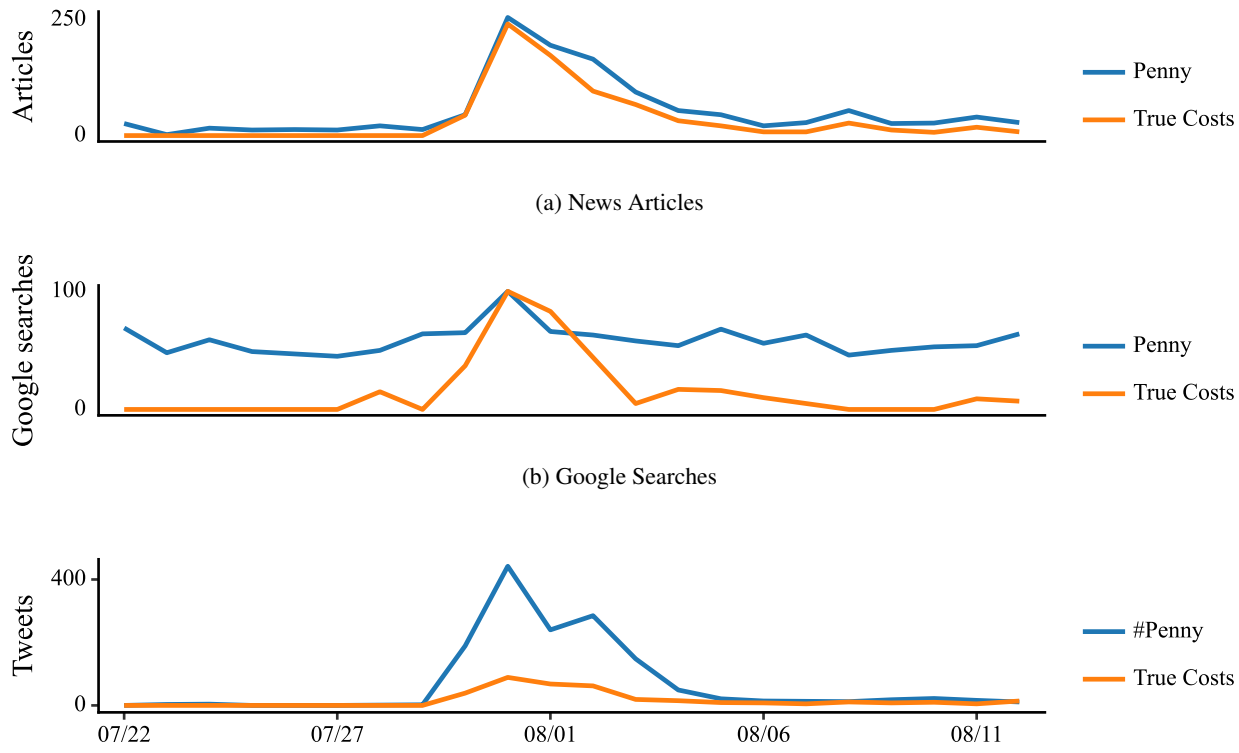
Notes: Campaign at the point of sale. Shown are the organic fruit yogurt and the shelf divider explaining the campaign. Main text (top): "Mild flavor, intense price. So that it also tastes good for the environment. Every product has an impact on the environment. For our Naturgut organic fruit yogurt, you can offset this now until 08/05/2023 with the 'True Cost Price'. The difference of €0.37 will go to our Zukunstbauer project, which we are implementing together with the Berchtesgadener Land dairy. In addition, we are increasing the donation amount by €50,000." Text snippets (middle): "incl. 0.37 true costs" (left) and "until August 5" (right). Bottom left: barcode and link to true cost page with additional information. Footnote: "Calculated by the University of Greifswald and Nuremberg Institute of Technology."

Figure 2: **True Cost Estimates Used in Penny Campaign**



Notes: Uninternalized environmental externalities ("true costs") of all nine campaign products per kg of product. Externalities are estimated using true cost accounting (Michalke et al., 2025; Pieper et al., 2020). Product processes are modeled using the Agrifootprint and Agribalyse databases, ingredients, and a literature-based adjustment for production methods. Environmental impacts are aggregated using the ReCiPE life cycle impact assessment (Huijbregts et al., 2017) and monetized using social cost estimates from UBA (2020) and de Bruyn et al. (2018).

Figure 3: **Coverage of Penny True Cost Campaign**



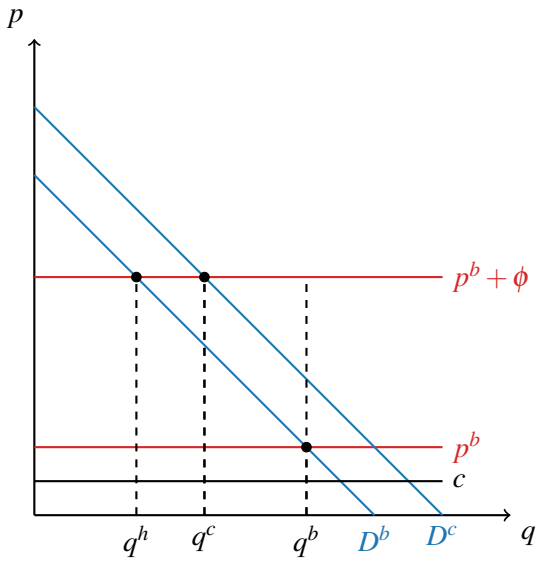
(a) News Articles

(b) Google Searches

(c) Tweets

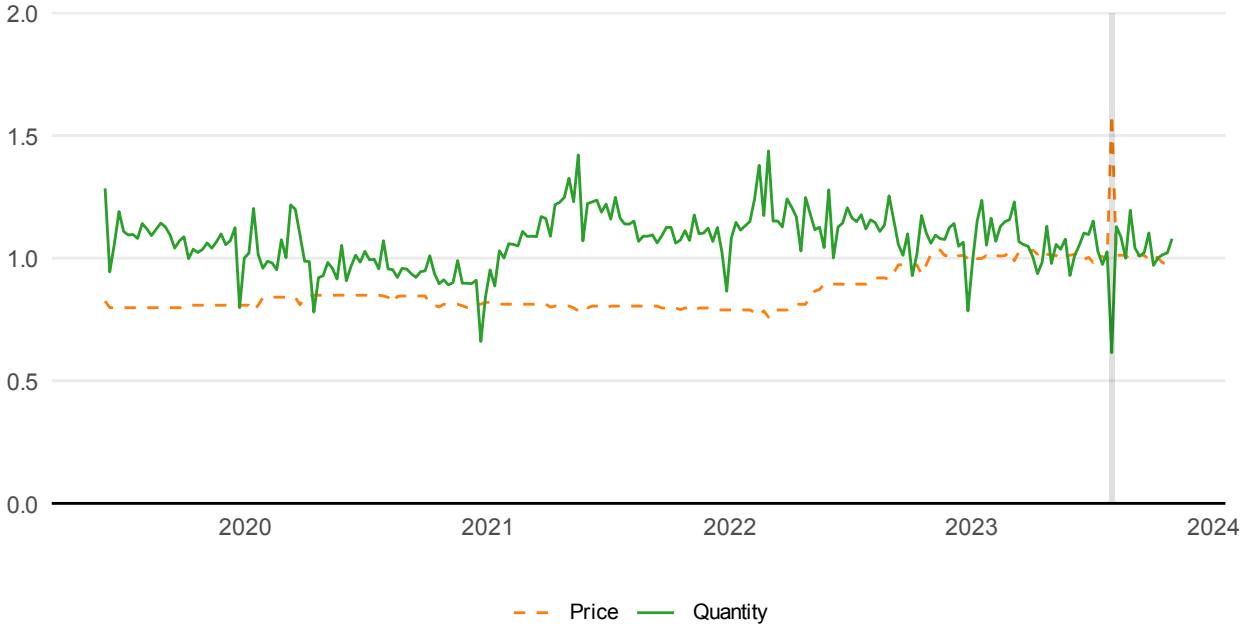
Notes: This figure shows coverage of the media campaign. (a) Number of media articles mentioning Penny or Penny and the true cost campaign on each day. Articles come from the Factiva database. They were filtered for the word Penny and included all articles for the time period in German language. Coders then manually checked if the article was about Penny and the true cost campaign. (b) Google search score for each day for the terms "Penny" and "true costs"/"true prices". (c) Number of tweets with the hashtag Penny or mentioning "true costs"/"true prices".

Figure 4: **Campaign Welfare Components**



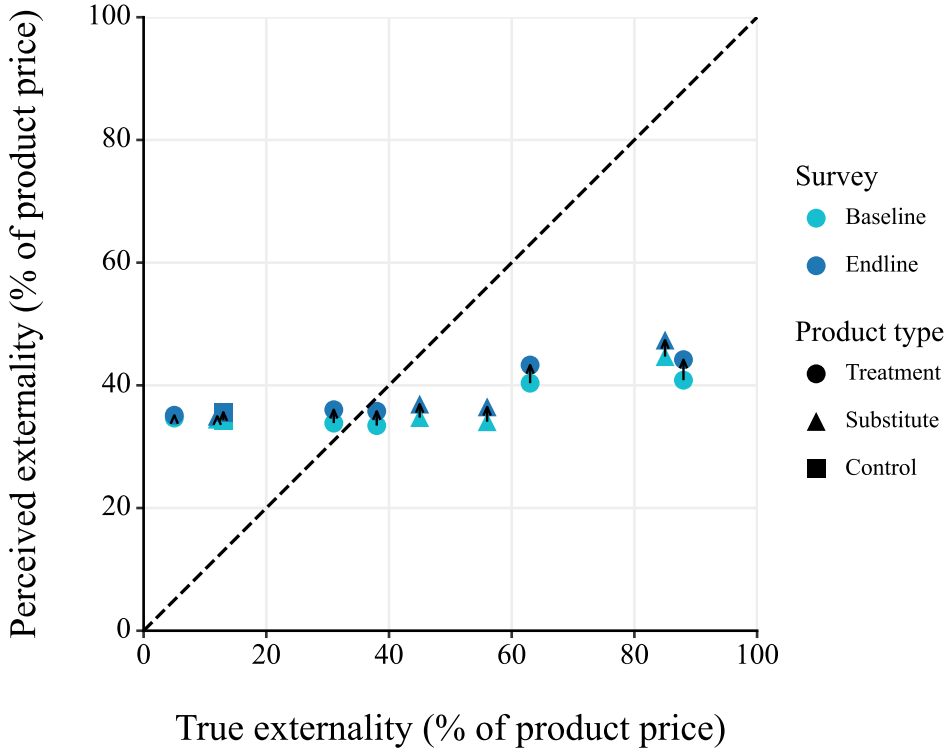
Notes: This graph shows the change in welfare due to a campaign where consumers pay for a donation to offset externalities. p^b is the baseline price. $p^c = p^b + \phi$ is the campaign price, where ϕ are uninternalized environmental externalities. D^b is the baseline inverse demand curve, without warm glow. D^c is the campaign inverse demand curve, which is to the right of D^b because consumers experience warm glow from the donation. q^b is the baseline equilibrium quantity. q^h is the hypothetical equilibrium quantity if the price were p^c, but there was no warm glow from the donation. q^c is the campaign equilibrium quantity.

Figure 5: **National Average Prices and Total Quantity Sold**



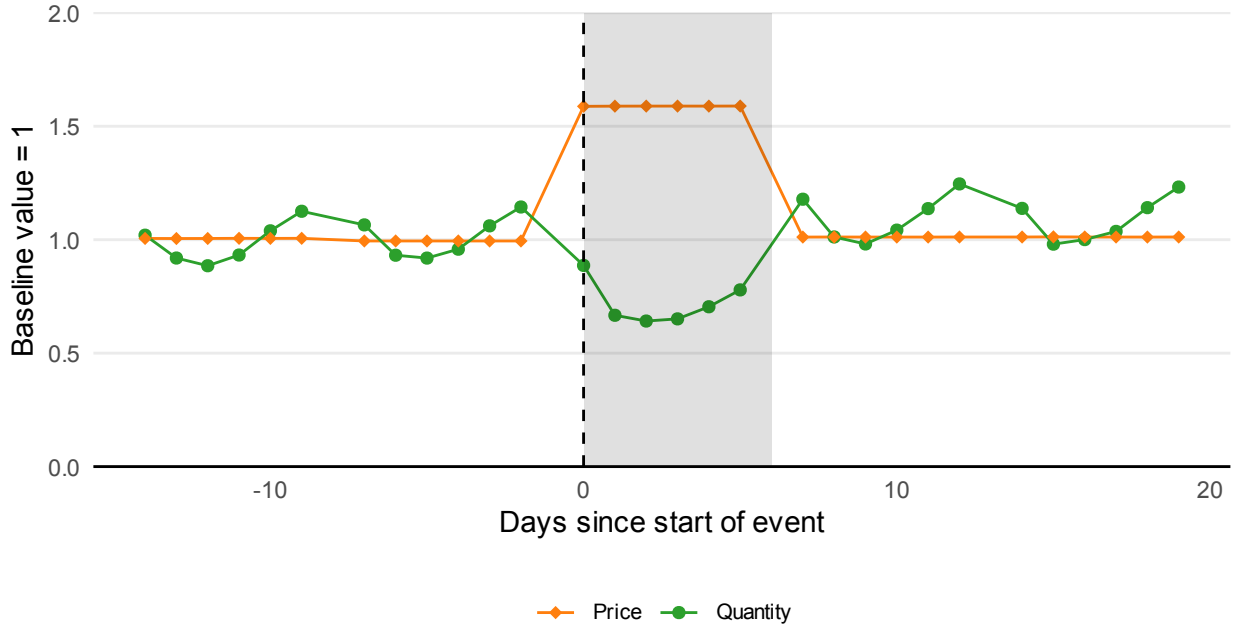
Notes: This graphs shows the weekly price (yellow line, left axis) and average quantity demanded per store and day (green line, right axis) for the the average campaign product. The short downward spikes in price correspond to sales events. The upward spike in August 2023 corresponds to the campaign event.

Figure 6: **Externality Beliefs**



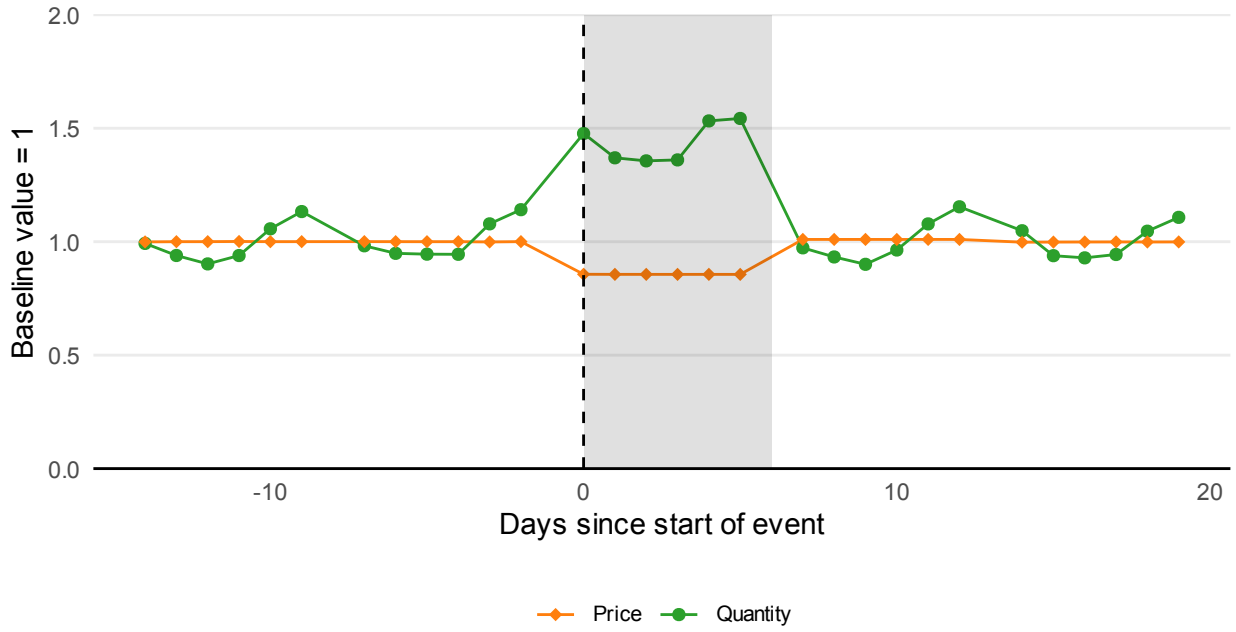
Notes: This graph shows the externality beliefs (y-axis) versus our estimates (x-axis). Light blue: baseline response. Dark blue: endline response. Circle: treated products featured in the campaign. Triangle: substitute products in the same product category as treated products. Square: non-food control product. Arrows indicate the direction of change. Participants were incentivized to match our estimate.

Figure 7: **Prices and Quantities Sold During True Cost Campaign**



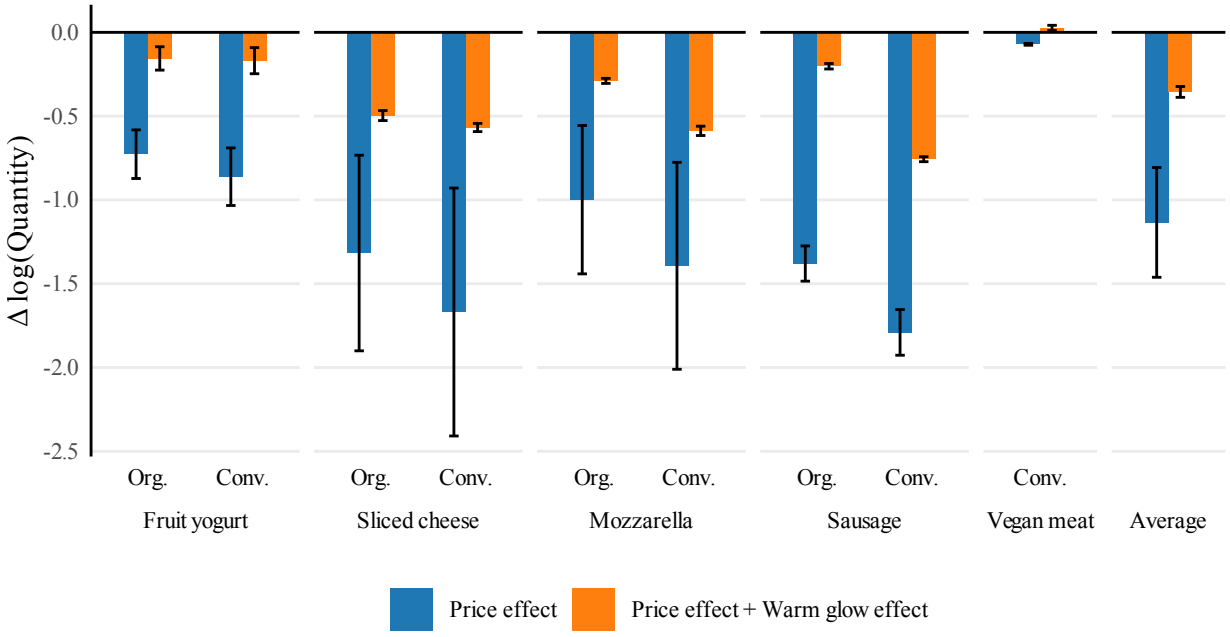
Notes: This graph shows the campaign product price (yellow line) and quantity (green line) around the true cost campaign. X-axis: days since the start of the campaign. Y-axis: quantity/price, normalized by the quantity/price two weeks before the start of the campaign ($t = -14$). Gray area: campaign period. Included are all campaign products (see Table 1). Quantities and prices are normalized for each product separately and then averaged. Sundays are removed since most stores are closed.

Figure 8: **Prices and Quantities Sold During Standard Price Promotions**



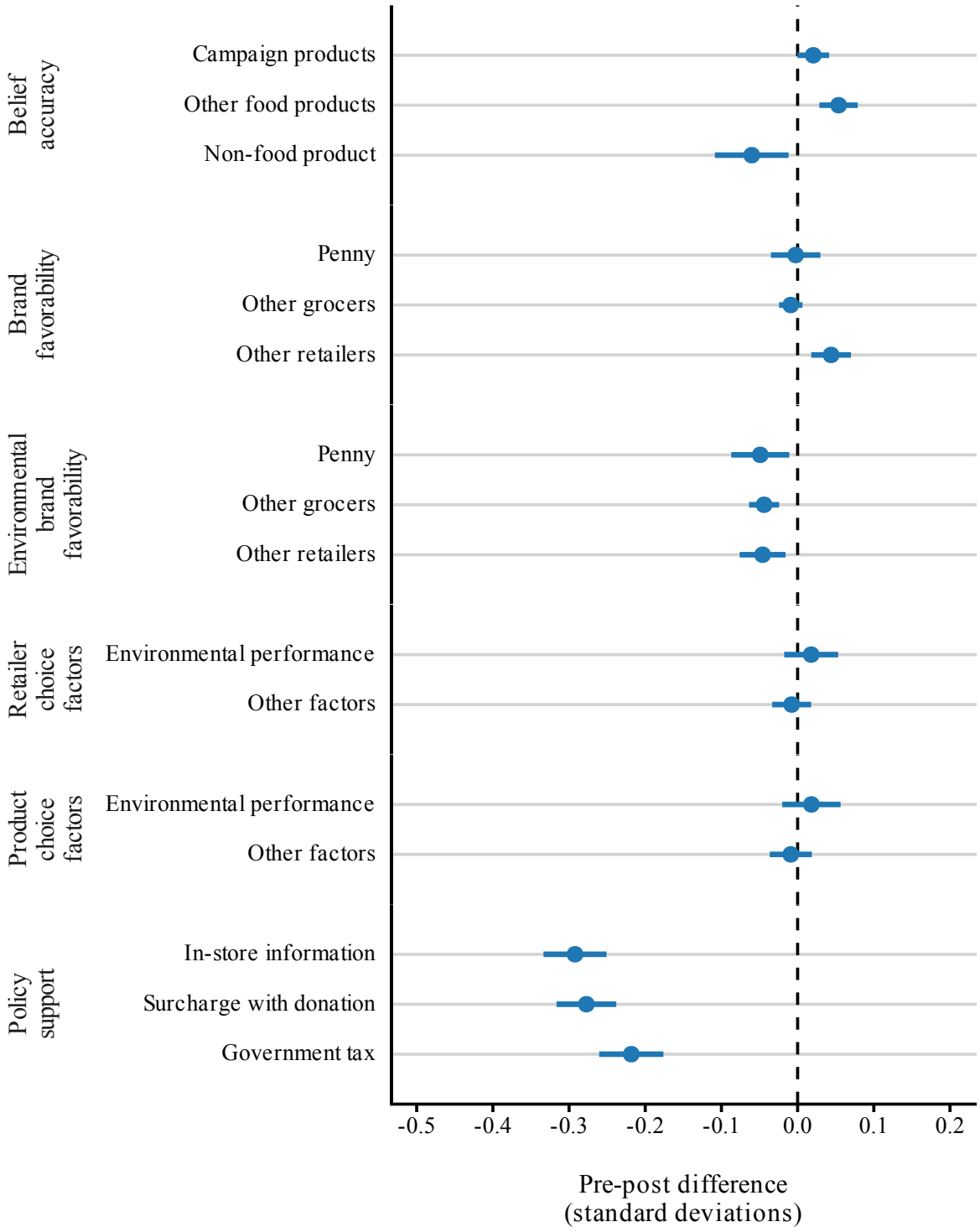
Notes: This graph shows the campaign product price (yellow line) and quantity (green line) around sales events. X-axis: days since the Monday of each sales event. Y-axis: quantity/price, normalized by the quantity/price two weeks before each sales event ($t = -14$). Included are all campaign products (see Table 1). Quantities and prices are normalized for each product and sales event separately and then averaged. Sundays are removed since most stores are closed.

Figure 9: **Campaign Price and Warm Glow Effect**



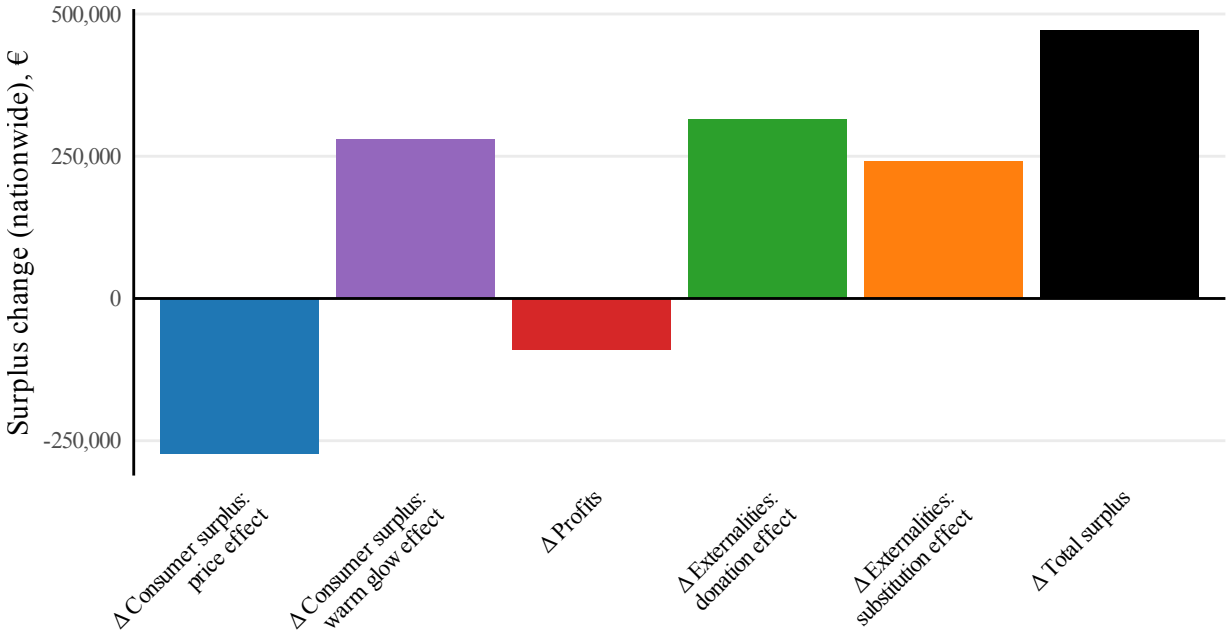
Notes: This graph shows the price effect (blue bars) and the approximate overall campaign effect (orange bars) on log quantities for each product. The price effect for product j in category c is $-\sigma^c \Delta \ln p_j$ and the warm glow effect is $\tau_j = \sigma^c \ln \alpha_j^c$. The price change Δp_j is equal to the uninternalized environmental externalities ϕ_j. The parameters σ^c and τ_j are estimated using equation (8). The full regression results are shown in Table A3. We calculate the standard errors using the delta method.

Figure 10: **Survey Campaign Effects**



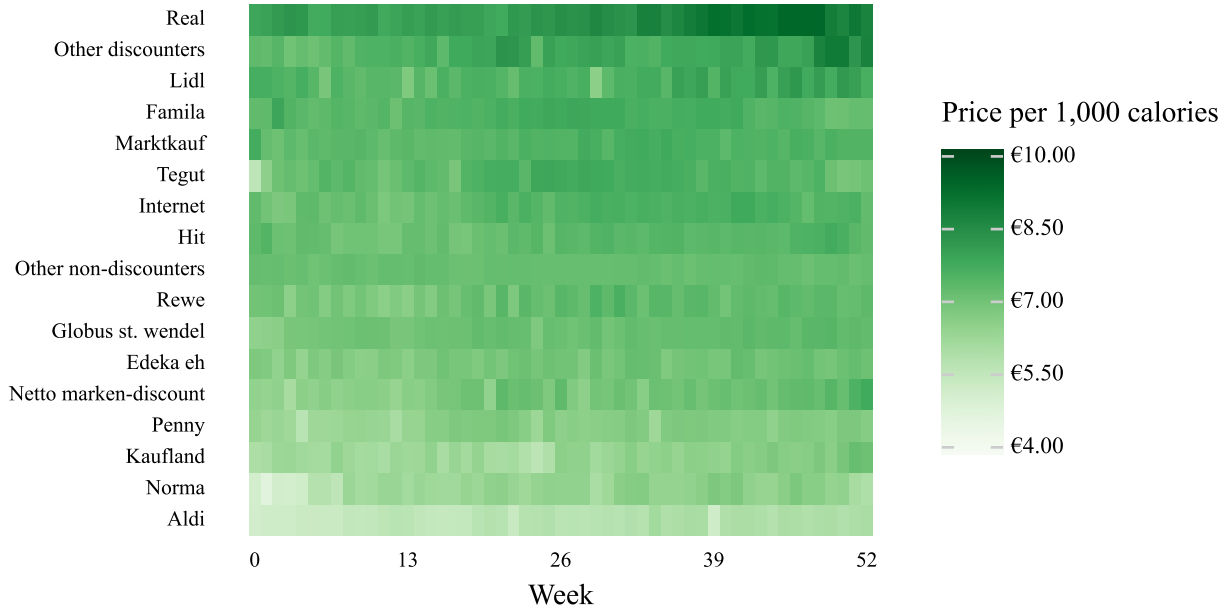
Notes: This graph shows the difference in the mean survey response before and after the campaign. Differences were normalized using the pre-campaign standard deviation. Error bars: 95% confidence interval.

Figure 11: **Welfare Effects of Campaign**



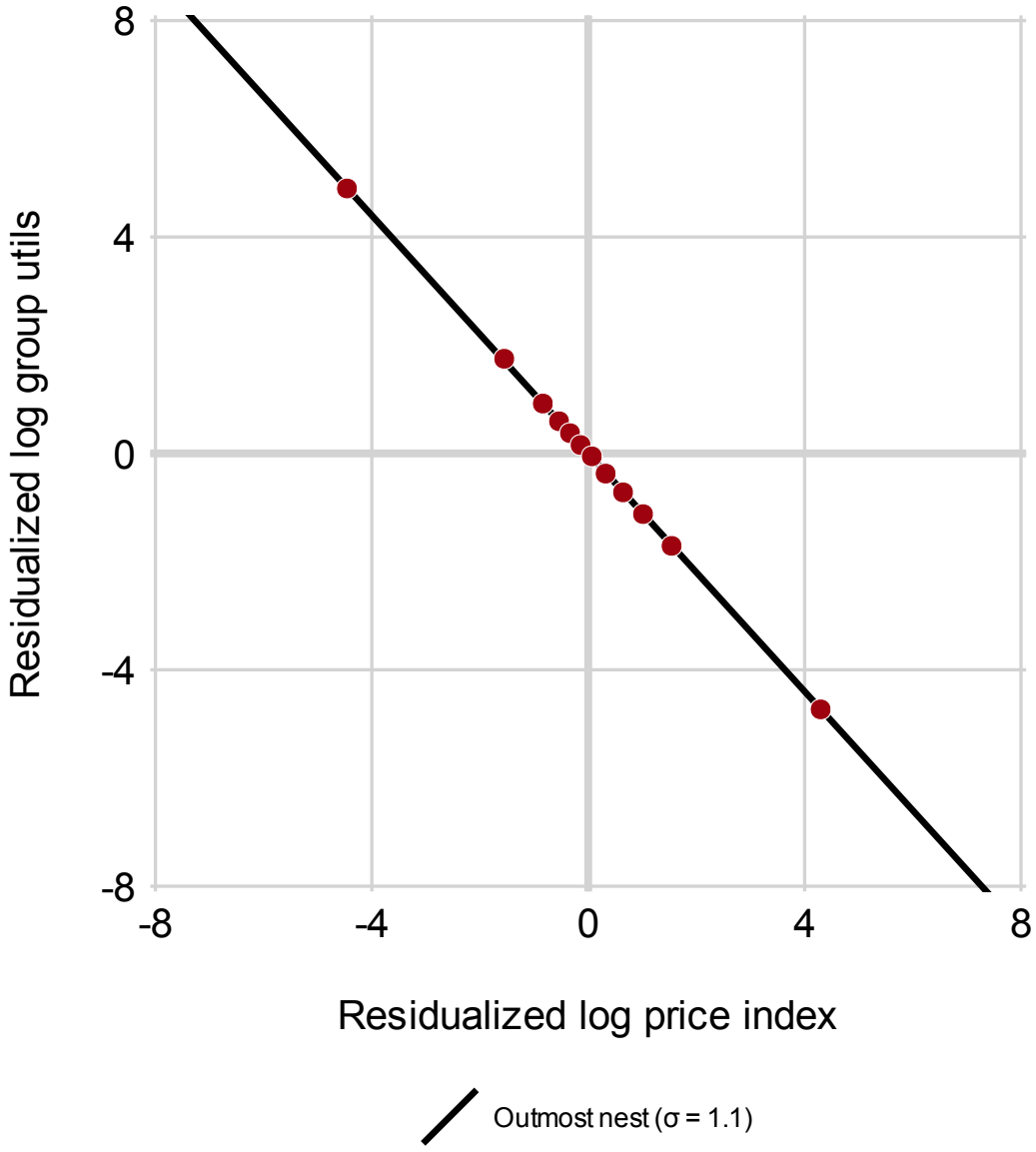
Notes: This figure shows changes in welfare due to Penny's true cost campaign. For the calculations and assumptions, see Section 5.5.

Figure 12: **Heat Map of Prices: Meat Substitutes Example**



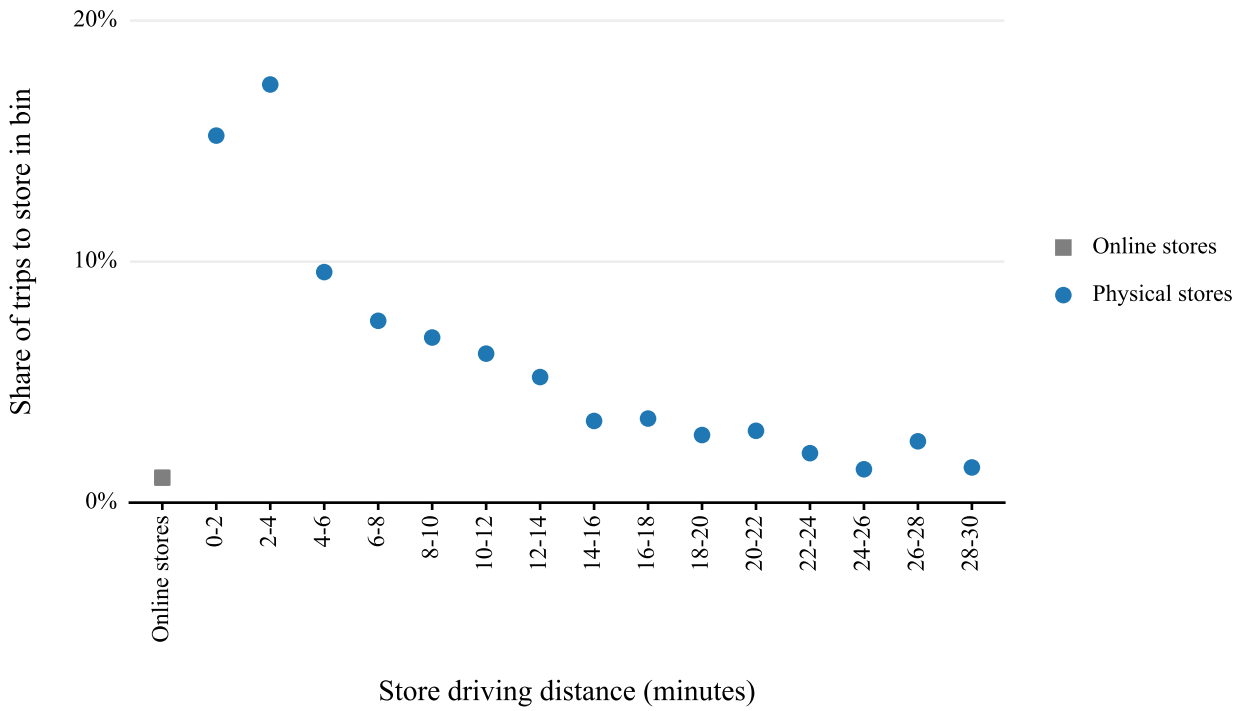
Notes: This figure illustrates the price variation used to identify σ in equation (16), using meat substitutes as the example category. Each row of the y-axis is a retailer. Each column of the x-axis is weeks of calendar year 2022. The color intensity reflects the average price per calorie of all purchases in that category.

Figure 13: **Binned Scatterplot of Quantity and Price**



Notes: This is a binned scatter plot of equation (16): the relationship between quantity and fitted price deviations relative to a vector of fixed effects.

Figure 14: **Trip Shares by Driving Distance**



Notes: This figure illustrates the variation used to identify θ_2 in equation (17): the share of household grocery shopping trips that are to stores within each driving distance bin.

Online Appendix

Optimal Green Retailing: Theory and Evidence

Christoph Semken, Amelie Michalke, Lennart Stein, Freek van Sambeek, Santiago Varela Seoane, Tobias Gaugler, and Hunt Allcott

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A Campaign Appendix

A.1 In-store Explainers

The campaign officially launched with the opening of German Penny branches on Monday July 31, 2023. This was accompanied by extensive advertising at the point of sale. The true cost products could be found at their usual locations in the store. Advertising material included the following.

1. Handout (A1, right): The weekly brochure was displayed in Penny stores and provided customers with additional information. The scientific cooperation with the University of Greifswald and the Nuremberg Institute of Technology was mentioned. With a QR code, customers were able to access a landing page that included details on method and backgrounds of the campaign, a quiz for customers to test their knowledge of true costs and FAQs.

2. Entrance poster (A1, left): In front of the entrance to each Penny store a large image poster showed all campaign products and informed consumers on the campaign happening prior to entering the store. The main slogan was "True cost. What is it and how do you help the environment? Come in and find out!". In addition, the goal of the campaign was explained and reference was made to the calculation basis of the University of Greifswald and Nuremberg Institute of Technology.

3. Checkout posters: There were large customer posters in the checkout area. Like the image posters in front of the store, these also presented key facts about the campaign.

4. Shelf dividers: There was a large shelf divider placed next to each campaign product, see 1. The headlines contained a humorous headline and reference to the environmental aspect of the campaign. In addition, the goal of the campaign was explained again and reference was made to the calculation basis of the University of Greifswald and the Nuremberg Institute of Technology.

5. Price tag (nine): Sometimes, the price tag was surrounded by an explainer. The true cost price was shown on the right side. On the left side, the campaign information for the respective product and the QR code were provided. For example: "Every product has an impact on the environment. With our SAN FABIO Mozzarella you can reduce this now until August 5, 2023 with the 'True cost price'. The difference of €0.66 goes to our project future farmer, which we are running together with the Berchtesgadener Land dairy. In addition, we will increase the donation amount by €50,000."

6. Checkout information: Information sheets were placed at the checkout. These were large posters with general information about the campaign (e.g., products and duration) on the front, and a detailed FAQ and product overview on the back.

7. Website (A1, center): The campaign website provided background information on the campaign, including the true cost methodology, the campaign products, the differences between organic and

vegan products, and the future farmer project, were mentioned. The website also featured a digital knowledge quiz.

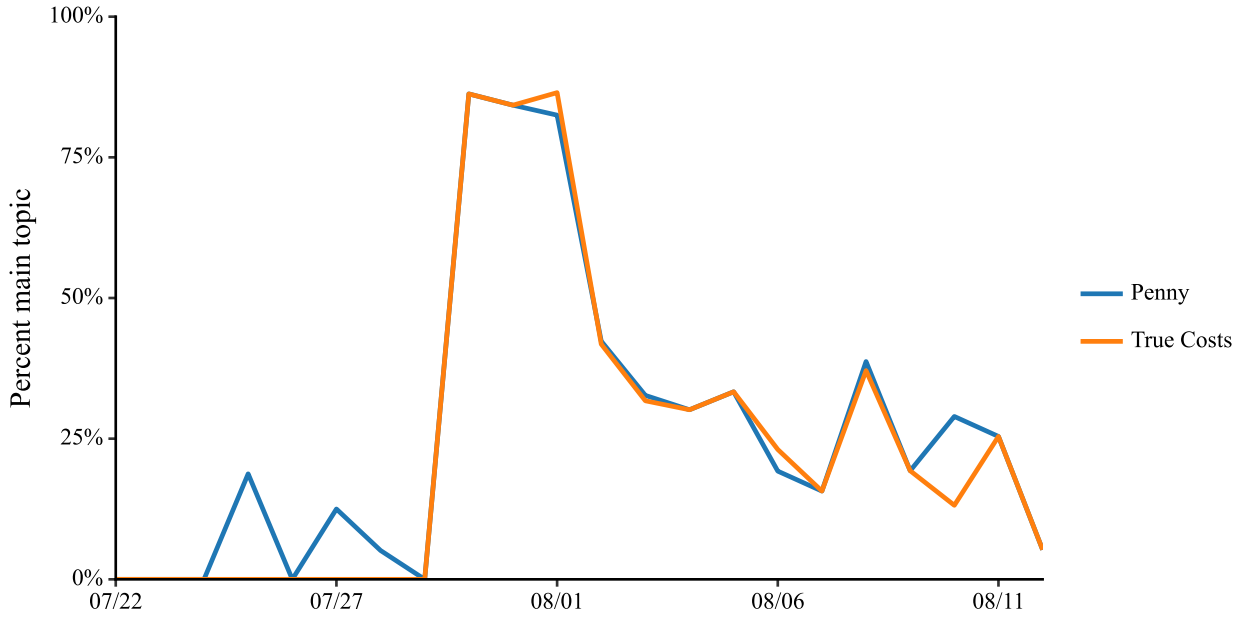
Figure A1: **Campaign Advertising**



Notes: Examples of true cost campaign's advertising materials: poster (left), landing page website (center) and brochure (right).

A.2 Media Coverage

Figure A2: **Campaign Media Coverage Main Topic**



Notes: This figure shows the percentage of articles were Penny or the true cost campaign were the main topic of those mentioning Penny. Articles come from the Factiva database. They were filtered for the word Penny in German language articles. Coders manually checked if Penny and/or the true cost campaign was the main topic.

B Data Appendix

B.1 Survey Descriptive Statistics

Table A1: **Survey Demographs**

	Unweighted sample	Weighted sample	German adults
Male	0.50	0.49	0.49
Age	49.14	44.74	44.74
Years of education	14.81	12.94	12.94
Income	€3,210	€3,165	€3,165
Shops at Penny	0.68	0.29	0.29

Notes: The table compares the mean value of several variables in the unweighted survey sample, weighted survey sample, and German population. The unweighted survey sample pools the general population and Penny shopper subsamples. The survey weights for the weighted sample are created using entropy balancing (Hainmueller, 2012). The population values for male, age, and income are obtained from the German Federal Statistical Office. "Years of education" is estimated using the highest degree obtained and the corresponding average years of education. "Shops at Penny" is set to one in the sample if the participant reported shopping at Penny at least once a month. We estimate the population average as the percentage of home scanner panelists who shop at Penny at least once a month on average in 2022.

B.2 Media Intercoder Agreement

Table A2: **Media Coding Agreement Rates**

#	Question	Agreement Rate
1	Talks about Penny	99%
2	Penny is main topic	99%
3	Talks about true cost campaign	100%
4	True cost campaign is main topic	96%
5	Contains explanation of true cost issue	98%
6	Contains explanation of true cost methodology	100%
7	Discusses aim: experiment/science communication	98%
8	Discusses aim: awareness of topic	82%
9	Discusses aim: political debate	98%
10	Discusses aim: greenwashing/marketing	92%
11	Discusses aim: patronization consumers	91%
12	Discusses problem: price hikes	86%
13	Discusses problem: methodology	97%
14	Sentiment towards Penny	69%
15	Sentiment towards true cost campaign	86%

Notes: This table shows the intercoder agreement rate for all media coding questions. Ninty-three articles from between July 17 and August 12 were coded independently by two coders. The agreement rate is the percentage of articles were both coders gave the same answers, conditional on both answering the question.

C Survey Questionnaire

C.1 Baseline survey

C.1.1 Intro

Welcome Screen

Variable	English	German
	Welcome to this survey about shopping behavior. Please click **"Next"** to begin.	Herzlich willkommen zu dieser Umfrage zum Kaufverhalten. Bitte klicken Sie auf **"Weiter"**, um zu beginnen.

Consent form

Variable	English	German
	Survey on shopping behavior **What is this study about?** A team of scientists from the University of Greifswald and the Nuremberg University of Technology would like to ask you about your shopping behavior. The project is funded by the European Union and the German Federal Ministry of Education and Research. Participation is voluntary. You can stop participating at any time without giving a reason. This is a two-part study. This is the first part of the survey, which lasts about 20 minutes. You will be invited to the second part in August. **What happens with the data?** Your data will be collected with anonymous identifiers, treated confidentially and evaluated for scientific purposes only. We may post the anonymized data from this study in a research data repository so that other researchers can reproduce our results. Before posting the data, we will remove any information that could identify you personally.	**Umfrage zum Kaufverhalten** **Worum geht es in dieser Studie?** Ein Team von WissenschaftlerInnen der Universität Greifswald und der Technischen Hochschule Nürnberg möchte Sie zu Ihrem Kaufverhalten befragen. Das Forschungsprojekt wird von der Europäischen Union und dem deutschen Bundesministerium für Bildung und Forschung finanziert. Ihre Teilnahme ist freiwillig. Sie können die Umfrage und somit Ihre Teilnahme jederzeit und ohne Angabe von Gründen beenden. Es handelt sich um eine zweiteilige Studie. Dies ist der erste Teil der Umfrage, der etwa 20 Minuten dauert. Sie werden im August zum zweiten Teil eingeladen. **Was geschieht mit den Daten?** Ihre Daten werden mit anonymen Identifikatoren erfasst, vertraulich behandelt und ausschließlich für wissenschaftliche Zwecke ausgewertet. Wir werden möglicherweise die anonymisierten Daten aus dieser Studie in einem Forschungsdatenarchiv veröffentlichen, damit andere ForscherInnen unsere Ergebnisse reproduzieren können. Bevor wir die Daten veröffentlichen, werden wir alle Informationen entfernen, die Sie persönlich identifizieren könnten.

Variable	English	German
	Data privacy concept Data retention period (1) & legal basis (2): 10 years (1). You are hereby informed of the rights set forth in the GDPR (2): The legal basis for processing the personal data concerning you is your voluntary consent in accordance with the GDPR (Art. 6 Lawfulness of processing §1.a and Art. 9 Processing of special categories of personal data §2.a). Regarding your data, you have the following rights: Right of information (Art 15 GDPR). You have a right of information to the personal data concerning you that is collected, processed or, if applicable, transmitted to third parties in the context of the study (if applicable, handing over a copy free of charge). Right to rectification (Art 16 GDPR). You have the right to have inaccurate personal data concerning you corrected. Right to erasure (Art 17 GDPR). You have the right to have personal data concerning you deleted, if this is possible. If, at the time of your revocation, your data has already been received in project publications, these are exempt from deletion (Art 89 GDPR).	**Datenschutzkonzept** Dauer der Datenaufbewahrung (1) & Rechtsgrundlage (2): 10 Jahre (1) Sie werden hiermit über die in der DSGVO (2) festgelegten Rechte informiert: Die Rechtsgrundlage zur Verarbeitung der Sie betreffenden personenbezogenen Daten bildet Ihre freiwillige Einwilligung gemäß DSGVO (Art. 6 Rechtmäßigkeit der Verarbeitung Abs.1 Satz a und Art. 9 Verarbeitung besonderer Kategorien personenbezogener Daten Abs. 2 Satz a). Bezüglich Ihrer Daten haben Sie folgende Rechte: Recht auf Auskunft (Art 15 DSGVO) Sie haben ein Recht auf Auskunft über die Sie betreffenden personenbezogenen Daten, die im Rahmen der Studie erhoben, verarbeitet oder ggf. an Dritte übermittelt werden (ggf. Aushändigen einer kostenfreien Kopie). Recht auf Berichtigung (Art 16 DSGVO) Sie haben das Recht, Sie betreffende, unrichtige personenbezogene Daten berichtigen zu lassen. Recht auf Löschung (Art 17 DSGVO) Sie haben das Recht auf Löschung der Sie betreffenden personenbezogenen Daten, sofern dies möglich ist. Sollten zum Zeitpunkt Ihres Widerrufs Ihre Daten bereits in Projektveröffentlichungen eingegangen sein, sind diese von der Löschung ausgenommen (Art 89 DSGVO).

Variable	English	German
	Right to restriction of processing (Art 18 GDPR). Under certain conditions, you have the right to request restriction of processing, i.e. the data may only be stored and not processed. You must request this. To do so, please contact your investigator or the data protection officer of the test center (see address below). Right to data transfer (Art 20 GDPR). You have the right to receive the personal data relating to you that you have provided to the study coordinator. This allows you to request that this data be transferred either to you or, where technically possible, to another entity designated by you.	Recht auf Einschränkung der Verarbeitung (Art 18 DSGVO) Unter bestimmten Voraussetzungen haben Sie das Recht, eine Einschränkung der Verarbeitung zu verlangen, d. h. die Daten dürfen nur gespeichert und nicht verarbeitet werden. Dies müssen Sie beantragen. Hierfür wenden Sie sich bitte an Ihren Prüfer oder an den Datenschutzbeauftragten des Prüfzentrums (siehe Anschrift unten). Recht auf Datenübertragung (Art 20 DSGVO) Sie haben das Recht, die Sie betreffenden personenbezogenen Daten, die Sie dem Verantwortlichen für die klinische Studie bereitgestellt haben, zu erhalten. Damit können Sie beantragen, dass diese Daten entweder Ihnen oder, soweit technisch möglich, an eine andere von Ihnen benannte Stelle übermittelt werden.

Variable	English	German
	Right to object (Art 21 GDPR). You have the right to object at any time to specific decisions or measures concerning the processing of personal data relating to you. Such processing will subsequently no longer take place as a matter of principle. The processing of your personal data is only lawful with your consent (Art 6 GDPR). You have the right to revoke your consent to the processing of personal data at any time. The revocation of consent does not affect the lawfulness of the processing carried out on the basis of the consent until the revocation (Article 7, paragraph 3 GDPR). However, if consent is given again, the data collected up to that point may be processed by the entity named in the patient information and consent form (Article 7, paragraph 3 GDPR). If no consent is given for the processing of the data collected up to this point, Art 17 GDPR and Art 89 GDPR apply. If you would like to make use of one of these rights, please contact the study coordination or the data protection officer (see address below). In the event of contacting the study coordination with a request to claim the right to deletion, a suspension of pseudonymization may have to be accepted.	Recht auf Widerspruch (Art 21 DSGVO) Sie haben das Recht, jederzeit gegen konkrete Entscheidungen oder Maßnahmen zur Verarbeitung der Sie betreffenden personenbezogenen Daten Widerspruch einzulegen. Eine solche Verarbeitung findet anschließend grundsätzlich nicht mehr statt. Die Verarbeitung Ihrer personenbezogenen Daten ist nur mit Ihrer Einwilligung rechtmäßig (Artikel 6 DSGVO). Sie haben das Recht, Ihre Einwilligung zur Verarbeitung personenbezogener Daten jederzeit zu widerrufen. Durch den Widerruf der Einwilligung wird die Rechtmäßigkeit der aufgrund der Einwilligung bis zum Widerruf erfolgten Verarbeitung nicht berührt (Artikel 7, Absatz 3 DSGVO). Bei erneuter Einwilligung dürfen jedoch die bis zu diesem Zeitpunkt erhobenen Daten durch die in der Patienteninformation- und Einwilligungserklärung genannten Stelle verarbeitet werden (Artikel 7, Absatz 3 DSGVO). Wenn keine Einwilligung zur Verarbeitung der bis zu diesem Zeitpunkt erhobenen Daten gegeben wird, greift Art 17 DSGVO und Art 89 DSGVO. Möchten Sie eines dieser Rechte in Anspruch nehmen, wenden Sie sich bitte an die Studienkoordination oder den Datenschutzbeauftragten (siehe Anschrift unten). Im Falle einer Kontaktaufnahme zur Studienkoordination mit Anliegen der Inanspruchnahme des Rechts auf Löschung ist ggf. eine Aussetzung der Pseudonymisierung in Kauf zu nehmen.

Variable	English	German
	Contact of the study coordination: M. Sc. Sustainability Geography, Lennart Stein University of Greifswald, Chair of Sustainability Science and Applied Geography, Jahnstraße 16, 17489 Greifswald, Germany E-mail: lennart.stein@uni-greifswald.de You can also contact the Data Protection Officer of the University of Greifswald at any time, should you have any questions regarding aspects of data protection: Data Protection Officer René Schülke SIS - Schweriner IT- und Servicegesellschaft mbH Eckdrift 93 19061 Schwerin Phone +49 385 545 5203 datenschuetzer@uni-greifswald.de You also have the right to file a complaint with the supervisory authority/authorities if you believe that the processing of personal data concerning you violates the GDPR: The State Commissioner for Data Protection and Freedom of Information of Mecklenburg-Western Pomerania Werderstraße 74a 19055 Schwerin **Would you like to volunteer for this study?** Checkbox "I would like to participate in this study voluntarily". [only allow to proceed if checkbox ticked]	**Kontakt der Studienkoordination:** M. Sc. Nachhaltigkeitsgeographie, Lennart Stein Universität Greifswald, Lehrstuhl Nachhaltigkeitswissenschaft und Angewandte Geographie, Jahnstraße 16, 17489 Greifswald E-Mail: lennart.stein@uni-greifswald.de Sie können sich jederzeit auch an den Datenschutzbeauftragten der Universität Greifswald wenden, sofern Sie Fragen zu Aspekten des Datenschutzes haben sollten: Behördlicher Datenschutzbeauftragter René Schülke SIS - Schweriner IT- und Servicegesellschaft mbH Eckdrift 93 19061 Schwerin Telefon +49 385 545 5203 datenschuetzer@uni-greifswald.de Außerdem haben Sie das Recht, Beschwerde bei der/den Aufsichtsbehörde/n einzulegen, wenn Sie der Ansicht sind, dass die Verarbeitung der Sie betreffenden personenbezogenen Daten gegen die DSGVO verstößt: Der Landesbeauftragte für Datenschutz und Informationsfreiheit Mecklenburg-Vorpommern Werderstraße 74a 19055 Schwerin **Möchten Sie freiwillig an dieser Studie teilnehmen?** Checkbox "Ich möchte an dieser Studie freiwillig teilnehmen". [Antwort verpflichtend]

C.1.2 Screener

Shopping decision

Variable	English	German
shop_decision	**Which person in your household predominantly makes the decision when buying groceries?** • Me alone • Me and someone else • Someone else	**Welche Person in Ihrem Haushalt trifft überwiegend die Entscheidung beim Einkauf von Lebensmitteln?** • Ich alleine • Ich und jemand anders • Jemand anders

Shop frequency

Variable	English	German
shop_frequency	**How often do you shop at the following shops?** **[Options]** • several times a week • once a week • every 2 weeks • once a month • every 2-3 months • less often • never, but there is a market within reach • never, there is also no market within reach • I do not know this brand] [rows, order randomized] • ALDI • Lidl • PENNY • REWE • Edeka • Bauhaus • MediaMarkt	**Wie häufig kaufen Sie in den folgenden Geschäften ein?** [Optionen] • mehrmals pro Woche • einmal pro Woche • alle 2 Wochen • einmal pro Monat • alle 2-3 Monate • seltener • nie, es gibt aber einen Markt in erreichbarer Nähe • nie, es gibt auch keinen Markt in erreichbarer Nähe • kenne ich nicht [Zeilen, zufällige Reihenfolge] • ALDI • Lidl • PENNY • REWE • Edeka • Bauhaus • MediaMarkt

State, gender and age

Variable	English	German
state	**In which federal state do you live or is your main residence located?** • Baden-Wuerttemberg • Bavaria • Berlin • Brandenburg • Bremen • Hamburg • Hesse • Mecklenburg-Western Pomerania • Lower Saxony • North Rhine-Westphalia • Rhineland-Palatinate • Saarland • Saxony • Saxony-Anhalt • Schleswig-Holstein • Thuringia	**In welchem Bundesland wohnen Sie bzw. liegt Ihr Hauptwohnsitz?** • Baden-Württemberg • Bayern • Berlin • Brandenburg • Bremen • Hamburg • Hessen • Mecklenburg-Vorpommern • Niedersachsen • Nordrhein-Westfalen • Rheinland-Pfalz • Saarland • Sachsen • Sachsen-Anhalt • Schleswig-Holstein • Thüringen
gender	**You are…?** • male • female • other [note: diverse does not run into the quota, but is also not screened out; force answer]	**Sie sind…?** • männlich • weiblich • divers [Hinweis: Divers läuft nicht in die Quotierung ein, wird aber auch nicht ausgescreent]
age	**How old are you?** Please enter your age as a number (e.g. 54). [numeric input field]	**Wie alt sind Sie?** Bitte tragen Sie Ihr Alter als Zahl ein (z.B. 54). [Eingabefeld]

C.1.3 Appeal to pro-sociality

Variable	English	German
attention_help	**For this particular study, it is especially important to gather high-quality data. Do you promise to carefully give your best answers to each question on our surveys?** • I will not provide my best answers. • Yes, I am happy to help! I will provide my best answers. • I can't promise either way. [if not yes, return participant to Cint]	**Für diese spezielle Studie ist es besonders wichtig, qualitativ hochwertige Daten zu sammeln. Versprechen Sie, jede Frage in unseren Umfragen sorgfältig nach bestem Wissen und Gewissen zu beantworten?** • Ich werde nicht meine besten Antworten geben. • Ja, ich helfe gerne! Ich werde meine besten Antworten geben. • Ich kann beides nicht versprechen. [wenn nicht ja, Teilnehmer an Cint zurückschicken]

C.1.4 Brand

Brand favorability

Variable	English	German
image	**How much do you like or dislike the following retailers?** [options] • Strongly dislike • Moderately dislike • Slightly dislike • Neutral • Slightly like • Moderately like • Strongly like • do not know this brand [rows, order randomized] • ALDI • Lidl • PENNY • REWE • Edeka • Bauhaus • MediaMarkt	**Wie sehr mögen Sie die folgenden Einzelhändler?** [Optionen] • Mag ich überhaupt nicht • Mag ich nicht • Mag ich eher nicht • Neutral • Mag ich eher • Mag ich • Mag ich sehr • Ich kenne diese Marke nicht [Zeilen, zufällige Reihenfolge] • ALDI • Lidl • PENNY • REWE • Edeka • Bauhaus • MediaMarkt

Brand favorability on ecological issues

Variable	English	German
image_env	**How good or bad do you think the following retailers are in terms of their environmental commitment?** [options] • Very bad • Moderately bad • Slightly bad • Neutral • Slightly good • Moderately good • Very good • do not know this brand [rows, order randomized] • ALDI • Lidl • PENNY • REWE • Edeka • Bauhaus • MediaMarkt	**Wie gut oder schlecht sind Ihrer Meinung nach die folgenden Einzelhändler in Bezug auf ihr Umweltengagement?** [Optionen] • Sehr schlecht • Mäßig schlecht • Geringfügig schlecht • Neutral • Geringfügig gut • Mäßig gut • Sehr gut • Ich kenne diese Marke nicht [Zeilen, zufällige Reihenfolge] • ALDI • Lidl • PENNY • REWE • Edeka • Bauhaus • MediaMarkt

C.1.5 Decision factors

Retailers

Variable	English	German
factors_retailer	**When choosing a supermarket, how important are each of these factors?** [options] • Not Important • Slightly Important • Moderately Important • Important • Very Important [rows, randomize order] • Location • Price • Product quality • Environmental performance	**Wie wichtig sind die folgenden Faktoren bei der Auswahl eines Supermarktes?** [Optionen] • Unwichtig • Eher unwichtig • Wichtig • Eher wichtig • Sehr wichtig [Zeilen, zufällige Reihenfolge] • Standort • Preis • Qualität der Produkte • Umweltfreundlichkeit

Products

Variable	English	German
factors_product	**How important are the following considerations when choosing which specific brands and grocery products to buy?** [options] • Not Important • Slightly Important • Moderately Important • Important • Very Important [rows, randomize order] • Price • Environmental performance • Quality	**Wie wichtig sind Ihnen die folgenden Überlegungen bei der Entscheidung, welche spezifischen Marken und Lebensmittel Sie kaufen?** [Optionen] • Unwichtig • Eher unwichtig • Wichtig • Eher wichtig • Sehr wichtig [Zeilen, zufällige Reihenfolge] • Preis • Umweltfreundlichkeit • Qualität

C.1.6 True costs

Concept explainer

Variable	English	German
	True costs The true cost of products often differs from the regular sale price you pay in the grocery store, because that regular market price doesn't include all societal costs from environmental damages. For example, farms and farm animals can emit methane, which is a greenhouse gas. Food preparation and transport also generate greenhouse gas emissions. The full societal costs of climate change caused by those emissions from food production are not included in the regular sales price you pay in the grocery store. Recently, researchers have tried to compute the true cost of food, including impacts of the item's production on human health, water pollution, soil pollution and climate change.	**Wahre Kosten** Die wahren Kosten von Produkten unterscheiden sich oft von dem regulären Preis, den Sie im Supermarkt zahlen, weil dieser reguläre Marktpreis nicht alle Umweltkosten einschließt, die bei der Produktion entstehen. Beispielsweise stoßen landwirtschaftliche Betriebe und Nutztiere das Treibhausgas Methan aus. Auch die Zubereitung und der Transport von Lebensmitteln verursachen Treibhausgasemissionen. Die gesamten gesellschaftlichen Kosten des Klimawandels, die durch diese Emissionen aus der Lebensmittelproduktion verursacht werden, sind in dem regulären Preis, den Sie im Supermarkt zahlen, nicht enthalten. In jüngster Zeit haben ForscherInnen versucht, die wahren Kosten von Lebensmitteln, einschließlich der Auswirkungen der Lebensmittelproduktion auf die menschliche Gesundheit, die Wasser- und Bodenverschmutzung und den Klimawandel zu berechnen.

Support for TCA info/surcharge/cross-subsidy

Variable	English	German
support_info	**Would you like the grocery stores you shop in to provide information on the true cost of grocery items?** [options] • Definitely not • Probably not • Maybe • Probably • Definitely	**Würden Sie es begrüßen, wenn die Lebensmittelgeschäfte, in denen Sie einkaufen, Informationen über die wahren Kosten von Lebensmitteln bereitstellen würden?** [Optionen] • überhaupt nicht • eher nicht • vielleicht • eher schon • definitiv
support_surcharge	**Would you like the grocery stores you shop in to charge the true cost of grocery items and use the additional revenue to reduce environmental damages?** [options] • Definitely not • Probably not • Maybe • Probably • Definitely	**Würden Sie es begrüßen, wenn die Lebensmittelgeschäfte, in denen Sie einkaufen, die wahren Kosten für Lebensmittel in Rechnung stellen und die zusätzlichen Einnahmen zur Verringerung der Umweltschäden verwenden würden?** [Optionen] • überhaupt nicht • eher nicht • vielleicht • eher schon • definitiv

Variable	English	German
support_tax	**Would you like the government to change taxes to align each grocery item's regular sales price with the true cost? (Additional tax revenues could be used to fund government programs or reduce other kinds of taxes.)** [options] • Definitely not • Probably not • Maybe • Probably • Definitely	**Würden Sie es begrüßen, wenn die Regierung die Steuern so ändern würde, dass die regulären Preise der einzelnen Lebensmittel an die wahren Kosten angepasst werden? (Zusätzliche Steuereinnahmen könnten zur Finanzierung von Regierungsprogrammen oder zur Senkung anderer Steuern verwendet werden.)** [Optionen] • überhaupt nicht • eher nicht • vielleicht • eher schon • definitiv

True cost estimate introduction

[randomize A and B; for the Penny sample, payouts were shown in points: €1 = 600 points]

Variable	English	German
A	We would now like to elicit your beliefs on the additional true costs of 10 items. By "additional true cost," we specifically mean societal costs from environmental damages that are not already included in the regular market price of the product. You can **earn up €0.50** or good guesses. Specifically, for each guess that is within 2 percent of the true costs calculated by a team of researchers, you will earn €0.05. The bonus payments will be added to your participation fee and paid out later. We imagine you do not know the exact right answer, but please give your best guess.	Wir möchten Sie nun um Ihre Meinung zu den zusätzlichen wahren Kosten von 10 Produkten befragen. Mit "zusätzlichen wahren Kosten" meinen wir insbesondere die gesellschaftlichen Kosten für Umweltschäden, die nicht bereits im regulären Preis des Produkts enthalten sind. Wir möchten, dass Sie sehr genau und reflektiert nachdenken. Für gute Schätzungen können Sie daher bis zu **0,50 € verdienen**. Konkret erhalten Sie für jede Schätzung, die innerhalb von 2 Prozent der von einem Forschungsteam berechneten wahren Kosten liegt, 0,05 €. Die Bonuszahlungen werden zu Ihrer Teilnahmegebühr hinzugerechnet und versetzt ausgezahlt. Wir gehen davon aus, dass Sie die exakte richtige Antwort nicht kennen, aber bitte geben Sie Ihre beste Schätzung ab.

Variable	English	German
B	We would now like to elicit your beliefs on the additional true costs of 10 items. By "additional true cost," we specifically mean societal costs from environmental damages that are not already included in the regular market price of the product. You can **earn up €2.00** for good guesses. Specifically, for each guess that is within 2 percent of the true costs calculated by a team of researchers, you will earn €0.20. The bonus payments will be added to your participation fee and paid out later. We imagine you do not know the exact right answer, but please give your best guess.	Wir möchten Sie nun um Ihre Meinung zu den zusätzlichen wahren Kosten von 10 Produkten befragen. Mit "zusätzlichen wahren Kosten" meinen wir insbesondere die gesellschaftlichen Kosten für Umweltschäden, die nicht bereits im regulären Preis des Produkts enthalten sind. Wir möchten, dass Sie sehr genau und reflektiert nachdenken. Für gute Schätzungen können Sie daher bis zu **2,00 € verdienen**, denn wir möchten, dass Sie sehr genau und reflektiert nachdenken. Konkret erhalten Sie für jede Schätzung, die innerhalb von 2 Prozent der von einem Forschungsteam berechneten wahren Kosten liegt, 0,20 €. Die Bonuszahlungen werden zu Ihrer Teilnahmegebühr hinzugerechnet und versetzt ausgezahlt. Wir gehen davon aus, dass Sie die exakte richtige Antwort nicht kennen, aber bitte geben Sie Ihre beste Schätzung ab.

Perceived level of true costs

Variable	English	German
belief	**Please estimate, to the best of your knowledge, the additional true costs (in % of the regular selling price) of the following products** **You see: Product name, manufacturing type, weight and regular selling price.** Click anywhere on the scale to begin. [slider, 0-90%, starting point hidden] [rows,randomize order] • Sausages, conventional, 400g, 3.19€ • Sausages, organic, 200g, 3.29€ • Fruit yogurt, conventional, 450g, 1.19€ • Fruit yogurt, organic, 400g, 1.19€ • Vegan schnitzel, conventional, 200g, 2.69€ • Neck steak pork, conventional, 600g, 4.99€ • Cream cheese, conventional, 200g, 0.99€ • Cream cheese, organic, 200g, 1.19€ • Soy yogurt, conventional, 500g, 1.39€ • Waste bags 120L, 20 pieces, 400g, 2.99€	**Bitte schätzen Sie nach bestem Wissen die zusätzlichen wahren Kosten (in % des regulären Verkaufspreises) für die folgenden Produkte Sie sehen: Produktnamen, Herstellungsart, Gewicht und den regulären Verkaufspreis.** Klicken Sie auf eine beliebige Stelle der Skala, um zu beginnen. [Schieberegler, 0-90%, Startpunkt ausgeblendet] [Zeilen, Reihenfolge zufällig] • Würstchen, konventionell, 400g, 3,19€ • Würstchen, Bio, 200g, 3,29€ • Fruchtjoghurt, konventionell, 450g, 1,19€ • Fruchtjoghurt, Bio, 400g, 1,19€ • Veganes Schnitzel, konventionell, 200g, 2,69€ • Nackensteak Schwein, konventionell, 600g, 4,99€ • Frischkäse, konventionell, 200g, 0,99€ • Frischkäse, Bio, 200g, 1,19€ • Sojajoghurt, konventionell, 500g, 1,39€ • Abfallsäcke 120L, 20 Stück, 400g, 2.99€
time_belief	[question timer]	[Zeitmessung]

C.1.7 Campaign

Campaign reach

Variable	English	German
had_campaign	Please check the box next to any retailer that had a nationwide awareness campaign about the true cost of food in the past four weeks. [randomize order] • ALDI • Lidl • PENNY • REWE • Edeka • Bauhaus • MediaMarkt • none of the above	Bitte kreuzen Sie alle Einzelhändler an, die in den letzten vier Wochen eine landesweite Kampagne über die wahren Kosten von Lebensmitteln durchgeführt haben. [zufällige Reihenfolge] • ALDI • Lidl • PENNY • REWE • Edeka • Bauhaus • MediaMarkt • keiner der oben genannten

C.1.8 Attitudes

Variable	English	German
environmentalism	**On a scale from 1 (not at all environmentally conscious) to 6 (very environmentally conscious), how environmentally conscious are you?** • 1 = not at all environmentally conscious • 2 • 3 • 4 • 5 • 6 = very environmentally conscious	**Auf einer Skala von 1 für gar nicht umweltbewusst bis 6 für sehr umweltbewusst, wie umweltbewusst sind Sie?** • 1 = gar nicht umweltbewusst • 2 • 3 • 4 • 5 • 6 = sehr umweltbewusst

C.1.9 Attention check

Variable	English	German
attention_read	We want to do a final check to make sure everyone is giving thoughtful responses. If you have been paying attention to the survey, please write the word “mayo” when we ask about your favorite food. **What is your favorite food?** [text box] [return to Cint with code for failed attention check if not “Mayo”, “Majo”, “Mayonnaise”, “mayo” (case insensitive)]	Wir möchten eine letzte Kontrolle durchführen, um sicherzugehen, dass Sie alle Ihre Antworten sorgfältig ausgefüllt haben. Wenn Sie die Umfrage aufmerksam verfolgt haben, schreiben Sie bitte das Wort ”Mayo”, wenn wir Sie nach Ihrem Lieblingsessen fragen. **Was ist Ihr Lieblingsessen?** [Textfeld] [zurück zu Cint mit Code für fehlgeschlagene Aufmerksamkeitsprüfung, wenn es sich nicht um “Mayo”, “Majo”, “Mayonnaise”, “mayo” handelt; (Groß-/Kleinschreibung wird nicht berücksichtigt)]

C.1.10 Demographics

Variable	English	German
education	**Which of the following options best describes your highest educational degree?** [simple choice] • Elementary school • Secondary school degree, Realschule degree (also transition to 11th grade Gymnasium/comprehensive school) • Apprenticeship diploma, vocational qualification from a vocational school • Technical college entrance qualification, high school diploma, Abitur *and* apprenticeship diploma • Master craftsman • Bachelor's degree • Master's degree, diploma • Doctor	**Welche der folgenden Optionen beschreibt Ihren höchsten Bildungsabschluss am besten?** [einfache Auswahl] • Grundschule • Hauptschulabschluss, Realschulabschluss (auch Übergang in 11. Klasse Gymnasium/Gesamtschule) • Lehrabschluss, berufsqualifizierender Abschluss einer Berufsfachschule • Fachhochschulreife, Abitur • Abitur *und* Lehrabschluss • Meister • Bachelor • Master, Diplom • Doktor

Variable	English	German
household_size	**How many people live in your household?** [simple choice] • 1 • 2 • 3 • 4 • 5 • 6 • 7 or more **What is your monthly net household income?** *The household net income is calculated from salary/wages/pension/self-employment/pension of ALL persons after deduction of taxes and social security contributions. Added to this are allowances, income from rent, child benefit, etc.* [simple choice] • 0-600€ • 601-1200€ • 1201-1800€ • 1801-2400€ • 2401-3000€ • 3001-3600€ • 3601-4200€ • 4201-4800€ • 4801-5400€ • 5401-6000€ • More than 6000€	**Wie viele Menschen leben in Ihrem Haushalt?** [einfache Auswahl] • 1 • 2 • 3 • 4 • 5 • 6 • 7 oder mehr **Wie hoch ist Ihr monatliches Haushaltsnettoeinkommen?** *Das Haushaltsnettoeinkommen errechnet sich aus Gehalt/Lohn/Rente/Selbstständigkeit/ Rente ALLER Personen nach Abzug von Steuern und Sozialversicherungsbeiträgen. Hinzu kommen Freibeträge, Mieteinnahmen, Kindergeld usw.* [einfache Auswahl] • 0-600€ • 601-1200€ • 1201-1800€ • 1801-2400€ • 2401-3000€ • 3001-3600€ • 3601-4200€ • 4201-4800€ • 4801-5400€ • 5401-6000€ • Mehr als 6000€

C.1.11 End

Variable	English	German
	Thank you for participating in this survey. Your response has been recorded.	Wir danken Ihnen für Ihre Teilnahme an dieser Umfrage. Ihre Antwort wurde erfasst.

C.2 Endline survey

C.2.1 Intro

Welcome screen

Variable	English	German
	Welcome to the second part of our survey about shopping behavior. Please click **"Next"** to begin.	Willkommen zum zweiten Teil unserer Umfrage zum Kaufverhalten. Bitte klicken Sie **"Weiter"** um zu beginnen.

Explainer follow-up

Variable	English	German
	You already participated in our first survey about shopping behavior. Some of the questions are repeated. Please answer them to your best knowledge and views right now. As a reminder, this survey is run by a team of independent scientists from the University of Greifswald and the Nuremberg University of Technology and your answers are kept entirely confidential.	Sie haben bereits an unserer ersten Umfrage zum Kaufverhalten teilgenommen. Einige der Fragen werden wiederholt. Bitte beantworten Sie diese nach Ihrem besten Wissen und Ihren Ansichten in diesem Moment. Zur Erinnerung: Diese Umfrage wird von einem Team unabhängiger WissenschaftlerInnen der Universität Greifswald und der Technischen Hochschule Nürnberg durchgeführt und Ihre Antworten werden absolut vertraulich behandelt.

C.2.2 Brand

[same as baseline]

C.2.3 Decision factors

[same as baseline]

C.2.4 True costs

[same as baseline]

C.2.5 Campaign

Campaign reach

Variable	English	German
had_campaign	Please check the box next to any retailer that had a nationwide awareness campaign about the true cost of food in the past four weeks. [randomize order] • ALDI • Lidl • PENNY • REWE • Edeka • Bauhaus • MediaMarkt • none of the above	Bitte kreuzen Sie alle Einzelhändler an, die in den letzten vier Wochen eine landesweite Kampagne über die wahren Kosten von Lebensmitteln durchgeführt haben. [Zeilen, zufällige Reihenfolge] • ALDI • Lidl • PENNY • REWE • Edeka • Bauhaus • MediaMarkt • keiner der oben genannten

Understanding of campaign

[only show if selected Penny]

Variable	English	German
	You said you remember that Penny had a campaign about the true cost of food. Please select the answers below that most closely match your memory of the Penny campaign.	Sie haben angegeben, dass Sie sich daran erinnern, dass es eine Penny-Kampagne über die wahren Kosten von Lebensmitteln gab. Bitte wählen Sie unten die Antworten aus, die Ihrer Erinnerung an die Penny-Kampagne am ehesten entsprechen.
fact_who_estimated	**Who estimated the true costs used in the Penny campaign?** [randomize order] • Penny • A consultancy • The ministry for the environment • The European Commission • A team of independent scientists	**Wer hat die wahren Kosten ermittelt, die in der Penny-Kampagne verwendet wurden?** [zufällige Reihenfolge] • Penny • Ein Beratungsunternehmen • Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz (BMUV) • Die Europäische Kommission • Ein Team von unabhängigen WissenschaftlerInnen

Variable	English	German
fact_products	**Which of the following products were included in the Penny campaign?** *Select all that apply.* [checkboxes, randomize order] • Sausages, conventional • Sausages, organic • Fruit yogurt, conventional • Fruit yogurt, organic • Vegan schnitzel, conventional • Neck steak pork, conventional • Fresh cheese, conventional • Fresh cheese, organic • Soy yogurt, conventional • Waste bags 120L • none of the above	**Welche der folgenden Produkte waren Teil der Penny-Kampagne ?** *Wählen Sie alle zutreffenden aus.* [Kontrollkästchen; zufällige Reihenfolge] • Würstchen, konventionell • Würstchen, Bio • Fruchtjoghurt, konventionell • Fruchtjoghurt, Bio • Veganes Schnitzel, konventionell • Nackensteak Schwein, konventionell • Frischkäse, konventionell • Frischkäse, Bio • Sojajoghurt, konventionell • Abfallsäcke 120L • keines der oben genannten
fact_donation	**What was done with the additional revenue raised by the campaign?** [randomize order] • It was kept by Penny to increase profits • It was given to the government • It was given to farmer who sell products to Penny • It was given to scientists	**Was wurde mit den durch die Penny-Kampagne eingenommenen Mehreinnahmen gemacht?** [zufällige Reihenfolge] • Es wurde von Penny behalten, um die Gewinne zu erhöhen • Es wurde an die Regierung gegeben • Es wurde an Landwirte gegeben, die Produkte an Penny verkaufen • Es wurde an WissenschaftlerInnen gegeben
fact_timer	[question timer]	[Zeitmessung]

Perceived effectiveness of donation

Variable	English	German
statement	The discounter Penny did in fact have a true cost campaign from July 31st to August 5th. Consumers had to pay the additional true costs on top of the regular sales price. The additional revenue went to Penny's "Zukunftsbauer" project, which supports farmers that sell their products to Penny to make their farms more energy efficient.	Tatsächlich hat der Discounter Penny vom 31. Juli bis zum 5. August eine Kampagne zu wahren Kosten durchgeführt. Verbraucherinnen und Verbraucher mussten zusätzlich zum regulären Preis die wahren Kosten bezahlen. Die Mehreinnahmen gingen an Penny's Projekt "Zukunftsbauer", welches Landwirte, die ihre Produkte an Penny verkaufen, dabei unterstützt, ihre Betriebe energieeffizienter zu machen.
effective_donation	**How much do you agree with the following statements about the additional revenue from the Penny campaign?** [options] • Strongly disagree • Moderately disagree • Neither agree nor disagree • Moderately agree • Strongly agree [rows, randomize order] • Donating the additional revenue to Penny's Zukunftsbauer project was a good choice. • The Zukunftsbauer project is effective in addressing the environmental damages caused by food items. • The additional revenue should be redistributed to consumers. • The additional revenue should be given to governments to invest in the green transition.	**Wie sehr stimmen Sie den folgenden Aussagen zur Verwendung der Mehreinnahmen aus der Penny-Kampagne zu?** [Optionen] • Stimme überhaupt nicht zu • Stimme eher nicht zu • Weder noch • Stimme eher zu • Stimme völlig zu [Zeilen, zufällige Reihenfolge] • Es war eine gute Entscheidung, die Mehreinnahmen an das Projekt "Zukunftsbauer" von Penny zu spenden. • Das Projekt "Zukunftsbauer" ist ein wirksames Mittel gegen die durch Lebensmittel verursachten Umweltschäden. • Die Mehreinnahmen sollten an die Verbraucher umverteilt werden. • Die Mehreinnahmen sollten Regierungen zur Verfügung gestellt werden, um in einen grünen Wandel zu investieren.

Perceived effectiveness of campaign

Variable	English	German
effective_campaign	**How much do you agree with the following statements about the impact of Penny's true cost campaign?** [options] • Strongly disagree • Moderately disagree • Neither agree nor disagree • Moderately agree • Strongly agree [rows, randomize order] • The campaign raised awareness about the true costs of food. • The campaign led to a debate about political reforms. • The campaign directly reduced environmental damages, because fewer products with high true costs were bought. • The campaign was merely greenwashing/marketing, without positive societal impacts.	**Wie sehr stimmen Sie den folgenden Aussagen zu den Auswirkungen der Penny-Kampagne zu wahren Kosten zu?** [Optionen] • Stimme überhaupt nicht zu • Stimme eher nicht zu • Weder noch • Stimme eher zu • Stimme völlig zu [Zeilen, zufällige Reihenfolge] • Die Kampagne hat das Bewusstsein für die wahren Kosten von Lebensmitteln erhöht. • Die Kampagne hat zu einer Debatte über politische Reformen geführt. • Die Kampagne hat die Umweltschäden direkt reduziert, da weniger Produkte mit hohen wahren Kosten gekauft wurden. • Die Kampagne war lediglich Greenwashing/Marketing, ohne positive gesellschaftliche Auswirkungen.

Reason for (not) buying treated products

Reasons: shopped at Penny

Variable	English	German
shopped_penny	**Did you shop at a Penny store between the 31st of July and the 5th of August?** • Yes • No • I do not remember/I am not sure.	**Haben Sie zwischen dem 31. Juli und dem 5. August in einem Penny-Markt eingekauft?** • Ja • Nein • Weiß ich nicht mehr/ Ich bin mir nicht sicher

Reasons: bought campaign products

[only show if selected yes]

Variable	English	German
bought_products	**Did you buy any true cost campaign products and with it paid the true cost price?** • Yes • No • I do not remember/I am not sure.	**Haben Sie Produkte aus der Kampagne zu wahren Kosten gekauft und somit den ”wahre Kosten”-Preis bezahlt?** • Ja • Nein • Weiß ich nicht mehr/ Ich bin mir nicht sicher

Reasons: why bought - page 1

[only show if selected yes]

Variable	English	German
which_products	**Which of the following true cost campaign products did you buy?** [randomized order] • Mühlenhof wiener sausages • Naturgut organic sausages • PENNY Zukunftsbauer fruit yogurt • Naturgut organic fruit yogurt • FOOD FOR FUTURE Vegan schnitzel • Lindenhof Maasdam cheese slices • Naturgut organic cheese slices • SAN FABIO mozzarella • Naturgut organic mozzarella • I do not remember/I am not sure	**Welche der folgenden Produkte aus der Kampagne zu wahren Kosten haben Sie gekauft?** [zufällige Reihenfolge] • Mühlenhof Wiener • Naturgut Bio-Würstchen • PENNY Zukunftsbauer Fruchtjoghurt • Naturgut Bio-Fruchtjoghurt • FOOD FOR FUTURE Vegane Schnitzel • Lindenhof Maasdamer Scheiben • Naturgut Bio-Käsescheieben • SAN FABIO Mozzarella • Naturgut Bio-Mozzarella • Weiß ich nicht mehr / Ich bin mir nicht sicher

Reasons: why bought - page 2

Variable	English	German
why_bought	**How important were the following reasons for buying the products you selected above?** [options] • Not Important • Slightly Important • Moderately Important • Important • Very Important [rows, randomized order] • Donation to the Zukunftsbauer project • Interest in sustainability • Interest through advertising / reporting • I always buy this (these) product(s)	**Wie wichtig waren die folgenden Gründe für den Kauf der von Ihnen gewählten Produkte?** [Optionen] • Nicht wichtig • Kaum wichtig • Eher wichtig • Wichtig • Sehr wichtig [Zeilen; zufällige Reihenfolge] • Spende an das Projekt "Zukunftsbauer" • Interesse an Nachhaltigkeit • Interesse durch Werbung / Berichterstattung • Ich kaufe diese(s) Produkt(e) immer

Reasons: why not bought

[only show if selected no]

Variable	English	German
why_not_bought	**How important were the following reasons for not buying any of true cost campaign products?** [options] • Not Important • Slightly Important • Moderately Important • Important • Very Important [rows, order randomized] • The products were too expensive • I generally do not buy these product • I did not understand the campaign • I did not want to donate to the Zukunftsbauer project • I do not care about environmental aspects • I did not want to support the campaign	**Wie wichtig waren die folgenden Gründe, keines der wahren Kosten Produkte zu kaufen?** [Optionen] • Nicht wichtig • Kaum wichtig • Eher wichtig • Wichtig • Sehr wichtig [Zeilen; zufällige Reihenfolge] • Die Produkte waren zu teuer • Ich kaufe diese Produkt generell nicht • Ich habe die Kampagne nicht verstanden • Ich wollte nicht an das Projekt “Zukunftsbauer” spenden • Umweltaspekte sind mir nicht wichtig • Ich wollte die Kampagne nicht unterstützen

C.2.6 End

Variable	English	German
	Thank you for participating in this survey. Your response has been recorded.	Wir danken Ihnen für Ihre Teilnahme an dieser Umfrage. Ihre Antwort wurde erfasst.

D Media Coding Instructions

D.1 Introduction

Your task is to classify media articles. Please answer the questions below for each article and save the results in the spreadsheet sent to you. For yes/no questions, add 1 (yes) or 0 (no) to the corresponding column. Refer to the coding scheme at the end of the document for the coding of the sentiment questions. Only fill out questions 5-15 if questions 1 and 3 were coded as 1 (yes). Otherwise, fill the corresponding columns with an "x".

D.2 Questions

D.2.1 General questions

1. Does the article talk about Penny?
2. Is Penny the main topic of the article?
    - If Penny is one of three topics (e.g. articles that pick up on three news items of the day), Penny is not rated as a main topic.
3. Does the article talk about Penny's true cost campaign?
4. Is Penny's true cost campaign the main topic of the article?

D.2.2 Did the article contain the following?

5. Explanation of true cost issue (what true costs are)
    - Example:
        - "It is about the hidden environmental costs that arise along the supply chain but are not taken into account in the sales price of products, services and food."
          ("Es geht dabei um die verborgenen Umweltkosten, die entlang der Lieferketten entstehen, aber nicht im Verkaufspreis von Produkten, Dienstleistungen und Lebensmitteln berücksichtigt werden.")
6. True cost methodology (how true costs are calculated)
    - Aspects of the following categories relating to methodology are included:
        - "Health", "water", "soil" or "climate change" are mentioned
        - "True cost accounting" as a process is mentioned, examples:
            * "Accounting for environmental costs"
            * "Life cycle analysis" or "life cycle assessments"
            * "Monetization" or "cost factors"

D.2.3 Were the following aims discussed?

7. Experiment/science communication

   - There is a scientific approach/experiment behind it, examples:
     - "Experiment at Penny: What's behind the 'true prices' of food. Scientists have calculated that many foods should be significantly more expensive."
       ("Experiment bei Penny: Was sich hinter den "wahren Preisen" von Lebensmitteln verbirgt. Wissenschaftler haben berechnet, dass viele Lebensmittel deutlich teurer sein müssten.")
     - "The background to this is a one-week experiment conducted by the company in cooperation with the Technical University of Nuremberg and the University of Greifswald."
       ("Hintergrund ist ein einwöchiges Experiment, das das Unternehmen in Zusammenarbeit mit der Technischen Hochschule Nürnberg und der Universität Greifswald durchgeführt hat.")

8. Awareness about topic/transparency (taking societal aspect into account), examples:

   - Consumers' perspective on awareness is discussed
   - Transparency through TCA for consumption is addressed
   - Social debate about current system and TCA is addressed
     - Example CEO of Penny: "We don't have a solution to the problem, but as retailers we see ourselves as part of the problem and would therefore like to open up the debate."
       ("Wir haben keine Lösung des Problems, sehen uns als Handel aber als Teil des Problems und möchten daher die Debatte darüber eröffnen.")
       $\rightarrow$ sometimes only a shortened version of this quote was used
     - Example: "The retailer is well aware of this, but nevertheless wants to signal its intentions."
       ("Dem Händler ist das durchaus bewusst, er will aber trotzdem ein Zeichen setzen.")

9. Political debate

   - Political discourse on the current system is encouraged
   - Possible measures for implementing TCA, such as CSRD, taxes or subsidies at European level are discussed
   - Responsibility for current problems at political level is discussed

10. Greenwashing

    - Greenwashing / PR stunt / pure marketing/advertising campaign
      - Example: criticism from marketing expert "Martin Fassnacht from WHU Düsseldorf" is covered

11. Patronize consumers

    - Example: "Discounter Penny wants to patronize its customers with "true prices."
      ("Discounter Penny will seine Kunden mit "wahren Preisen" erziehen.")

D.2.4 Were the following problems discussed?

12. Price hike

    - Price shock, examples:
      - "Despite inflation"
      - "We recognize that many of our customers are suffering from the unchanged high food prices. Nevertheless, we have to face up to the uncomfortable message that the prices of our food along the supply chain do not reflect the environmental impact costs," says Penny CEO Stefan Görgens
        ("Wir sehen, dass viele unserer Kundinnen und Kunden unter den unverändert hohen Lebensmittelpreisen leiden. Dennoch müssen wir uns der unbequemen Botschaft stellen, dass die Preise unserer Lebensmittel, die entlang der Lieferkette anfallen, die Umweltfolgekosten nicht widerspiegeln", sagt Penny-CEO Stefan Görgens)

13. Issues with true cost methodology

    - Discussion of the content of the calculations, examples:
      - Completeness of the calculations
      - Cost factors
      - "Questionable methodology"
      - Social costs not included, etc.

D.2.5 What was the overall sentiment towards ___?

14. Penny

    - Use coding scheme
      - Negative example: "Why is a discounter doing the campaign if they are responsible for the current food price policy?"

15. The true cost campaign

    - Use coding scheme

D.3 Coding scheme

Questions 1-13:

Yes/definitely	1
No/definitely not	0
Not sure/Not discussed/Conflicting	-1
Does not apply	x

Questions 14-15:

Positive (more positive than negative arguments/views)	1
Neutral (neutral report, about the same positive as negative arguments/views)	0
Ambivalent (positive and negative arguments/views with high tonality)	-1
Negative (more negative than positive arguments/views)	-2
Does not apply	x

Notes:

- There is a 'notes' column at the end – use it to write down anything unusual that you see that could be useful to know (can be empty most of the time).
- Often articles were distributed by editorial networks and especially small newspapers / online media thus used the exact same article. Here not every article must be evaluated individually: In these cases, the coding should be copied between identical articles. Nevertheless, all articles should be listed here and the rating scales added up.

E Campaign Evaluation Appendix

E.1 Price and Warm Glow Effect

Table A3: **Campaign Price and Warm Glow Effect**

	ln(Quantity)		
	(1)	(2)	(3)
-ln(Price) x Meat	2.68***	2.72***	2.83***
	(0.10)	(0.08)	(0.11)
-ln(Price) x Cheese	2.62***	2.52***	2.51***
	(0.48)	(0.50)	(0.57)
-ln(Price) x Yogurt	2.28***	2.30***	2.69***
	(0.20)	(0.19)	(0.27)
-ln(Price) x Vegetarian	1.44***	1.44***	1.41***
	(0.03)	(0.04)	(0.05)
Campaign x Fruit yogurt, organic	0.52***	0.53***	0.57***
	(0.05)	(0.05)	(0.08)
Campaign x Sliced cheese, organic	0.91***	0.85***	0.82***
	(0.25)	(0.27)	(0.30)
Campaign x Mozzarella, organic	0.80***	0.76***	0.71***
	(0.19)	(0.20)	(0.23)
Campaign x Sausage, organic	1.10***	1.12***	1.18***
	(0.05)	(0.04)	(0.05)
Campaign x Fruit yogurt, conventional	0.57***	0.56***	0.69***
	(0.08)	(0.08)	(0.12)
Campaign x Sliced cheese, conventional	1.19***	1.13***	1.10***
	(0.32)	(0.34)	(0.38)
Campaign x Mozzarella, conventional	0.89***	0.84***	0.81**
	(0.26)	(0.28)	(0.32)
Campaign x Sausage, conventional	0.87***	0.90***	1.03***
	(0.07)	(0.05)	(0.07)
Campaign x Vegan schnitzel, conventional	0.07***	0.07***	0.10***
	(0.00)	(0.00)	(0.01)
Product x price window FE	✓	✓	✓
Product x campaign window FE		✓	✓
Product x sales window FE		✓	✓
Category x day FE			✓
Observations	1,076,257	1,076,257	1,076,257
R^2	0.90509	0.90566	0.92029

Notes: This table shows the results from a regression to recover the elasticity of substitution for different categories and the campaign effect for different products. The regression model for column (3) is shown in equation (8). Observations are at the product-day level. Included are campaign product sales during the entire sample period.

Table A4: **Campaign Price and Warm Glow Effect, Robustness**

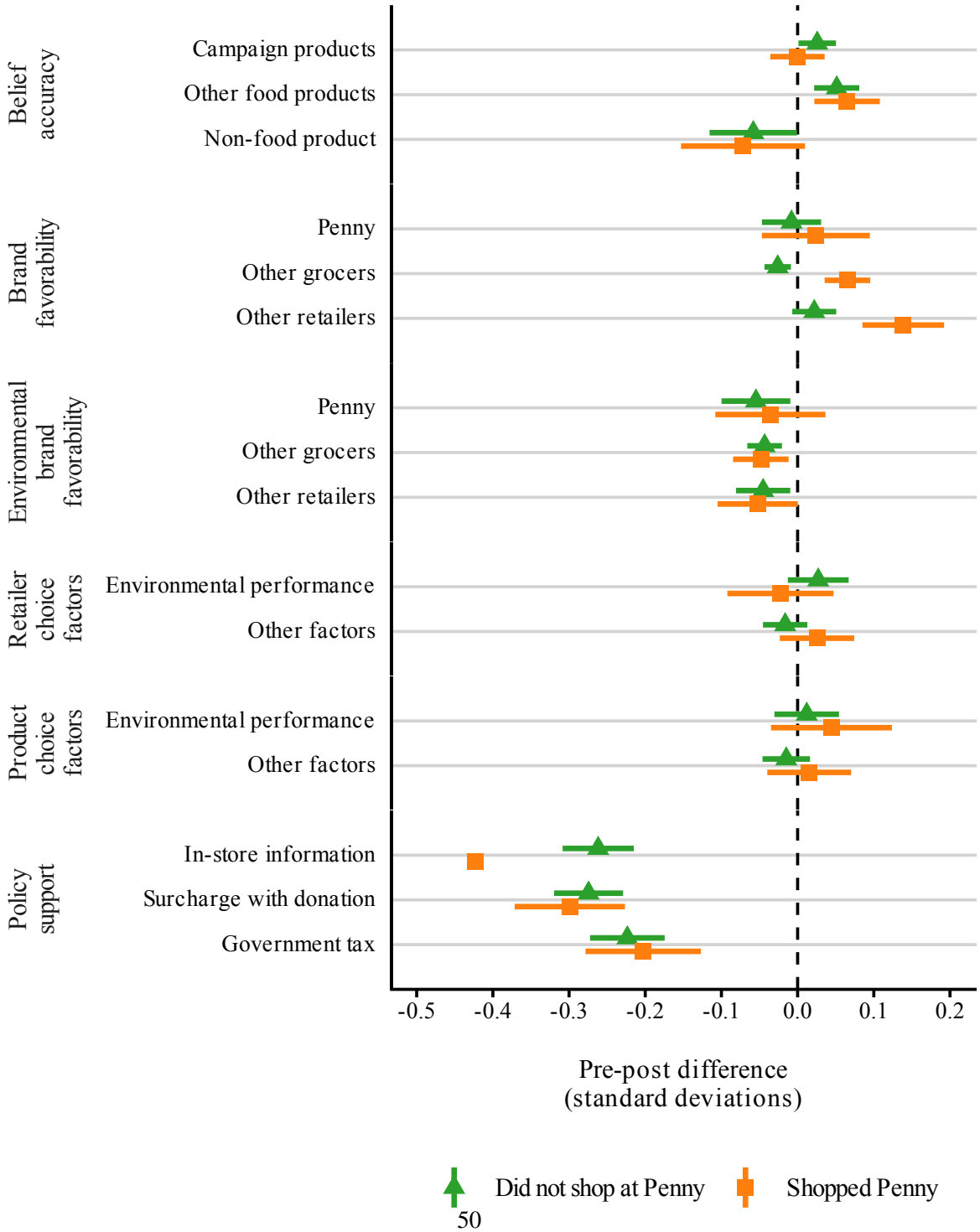
	ln(Quantity)				
	(1)	(2)	(3)	(4)	(5)
-ln(Price) x Meat	2.83***	2.83***	2.83***	2.83***	2.83***
	(0.24)	(0.11)	(0.11)	(0.17)	(0.18)
-ln(Price) x Cheese	2.51***	2.51***	2.51***	2.51***	2.51***
	(0.25)	(0.57)	(0.57)	(0.38)	(0.46)
-ln(Price) x Yogurt	2.69***	2.69***	2.69***	2.69***	2.69***
	(0.19)	(0.27)	(0.27)	(0.19)	(0.20)
-ln(Price) x Vegetarian	1.41***	1.41***	1.41***	1.41***	1.41***
	(0.24)	(0.05)	(0.03)	(0.12)	(0.14)
Campaign x Fruit yogurt, organic	0.57***	0.57***	0.57***	0.57***	0.57***
	(0.10)	(0.08)	(0.06)	(0.06)	(0.06)
Campaign x Sliced cheese, organic	0.82***	0.82***	0.82***	0.82***	0.82***
	(0.16)	(0.30)	(0.30)	(0.21)	(0.25)
Campaign x Mozzarella, organic	0.71***	0.71***	0.71***	0.71***	0.71***
	(0.13)	(0.23)	(0.23)	(0.16)	(0.19)
Campaign x Sausage, organic	1.18***	1.18***	1.18***	1.18***	1.18***
	(0.16)	(0.05)	(0.06)	(0.08)	(0.09)
Campaign x Fruit yogurt, conventional	0.69***	0.69***	0.69***	0.69***	0.69***
	(0.12)	(0.12)	(0.11)	(0.08)	(0.09)
Campaign x Sliced cheese, conventional	1.10***	1.10***	1.10***	1.10***	1.10***
	(0.19)	(0.38)	(0.38)	(0.26)	(0.31)
Campaign x Mozzarella, conventional	0.81***	0.81**	0.81**	0.81***	0.81***
	(0.17)	(0.32)	(0.32)	(0.22)	(0.26)
Campaign x Sausage, conventional	1.03***	1.03***	1.03***	1.03***	1.03***
	(0.24)	(0.07)	(0.07)	(0.12)	(0.12)
Campaign x Vegan schnitzel, conventional	0.10	0.10***	0.10***	0.10***	0.10***
	(0.15)	(0.01)	(0.00)	(0.02)	(0.02)
Product x campaign window FE	✓	✓	✓	✓	✓
Product x sales window FE	✓	✓	✓	✓	✓
Product x price window FE	✓	✓	✓	✓	✓
Category x day FE	✓	✓	✓	✓	✓
Standard error/cluster	i.i.d.	w, j	m, j	NW-7	NW-28
Observations	1,076,257	1,076,257	1,076,257	1,076,257	1,076,257
R^2	0.92029	0.92029	0.92029	0.92029	0.92029

Notes: The level of clustering is indicated in the row "Standard error of cluster type". Otherwise, the regression model is as in A3, column (3).

E.2 Survey Results

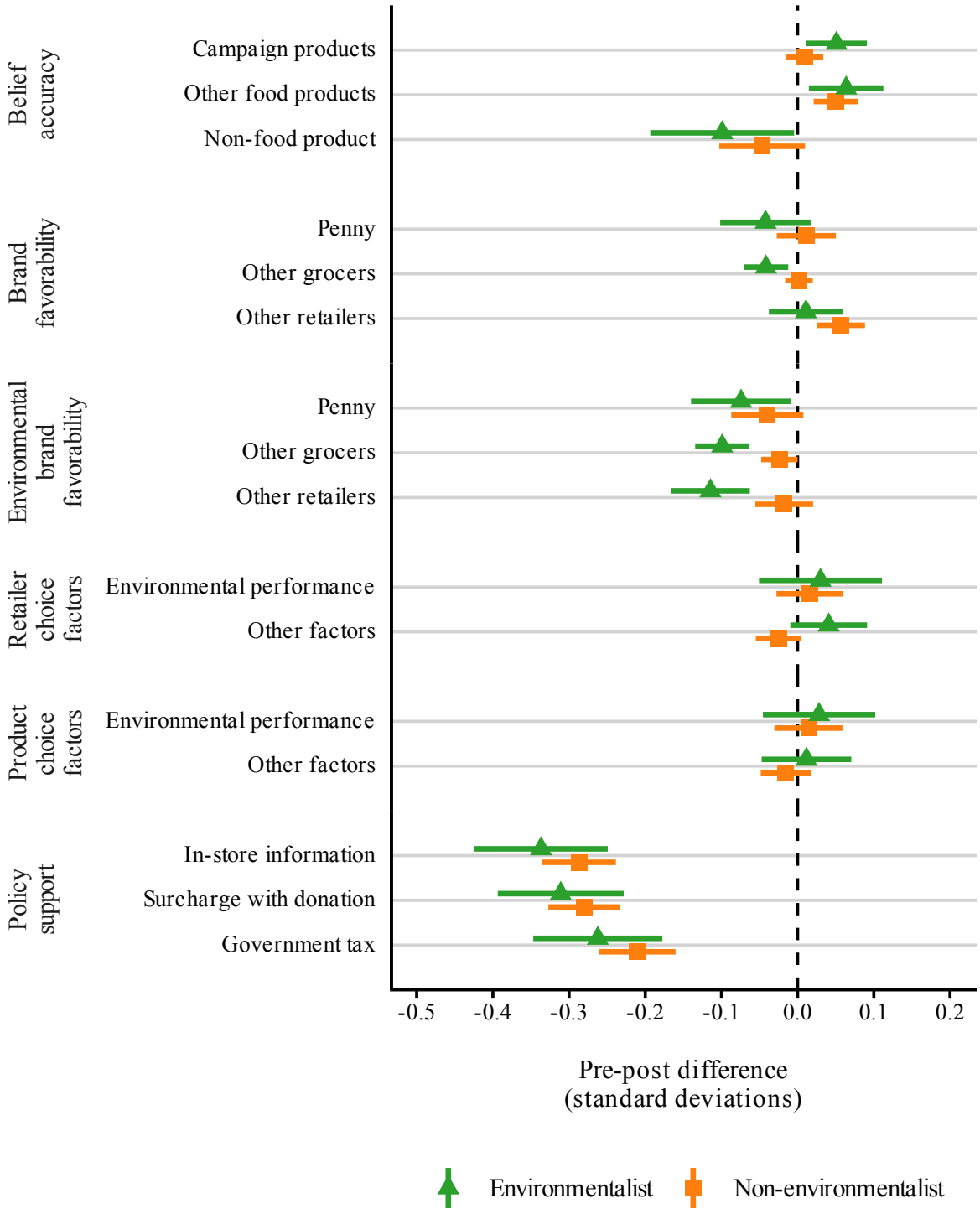
E.2.1 Pre-post Difference Heterogeneity

Figure A3: **Survey Campaign Effects, Penny Shoppers**



Notes: This graph shows the difference in the mean survey response before and after the campaign. Differences were normalized using the pre-campaign standard deviation. Green triangles: participants who did not shop at Penny during the campaign week. Orange squares: participants who did. Error bars: 95%

Figure A4: **Survey Campaign Effects, Environmentalists**



Notes: This graph shows the difference in the mean survey response before and after the campaign. Differences were normalized using the pre-campaign standard deviation. Green triangles: self-identified environmentalists. Orange squares: non-environmentalists. Error bars: 95% confidence interval.

E.2.2 Reasons for (not) Buying Products

Table A5: Reasons for buying products (% important or very important)

	All	Environmentalists	Shopped Penny
Donation to "Future Farmers" project	67	84	67
Interest in sustainability	69	77	69
Interest through advertising / reporting	55	72	55
Always buys product(s)	72	71	72

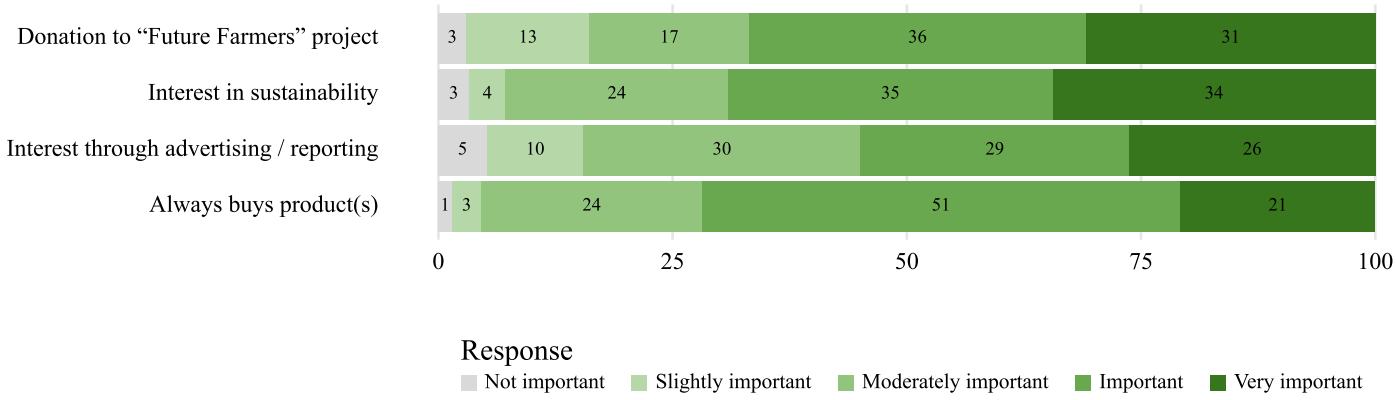
Notes: This table displays the percentage of respondents that correctly answered questions about aspects of the campaign. Percentages are shown by sample. "Environmentalists" are respondents who are strictly more environmentally conscious than the median respondent based on a question in the survey about environmentalism. "Shopped Penny" denotes the sample of respondents that shopped at Penny during the campaign.

Table A6: Reasons for not buying products (% important or very important)

	All	Environmentalists	Shopped Penny
Too expensive	65	71	65
Generally does not buy campaign products	41	43	41
Did not understand	13	22	13
Did not want to donate to "Future Farmers" project	17	12	17
Does not care about environmental aspects	22	16	22
Did not want to support campaign	25	27	25

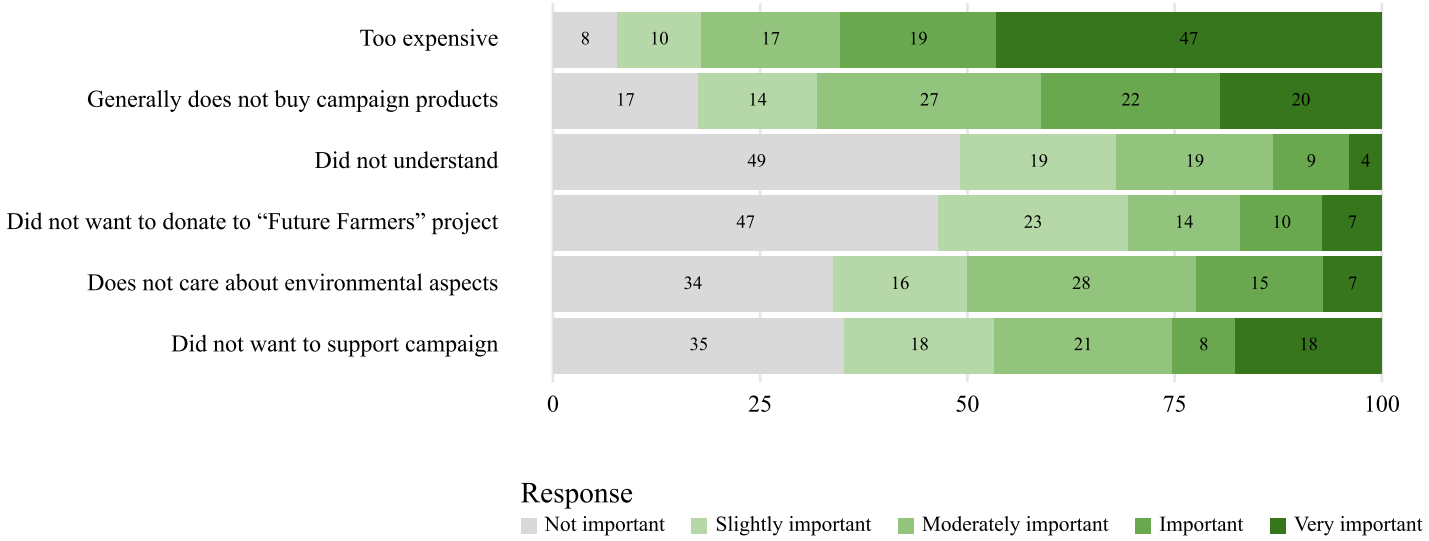
Notes: This table displays the percentage of respondents that correctly answered questions about aspects of the campaign. Percentages are shown by sample. "Environmentalists" are respondents who are strictly more environmentally conscious than the median respondent based on a question in the survey about environmentalism. "Shopped Penny" denotes the sample of respondents that shopped at Penny during the campaign.

Figure A5: **Reasons for Buying Campaign Products**



Notes: This figure shows the percentage of respondents stating the importance of different reasons for buying campaign products, among all customers who shopped at Penny during the campaign and bought one or more campaign products.

Figure A6: **Reasons for Not Buying Campaign Products**



Notes: This figure shows the percentage of respondents stating the importance of different reasons for not buying campaign products, among all customers who shopped at Penny during the campaign and did not buy any campaign products.

E.2.3 Effectiveness of Campaign

Table A7: Facts about campaign (% correct)

	All	Environmentalists	Shopped Penny
Penny had campaign	58	62	74
Penny had campaign, but not at baseline	54	57	64
Only Penny had campaign	55	57	64
Scientists calculated true costs	37	35	36
Campaign products identified	41	45	41
Non-campaign products identified	77	74	79
Additional revenue was donated to farmers	72	75	71

Notes: This table displays the percentage of respondents that correctly answered questions about aspects of the campaign. Percentages are shown by sample. "Environmentalists" are respondents who are strictly more environmentally conscious than the median respondent based on a question in the survey about environmentalism. "Shopped Penny" denotes the sample of respondents that shopped at Penny during the campaign. "Penny had campaign" is correct if Penny is part of the chains the respondent thinks had a campaign. "Only Penny had campaign" is correct if Penny is the only chain the respondent thinks had a campaign. "Campaign products identified" is the percentage of campaign products the respondent correctly identified to be part of the campaign. "Non-campaign products identified" is the percentage of non-campaign products the respondent correctly identified to not be part of the campaign.

Table A8: Effectiveness of donation (% agree)

	All	Environmentalists	Shopped Penny
"Future Farmers" project was a good choice	66	76	67
"Future Farmers" project is effective at addressing damages caused	51	67	51
Revenue should have been redistributed to consumers	31	34	40
Revenue should have been given to government for green investments	19	23	22

Notes: This table displays the percentage of respondents that correctly answered questions about aspects of the campaign. Percentages are shown by sample. "Environmentalists" are respondents who are strictly more environmentally conscious than the median respondent based on a question in the survey about environmentalism. "Shopped Penny" denotes the sample of respondents that shopped at Penny during the campaign.

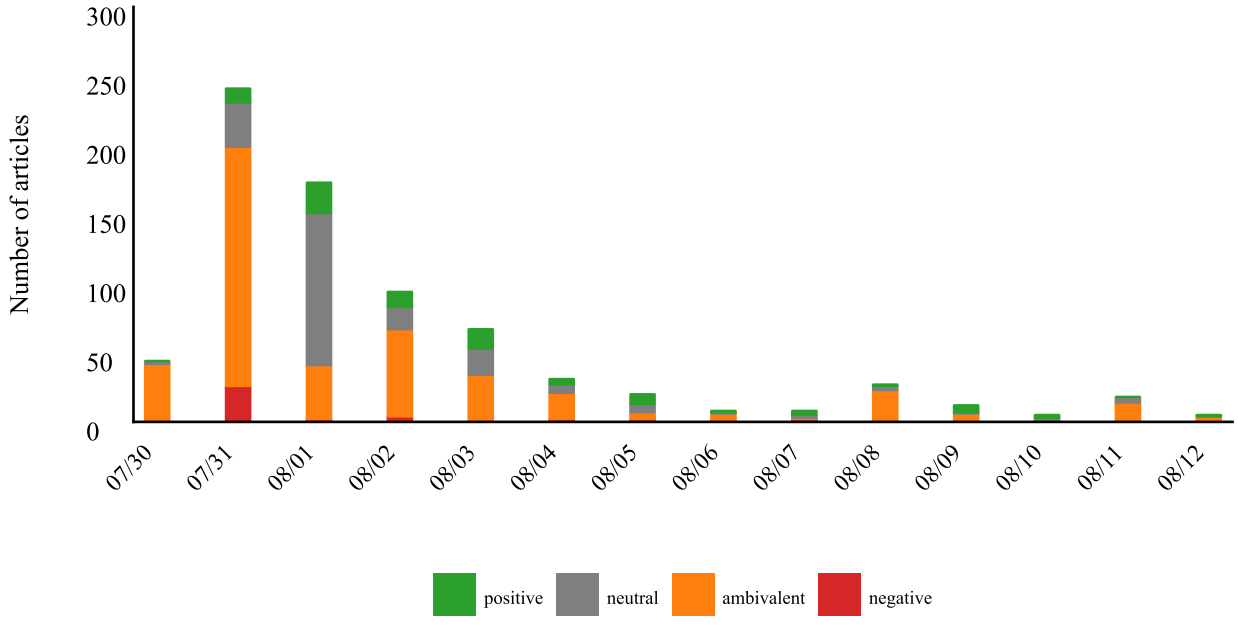
Table A9: Effectiveness of campaign (% agree)

	All	Environmentalists	Shopped Penny
Campaign raised awareness	51	68	50
Campaign led to political debate	32	45	36
Campaign directly reduced damages	20	28	25
Campaign was mere greenwashing, without positive impacts	46	45	47

Notes: This table displays the percentage of respondents that correctly answered questions about aspects of the campaign. Percentages are shown by sample. "Environmentalists" are respondents who are strictly more environmentally conscious than the median respondent based on a question in the survey about environmentalism. "Shopped Penny" denotes the sample of respondents that shopped at Penny during the campaign.

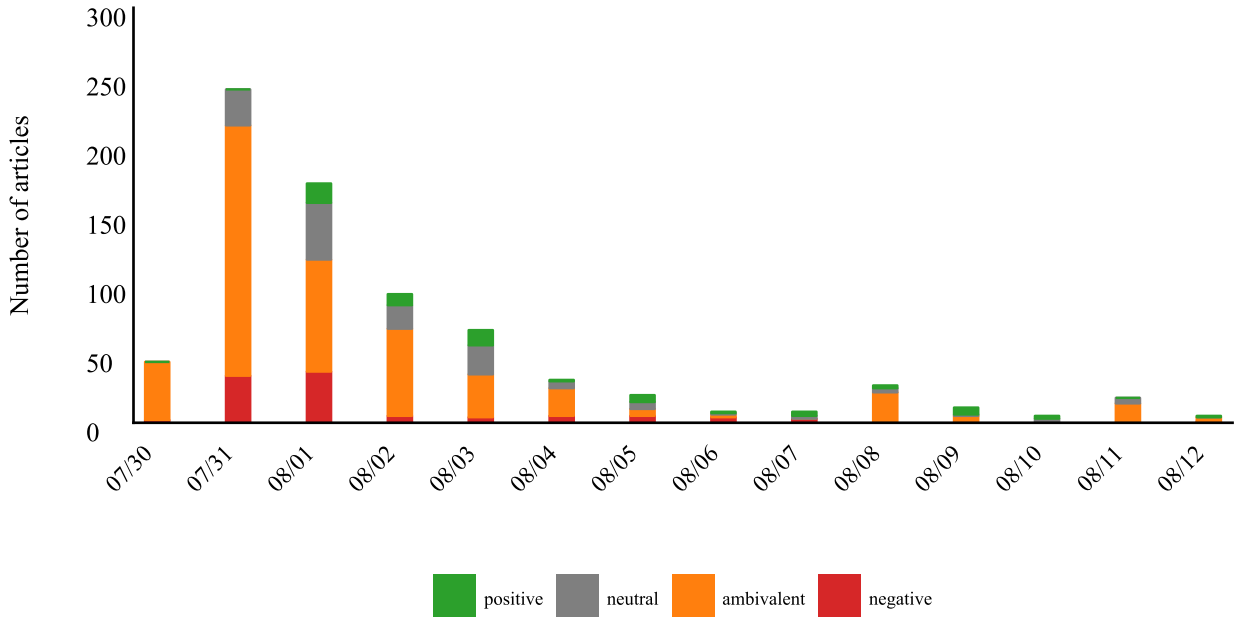
E.3 Media Analysis

Figure A7: **Article Sentiments Penny**



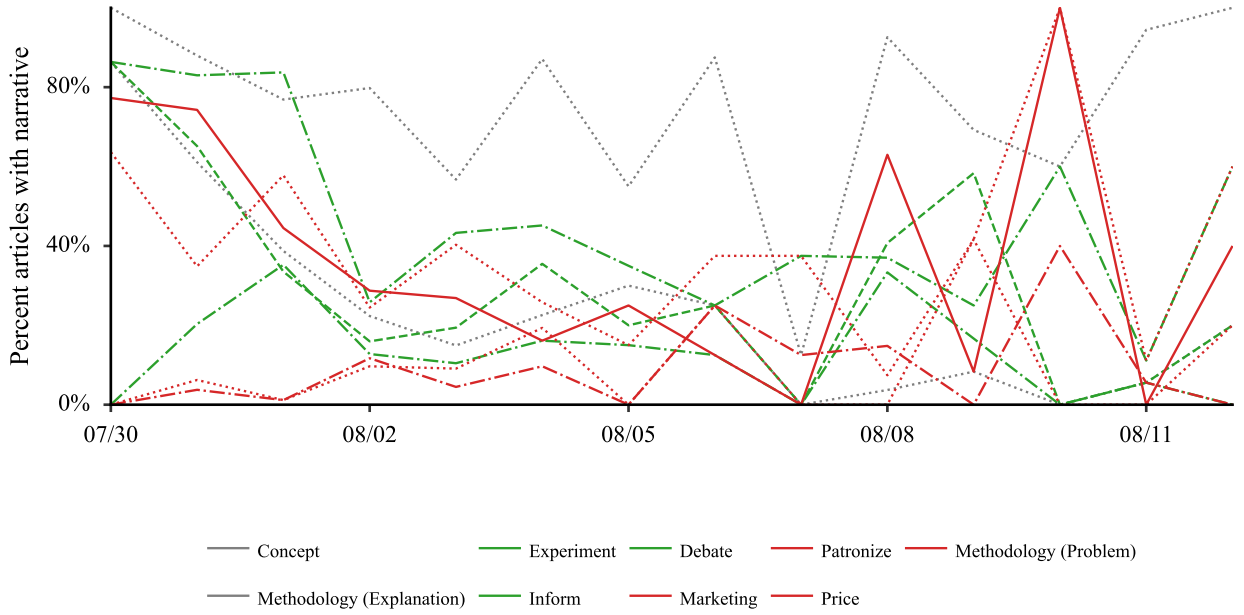
Notes: This figure shows the sentiment towards Penny of articles about Penny. The articles were assessed manually by coders according to the following definitions. Positive: more positive than negative arguments/views. Neutral: mostly objective information, without strong positive or negative arguments/views. Ambivalent: mix of positive and negative arguments/views with high tonality. Negative: more negative than positive arguments/views.

Figure A8: **Article Sentiments Campaign**



Notes: This figure shows the sentiment towards the true cost campaign of articles about the true cost campaign. The articles were assessed manually by coders according to the following definitions. Positive: more positive than negative arguments/views. Neutral: mostly objective information, without strong positive or negative arguments/views. Ambivalent: mix of positive and negative arguments/views with high tonality. Negative: more negative than positive arguments/views.

Figure A9: **Article Narratives**



Notes: This figures shows the narratives of media articles about the true cost campaign. The articles were assessed manually by coders. The narratives were coded in three categories: (1) explainers, (2) portrayed aims, and (3) problems. They were defined as follows. (1) Concept: what true costs are. Methodology: how true costs are calculated. (2) Experiment: campaign was a scientific experiment. Inform: campaign raised awareness. Debate: campaign encouraged political discourse. Marketing: campaign was greenwashing / a PR stunt. Patronize: campaign patronized consumers. (3) Price: concerns about price hikes and current inflation. Methodology: critiques of true cost methodology.

F Campaign Theoretical Results Appendix

F.1 Demand Model

Appendix G derives product-level demand for a three nested CES utility function. Removing the group, retailer and week subscripts, from equation (61) we have that:

$$q_j = \left(\frac{\alpha_j}{p_j}\right)^{\sigma_c} \underbrace{\left(\frac{\alpha_c}{P_c}\right)^{\sigma_g} \left(\frac{\alpha_g}{P_g}\right)^{\sigma} \frac{y}{D} P_g^{\sigma_g} P_c^{\sigma_c}}_{C} \tag{24}$$

for product j in category c and group g.

Adding subscript t and taking logs gives:

$$\ln q_{jt} = \sigma_{ct} \ln \alpha_{jt} - \sigma_{ct} \ln p_{jt} + \underbrace{\ln C_{jt}}_{\delta_{ct}} \tag{25}$$

Assume the following structure for the elasticity of substitution and taste parameter:

$$\sigma_{ct} = \sigma_c, \tag{26}$$

$$\alpha_{jt} = \begin{cases} \alpha_j^c \cdot \alpha_j^{cw} \cdot \tilde{\alpha}_{jt} & \text{if } j \in J^c \text{ and } t \in T^c \\ \alpha_j^{cw} \cdot \tilde{\alpha}_{jt} & \text{if } j \in J^c \text{ and } t \in T^{cw} \text{ and } t \notin T^c \\ \alpha_{je}^{sw} \cdot \tilde{\alpha}_{jt} & \text{if } t \in T_{je}^{sw} \\ \tilde{\alpha}_{jt} & \text{otherwise} \end{cases}, \tag{27}$$

$$\tilde{\alpha}_{jt} := \alpha_{jw} \cdot \kappa_{jt}, \tag{28}$$

where c is the product's category, J^c are the campaign products, T^c is the campaign week, T^{cw} is the 5-week window centered around the campaign week, T_{je}^{sw} is the five week window centered around sales event e for product j, and w is a price window. A new price window starts when:

$$p_{jt} \neq p_{j(t-1)} \quad \bigwedge \quad (j \notin J^c \quad \bigvee \quad t \notin T^c \quad \bigwedge \quad t \notin T_j^s). \tag{29}$$

As a result:

$$\begin{aligned} \sigma_c \ln \alpha_{jt} = {} & \mathbb{1}(j \in J^c)\mathbb{1}(t \in T^c) \underbrace{\sigma_c \ln \alpha_j^c}_{\tau_j} + \mathbb{1}(j \in J^c)\mathbb{1}(t \in T^{cw}) \underbrace{\sigma_c \ln \alpha_j^{cw}}_{\delta_j^{cw}} \\ & + \mathbb{1}(t \in T_{je}^{sw}) \underbrace{\sigma_c \ln \alpha_{je}^{sw}}_{\delta_{je}^{sw}} + \underbrace{\sigma_c \ln \alpha_{jw}}_{\delta_{jw}} + \underbrace{\sigma_c \ln \kappa_{jt}}_{\varepsilon_{jt}} \end{aligned} \tag{30}$$

Substituting this expression into (25) gives:

$$\begin{aligned}\ln q_{jt} = &-\sigma_c \ln p_{jt} + \mathbb{1}(j \in J^c)\mathbb{1}(t \in T^c)\tau_j + \mathbb{1}(j \in J^c)\mathbb{1}(t \in T^{cw})\delta_j^{cw} \\ &+ \mathbb{1}(t \in T_{je}^{sw})\delta_{je}^{sw} + \delta_{jw} + \delta_{ct} + \varepsilon_{jt}\end{aligned} \tag{31}$$

F.2 Welfare Components

Let $\boldsymbol{d}^c$, $\boldsymbol{p}^c = \tilde{\boldsymbol{p}} + \boldsymbol{d}^c$, $\boldsymbol{\phi}^c = \tilde{\boldsymbol{\phi}} - \nu \boldsymbol{d}^c$, and $\boldsymbol{q}^c$ be donations, prices, externalities, and observed quantities during the campaign. Donations during the campaign are $d_j^c = \phi_j$ for the treated products and $d_j^c = 0$ otherwise. Similarly, let $\boldsymbol{d}^b = \boldsymbol{0}$, $\boldsymbol{p}^b = \tilde{\boldsymbol{p}}$, $\boldsymbol{\phi}^b = \tilde{\boldsymbol{\phi}}$,and $\boldsymbol{q}^b$ be donations, prices, externalities, and counterfactual "baseline" quantities without the campaign. Finally, let $\boldsymbol{d}^h = \boldsymbol{0}$, $\boldsymbol{p}^h = \boldsymbol{p}^c$, $\boldsymbol{\phi}^h = \tilde{\boldsymbol{\phi}}$, and $\boldsymbol{q}^h$ be the corresponding variables in a hypothetical scenario where the price increases as in the campaign, but there is no donation and no warm glow.

Let CS denote the consumer surplus. We define ΔCS, ΔE and $\Delta\Pi$ as the changes in consumer surplus, externalities and profits:

$$\Delta CS = CS^c - CS^b \tag{32}$$

$$= \underbrace{CS^c - CS^h}_{\text{warm glow } \Delta WG} + \underbrace{CS^h - CS^b}_{\text{consumption utility } \Delta CU} \tag{33}$$

$$\Delta E = \boldsymbol{q}^c \cdot \boldsymbol{\phi}^c + n^c \phi_n - \left(\boldsymbol{q}^b \cdot \boldsymbol{\phi}^c + n^b \phi_n\right) \tag{34}$$

$$= \underbrace{\left(\boldsymbol{q}^c - \boldsymbol{q}^b\right) \cdot \tilde{\boldsymbol{\phi}} + \left(n^c - n^b\right) \phi_n}_{\text{consumption externalities } \Delta CE} - \underbrace{\nu \boldsymbol{q}^c \cdot \boldsymbol{d}^c}_{\text{donation } \Delta D} \tag{35}$$

$$\Delta\Pi = \boldsymbol{q}^c \cdot (\tilde{\boldsymbol{p}}^c - \boldsymbol{c}^c) - \left(\boldsymbol{q}^b \cdot \left(\tilde{\boldsymbol{p}}^b - \boldsymbol{c}^b\right)\right) \tag{36}$$

F.3 Consumer Surplus

Consumer surplus during the campaign week is

$$CS(\boldsymbol{q}, \boldsymbol{p}, \boldsymbol{\alpha}) = \sum_j \sum_{t=0}^{6} \int_0^{q_{jt}} (D_{jt}(x, \alpha_{jt}) - p_{jt}) dx \tag{37}$$

where $D_{jt}(q_{jt}, \alpha_{jt})$ is the inverse demand function. In CES, inverse demand is

$$D_{jt}(q_{jt}, \alpha_{jt}) = \alpha_{jt} \left(\frac{C_{jt}}{q_{jt}}\right)^{\frac{1}{\sigma_c}} \tag{38}$$

Hence, consumer surplus is

$$CS(\boldsymbol{q},\boldsymbol{p},\boldsymbol{\alpha}) = \sum_j \sum_{t=0}^{6} \int_0^{q_{jt}} \alpha_{jt} \left(\frac{C_{jt}}{q_{jt}}\right)^{\frac{1}{\sigma_c}} - p_{jt} dx \tag{39}$$

$$= \sum_j \sum_{t=0}^{6} \alpha_{jt} C_{jt}^{\frac{1}{\sigma}} \frac{(q_{jt})^{1-\frac{1}{\sigma_c}}}{\left(1-\frac{1}{\sigma_c}\right)} - p_{jt} q_{jt} \tag{40}$$

Based on this, we can compute the change in consumer surplus from the campaign. Let $\tilde{\alpha}_{jt} := \bar{\alpha}_{jt} C_{jt}^{\frac{1}{\sigma_c}}$. Consumer surplus for the three scenarios is:

$$CS^b := CS\left(\boldsymbol{q}^b, \boldsymbol{p}^b, \boldsymbol{\alpha}^b\right) \tag{41}$$

$$= \sum_j \sum_{t=0}^{6} \tilde{\alpha}_{jt} \frac{\left(q_{jt}^b\right)^{1-\frac{1}{\sigma_c}}}{\left(1-\frac{1}{\sigma_c}\right)} - p_{jt}^b q_{jt}^b \tag{42}$$

$$CS^c := CS\left(\boldsymbol{q}^c, \boldsymbol{p}^c, \boldsymbol{\alpha}^c\right) \tag{43}$$

$$= \sum_j \sum_{t=0}^{6} \alpha_j^c \tilde{\alpha}_{jt} \frac{\left(q_{jt}^c\right)^{1-\frac{1}{\sigma_c}}}{\left(1-\frac{1}{\sigma_c}\right)} - p_{jt}^c q_{jt}^c \tag{44}$$

$$CS^h := CS\left(\boldsymbol{q}^h, \boldsymbol{p}^c, \boldsymbol{\alpha}^b\right) \tag{45}$$

$$= \sum_j \sum_{t=0}^{6} \tilde{\alpha}_{jt} \frac{\left(q_{jt}^h\right)^{1-\frac{1}{\sigma_c}}}{\left(1-\frac{1}{\sigma_c}\right)} - p_{jt}^c q_{jt}^h \tag{46}$$

Note that in all three cases, $\tilde{\alpha}_{jt}$ is a sufficient statistic for $\bar{\alpha}_{jt}$ and C_{jt}.

G Structural Model Appendix

G.1 Structural Model Derivation

Preliminaries. Denote the set of product groups by G. Individual groups will be indexed by $g \in G$. Denote the set of categories within a group by C_g, and by $\mathscr{C}^g$ the number of products in C_g. Individual categories will be indexed by $c \in C_g$. Denote by J_c the set of products within a category c, and by $\mathscr{J}^c$ the number of products in J_c. Individual quantities chosen for each product are denoted by q_j. Consumer groups are indexed by k, retailers are indexed by r, and weeks are indexed by w.

Consumers choose quantities q_j of each product to maximize utility:

$$u\left(\boldsymbol{\nu}_{gkrw}, n_{krw}; \boldsymbol{\alpha}_{krw}, m\right) = n_{krw} + \left(\sum_g \alpha_{gkrw} \nu_{hkrw}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{m\sigma}{\sigma-1}} \tag{47}$$

where

$$\nu_g\left(\boldsymbol{\mu}_{ckrw}; \boldsymbol{\alpha}_{krw}^g\right) = \left(\sum_c \alpha_{ckrw} \mu_{ckrw}^{\frac{\sigma_g-1}{\sigma_g}}\right)^{\frac{\sigma_g}{\sigma_g-1}} \tag{48}$$

and

$$\mu_c\left(\boldsymbol{q}_{ckrw}; \boldsymbol{\alpha}_{krw}^c\right) = \left(\sum_j \alpha_{jkrw} q_{jkrw}^{\frac{\sigma_c-1}{\sigma_c}}\right)^{\frac{\sigma_c}{\sigma_c-1}} \tag{49}$$

subject to the budget constraint $y_{krw} = n_{krw} + \sum_{g\in G}\sum_{c\in C_g}\sum_{j\in J_c} p_{jrw} q_{jkrw}$. We solve this problem by backward induction.

Problem in the inner nest. In the inner nest, consumer solves the optimal choice of products within a category by maximizing equation (49) subject to $y_{ckrw} = \sum_{j\in J_c} p_{jrw} q_{jkrw}$, where y_{ckrw} is the (latent) level of expenditure that consumers of group k choose to spend in retailer r in week w.

By properties of CES, demand for each product q_{jkrw} is given by

$$q_{jkrw}^* = \left(\frac{\alpha_{jkrw}}{p_{jrw}}\right)^{\sigma_c} \frac{y_{ckrw}}{D_{ckrw}} \tag{50}$$

where $D_{ckrw} = \sum_{j\in J_c} \alpha_{jkrw}^{\sigma_c} p_{jrw}^{1-\sigma_c}$. Indirect utility from consuming products in category c is

$$\mu_c = y_c D_c^{\frac{1}{\sigma_c - 1}} \tag{51}$$

This allows to derive an expression for total expenditure in goods from group g by summing expenditure over all categories c in group g:

$$\sum_{c \in C_g} y_{ckrw} = \sum_{c \in C_g} \mu_{ckrw} D_{ckrw}^{\frac{1}{1-\sigma_c}} = \sum_{c \in C_g} \mu_{ckrw} P_{ckrw} \tag{52}$$

where $P_{ckrw} = D_{ckrw}^{\frac{1}{1-\sigma_c}}$. This allows to write the problem for the middle nest as a choice of μ_{ckrw}'s given prices P_{ckrw}.

Problem in the middle nest. Let $v_{ckrw}(\mu_{1krw}, ..., \mu_{\mathscr{C}_g krw})$ be the utility from consuming μ_c utils from category c. At the category level, the consumer wants to maximize equation (48) subject to $y_{gkrw} = \sum_{c \in C_g} \mu_{ckrw} P_{ckrw}$.

Again by properties of CES, category-level demands are given by

$$\mu^*_{ckrw} = \left(\frac{\alpha_{ckrw}}{P_{ckrw}} \right)^{\sigma_g} \frac{y_{gkrw}}{D_{gkrw}} \tag{53}$$

where $D_{gkrw} = \sum_{c \in C_g} \alpha_{ckrw}^{\sigma_g} P_{ckrw}^{1-\sigma_g}$.

Expenditure in category c is given by

$$y_{ckrw} = \mu^*_{ckrw} P_{ckrw} = \alpha_{ckrw}^{\sigma_g} P_{ckrw}^{1-\sigma_g} \frac{y_{gkrw}}{D_{gkrw}} \tag{54}$$

Indirect utility from category consumption choices in group g is

$$v_{gkrw} = y_{gkrw} D_{gkrw}^{\frac{1}{\sigma_g - 1}} \tag{55}$$

Hence, total expenditure in inside goods is the sum of expenditures over all inside product groups:

$$\sum_{g \in G} y_{gkrw} = \sum_{g \in G} v_{gkrw} D_{gkrw}^{\frac{1}{1-\sigma_g}} = \sum_{g \in G} v_{gkrw} P_{gkrw} \tag{56}$$

where $P_{gkrw} = D_{gkrw}^{\frac{1}{1-\sigma_g}}$. Again, the problem for the outer nest becomes a choice of v_{gkrw}'s given prices P_{gkrw}.

Problem in the outer nest. In the outer nest, consumer chooses expenditure allocations across the inside product groups and the numeraire good. Specifically, consumer maximizes equation (47) subject to $y_{krw} = n_{krw} + \sum_{g \in G} v_{gkrw} P_{gkrw}$.

By the same arguments as before, group-level demands can be written as

$$v^*_{gkrw} = \left(\frac{\alpha_{gkrw}}{P_{gkrw}} \right)^{\sigma} \frac{y_{krw}}{D_{krw}} \tag{57}$$

where $D_{krw} = \sum_{g \in G} \alpha^{\sigma}_{gkrw} P^{1-\sigma}_{gkrw}$. As before, expenditure in group g is given by

$$y_{gkrw} = v_{gkrw} P_{gkrw} = \alpha^{\sigma}_{gkrw} P^{1-\sigma}_{gkrw} \frac{y_{krw}}{D_{krw}} \tag{58}$$

From these expressions, we can link the three nests of the problem. Specifically, by plugging equation (58) in (53), we can obtain category-level demands as a function of total expenditure in the inside goods:

$$\mu^*_{ckrw} = \left(\frac{\alpha_{ckrw}}{P_{ckrw}} \right)^{\sigma_g} \left(\frac{1}{D_{gkrw}} \right) \left(\frac{\alpha_{gkrw}}{P_{gkrw}} \right)^{\sigma} \left(\frac{I_{krw}}{D_{krw}} \right) P_{gkrw} = \left(\frac{\alpha_{ckrw}}{P_{ckrw}} \right)^{\sigma_g} \left(\frac{\alpha_{gkrw}}{P_{gkrw}} \right)^{\sigma} \left(\frac{I_{krw}}{D_{krw}} \right) P^{\sigma_g}_{gkrw} \tag{59}$$

Plugging equation (58) in (54) allows to compute category-level expenditures as a function of total expenditure in the inside good:

$$y_{ckrw} = \alpha^{\sigma_g}_{ckrw} P^{1-\sigma_g}_{ckrw} \frac{1}{D_g} \left(\alpha^{\sigma}_{gkrw} P^{1-\sigma}_{g} \frac{I_{krw}}{D_{krw}} \right) \tag{60}$$

By plugging equation (60) in (50), we can derive a final expression for product-level demand as a function of inside goods expenditure I_{krw}:

$$q_{jkrw} = \left(\frac{\alpha_{jkrw}}{p_{jrw}} \right)^{\sigma_c} \left(\frac{\alpha_{ckrw}}{P_{ckrw}} \right)^{\sigma_g} \left(\frac{\alpha_{gkrw}}{P_{gkrw}} \right)^{\sigma} \frac{y_{krw}}{D_{krw}} P^{\sigma_g}_{gkrw} P^{\sigma_c}_{ckrw} \tag{61}$$

To close the model, we need to pin down expenditure in the numeraire good. To derive this, we rely on the fact that, under optimality, the marginal utility of the inside goods bundle must equal 1, the marginal utility of the numeraire good (ten Raa 2015). In equilibrium, expenditure on the bundle of inside goods is $I_{krw} = y_{krw} - n_{krw}$. Indirect utility is given by $v(\boldsymbol{q}_{krw}, y_{krw}) = n_{krw} + I^m_{krw} D^{\frac{m}{\sigma-1}}_{krw}$. Hence, marginal utility from expenditure on the inside goods bundle is

$$\frac{\delta v}{\delta I_{krw}} = m I^{m-1}_{krw} D^{\frac{m}{\sigma-1}}_{krw} \tag{62}$$

Equating equation (62) to 1, it follows that expenditure on the bundle of inside goods in equilibrium is given by

$$I_{krw} = \left(\frac{1}{m D_{krw}^{\frac{m}{\sigma-1}}} \right)^{\frac{1}{m-1}}. \tag{63}$$

G.2 Structural Model Estimation

Taste parameter identification. Following equation (50), optimal demand for product j is given by (omitting other subindices for brevity):

$$q_j^* = \left(\frac{\alpha_j}{p_j} \right)^{\sigma} \frac{y}{D} \tag{64}$$

Rearranging:

$$\frac{D}{y} = \frac{\alpha_j^{\sigma} p_j^{-\sigma}}{q_j} \tag{65}$$

Since the left-hand side of equation (65) is constant across products, for any two products j and k, it follows that

$$\frac{\alpha_j^{\sigma} p_j^{-\sigma}}{q_j} = \frac{\alpha_k^{\sigma} p_k^{-\sigma}}{q_k}, \tag{66}$$

which can be rewritten as

$$\alpha_k = \alpha_j \left(\frac{q_k p_j^{-\sigma}}{q_j p_k^{-\sigma}} \right)^{\frac{1}{\sigma}}. \tag{67}$$

Taking the sample mean over all products k in the category:

$$\frac{1}{\mathscr{J}_c} \sum_k \alpha_k = \frac{1}{\mathscr{J}_c} \sum_k \alpha_j \left(\frac{q_k p_j^{-\sigma}}{q_j p_k^{-\sigma}} \right)^{\frac{1}{\sigma}} \tag{68}$$

Rearranging, and letting $\varphi = \frac{1}{\mathscr{J}_c} \sum_k \alpha_k$ be the mean of the taste parameters, we arrive at a unique solution for α_j as a function of φ:

$$\alpha_j = \mathscr{J}_c \varphi \frac{q_j^{\frac{1}{\sigma}} p_j}{\sum_k q_k^{\frac{1}{\sigma}} p_k}. \tag{69}$$

Taste parameters at the category and product levels can be derived analogously.

Inside goods expenditure. Equation (63) pins down expenditure on the inside goods I_{krw} as a function of m and $D_{krw} = \sum_{g \in G} \alpha_{gkrw}^{\sigma} P_{gkrw}^{1-\sigma}$, which, given P_{gkrw}, is a function of the scale of the taste parameters φ.

We solve for m and φ by minimizing the distance between inside good expenditures in the data and its model-implied counterparts.

Taste parameter scaling. To close the model, we need to pin down the scale of the taste parameters in the three nests. Let φ, φ' and φ'' be the mean of the taste parameters at the group, category, and product level, respectively. The three parameters affect the recovery of I_{krw}: φ determines the scale of α_{gkrw}, and φ' and φ'' determine the scale of the price index P_{gkrw}. We identify φ via the minimum distance estimator described above. We identify φ' by minimizing the distance between quantities demanded in the data and its model-implied counterparts, using equation (61). To counteract the cross-sectional variation in P_{gkrw} that comes purely from differences in the number of products per product category, we calibrate φ''_c such that the CES price indices for each chain $\times$ product category attain the same sample mean over all weeks.