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 selected 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. To quantify the effects of alternative policies, we build a structural model of retailer and grocery choice, in which we allow for rich substitution patterns across product categories, and estimate it using home scanner data. The model predicts that a cross-subsidy from high- to low-externality foods can generate even larger welfare gains per dollar of forgone profits than the pricing campaign. However, the welfare gains of such unilateral green retailing campaigns remain orders of magnitude below a first-best Pigouvian tax.

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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. Can firms both help the environment and increase profits? For retailers, what are the merits of different environmental strategies, such as decarbonizing supply chains, green marketing campaigns, and 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 may place some 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 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, imperfectly competitive retailers sell goods with different negative production externalities. At least some consumers are altruistic: due to pure altruism 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 CO2 emission offsets. Retailers maximize profits net of negative environmental externalities, with some weakly positive 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 on how its pricing affects substitution to other products with higher or lower externalities. In that case, both costly externality reductions and cross-subsidies can be optimal. For example, the retailer might increase the price of beef, which imposes large negative externalities, while reducing the price of plant-based meat substitutes. The retailer's optimal abatement for a given product depends on the extent to which abatement increases demand and, if $\omega > 0$, the extent to which abatement reduces externalities from that product and the effects on externalities from substitution.

We use the framework to introduce a new statistic that we call the marginal value of profit reduction, or MVPR. It is a cousin to the marginal value of public funds (MVPF) introduced by Hendren and Sprung-Keyser (2020). While the MVPF is the value of societal benefits per dollar of spending on a given government program, the MVPR is the ratio of societal benefits per dollar of profit reduction on a given corporate strategy. We use the MVPR to rank different corporate strategies that might benefit consumers or the en-

vironment at the firm's expense, and we imagine that the MVPR concept could be more broadly useful in evaluating corporate social and environmental strategies outside this paper.

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 59 percent of Germans reported hearing about Penny's campaign.

Penny's campaign could have affected demand for the nine campaign products 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 above and below the base price, this implies that the warm glow effect shifted demand significantly outward. We do not find statistically significant substitution to products in the same categories.

To understand the mechanisms for these effects, 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. While actual uninternalized externalities differ substantially across products, consumers' (incentivized) average beliefs about those 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 20 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, initially in a simplified setting assuming that there is no substitution to or from other retailers. We assume that the donation shifted the demand curve outward, to explain the lower-than-expected demand response. We estimate that the price increase reduced consumer surplus by about €274,000, while the demand shift due to the donation increased consumer surplus by €279,000. The change in purchases reduced externalities by between €0 and €241,000, depending on which products consumers bought instead, in addition to the

€316,000 in donations to agricultural energy efficiency.[1] Penny's profits dropped by €19,000 during the campaign, assuming no change in demand for other products. Overall, we estimate that the marginal value of profit reduction from the campaign is 17-29. That is, the campaign generated between €17 and €29 of consumer surplus and environmental benefits for every €1 of lost profits.

Of course, a true cost pricing campaign on a subset of products is only one possible strategy that retailers might consider. Moreover, an initiative's effects depend importantly on substitution across products. To evaluate alternative possible strategies and substitution patterns, 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 shorter travel times. Second, once at a retailer, they make a continuous choice of how much to buy of each grocery product. We identify grocery product substitution patterns from time series price variation from retailer promotions, following Allcott et al. (2019b), DellaVigna and Gentzkow (2019), and others. We identify retailer preferences by combining price variation across retailers and product categories with 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 consider three counterfactual scenarios. First, we consider the effects of a voluntary policy in which Penny implemented the true cost campaign for one year, instead of one week, for the nine products selected in the real-world campaign. This counterfactual campaign has positive welfare effects, with reductions in externalities from donations and shifts to low-externality products more than offseting decreases in conusmer surplus and profits at Penny. Increases in surplus are larger once we account for the demand shift effect of the campaign. Second, 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 slightly larger effects than the year-long true cost campaign, by introducing externality pricing to all products within a category while keeping revenues constant for the retailer. Third, 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, estimated welfare effects are substantially larger than those estimated for the voluntary retailer campaigns. This underscores that unilateral voluntary action by firms is not a substitute for efficient government policy.

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 envi-

[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.

[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).

ronmental 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.

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 report having objectives that are broader than just profits, 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 may 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 at least four reasons. First, retail policies targeting consumption changes can be highly impactful. A significant share of global greenhouse gas 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

[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. (2019a), 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).

more greenhouse gases 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. Third, as consumer-facing entities, retailers are well-positioned to gain reputational benefits from implementing green policies.

Fourth, 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 grocery retail policies can shift consumption toward the social optimum in cases where first-best policies are politically or technically infeasible.

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. 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). The main discounters are Aldi, Lidl, Netto Markendiscount, Penny, and Norma (Aygün 2012; Hahn Gruppe 2023), with a combined market share of 33 percent (NielsenIQ 2023). Penny had a 3.3 percent market share and generated €8.8 billion in revenues in 2022 (NielsenIQ 2023; 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 dairy products, and one plant-based meat alternative. Except for the latter, the products always included the conventional and organic version of the same product. Penny's management chose the nine products. 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. 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 rounded up

the donations and added €50,000, donating a total of exactly €375,000, and this amount was also matched by the dairy supplier. 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. Thus, it is unlikely that consumers were aware of it when shopping during the campaign week. Moreover, only 6.3 percent of vouchers were redeemed.

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 assessments of marginal damages to monetize each product's 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 per kilogram (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 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.[7] In most of these articles and unlike before the campaign, Penny was the main topic; see Appendix 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. To match our empirical setting, we consider only externalities from products sold, not externalities from the retailer's internal operations.

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.

[7] 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 4.5.

Consumers choose inside good consumption $\boldsymbol{q}$ plus the quantity of a numeraire good n. Consumers maximize utility $u(\boldsymbol{q}, n; \boldsymbol{\phi})$ subject to their budget constraint.[8] The inclusion of the term $\boldsymbol{\phi}$ captures altruism, and we assume weakly higher demand for products with less negative externalities: $\partial q_j / \partial \phi_j \leq 0$. We assume for simplicity that consumers perceive the externalities correctly. As we show in Section 5.1, 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. Marginal cost is a weakly decreasing function of negative externalities: $c_j'(\phi_j) \leq 0$, meaning that it's more expensive to make goods with lower negative externalities. 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

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

As written, the retailer cares about externalities from products sold by other retailers. Without this term, 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. For example, 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

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

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, 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 and from other retailers.

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

[8] For simplicity, the externality of the numeraire good is assumed to be zero. In Europe, this can be partially justified by the existence of the Emissions Trading System.

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

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 effect on externalities from product j, and the indirect externality effects through diversion.

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 might reduce retailers' incentive to decarbonize an already low-externality product, because they would ignore how demand shifts from higher-externality products when they decarbonize.

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.

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 ($\partial q_{jr}/\partial \phi_{jr} < 0$). 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 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 pro-environmental initiatives at otherwise profit-maximizing retailers can generate large environmental benefits per dollar of profit lost.

3.3 Welfare Effects

We use our framework to evaluate the welfare effects of corporate strategies and government policies related to green retail. Let ΔCS, $\Delta\Pi$, ΔE, and ΔG be the changes in consumer surplus, profits, uninternalized externalities, and net government revenues, respectively, from a non-marginal change in a retailer's policy. Green retailing policies may affect externalities through changes in the composition of goods purchased or the per-product externalities.

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

$$\Delta TS = \Delta CS + \Delta\Pi - \Delta E + \Delta G. \tag{4}$$

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

$$MVPR = \frac{\Delta CS + \sum_{k \neq r} \Delta \Pi_k - \Delta E + \Delta G}{-\Delta \Pi_r}. \tag{5}$$

The MVPR is analogous to the marginal value of public funds (MVPF) proposed by Hendren and Sprung-Keyser (2022). While the MVPF allows a government to compare the net benefits of alternative policies per dollar of government spending, the MVPR allows a firm to compare the net benefits of alternative strategies per dollar of profit loss. 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 weigh consumer surplus or negative externality reduction more heavily than effects on competitors' profits. Indeed, equation (1) assumes that the weights on the consumer surplus, government surplus, and other firms' profits are zero. A final advantage of the MVPR compared to the change in total surplus is that by normalizing into effects on profits, corporate strategies of different magnitudes can be compared.

3.3.1 Offsets

In Penny's true cost campaign, Penny increased the prices of certain goods and donated the additional markup to projects that should reduce externalities. To illustrate the welfare effects of this strategy, we temporarily abstract away from substitution to other inside goods and consider a stylized example of 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 monopolist offsets the entire externality ϕ. In this case, the product and retailer substitution terms of equation (21) equal 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 $c^c = c^b + \phi$. 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 ABCF 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 starting at campaign quantity q^c (or line segment CD).[9] Let CS^c, CS^b and CS^h be consumer surplus for the campaign, baseline and hypothetical

[9]Note that the order of the decomposition matters. Alternatively, one can set the warm glow effect to the difference in the demand curves at the baseline price p^b and the price effect to the be the difference in the area under the campaign demand curve D^c at p^b and p^c.

scenarios, respectively. Then,

$$\Delta CS = \underbrace{CS^c - CS^h}_{\text{warm glow effect}} + \underbrace{CS^h - CS^b}_{\text{price effect}}. \tag{6}$$

We also decompose the externality change into a donation and a substitution effect. The donation effect is the campaign quantity q^c times the difference in the price $p^c - p^b = \phi$ (area ABDG). The substitution effect on externalities of one good is the difference between the campaign quantity q^c and the baseline quantity q^b times the externality ϕ (area DEFG). 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 (area FGHI).

3.3.2 Cross-subsidy

Later in the paper, we consider an alternative green retail strategy: a cross-subsidy. Equation (2) shows that if $\omega > 0$, it can be optimal to cross-subsidize high-ϕ and low-ϕ goods. Define ϕ^{max} and ϕ^{min} as the highest- and lowest-externality goods. 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 Penny believed might contain substitutes, 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), product-level information (e.g., brand, name, size, and whether the product is organic), and receipt-level information about campaign voucher usage.

The 2.8 billion item-level scans cover 14 percent of revenues in 2022. Thanks to the relatively high demand for control group products, the 1.1 billion observations in the receipt data cover 77 percent of revenues (in 2022).

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, because only a handful of stores are open on Sundays. Appendix Figure A3 shows the price and average quantity sold for the average campaign product.

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. The AiMark data are 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 households 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, assuming no traffic.

We limit the analysis to standard grocery items, excluding alcohol, beverages, baby food, and non-food items. We define 23 categories of goods based on our assessment of (i) product homogeneity (elastic substitution within a category and less elastic substitution across categories) and (ii) similar uninternalized externalities. Appendix Table A1 presents the average uninternalized externalities, average purchases (in calories per household-week), and number of products for each category.

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.[10]

4.3 Product Characteristics Data

We obtain product characteristics from Open Food Facts, a crowdsourced database of food products. From Open Food Facts, we obtain kcal/g for products in the home scanner data. We merge this dataset with the home scanner dataset by barcode, and compute kcal/g per category as the average kcal/g over all products in the category for which we observe nutritional content. We measure consumption in kilocalories throughout the paper.

[10] In the home scanner data, we are only able to see prices for a product-chain combination in a given week if at least one household in the sample purchased the product within that week. For products that are infrequently purchased, this leads to an imbalanced panel of prices over time. We assume that consumers' choice set consists of all products that have been purchased by at least one household in at least one week. The procedure for imputing prices of product-chains for which we don't observe purchases in a given week is described in Appendix B.2.

4.4 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).[11] 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 retailers 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; Destatis 2021b), number of household members, and household income (Destatis 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 reasons 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

[11] 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.

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 Appendix Table A2.

4.5 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 showed high inter-coder agreement of at least 82 percent on all questions, except sentiments toward Penny where the agreement was 69 percent, see Appendix Table A3.

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 and look at various other survey outcomes, including perceptions of Penny and policy preferences. Second, we show that the polarizing view of the campaign is in line with media coverage at the time. Third, we show that consumers responded less strongly to the change in prices than under other week-long price changes. Finally, we estimate the effect of the campaign on total welfare.

5.1 Survey Results

We begin by analyzing a nationally representative survey we fielded 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.

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 5 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. 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, and we thus do not model changes in beliefs.

The campaign was remarkably well known. At endline, 59 percent of participants knew that Penny had a true cost campaign. Surprisingly, while this number is higher for those who had shopped at Penny (75 percent), it is still high for those who had not (55 percent). The number is also robust to over-reporting: 56 percent of participants only selected Penny (and none of the other six retailers listed), while 56 percent selected Penny at endline but not at baseline. However, participants did not understand the details well. Only 40 percent knew that the true costs were calculated by scientists.

Instead of externality beliefs, the survey results suggest that the lower-than-expected reduction in demand comes from the donation. Participants who reported buying at least one campaign product (n=119) agreed that important factors were the donation (68 percent) and their interest in sustainability generally (74 percent).

After the campaign, there was a strong reduction in the support for true cost information, true cost pricing, and environmental taxation, see Figure 8. 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 53 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 any positive impact. See Appendix E.1 for additional supporting information and results of the surveys.

5.2 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 both strong positive and negative views; see Appendix Figure A8. Interestingly, sentiments towards the campaign itself were more likely to be positive; see Appendix Figures A8 and A10. 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 A10).

5.3 Effect on Sales

In this subsection, we estimate the effect of the campaign on demand and compare it to the effect that would be predicted by the campaign products' demand elasticity. To derive our estimating equation, we assume that consumers maximize a constant elasticity of substitution (CES) utility function, consistent with our structural model in Section 6. Under CES utility, demand for product j in category c on day t is:

$$q_{jt} = \left(\frac{\alpha_{jt}}{p_{jt}}\right)^{\sigma_c} C_{ct}, \tag{7}$$

where q_{jt} is the quantity demanded, α_{jt} is a demand shifter, p_{jt} is the price, σ_c is the elasticity of substitution, and C_{ct} is a function capturing substitution between products, between categories, and between inside goods and the numeraire. We write out C_{ct} formally in Section 6.

We allow for the possibility that the campaign affected the demand shifters α_{jt} for campaign products, perhaps because the promised donations to energy efficiency projects increased warm glow:

$$\alpha_{jt} = \begin{cases} \alpha_j^c \cdot \bar{\alpha}_{jt} & \text{during the campaign} \\ \bar{\alpha}_{jt} & \text{otherwise.} \end{cases} \tag{8}$$

To identify the elasticity parameter σ_c and the demand shifters α_j^c, we use an event study design. We identify σ_c using the effects of temporary sales that occurred before the campaign, and we infer the demand shifter α_j^c from the effects of the campaign on sales (residual of the price change). Penny usually implements temporary sales for a product at all stores nationwide. For a given product, we define a "sales event" as a period when the median price across stores is constant for one week and lower than the median price paid on each day of the previous and following four weeks.

We motivate this approach with event study graphs. Figure 7a shows the normalized price and quantity around sales events for the nine campaign products. In the average sales event, price decreases by 14 percent, and quantities increase by 46 percent, suggesting an arc price elasticity of about 3.2. Quantities are fairly stable in the weeks before and after, suggesting that the changes are caused by the price reduction and not by confounding changes in demand shifters.

Figure 7b 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. For the average campaign

product, price increased by 60 percent, and quantity decreased by 31 percent, suggesting an arc price elasticity of about 0.5. Comparing the two panels shows that demand is significantly less elastic during the campaign than during sales events. If demand is indeed isoelastic, then the reduced response to the price increase from the true cost campaign is consistent with some offsetting increase in the demand shifter α_j^c.

We run an event study regression to formally estimate the effects of the campaign and the prior sales events. To only use sales events for the identification of the price elasticity σ_c, we include a fixed effect for each price window w of product j starting when the price of good j changes, except during the campaign and during sales events. We also include fixed effects for the five-week windows around the campaign and each sales event, to control for changes in demand unrelated to the event. In Appendix F.1, we show that after logging equation (7) and disaggregating C_{ct} into various fixed effects, we have the following regression model:

$$\ln q_{jt} = -\sigma_c \ln p_{jt} + \mathbb{1}_{jt}^{c} \tau_j + \mathbb{1}_{jt}^{cw} \delta_j^{cw} + \sum_{e \in E_j} \mathbb{1}_t^{ew} \delta^{ew} + \delta_{jw} + \delta_{ct} + \varepsilon_{jt}, \tag{9}$$

where $\mathbb{1}_{jt}^{c}$ is an indicator for whether j is a campaign product and t is in the campaign week, $\mathbb{1}_{jt}^{cw}$ is an indicator for whether 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 an indicator for whether 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. We cluster standard errors by product and week of sample.

Table 2 presents the full regression results. Column (3) is our main specification. In that column, the price elasticities for the four product categories range from 1.41 to 2.83. Across the nine campaign products, the campaign increased demand shifters by between 0.10 and 1.18 log points, after accounting for the price change during the campaign. The results are robust to a different selection of fixed effects (columns 1-2) and to different standard error specifications (Appendix Table A9).

Using the regression results, we decompose the campaign effect into the predicted effect of the price change and the residual effect on the demand shifter α_j^c. Our measure for the campaign effect is $\mathbb{E}(\Delta \ln q_{jt} | p_{jt} = p_j^c, \alpha_{jt} = \alpha_j^c \cdot \bar{\alpha}_{jt}) - \mathbb{E}(\Delta \ln q_{jt} | p_{jt} = p_j^b, \alpha_{jt} = \bar{\alpha}_{jt})$, where p_j^c and p_j^b are the campaign and baseline prices and α_{jt} captures demand shifters. By (9) and using "hat" notation to indicate parameter estimates, the predicted effect of the campaign (including both price and demand shifter effects) is

$$\underbrace{\widehat{\Delta \ln q_j}}_{\text{campaign effect}} = \underbrace{-\widehat{\sigma}_c \Delta \ln p_j}_{\text{price effect}} + \underbrace{\widehat{\sigma_c \ln \alpha_j^c}}_{\text{demand shift}, = \widehat{\tau}_j}. \tag{10}$$

Figure 7 presents results. The first bar for each product is the predicted price effect, while the second bar is the approximate campaign effect. The difference between the two bars is the inferred (approximate) demand shift. For the average campaign product, the change in log demand is less than half what it would be without the demand shift. For one product, the demand shift more than offsets the price effect, leading to a slight increase in consumption relative to the baseline scenario.

Note that we are abstracting from category-level substitution and income effects captured by C_{ct} in equation (7) and by the fixed effects of (9). Using analogous regression specifications, we do not find a statistically significant effect on substitution toward other products (Appendix Table A11). However, the results are imprecisely estimated and we also cannot rule out full substitution (Appendix Section E.4). Similarly, we do not find any statistically significant effects on Penny's overall revenues, but cannot rule out economically meaningful effects (Appendix Section E.5). We will return to estimating substitution effects using our structural model in Section 7.

Several factors could explain these large implied demand shifts. First, demand might not be isoelastic. However, the elasticity would have to be very different above versus below the base price to explain our results. Second, stockpiling could magnify the effects of sales and dampen the effect of prices increases (Hendel and Nevo 2006). Following DellaVigna and Gentzkow (2019) and Allcott et al. (2019a), we include leads and lags of the prices to gauge the relevance of stockpiling. While these variables increase the model fit, their coefficients are two orders of magnitude smaller than the contemporaneous price (Appendix Table A10), meaning that stockpiling alone cannot explain the campaign demand shift. Third, if the true cost campaign price increases were advertised less heavily than typical sales, that could moderate the effect on purchases. However, 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. Fourth, the energy efficiency donations associated with the price increase could have shifted demand outward by activating warm glow. This is consistent with the survey results described in Section 5.1. In the next sections, we refer to this demand shift as a "warm glow effect" for shorthand, acknowledging that our data do not allow us to isolate warm glow as the cause.

5.4 Welfare

In this section, we estimate the welfare implications of the true cost campaign. We consider the effects of the price change and do not fully 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 3.3.1. 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 demand shift effect, and the change in externalities into a donation and substitution effect. Appendix F.2 provides formal definitions. 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—which simulate demand at baseline prices without and with the demand shift, respectively—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 demand shift. We use equation (7), 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 $\bar{\alpha}_{jt}^{\sigma_c} C_{ct}$. We then assume that baseline and hypothetical quantities are

$$q_{jt}^b = \bar{\alpha}_{jt}^{\sigma_c} C_{ct} \left(p_{jt}^b\right)^{-\sigma_c} \qquad q_{jt}^h = \bar{\alpha}_{jt}^{\sigma_c} C_{ct} \left(p_{jt}^c\right)^{-\sigma_c}.$$

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. We infer marginal cost assuming that all products have the same percent markup at baseline: $c_{jt} = \kappa p_{jt}$. We estimate κ as one minus the profit margin of Penny's parent company.[12] Finally, we assume that a 1€ donation offsets externalities by 1€.

Figure 9 presents results. We estimate that the price increase reduced consumer surplus by about €274,000, while the demand shift increased consumer surplus by €279,000. Assuming that consumers shift their expenditure to products with the same externalities, there was no change in externalities from product substitution. Assuming instead that consumers shifted their expenditure to an outside good with no externalities, the change in purchases reduced externalities by €241,000. In addition, the campaign led to €316,000 in donations to agricultural energy efficiency. Penny's profits decreased by €19,000 due to the campaign, assuming that demand for other products at Penny did not change. As a result, total surplus increased by an estimated €302,000-€543,000. The estimated marginal value of profit reduction (MVPR) from the campaign—that is, the ratio of consumer and environmental gains to profit reductions—is 17-29. In words, the campaign increased consumers surplus and reduced environmental externalities by between 17 and 29 euros for every euro of lost profit.

These welfare estimates only account for limited substitution effects. On the one hand, our consumer surplus and externality estimates are relative robust to substitution effect: the change in consumer surplus indirectly assumes substitution to the best available alternative, while we provide a plausible range for the effect on externalities. Given that households need to consume a certain amount of calories, it is likely that they bought other food items. If they substituted to products in the same category (at Penny or another retailer), the externalities will be approximately the same (our lower bound). However, given that the price change is proportional to externalities, it is likely that they switched to lower externality products on average, in which case the welfare effect would be closer to the upper bound. On the other hand, the estimated change in profits does not account for any substitution effects. If consumers substituted to other products within Penny, the change in profits will be lower, and depend on the prices and markups of the substitute products. At the same time, Penny's market share may have also changed, depending on the relative sizes of the negative effect of the price change and the positive effect of the demand shift. We return to this question in Section 7.

[12] We use the numbers for Penny's parent company, the REWE Group, since it does not disclose profits by subsidiary. We set $\kappa = 1 - \frac{\text{profit}}{\text{revenue}}$, where profit and revenue are the REWE Group's reported Earnings Before Interest, Taxes, Depreciation and Amortization (EBITDA) and revenues in 2023, respectively. Using REWE Group (2024), our estimate is $\kappa = 0.9382$.

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 make decisions 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 product consumption 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 consumer 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

$$\mu_c\left(\boldsymbol{q}_{ckrw};\boldsymbol{\alpha}^c_{krw}\right)=\left(\sum_j \alpha_{jkrw} q_{jkrw}^{\frac{\sigma_c-1}{\sigma_c}}\right)^{\frac{\sigma_c}{\sigma_c-1}} \tag{11}$$

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 the properties of the CES model, consumer utility over product categories and groups also has the

CES form.[13] 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

$$v_g\left(\boldsymbol{\mu}_{ckrw};\boldsymbol{\alpha}^g_{krw}\right)=\left(\sum_d \alpha_{dkrw}\mu_{dkrw}^{\frac{\sigma_g-1}{\sigma_g}}\right)^{\frac{\sigma_g}{\sigma_g-1}} \tag{12}$$

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

$$u\left(\boldsymbol{v}_{gkrw},n_{krw};\boldsymbol{\alpha}_{krw},m\right)=n_{krw}+\left(\sum_h \alpha_{hkrw}v_{hkrw}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{m\sigma}{\sigma-1}} \tag{13}$$

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

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

$$q_{jkrw}=\left(\frac{\alpha_{jkrw}}{p_{jrw}}\right)^{\sigma_c}\left(\frac{\alpha_{ckrw}}{P_{ckrw}}\right)^{\sigma_g}\left(\frac{\alpha_{gkrw}}{P_{gkrw}}\right)^{\sigma}\frac{y_{krw}}{D_{krw}}P_{gkrw}^{\sigma_g}P_{ckrw}^{\sigma_c} \tag{14}$$

as well as total expenditure on the inside goods:

$$I_{krw}=m^{\frac{1}{1-m}}D_{krw}^{\frac{1}{(1/m-1)(\sigma-1)}}. \tag{15}$$

Demand functions at the product group level take analogous expressions to equation (14).

6.1.2 Estimation

We identify the σ parameters using price variation within retailers across weeks. Logging equation (14) gives

$$\ln q_{jkrw}=\sigma_c\ln\alpha_{jkrw}-\sigma_c\ln p_{jrw}+\sigma_g\ln\alpha_{ckrw}+(\sigma_c-\sigma_g)\ln P_{ckrw}+\sigma\ln\alpha_{gkrw}+(\sigma-\sigma_c)\ln P_{gkrw}+\ln\left(\frac{y_{krw}}{D_{krw}}\right). \tag{16}$$

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

[13] A full derivation of the model is provided in Appendix G.1.

$$\ln q_{jkrw} = (1-\sigma_c)\ln p_{jrw} + \lambda_{jkr} + \lambda_{krw} + \lambda_{jkw} + \varepsilon_{jkrw}, \tag{17}$$

and we estimate equation (17) 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 (14). Given the α_{jkrw}, we construct category-level price indices $\boldsymbol{P}_{ckrw}$ and repeat the procedure at the 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 (15). For $\sigma > 1$, m and I are monotonically positively related when $0 < m < 1$.

6.1.3 Estimation Results

We first graphically illustrate the parameter identification strategy. Figure 10 illustrates an example of the variation used to identify σ_g in equation (17), using an example category for each product group (beverages, non-protein foods, and protein foods). Each 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_g, after conditioning on various fixed effects. Figure 11 is a binned scatterplot of the identification of σ, which we identify by estimating an equation analogous to equation (17) at the product group level. To minimize sample selection concerns, we identify the category-level elasticities by estimating equation (17) using the set of product-retailer pairs that are present in at least 50 weeks in the data.

Panel (a) of Table 3 presents the second stage parameter estimates, including elasticities of substitution σ and σ_g, scaling parameters ϕ and ϕ', and numeraire good substitution parameter m. We estimate a demand elasticity of substitution across product groups of 1.31. Our estimates for σ_g, the elasticities of substitution of product categories within a group, are typically between 1.5 and 5, which is consistent with analogous estimates in the US grocery retail market (e.g., Cao 2023). Elasticities of substitution within a nest are higher than elasticities of substitution across different nests, meaning that, if the price of one product category (for example, red meats) increases, consumers are more likely to substitute towards categories within the same nest (for example, meat substitutes) than towards categories in other nests (such as coffee).

We assess the sensitivity of our estimated elasticities to stockpiling. As in Section 5.3, we include leads and lags of prices to equation (17), where, for simplicity, we estimate a common price elasticity for all categories. Results are reported in Table A13. While lags are an orders of magnitude greater than those estimated in Table A10 for the Penny data, the contemporaneous price elasticity is similar to the one estimated in the main specification. Thus, it is unlikely that stockpiling alone explains the observed price responses.

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 a transaction made at retailer r in week w. In each transaction, household i has the preferences $\boldsymbol{\alpha}_{irw} \coloneqq (\boldsymbol{\alpha}_{ckrw}, \boldsymbol{\alpha}_{gkrw})$ associated with the chosen retailer r in week w.

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, as defined in equation (67) in Appendix G. d_{ir} is the driving 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

$$V_{irw} = \theta_1 [v_{irw}(\boldsymbol{p}_{rw}, I_{irw}; \boldsymbol{\alpha}_{irw}) - \chi d_{ir}] + \theta_2 l_{ir} + \xi_r. \tag{18}$$

θ_1 is the marginal utility of money net of travel costs, θ_2 is lower-income consumers' additional preference for discounters, and ξ_r is a retailer fixed effect. We calibrate χ, the marginal disutility of travel measured in euros per minute, to be equal to 0.32, the median earnings per minute in Germany in 2022 (Eurostat 2025). We 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 for each unique shopping trip t are:

$$Pr_{irt}(\boldsymbol{\theta}, \boldsymbol{\xi}) = \frac{e^{V_{irt}}}{\sum_{s \in \mathscr{R}_i} e^{V_{ist}}}. \tag{19}$$

The likelihood function is then

$$L(\boldsymbol{\theta}; \boldsymbol{\xi}) = \prod_i \prod_t Pr_{irt}(\boldsymbol{\theta}, \boldsymbol{\xi}). \tag{20}$$

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

6.2.3 Estimation Results

Figure 12 presents the variation that identifies θ_1, the marginal utility of money net of travel costs 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.

Variation in distance, as well as variation in prices across chains and time (as documented in Figure 10) and variation in taste parameters across consumer groups, chains, and time, is what identifies the marginal utility of money net of travel costs θ_1.

Panel (b) of Table 3 presents the first stage parameter estimates $\boldsymbol{\theta}$ and $\boldsymbol{\xi}$. We estimate that low-income households have an additional preference for discounters of 1.15€. We estimate strong brand preferences across retailers, with the most popular stores having baseline preferences that are about an order of magnitude higher than the additional discounter preference estimated for low-income households θ_2.

7 Counterfactuals

With the parameter estimates in hand, we turn to simulating counterfactual scenarios. We start by considering 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.

We assess these effects in two ways. First, we focus on the retailer's decision problem presented in our theoretical framework in equation (1). Second, we compute additional welfare-relevant metrics, including consumer and government surplus, competing retailers' profits, and externalities.

A more comprehensive welfare calculation allows us to shed light on the effects of alternative policies that Penny or the government might take. We analyze two alternative policies. We first consider what would happen if Penny implemented an ongoing revenue neutral cross-subsidy from high-carbon to low-carbon foods, instead of the true cost campaign. Additionally, we consider the effects of nationwide externality taxes on all grocery sales. Details on implementation of each of these are discussed in Appendix H.

7.1 Profit and Externality Effect Decomposition

To understand the quantities that affect the retailer's decision problem in equation (1), we decompose the effect of a campaign that changes prices and/or emissions at retailer r on its objective function into the following components:

$$\begin{aligned} &\underbrace{\underbrace{\Delta \boldsymbol{q}_r(\boldsymbol{p}_r^b - \boldsymbol{c}_r^b)}_{\text{demand}} + \underbrace{\boldsymbol{q}_r^b(\Delta \boldsymbol{p}_r - \Delta \boldsymbol{c}_r)}_{\text{markup}} + \underbrace{\Delta \boldsymbol{q}_r(\Delta \boldsymbol{p}_r - \Delta \boldsymbol{c}_r)}_{\text{demand} \times \text{markup}}}_{\text{profits}} \\ &- \omega \Big(\underbrace{\underbrace{\Delta \boldsymbol{q}_r \boldsymbol{\phi}_r^b}_{\text{demand}} + \underbrace{\boldsymbol{q}_r^b \Delta \boldsymbol{\phi}_r}_{\text{direct}} + \underbrace{\Delta \boldsymbol{q}_r \Delta \boldsymbol{\phi}_r}_{\text{demand} \times \text{direct}} + \underbrace{\Delta \boldsymbol{q}_{\setminus r} \boldsymbol{\phi}_{\setminus r}}_{\text{retailer substitution}}}_{\text{externalities}} \Big), \end{aligned} \tag{21}$$

where superscripts c and b denote counterfactual and baseline variables, respectively, and $\Delta x = x^c - x^b$.

We quantify all terms in Equation 21 for the campaign counterfactuals. We present this decomposition in Table 4, where Panel (a) presents the effects on profits and Panel (b) presents the effects on the exter-

nality components that enter the retailer's objective function. To gain further insights into how different counterfactuals affect retailers' incentives, we separate the demand effects in two columns: "Price Increasing", for the categories that experience a price increase as a result of the counterfactual policy, and "Price Non-Increasing", for the remaining categories.

The first row of each panel shows the effect of the yearlong true cost campaign without the demand shift effect. Firm profits decrease as a result of the decrease in demand for the campaign categories, while profits from the remaining categories are almost unaffected. The largest welfare effects come from the direct effect of the campaign on reducing externalities from the campaign products via donations. These are mediated by retailer substitution away from Penny.

The second row of each panel adds the demand shift effect on consumer demand. When consumers derive utility from consuming the campaign products, consumption of both campaign and non-campaign products increases. Because of the increase in consumption of the campaign products, there is an increase in externalities coming from demand effects. Because of the positive impact of the demand shift on consumer utility, there is retailer substitution into Penny, which is now an additional channel by which the campaign reduces externalities and increases profits for Penny.

7.2 Welfare

We now turn to analyzing aggregate welfare effects of counterfactual policies. The total surplus effect is the sum of changes in consumer surplus (both from price and demand shift effects), profits, negative externalities (both from substitution and donation effects) and government revenues:

$$\Delta TS = \Delta(CS : PE) + \Delta(CS : DS) + \Delta\Pi - \Delta(E : SE) - \nu\Delta(E : DE) + \Delta G. \tag{22}$$

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

$$CS = \sum_i \sum_t \frac{1}{\theta_1} \ln\left(\sum_r \exp\left(V_{irt}\right)\right) + K, \tag{23}$$

where V_{irt} is from equation (18) and K is an unknown constant that is differenced out when comparing counterfactuals.

The negative externality is

$$E = \sum_i \sum_t \left[\sum_r Pr_{irt}\left(\boldsymbol{\theta}, \boldsymbol{\xi}\right) \cdot \boldsymbol{q}_{irt}\left(\boldsymbol{p}_{rw(t)}\right)\right] \cdot \boldsymbol{\phi}, \tag{24}$$

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

$$GS = \sum_i \sum_t \left[\sum_r Pr_{irt}\left(\boldsymbol{\theta}, \boldsymbol{\xi}\right) \cdot \boldsymbol{q}_{irt}\left(\boldsymbol{p}_{rw(t)}\right) \right] \cdot \boldsymbol{\tau}. \tag{25}$$

Table 5 presents results in monetary terms. The first two rows present the effect of a counterfactual true cost campaign implemented by Penny for the whole year and for the nine products in the real-world campaign. The first row shows the effect of a campaign in which Penny charges the uninternalized externality on the treated products, and donates the proceeds, but consumers do not derive warm glow. This campaign has a limited effect on total surplus, with decreases in externalities through reduced consumption of treated categories and donations having a slightly greater effect than the decrease in consumer surplus from increased prices. In the second row we incorporate demand shift effects. We operationalize these by multiplying the taste parameters estimated in Section 6 for the treated products by the product-specific campaign multiplier α_j^C obtained from our estimates in Table 2 and equation (10).[14] The welfare effects of this campaign are amore than three times larger than those for the campaign without demand shift effects. This increase comes both from increased consumption of treated products and from retailer substitution into Penny due to the campaign, as shown in Section 7.1.

The third row presents the effects of the revenue-neutral cross-subsidy. In our model, the cross-subsidy has very limited effects on consumer surplus. However, firm profits experience a relatively large negative effect compared to the campaign. Intuitively, in order to maintain revenue constant, the retailer needs to decrease prices of low-externality categories, which are relatively popular among consumers and thus have a high weight on revenue and profits.[15] However, by increasing prices for all products in categories with high externalities, the cross-subsidy achieves large externality reductions compared to the campaign.

The last two rows show the effects of nationwide carbon and Pigouvian taxes. 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.

Figure 13 presents results for the unilateral policy counterfactuals (true-cost campaign and cross-subsidy)by surplus component, as well as the MVPR for each policy. The extended true-cost campaign without warm glow has an MVPR of 2.2. When consumers derive warm glow utility from consuming targeted categories, the negative impacts of the increased prices on consumer surplus are partially offset. As a result, our estimated MVPR is 11.5. MVPR for the cross-subsidy is 15.0, with its large effects on externality reductions driving the gains in total surplus. Still, its welfare gains rank considerably below those achievable via nationwide taxes.

[14] The campaign multipliers obtained in Table 2 are, in practice, a combination of demand shift due to warm glow as well as due to retailer substitution into Penny. In the structural model, taste parameters are estimated at the grocery choice stage, and thus are separate from retailer-specific preferences, which enter into the first stage. We discuss how we scale the demand shift parameter to ensure magnitudes are comparable between the reduced form and the structural model in Appendix H.

[15] Out of the 21 categories, only 6 experience a price increase in the cross-subsidy. However, as shown in Table A1, only one of these categories (red meats) is in the top 6 categories by weekly consumption.

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, when retailers enjoy strong brand preferences and are able to generate consumer warm glow, externality abatement campaigns by retailers could generate high environmental benefits with little costs in terms of profit reductions. 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: **Effects of Price Reductions and True Cost Campaign**

	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 (9). Observations are at the product-day level. Included are campaign product sales during the entire sample period.

Table 3: **Structural Demand Model Estimates**

Parameter	Estimate	S.E.
σ	1.31	(0.06)
$\sigma_{\text{Beverages}}$	1.31	(0.03)
$\sigma_{\text{Non-protein food}}$	1.44	(0.03)
σ_{Protein}	2.48	(0.10)
$\sigma_{\text{Alcoholic beverages}}$	1.92	(0.13)
$\sigma_{\text{Chocolate goods}}$	4.79	(0.16)
$\sigma_{\text{Dairy white}}$	1.98	(0.04)
$\sigma_{\text{Dairy yellow}}$	1.94	(0.04)
$\sigma_{\text{Deli/seasonings}}$	1.98	(0.09)
$\sigma_{\text{Fats non-veggie}}$	4.34	(0.16)
$\sigma_{\text{Fats veggie}}$	1.86	(0.17)
σ_{Fish}	2.06	(0.14)
σ_{Fruit}	2.11	(0.06)
σ_{Juices}	2.21	(0.12)
$\sigma_{\text{Meat poultry}}$	2.63	(0.10)
$\sigma_{\text{Meat substitutes}}$	2.85	(0.29)
$\sigma_{\text{Ready meals}}$	2.30	(0.14)
$\sigma_{\text{Red meats}}$	2.49	(0.03)
σ_{Sauces}	1.61	(0.06)
σ_{Sodas}	3.48	(0.09)
$\sigma_{\text{Staples cereals}}$	1.88	(0.03)
$\sigma_{\text{Staples rest}}$	0.67	(0.06)
$\sigma_{\text{Staples veggie}}$	1.73	(0.02)
$\sigma_{\text{Sugar confections}}$	4.68	(0.16)
$\sigma_{\text{Tea and coffee}}$	2.42	(0.23)
σ_{Water}	1.33	(0.12)
m	0.18	
ϕ	171.78	
ϕ'	0.11	

(a) **Second Stage: Continuous Choice of Grocery Category Quantities**

Parameter	Estimate	S.E.
θ_1	0.13	(7.1e-04)
θ_2	0.15	(3e-03)
ξ_{Internet}	0	
ξ_{Aldi}	0.91	(9e-03)
$\xi_{\text{Edeka eh}}$	0.92	(8.8e-03)
ξ_{Famila}	-0.63	(0.01)
$\xi_{\text{Globus st. wendel}}$	0.20	(0.01)
ξ_{Hit}	-0.73	(0.01)
ξ_{Kaufland}	1.02	(9.1e-03)
ξ_{Lidl}	0.88	(9e-03)
$\xi_{\text{Marktkauf}}$	-0.30	(0.01)
$\xi_{\text{Netto marken-discount}}$	0.75	(8.9e-03)
ξ_{Norma}	0.36	(9.7e-03)
$\xi_{\text{Other discounters}}$	-0.46	(0.01)
$\xi_{\text{Other non-discounters}}$	0.45	(8.7e-03)
ξ_{Penny}	0.64	(9.2e-03)
ξ_{Real}	-0.34	(0.01)
ξ_{Rewe}	0.92	(8.8e-03)
ξ_{Tegut}	-0.58	(0.01)

(b) **First Stage: Discrete Choice of Grocery Retailer**

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

Table 4: **Effect Decomposition in Objective Function**

Counterfactual	Demand		Markup	Demand x Markup	Total
	$\Delta p > 0$	$\Delta p \leq 0$			
Year-long pricing campaign, without demand shift	-386.2	-48.0	0	0	-434.2
Year-long pricing campaign, with demand shift	-314.1	-15.0	0	0	-329.1

(a) **Effects on Profits**

Counterfactual	Demand		Direct	Demand x Direct	Retailer Substitution	Total
	$\Delta p > 0$	$\Delta p \leq 0$				
Year-long pricing campaign, without demand shift	-353.4	-185.9	-60909.6	539.2	292.9	-60616.7
Year-long pricing campaign, with demand shift	-290.1	-34.4	-60909.6	324.5	102.7	-60806.9

(b) **Effects on Externalities**

Notes: This table presents the effects of counterfactual policies on the retailer's objective function. Magnitudes are in thousands of euros. "Whole-year true cost campaign" means that Penny implements the true cost campaign for the whole year, but there is no demand shift from the donation. "Whole-year true cost campaign, with demand shift" means that Penny implements the true cost campaign for the whole year, and the demand curve shifts outward due to the donation.

Table 5: **Counterfactual Simulations**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Counterfactual	Δ CS: PE	Δ CS: DS	$\Delta\Pi_r$	$\Delta\Pi_{\neq r}$	-Δ E: SE	-Δ E: DE	Δ G	Δ TS
Year-long pricing campaign, without demand shift	-0.19	0.00	-0.05	0.04	0.15	0.11	0.00	0.06
Year-long pricing campaign, with demand shift	-0.19	0.12	-0.02	0.01	0.14	0.15	0.00	0.21
Revenue-neutral cross-subsidy (€0.04)	0.00	0.00	-0.08	0.00	1.20	0.00	0.00	1.12
Carbon tax ($\tau = \phi_j$)	-286.87	0.00	-2.14	-14.93	195.29	0.00	214.08	105.43
Pigouvian tax ($\tau = \phi_j - (p_j - c_j)$)	-207.51	0.00	-1.79	-9.80	187.45	0.00	142.91	111.25

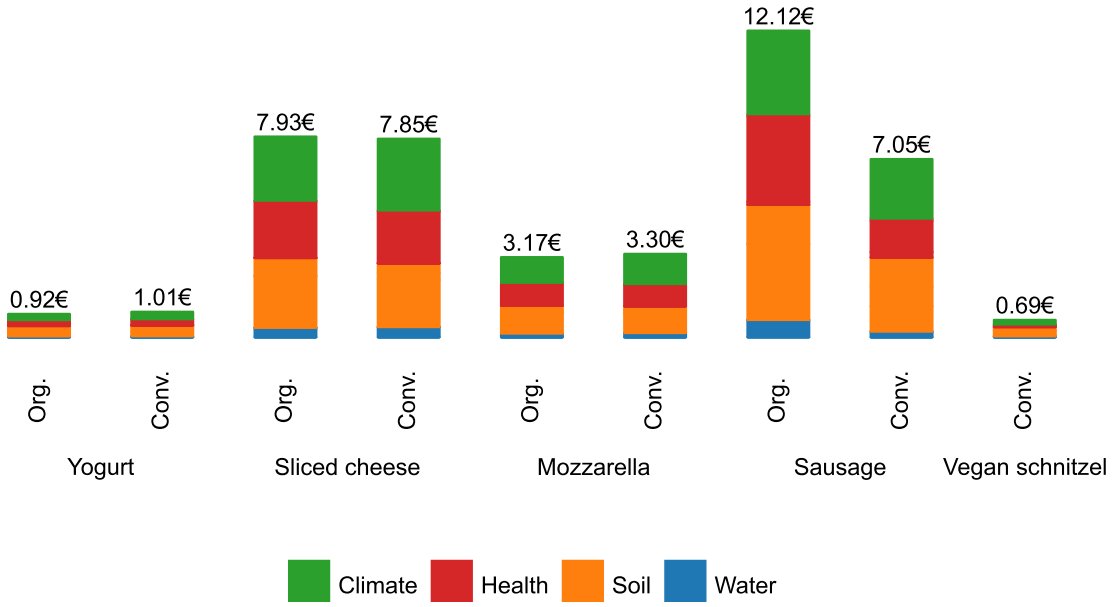
Notes: This table presents the effects of counterfactual policies on components of total surplus. "Whole-year true cost campaign" means that Penny implements the true cost campaign for the whole year, but there is no demand shift from the donation. "Whole-year true cost campaign, with demand shift" means that Penny implements the true cost campaign for the whole year,the demand curve shifts outward due to the donation. "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. "Δ CS: PE" denotes the change in consumer surplus attributable to the price effect. "Δ CS: DS" denotes the change in consumer surplus attributable to the demand shift effect. "$\Delta\Pi_r$" denotes the change in profits for the campaign retailer. "$\Delta\Pi_{\neq r}$" denotes the change in profits for the remaining retailers. "-Δ E: SE" denotes the (negative) change in externalities from the substitution effect. "- Δ E: DE" denotes the (negative) change in externalities from the donation effect. "Δ G" denotes the change in government surplus. "Δ TS" denotes the change in total surplus.

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



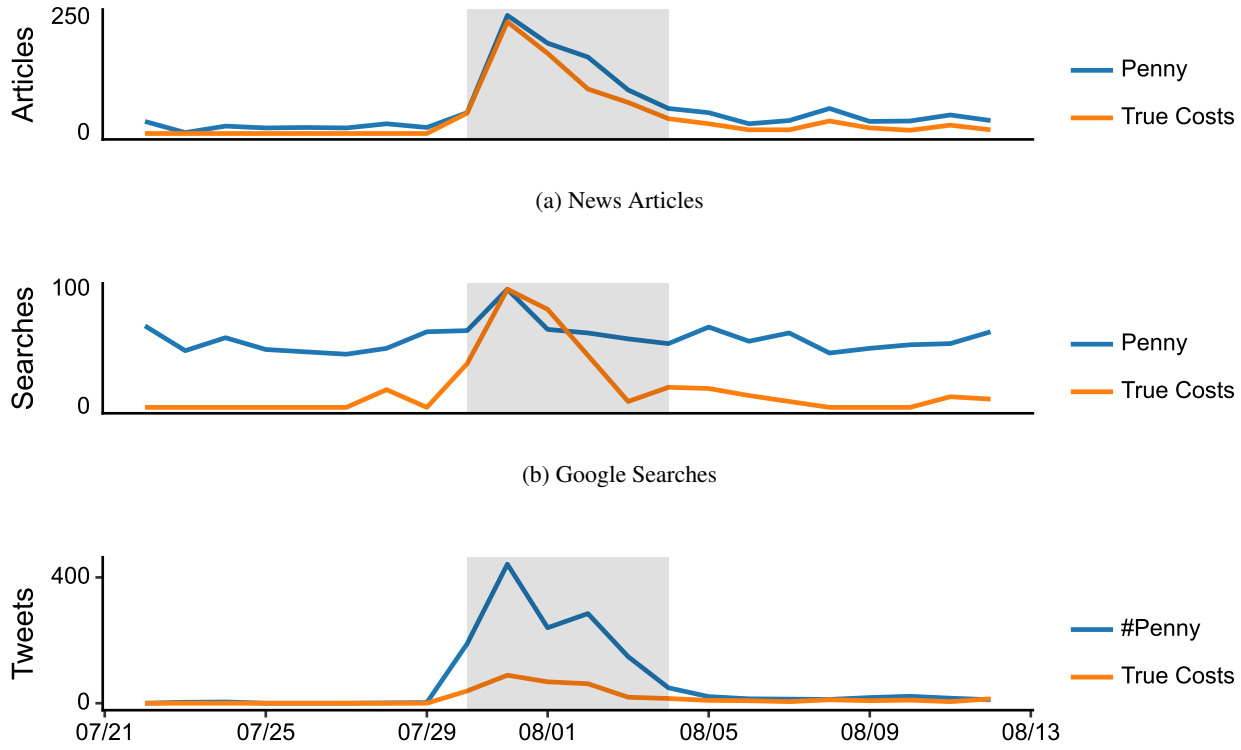
Notes: Campaign at the point of sale. Shown are the organic sausages and the shelf divider explaining the campaign. Main text (top): "You don't care for this price? The environment does. Every product has an impact on the environment. For our Naturgut organic sausages, you can now compensate it until August 5, 2023 with the 'True Cost Price'. The difference of €2.07 goes to our Future Farmer project, which we are implementing together with the Berchtesgadener Land dairy. Additionally, we are increasing the donation amount by €50,000." Text snippets (middle): "incl. 2.07 true costs'" (left, above price change) and "until August 5'" (right). Bottom left: barcode and link to true cost web page with additional information. Footnote (behind product): "Calculated by the University of Greifswald and Nuremberg Institute of Technology." Image source: LAND & FORST/Düwert (reprinted with permission).

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**



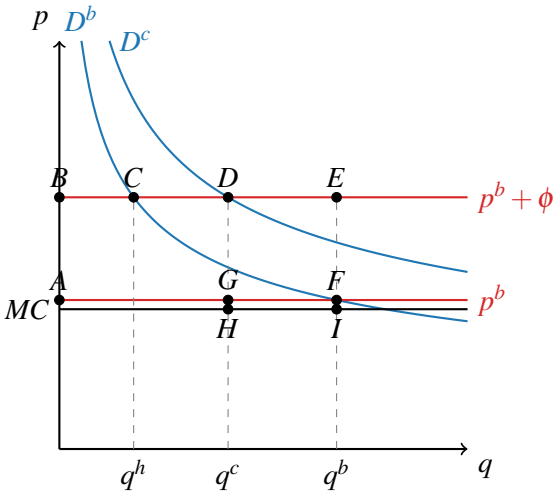
(a) News Articles

(b) Google Searches

(c) Tweets

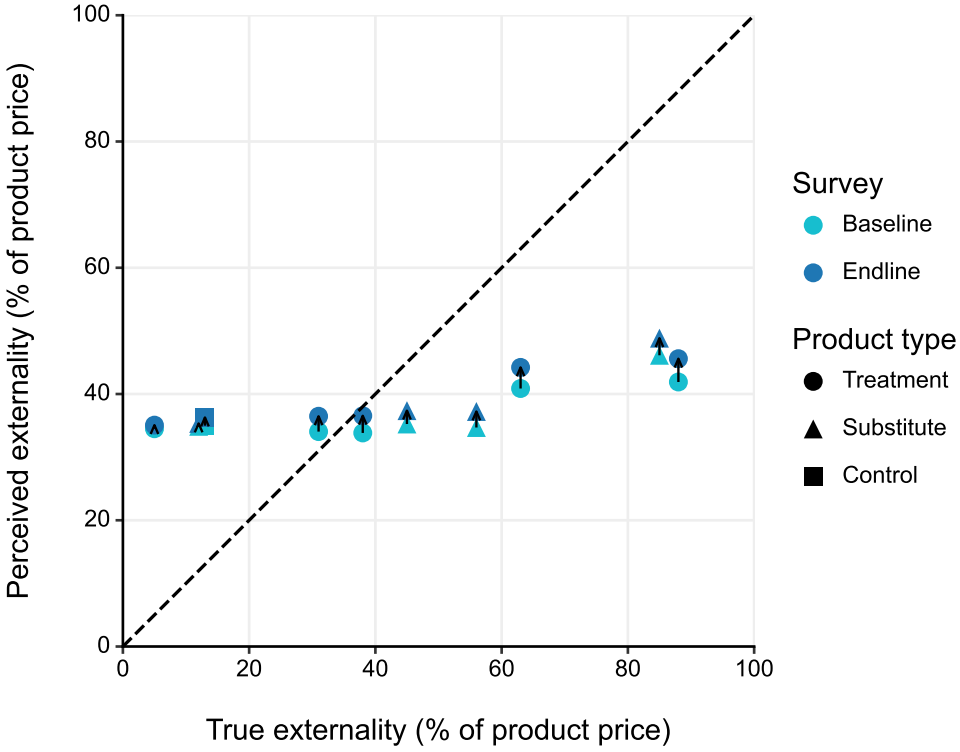
Notes: This figure shows coverage of the media campaign. Shaded area: campaign week (Sunday–Saturday). (a) Number of media articles mentioning Penny or Penny and the true cost campaign on each day. Articles come from the Factiva database. They were filtered for the word Penny and included all articles 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". Maximum over this period = 100. (c) Number of tweets with the hashtag Penny or mentioning "true costs"/"true prices".

Figure 4: **Campaign Welfare Components**



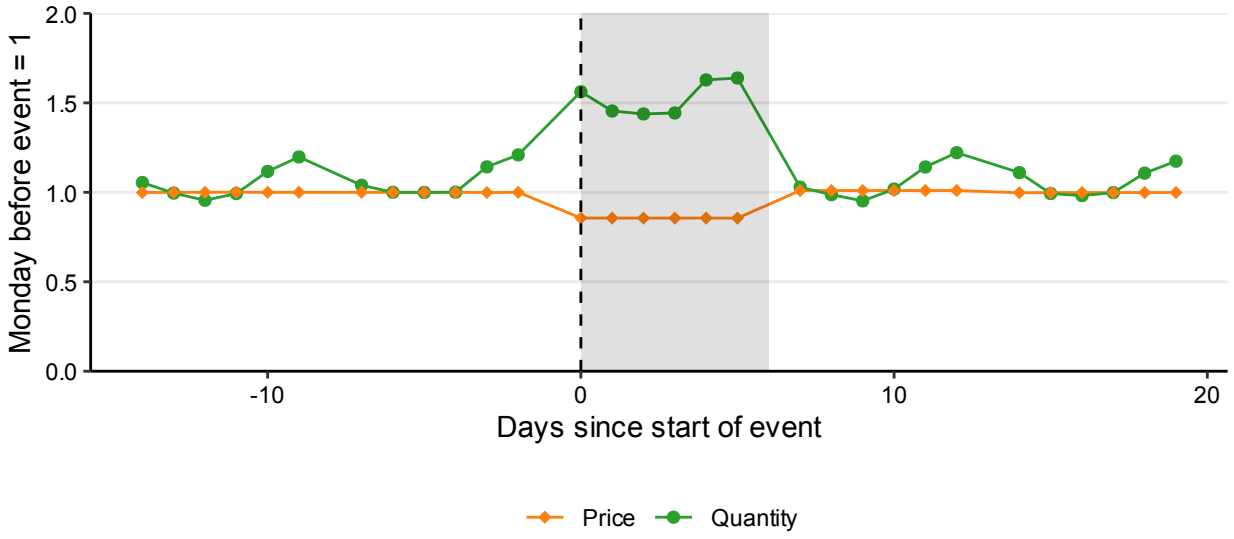
Notes: This graph shows the change in welfare due to a campaign where consumers pay for a donation to offset externalities for a single product. p^b: baseline price. $p^c = p^b + \phi$: campaign price, where ϕ are uninternalized environmental externalities. D^b: baseline inverse demand curve (without warm glow). D^c: campaign inverse demand curve (to the right of D^b because consumers experience warm glow from the donation). q^b: baseline equilibrium quantity. q^h: hypothetical equilibrium quantity if the price were p^c, but there was no warm glow from the donation. q^c: campaign equilibrium quantity. Area ABCF (under D^b): decrease in consumer surplus (price effect). Area between D^b and D^c starting at CD: increase in consumer surplus (demand shift). Area ABDG: decrease in externalities (donation effect). Area DEFG: decrease in externalities (substitution effect). Area: FGHI: decrease in retailer profits.

Figure 5: **Externality Beliefs**

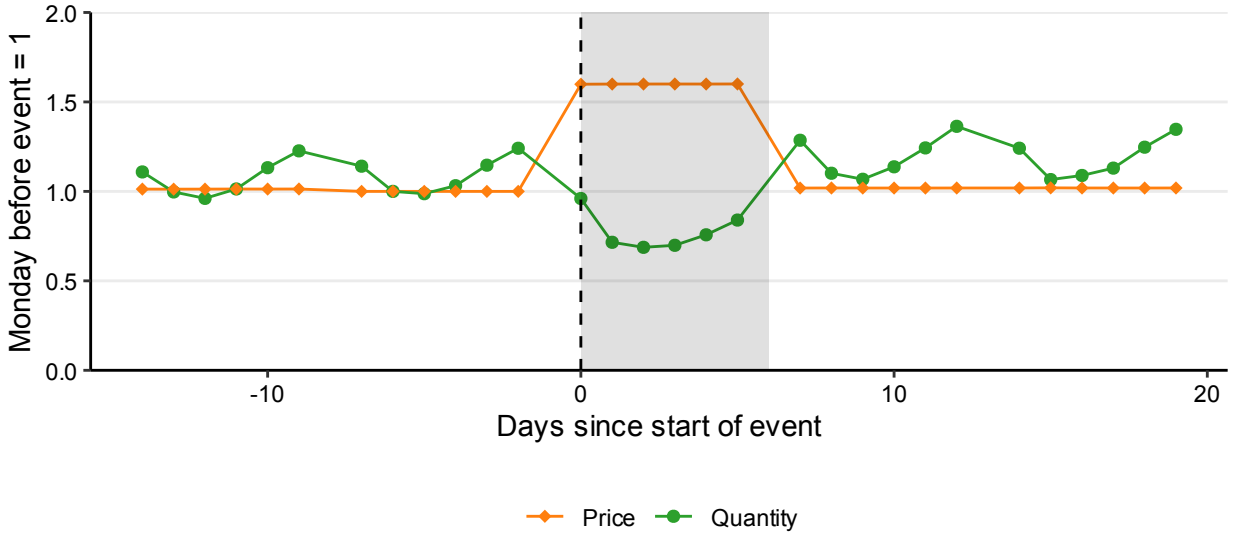


Notes: This graph shows the externality beliefs (y-axis) versus our estimates (x-axis). Light blue: baseline response. Dark blue: endline response. Circle: treated products featured in the campaign. Triangle: substitute products in the same product category as treated products. Square: non-food control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

Figure 6: Event Studies of True Cost Campaign and Standard Price Promotions



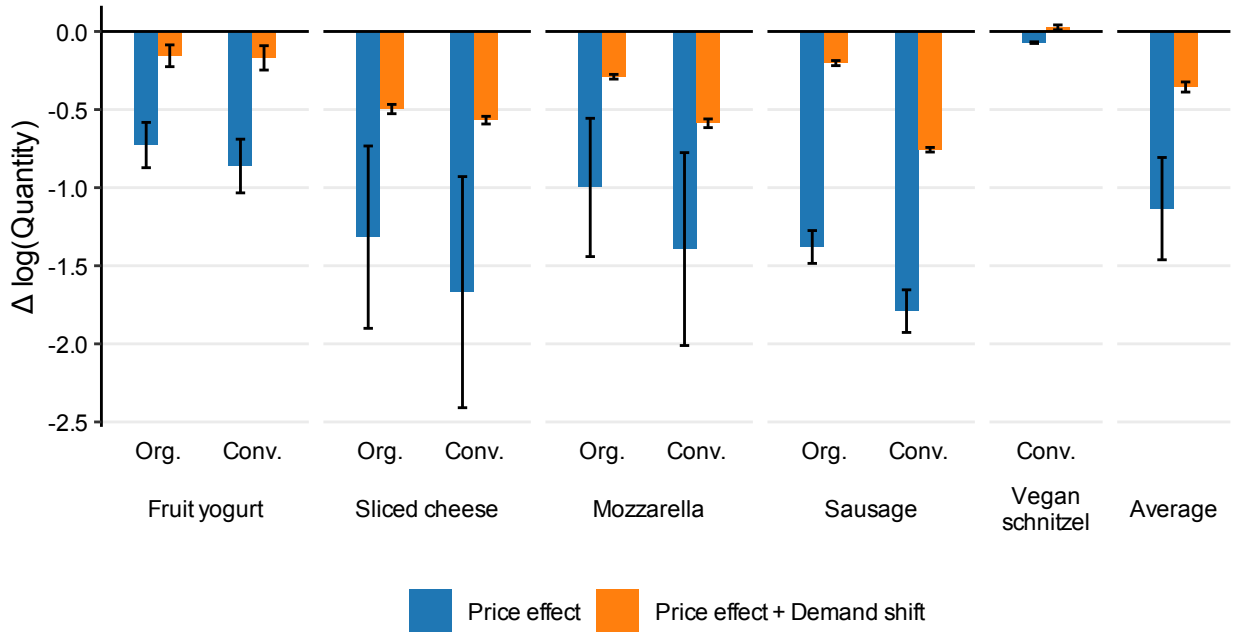
(a) **Prices and Quantities Sold During Standard Price Promotions**



(b) **Prices and Quantities Sold During True Cost Campaign**

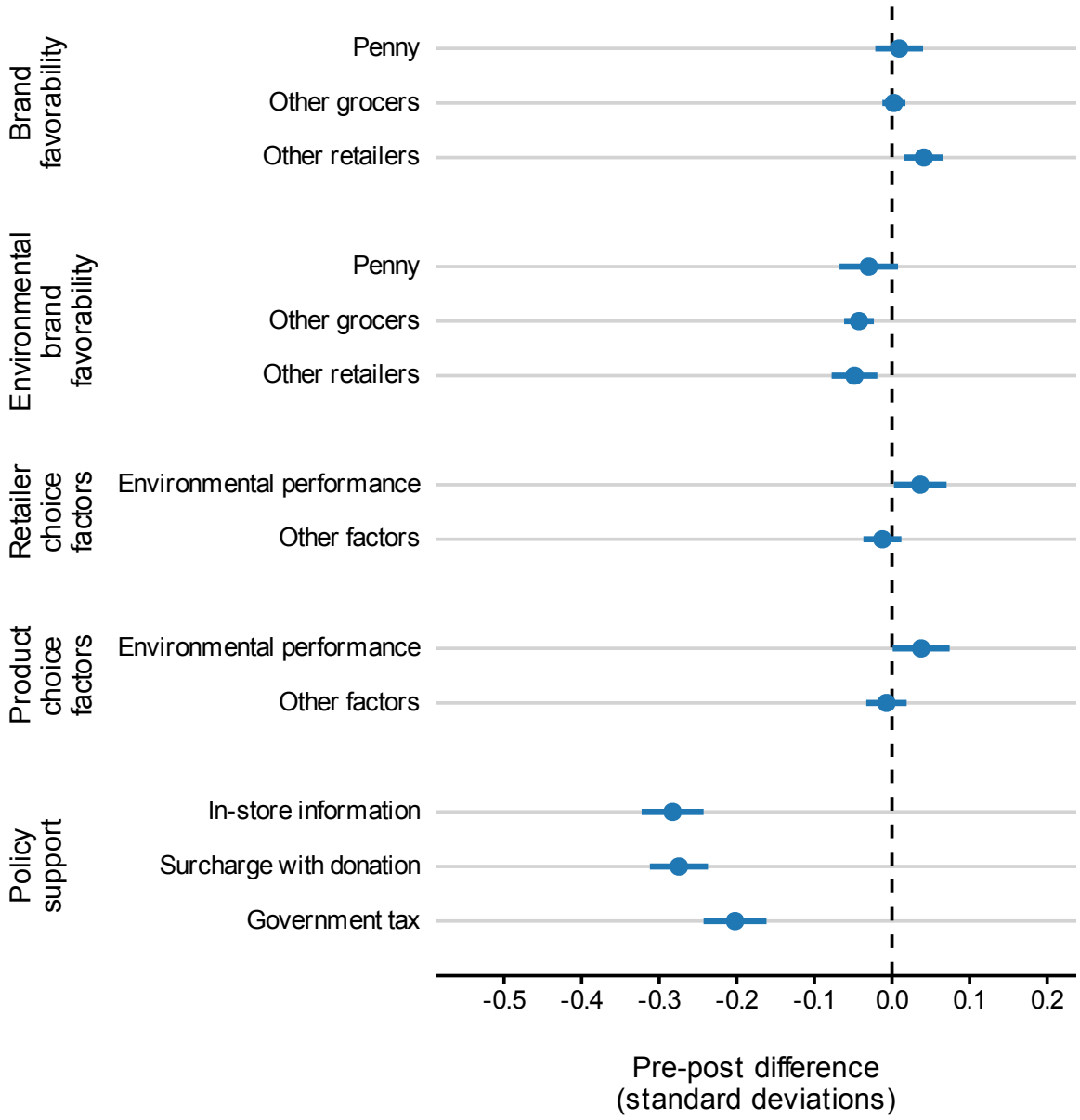
Notes: These graphs show the campaign product price (yellow line) and quantity (green line) around sales events (in Panel (a)) and the true cost campaign (in Panel (b)). X-axis: days since the start of the sales event or true cost campaign. Y-axis: quantity/price, normalized by the quantity/price the Monday before the event ($t = -7$). Gray area: sales event or 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 7: **Campaign Price and Warm Glow Effect**



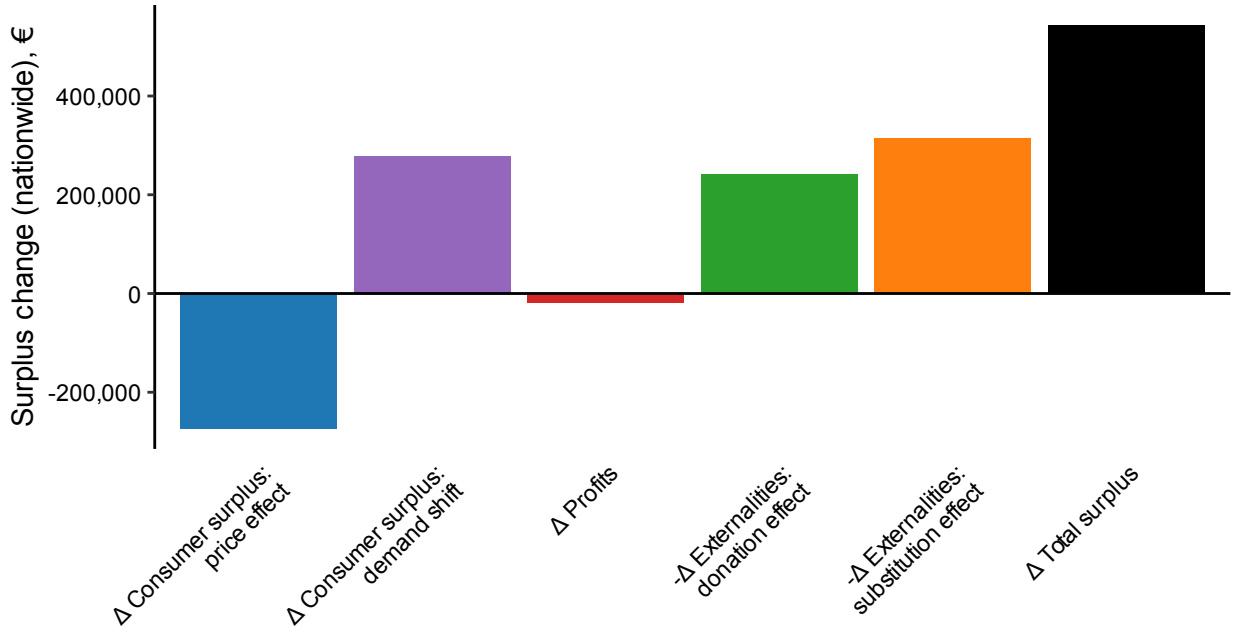
Notes: This graph shows the price effect (blue bars) and the approximate overall campaign effect (orange bars) on log quantities for each product. The price effect for product j in category c is $-\sigma^c \Delta \ln p_j$ and the demand shift is $\tau_j = \sigma^c \ln \alpha_j^c$. The price change Δp_j is equal to the uninternalized environmental externalities ϕ_j. The parameters σ^c and τ_j are estimated using equation (9). The full regression results are shown in Table 2. We calculate the standard errors using the delta method.

Figure 8: **Survey Campaign Effects**



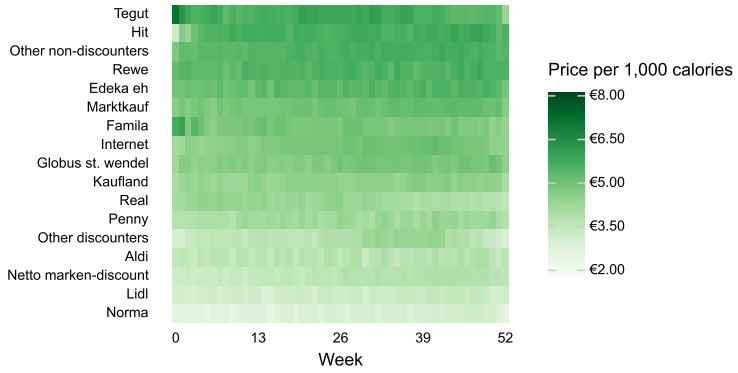
Notes: This graph shows the difference in the mean survey response before and after the campaign. Differences were normalized using the pre-campaign standard deviation. Error bars: 95% confidence interval.

Figure 9: **Welfare Effects of Campaign**

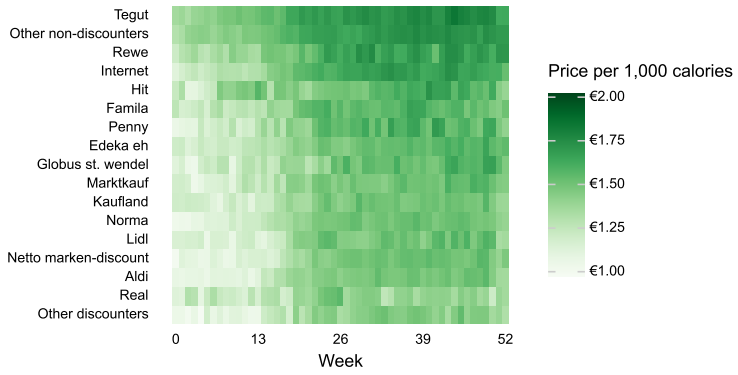


Notes: This figure shows changes in welfare due to Penny's true cost campaign. For the calculations and assumptions, see Section 5.4.

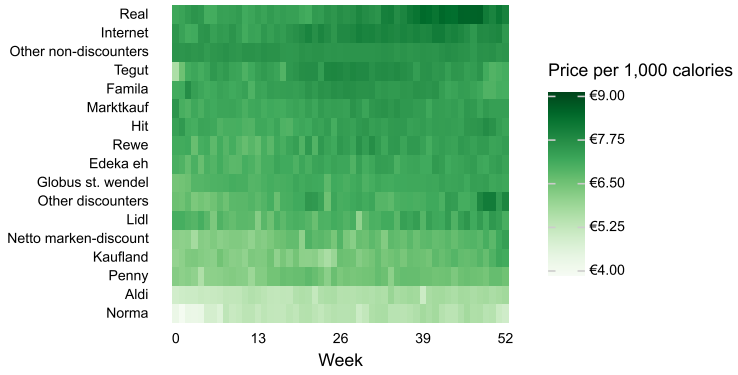
Figure 10: **Category-Level Price Variation**



(a) Sodas



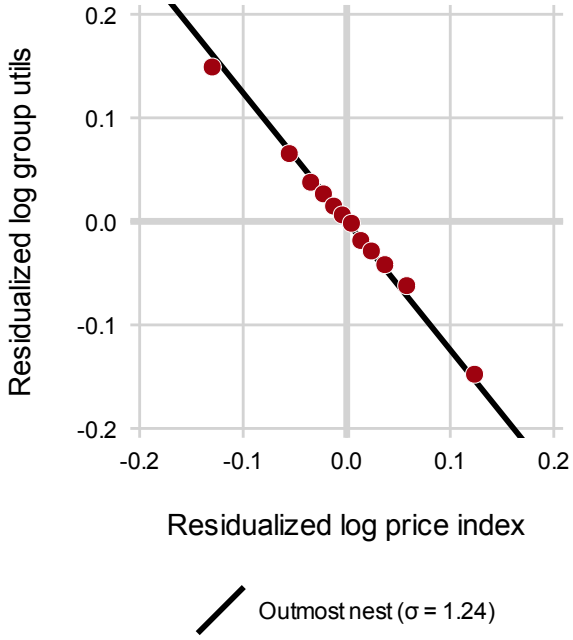
(b) Fats - Non-Veggie



(c) Meat Substitutes

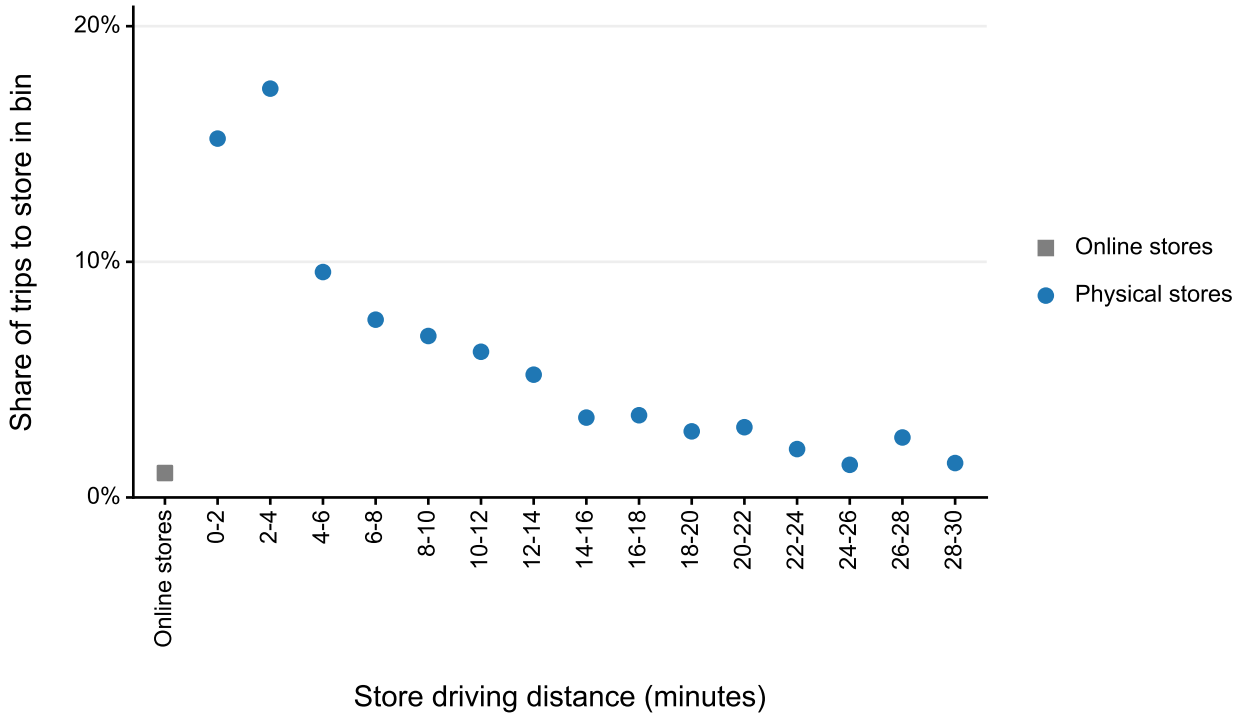
Notes: This figure illustrates the price variation used to identify σ_g in equation (17), using an example category for each product group. Each row of the y-axis is a retailer. Each column of the x-axis is weeks of calendar year 2022. The color intensity reflects the average price per calorie of all purchases in that category.

Figure 11: **Binned Scatterplot of Quantity and Price**



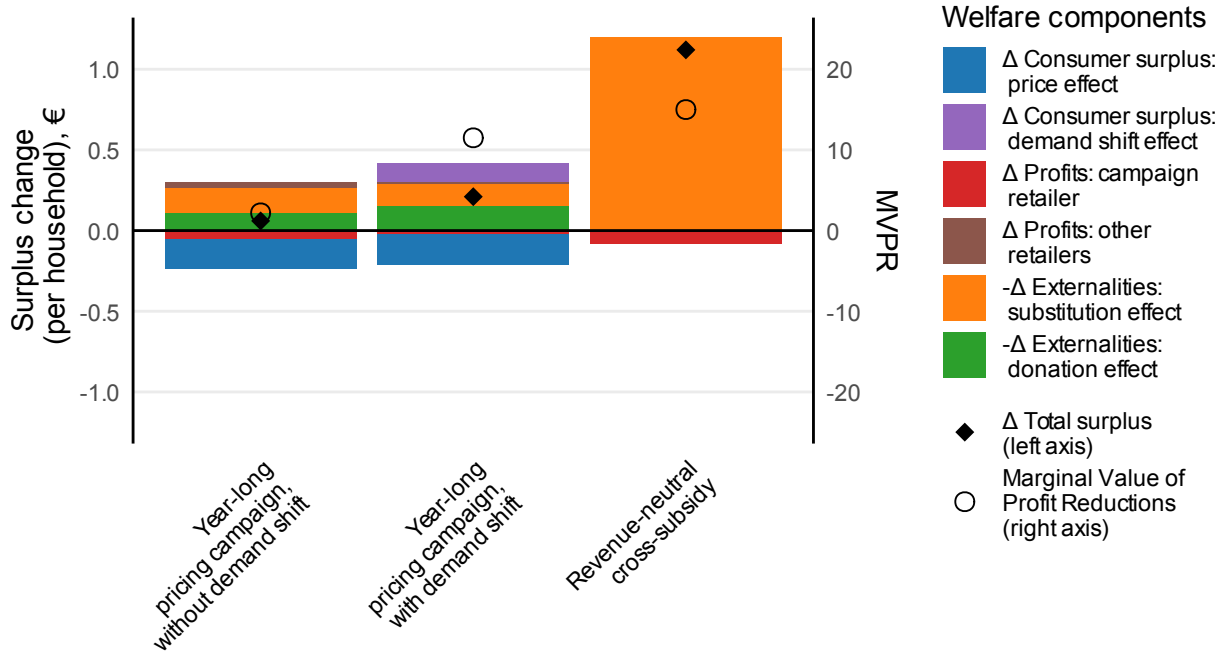
Notes: This is a binned scatter plot of equation (17): the relationship between quantity and fitted price deviations relative to a vector of fixed effects.

Figure 12: **Empirical Shopping Trip Probabilities by Driving Distance**



Notes: This figure illustrates the variation used to identify θ_2 in equation (18): the empirical probability of a household making grocery shopping trips to stores within each driving distance bin.

Figure 13: **Counterfactual Simulations: Surplus Decomposition and MVPR**



Notes: This figure shows the effects of unilateral counterfactual policies on components of total surplus and the marginal value of public funds (MVPR), which is defined as $MVPR = \frac{\Delta CS - \Delta E + \Delta GS + \sum_{k \neq r} \Delta \Pi_k}{-\Delta \Pi_r}$. "Year-long pricing campaign, without demand shift" means that Penny implements the true cost campaign for the whole year, and consumers do not derive warm glow from purchasing the campaign products. "Year-long true cost campaign, with demand shift" means that Penny implements the true cost campaign for the whole year, and consumers derive warm glow from purchasing the campaign products. "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.

Online Appendix

Optimal Green Retailing: Theory and Evidence

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

Table of Contents

A Campaign Appendix **56**
A.1 In-store Explainers . . . 56
A.2 Media Coverage . . . 58

B Data Appendix **59**
B.1 Penny Store Scanner Data Descriptives . . . 59
B.2 Home Scanner Data . . . 59
B.3 Survey Descriptive Statistics . . . 61
B.4 Media Intercoder Agreement . . . 62

C Survey Questionnaire **63**
C.1 Baseline survey . . . 63
C.2 Endline survey . . . 87

D Media Coding Instructions **97**
D.1 Introduction . . . 98
D.2 Questions . . . 98
D.3 Coding scheme . . . 100

E Campaign Evaluation Appendix **103**
E.1 Survey Results . . . 103
E.2 Media Analysis . . . 108
E.3 Price Effect and Demand Shift . . . 111

E.4 Substitution Results . . . 112
E.5 Revenue Results . . . 115

F Campaign Theoretical Results Appendix **118**
F.1 Demand Model . . . 118
F.2 Welfare Components . . . 119
F.3 Consumer Surplus . . . 119

G Structural Model Appendix **121**
G.1 Structural Model Derivation . . . 121
G.2 Structural Model Estimation . . . 124
G.3 Stockpiling . . . 126

H Counterfactual Simulations Appendix **126**

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.

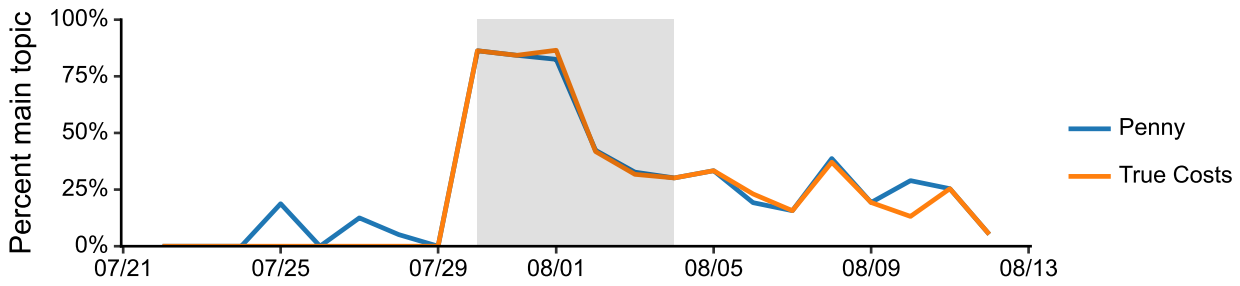
Figure A1: **Campaign Advertising**



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 Penny Store Scanner Data Descriptives

Figure A3: **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.

B.2 Home Scanner Data

We only observe the prices of product-chain combinations that have been purchased by at least one household in any given week. For products that are infrequently chosen, this leads to prices being missing for some weeks over the year. To estimate the model, we include product-chain combinations with zero purchases in a given week in consumers' choice set as follows: we assume that, if a product is available in week t, it is also available in weeks $t-1$ and $t+1$. In weeks without purchases, we impute the price for the product-chain combination as the maximum price of the next and last observed price for the same product-chain. In cases where this approach does not lead to a price imputation, we impute the remaining missing prices according to the following priority order: average category-chain price per year, average category-level national price per week, average category-level national price per year.

Appendix Table A1 presents the average uninternalized externalities, average purchases (in calories per household-week), and number of products for each category. Externality estimates are from Michalke et al. (2025). Red meat has the highest externalities per kilogram, but fish and tea and coffee have higher externalities per kcal, due to lower kcal/kg ratios. The red meats category groups together all non-poultry meats, including beef, pork, and lamb. We opt for this grouping since a finer categorization is only available for 13 percent of red meat sales. Externalities for the red meats category are computed as the sales-weighted average among purchases for which the finer classification is available.

Table A1: **Externalities by Category**

		Average weekly purchases per household (kcal)	**Uninternalized externalities (€/kcal)**	**Average # products per retailer**
Product Group	**Product Category**			
Beverages	Alcoholic Beverages	0.98	0.25	4,743
	Juices	0.27	0.37	1,352
	Sodas	0.52	0.28	2,475
	Tea And Coffee	0.48	4.50	1,577
	Water	0.38	0.00	1,953
Non Protein Food	Chocolate Goods	1.17	1.14	4,102
	Dairy White	3.13	0.43	6,665
	Dairy Yellow	1.29	0.90	5,471
	Deli/Seasonings	0.27	0.63	1,876
	Fats Non-Veggie	0.88	0.57	419
	Fats Veggie	1.27	0.35	442
	Fruit	1.50	0.07	13,424
	Ready Meals	0.33	1.13	2,407
	Sauces	1.59	0.19	2,928
	Staples Cereals	5.71	0.29	7,652
	Staples Rest	2.09	0.03	1,509
	Staples Veggie	1.00	0.19	11,956
	Sugar Confections	0.40	0.12	1,593
Protein Food	Fish	0.20	3.48	1,663
	Meat Poultry	0.35	1.97	2,378
	Meat Substitutes	0.04	0.32	306
	Red Meats	1.94	3.12	14,013

Notes: This table presents, for each category in the scanner data, the average weekly purchases per household, average number of products per retailer, and uninternalized externalities. Externalities/kg are estimated using true cost accounting (Michalke et al. 2025; Pieper et al. 2020). kcal/g information comes from Open Food Facts; we compute category-level kilocalories as the sales-weighted average over all products in the category.

B.3 Survey Descriptive Statistics

Table A2: **Survey Demographics**

	Unweighted sample	Weighted sample	German adults
Male	0.50	0.49	0.49
Age	49.14	43.95	43.95
Years of education	13.57	13.09	13.09
Income	€3,210	€3,812	€3,813
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, education, and income are obtained from the German Federal Statistical Office (Destatis 2022b; Destatis 2022a; Destatis 2022c; Destatis 2021c). "Years of education" is estimated using the highest degree obtained, based on the ISCED classification (UNESCO and UIS 2012). We calculate the average years of education for each level of education by weighing different degrees and school systems by their population shares (KBWN 2021; BIBB 2021; BIBB 2024; Autor:innengruppe Bildungsberichterstattung 2024; Destatis 2021a; Destatis 2023). "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.4 Media Intercoder Agreement

Table A3: **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:

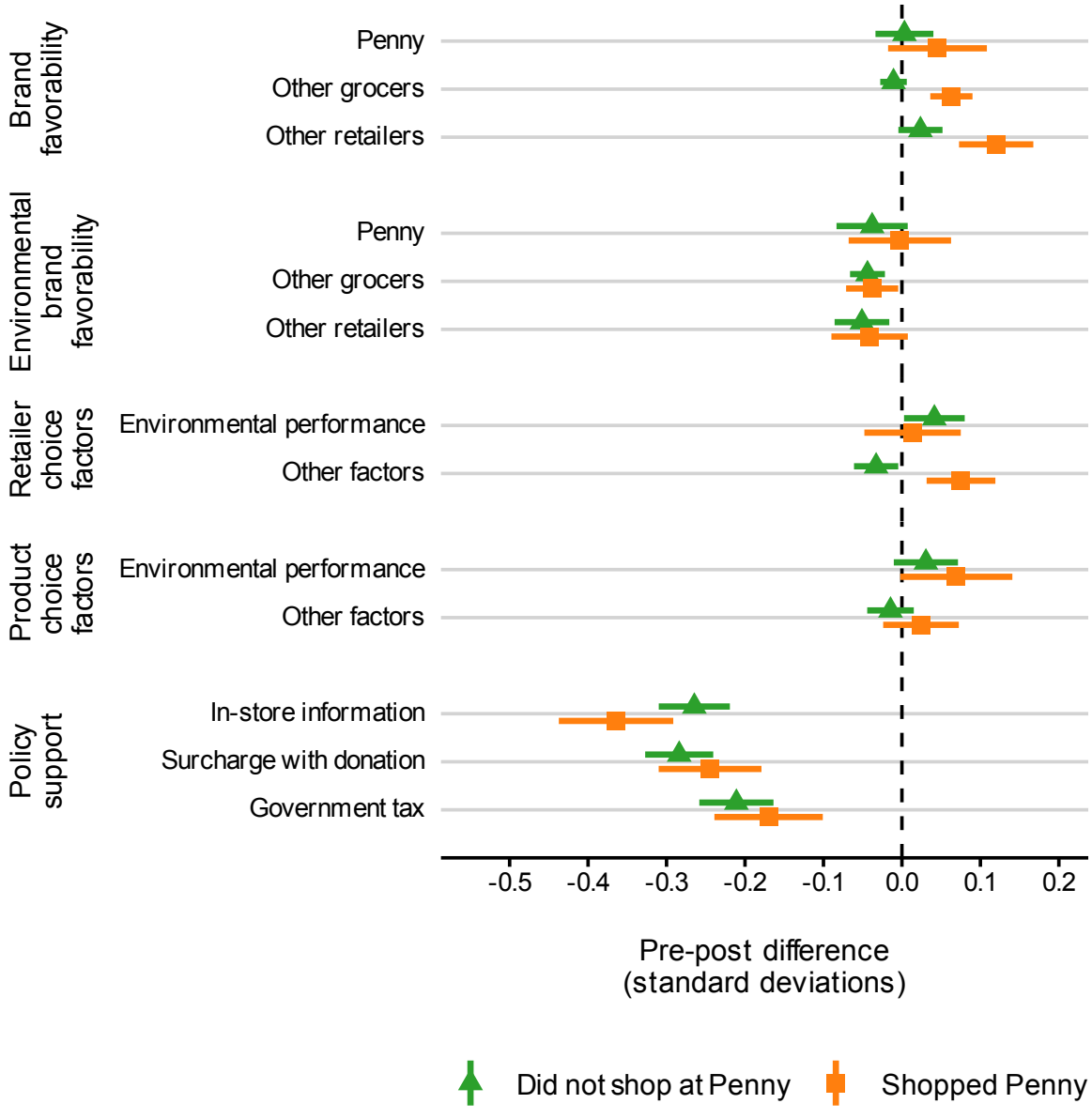
- There is a 'notes' column at the end – use it to write down anything unusual that you see that could be useful to know (can be empty most of the time).
- Often articles were distributed by editorial networks and especially small newspapers / online media thus used the exact same article. Here not every 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 Survey Results

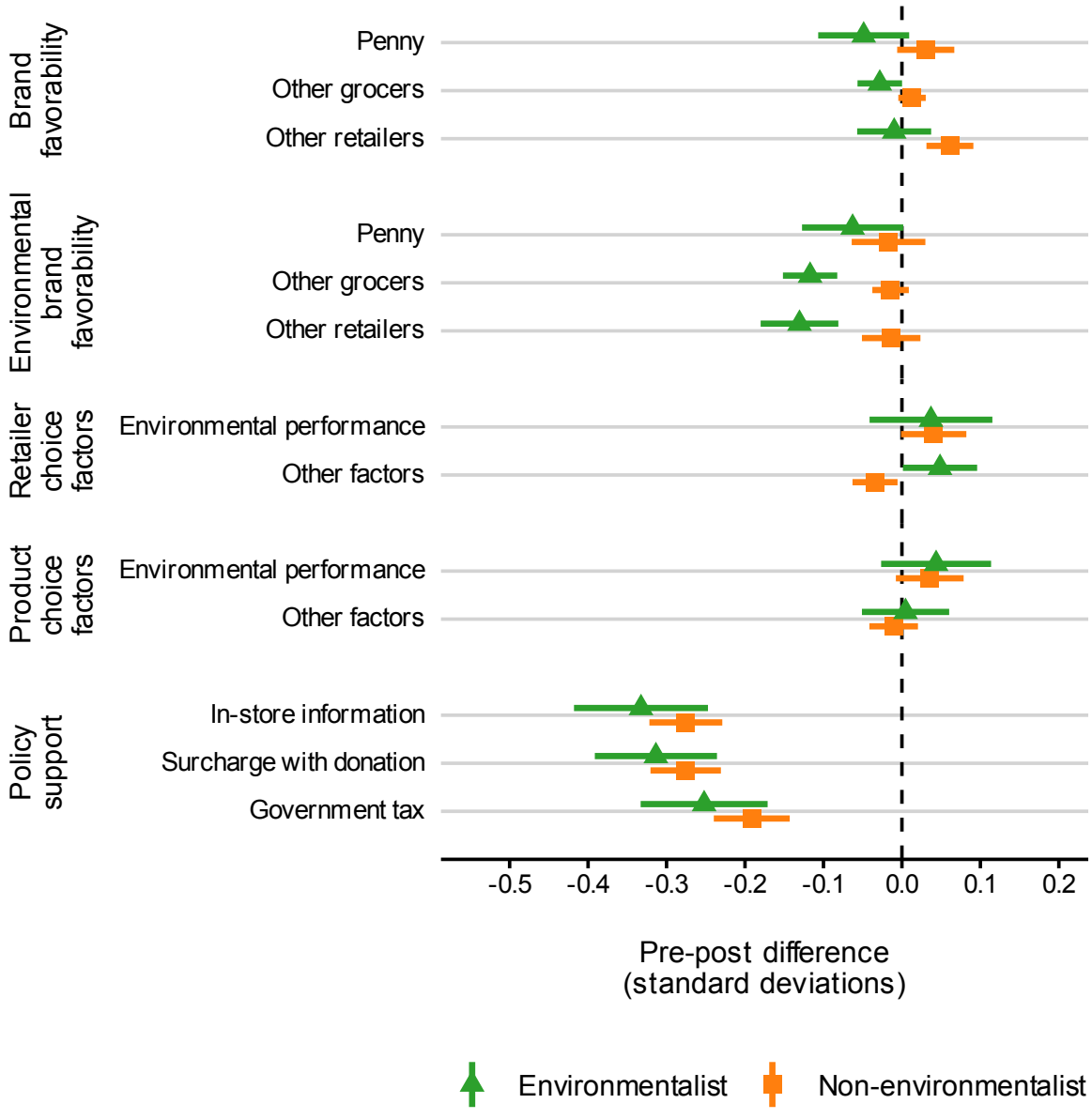
E.1.1 Pre-post Difference Heterogeneity

Figure A4: **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% confidence interval.

Figure A5: **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.1.2 Reasons for (not) Buying Products

Table A4: Reasons for buying products (% important or very important)

	All	Environmentalists	Shopped Penny
Donation to "Future Farmers" project	68	86	68
Interest in sustainability	74	82	74
Interest through advertising / reporting	58	73	58
Always buys product(s)	73	75	73

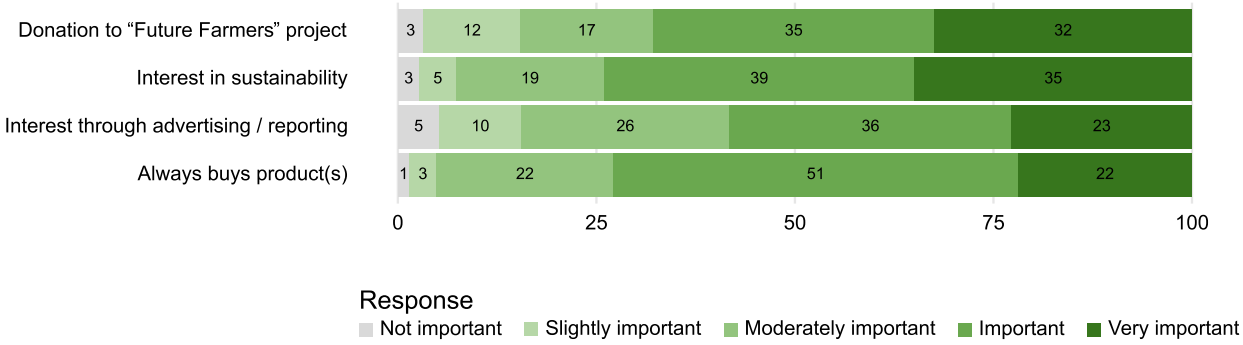
Notes: This table displays the percentage of respondents that correctly answered questions about aspects of the campaign. Percentages are shown by sample. "Environmentalists" are respondents who are strictly more environmentally conscious than the median respondent based on a question in the survey about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

Table A5: Reasons for not buying products (% important or very important)

	All	Environmentalists	Shopped Penny
Too expensive	63	70	63
Generally does not buy campaign products	43	44	43
Did not understand	12	20	12
Did not want to donate to "Future Farmers" project	16	14	16
Does not care about environmental aspects	20	16	20
Did not want to support campaign	25	30	25

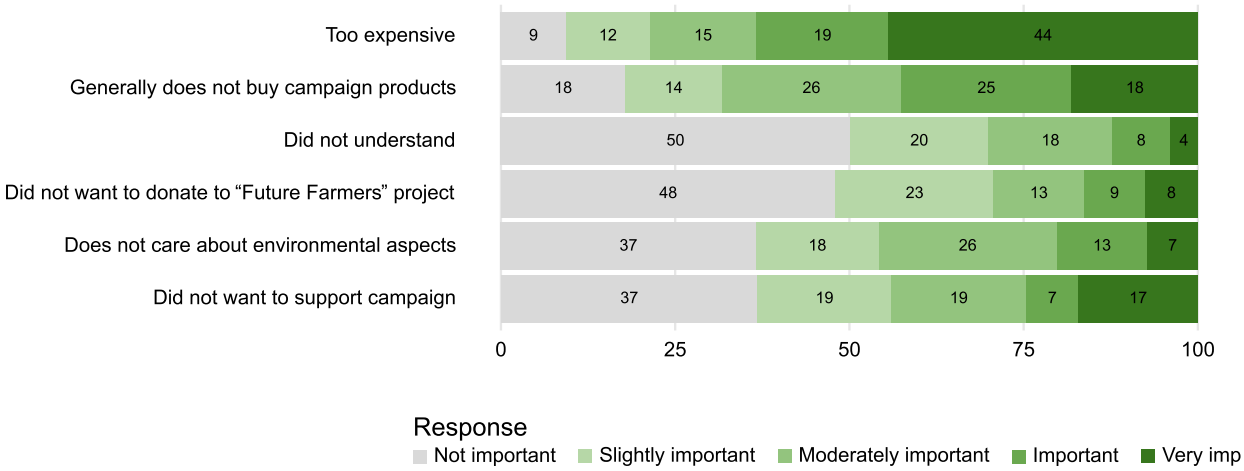
Notes: This table displays the percentage of respondents that correctly answered questions about aspects of the campaign. Percentages are shown by sample. "Environmentalists" are respondents who are strictly more environmentally conscious than the median respondent based on a question in the survey about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

Figure A6: **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 A7: **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.1.3 Effectiveness of Campaign

Table A6: Facts about campaign (% correct)

	All	Environmentalists	Shopped Penny
Penny had campaign	59	63	76
Penny had campaign, but not at baseline	56	58	66
Only Penny had campaign	56	58	65
Scientists calculated true costs	40	36	37
Campaign products identified	42	45	41
Non-campaign products identified	76	74	78
Additional revenue was donated to farmers	71	72	70

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 A7: Effectiveness of donation (% agree)

	All	Environmentalists	Shopped Penny
"Future Farmers" project was a good choice	67	76	69
"Future Farmers" project is effective at addressing damages caused	52	66	53
Revenue should have been redistributed to consumers	29	33	39
Revenue should have been given to government for green investments	20	26	23

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.

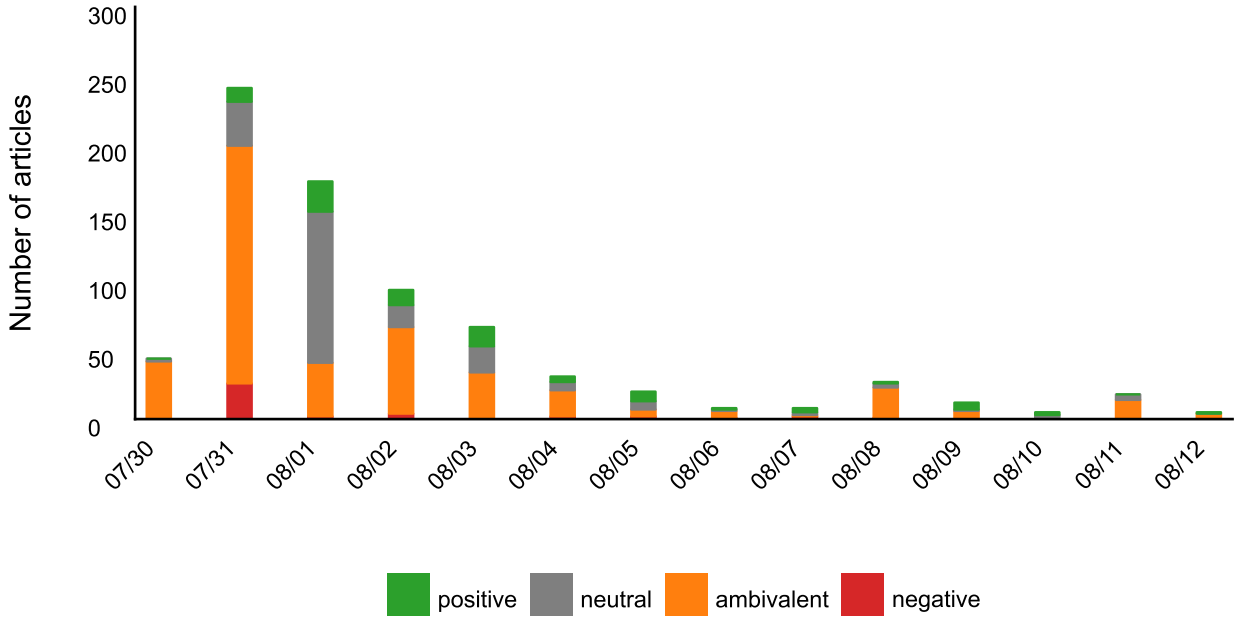
Table A8: Effectiveness of campaign (% agree)

	All	Environmentalists	Shopped Penny
Campaign raised awareness	53	68	53
Campaign led to political debate	32	43	39
Campaign directly reduced damages	20	27	26
Campaign was mere greenwashing, without positive impacts	46	47	46

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.

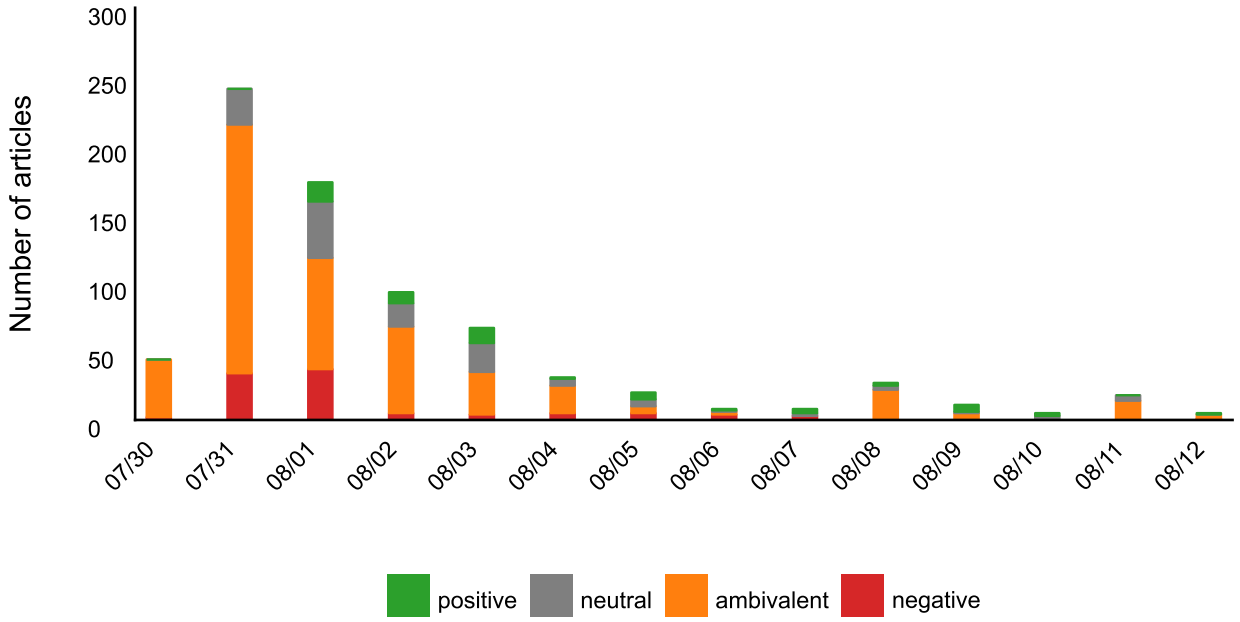
E.2 Media Analysis

Figure A8: **Sentiment Analysis of Media Articles about Penny**



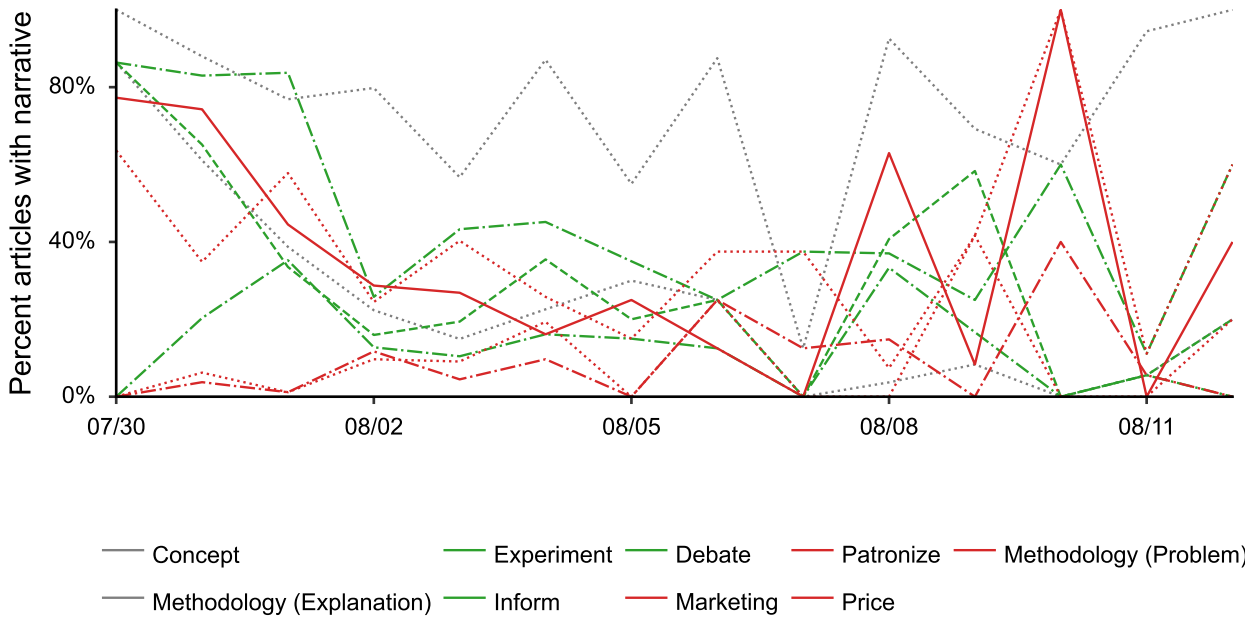
Notes: This figure shows the sentiment towards Penny of articles about Penny. The articles were assessed manually by coders according to the following definitions. Positive: more positive than negative arguments/views. Neutral: mostly objective information, without strong positive or negative arguments/views.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

Figure A9: Sentiment Analysis of Media Articles about the True Cost 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 A10: **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.

E.3 Price Effect and Demand Shift

Table A9: **Campaign Price Effect and Demand Shift, 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 Table 2, column (3).

Table A10: **Campaign Price and Demand Shift, Stockpiling**

	ln(Quantity)			
	(1)	(2)	(3)	(4)
-ln(Price)	2.405	2.379	2.367	2.398
	(0.304)	(0.284)	(0.285)	(0.284)
-ln(Price) (w-1)			-0.025	-0.001
			(0.012)	(0.014)
-ln(Price) (w-2)			-0.029	-0.009
			(0.011)	(0.012)
-ln(Price) (w-3)			-0.010	-0.011
			(0.009)	(0.010)
-ln(Price) (w-4)			0.005	-0.001
			(0.008)	(0.008)
-ln(Price) (w+1)				0.045
				(0.012)
-ln(Price) (w+2)				0.039
				(0.013)
-ln(Price) (w+3)				0.002
				(0.009)
-ln(Price) (w+4)				-0.002
				(0.008)
Product x campaign FE	✓	✓	✓	✓
Product x campaign window FE	✓	✓	✓	✓
Product x sales window FE	✓	✓	✓	✓
Product x price window FE	✓	✓	✓	✓
Category x day FE	✓	✓	✓	✓
Observations	1,076,257	680,791	680,791	680,791
AIC	-367,376.4	-653,237.3	-653,341.2	-653,510.2
BIC	5,399,359.2	2,497,675.1	2,497,616.9	2,497,493.6

Notes: This table shows the results from regressions to assess the incidence of stockpiling. Column (1) is analogous to equation (9), with a common price coefficient for all categories (i.e., σ instead of σ_c). Column (2) estimates the same specification as column (1), but restricts the sample to observations with non-missing price leads and lags for the four weeks before and after. Columns (3) and (4) add weekly lags and leads of the price coefficient. "AIC" and "BIC" report the Akaike Information Criterion and Bayesian Information Criterion, respectively.

E.4 Substitution Results

To analyze the effect of the true cost campaign on the demand for substitute products, we cannot use the CES-based regression in equation (9), due to the category-level fixed effect that contains the CES price index and, thus, unobserved taste parameters. Instead, we run the following regression for category c on day t:

$$\ln q^s_{ct} = -\sigma_c \ln p^s_{ct} + \sum_{w=-4}^{4} \mathbb{1}^w_t \delta^w + \delta_q + \delta_d + \varepsilon_{ct}, \tag{26}$$

where q^s_{ct} is the total quantity of substitute products sold (in calories), p^s_{ct} is the average price of substitute products (per calorie), δ^w is a fixed effect for week w (relative to the campaign week), δ_q is a quater-of-

sample fixed effect, and δ_d is a day-of-week fixed effect. We only have four non-overlapping categories, which is too few to cluster by category and month (Cameron and Miller 2015), so we report Newey-West standard errors with a lag of 7.

The results are shown in Appendix Table A11. There are no pre-trends and our coefficient of interest δ^0 is not statistically significant. However, while the point estimate for δ^0 is negative, we also cannot rule out full substitution for any category. For example, for cheese—the category where campaign products have the highest market share (5.3 during the campaign week)—the confidence interval for the campaign effect on substitute quantities is between -758 and 536 percent of the effect on campaign product quantities. [16]The confidence interval is even larger for the other product categories.

These large confidence intervals are due to a combination of low market share of campaign products and relatively high week-to-week variation. Appendix Figure A11 shows the price and quantity for all campaign products and their substitutes in four non-overlapping product categories. Both variables are scaled such that the baseline average (in the two weeks before the campaign) is equal to 1. Quantities are demeaned by weekday, and substitute quantities are scaled by baseline substitute over baseline campaign product demand. Thus, if there was full substitution of campaign product demand, the change in substitute quantity would be -1 times the change in campaign quantities. Instead, we see that the day-to-day variation in substitute quantities exceeds full substitution, meaning that we cannot reliably estimate the effect of the campaign on substitute demand.

[16]The change in daily quantities for substitutes in category c and campaign product j due to the campaign are

$$\Delta q^s_{ct} = q^{sc}_{ct}\left[1 - \frac{1}{\exp(\delta^o)}\right] \tag{27}$$

and

$$\Delta q_{jt} = q^c_{jt}\left[1 - \frac{1}{p_j^{\sigma_c}\exp(\tau_j)}\right], \tag{28}$$

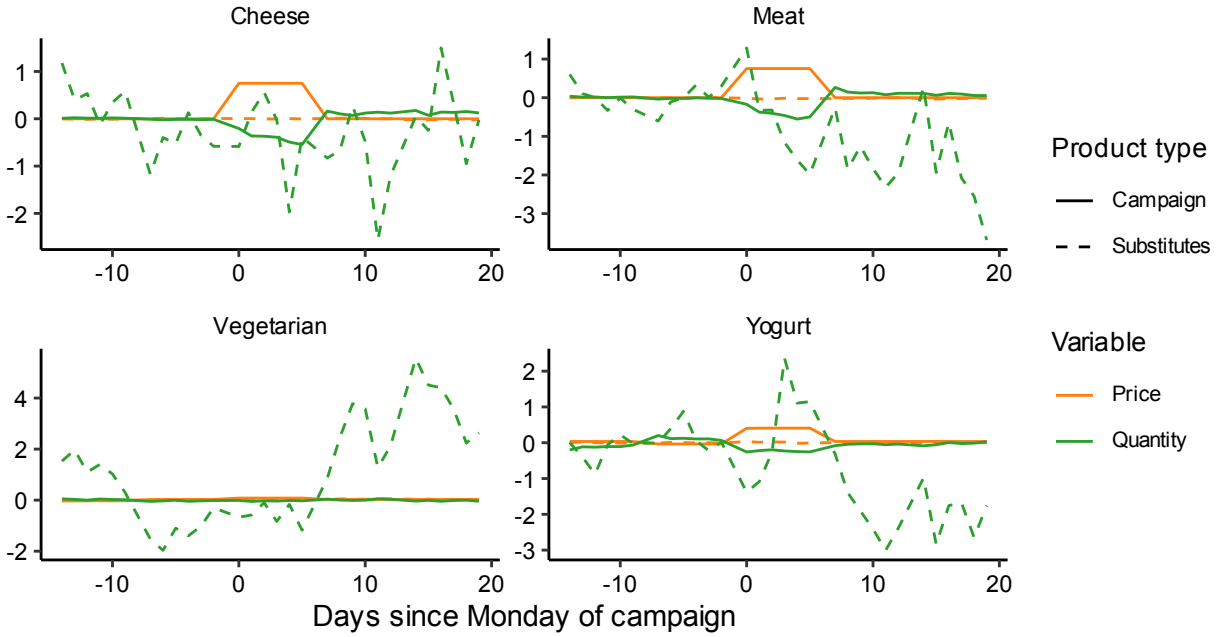
respectively, where q^{sc}_c and q^c_j are substitute and campaign product quantities during the campaign. We calculate these for the average day and sum over campaign products in each category to Δq_{ct}. We then calculate percentage substitution $\Delta q^s_{ct}/\Delta q_{ct}$ using the point estimates for σ_c and τ_j, and the upper and lower bounds for δ^0.

Table A11: **Campaign Substitution Effect**

	ln(Quantity)	
	(1)	(2)
-ln(Price) x Meat	-0.244	-0.243
	(0.091)	(0.091)
-ln(Price) x Cheese	0.095	0.097
	(0.105)	(0.105)
-ln(Price) x Yogurt	0.708	0.704
	(0.180)	(0.180)
-ln(Price) x Vegetarian	2.417	2.418
	(0.103)	(0.103)
Week = -4	0.023	0.026
	(0.138)	(0.137)
Week = -3	0.016	0.019
	(0.136)	(0.136)
Week = -2	-0.004	0.000
	(0.132)	(0.132)
Week = -1	-0.028	-0.025
	(0.121)	(0.120)
Week = 0	-0.015	-0.012
	(0.129)	(0.129)
Week = 1	-0.003	0.000
	(0.161)	(0.161)
Week = 2	0.002	0.005
	(0.160)	(0.160)
Week = 3	-0.074	-0.071
	(0.150)	(0.149)
Week = 4	0.003	0.006
	(0.127)	(0.126)
Quarter-of-sample FE	✓	✓
Day-of-week FE		✓
Standard error/cluster	NW-7	
Observations	5,548	5,548
R^2	0.87765	0.88058

Notes: This table shows the results from a regression to estimate the effect of the campaign on substitute demand for different product categories. The regression model for column (2) is shown in equation (26). Observations are at the category-day level. Included are sales during the entire sample period.

Figure A11: Campaign Substitution Event Study

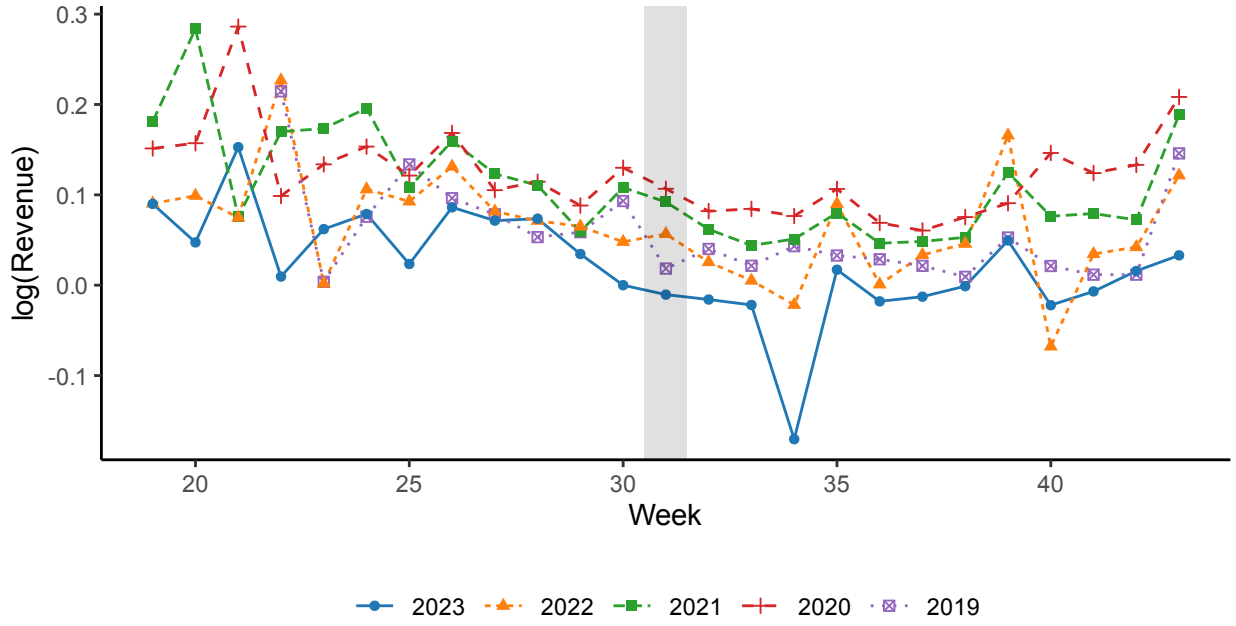


Notes: This figure displays the price and quantity indices for campaign products and their substitutes across four distinct product categories. Both variables are scaled so that the baseline average (calculated over the two weeks preceding the campaign) equals 1. Quantities are adjusted for weekday effects (demeaned by weekday), and substitute quantities are further scaled by the ratio of baseline substitute demand to baseline campaign product demand.

E.5 Revenue Results

We do not find any statistically significant effect of the campaign on Penny's short- and medium-term revenues. Appendix Figure A12 shows revenues for a 25-week window centered on the campaign week for 2019-23. Revenues are lower during the campaign week in 2023, but not much more than during the preceding weeks. A similar pattern holds for the post-campaign period, except for a one-week drop in revenues three weeks after the campaign. These results are confirmed through a regression, which shows no statistically significant association of the campaign year with revenues during the campaign week and the post-campaign period (see Appendix Table A12). Given that most negative news coverage of the campaign was concentrated during the campaign week and coverage had largely subsided two weeks later (see Appendix Figures A8 and A9), we conclude that the revenue decline observed three weeks after the campaign is unlikely to have been caused by the campaign itself.

Figure A12: **Revenue**s Around the Campaign Week



Notes: This figure shows Penny revenues for a 25-week window centered around the campaign week for the years 2019-23. Horizontal axis: calendar week (Western traditional). Gray area: campaign week (week 31). Revenues are estimated from the Penny receipt data (77 percent coverage), adjusted for food inflation, and measured relative to the week before the campaign.

Table A12: **Revenue Regression Results**

	log(Revenue)	
	(1)	(2)
2023	-0.0605	-0.0605
	(0.0127)	(0.0127)
Week 31 x 2023	-0.0184	-0.0184
	(0.0229)	(0.0230)
Post x 2023	-0.0169	-0.0050
	(0.0184)	(0.0160)
Week 33 x 2023		-0.1422
		(0.0223)
Calendar week FE	✓	✓
Standard error/cluster	NW-1	
Observations	122	122
R^2	0.59145	0.61848

Notes: This table shows the results for a regression of revenues on the 2023 campaign and post-campaign periods. Regression model: $\ln r_t = \alpha_w + \mathbb{1}_t^{w31}\mathbb{1}_t^{2023}\beta_1 + \mathbb{1}_t^{post}\mathbb{1}_t^{2023}\beta_2 + \mathbb{1}_t^{w34}\mathbb{1}_t^{2023}\beta_3 + \varepsilon_t$, where r_t are revenues in week t, α_w is a fixed effect for calendar week w, and $\mathbb{1}_t^{w31}$, $\mathbb{1}_t^{post}$, $\mathbb{1}_t^{w34}$ and $\mathbb{1}_t^{2023}$ are one during calendar week 31, the 12 weeks following the campaign, calendar week 34 and 2023, respectively, and zero otherwise. Included are the 25-week windows centered around the campaign campaign for 2019-23, shown in Figure A12. Revenues are estimated from the Penny receipt data (77 percent coverage), adjusted for food inflation, and measured relative to the week before the campaign. Column (2) shows our main specification, column (1) excludes the $\mathbb{1}_t^{w34}\mathbb{1}_t^{2023}$ indicator. Standard error estimator: Newey-West with one lag ($L = 1$).

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 (66) we have that:

$$q_j = \left(\frac{\alpha_j}{p_j}\right)^{\sigma_c} \underbrace{\left(\frac{\alpha_c}{P_c}\right)^{\sigma_g} \left(\frac{\alpha_g}{P_g}\right)^{\sigma} \frac{y}{D} P_g^{\sigma_g} P_c^{\sigma_c}}_{C} \tag{29}$$

for product j in category c and group g.

Adding subscript t and taking logs gives:

$$\ln q_{jt} = \sigma_{ct} \ln \alpha_{jt} - \sigma_{ct} \ln p_{jt} + \underbrace{\ln C_{jt}}_{\delta_{ct}} \tag{30}$$

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

$$\sigma_{ct} = \sigma_c, \tag{31}$$

$$\alpha_{jt} = \begin{cases} \alpha_j^c \cdot \alpha_j^{cw} \cdot \tilde{\alpha}_{jt} & \text{if } j \in J^c \text{ and } t \in T^c \\ \alpha_j^{cw} \cdot \tilde{\alpha}_{jt} & \text{if } j \in J^c \text{ and } t \in T^{cw} \text{ and } t \notin T^c \\ \alpha_{je}^{sw} \cdot \tilde{\alpha}_{jt} & \text{if } t \in T_{je}^{sw} \\ \tilde{\alpha}_{jt} & \text{otherwise} \end{cases}, \tag{32}$$

$$\tilde{\alpha}_{jt} := \alpha_{jw} \cdot \kappa_{jt}, \tag{33}$$

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:

$$p_{jt} \neq p_{j(t-1)} \quad \bigwedge \quad (j \notin J^c \quad \bigvee \quad t \notin T^c \quad \bigwedge \quad t \notin T_j^s). \tag{34}$$

As a result:

$$\begin{aligned} \sigma_c \ln \alpha_{jt} = {} & \mathbb{1}(j \in J^c)\mathbb{1}(t \in T^c) \underbrace{\sigma_c \ln \alpha_j^c}_{\tau_j} + \mathbb{1}(j \in J^c)\mathbb{1}(t \in T^{cw}) \underbrace{\sigma_c \ln \alpha_j^{cw}}_{\delta_j^{cw}} \\ & + \mathbb{1}(t \in T_{je}^{sw}) \underbrace{\sigma_c \ln \alpha_{je}^{sw}}_{\delta_{je}^{sw}} + \underbrace{\sigma_c \ln \alpha_{jw}}_{\delta_{jw}} + \underbrace{\sigma_c \ln \kappa_{jt}}_{\varepsilon_{jt}} \end{aligned} \tag{35}$$

Substituting this expression into (30) gives:

$$\begin{aligned}\ln q_{jt} = &-\sigma_c \ln p_{jt} + \mathbb{1}(j \in J^c)\mathbb{1}(t \in T^c)\tau_j + \mathbb{1}(j \in J^c)\mathbb{1}(t \in T^{cw})\delta_j^{cw} \\ &+ \mathbb{1}(t \in T_{je}^{sw})\delta_{je}^{sw} + \delta_{jw} + \delta_{ct} + \varepsilon_{jt}\end{aligned} \tag{36}$$

F.2 Welfare Components

Let $\boldsymbol{d}^b = \mathbf{0}$, $\boldsymbol{p}^b = \tilde{\boldsymbol{p}}$, $\boldsymbol{\phi}^b = \tilde{\boldsymbol{\phi}}$,and $\boldsymbol{q}^b$ be donations, prices, externalities, and counterfactual "baseline" quantities without the campaign. Similarly, 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. Finally, let $\boldsymbol{d}^h = \mathbf{0}$, $\boldsymbol{p}^h = \boldsymbol{p}^c$, $\boldsymbol{\phi}^h = \tilde{\boldsymbol{\phi}}$, 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:

$$\Delta CS = CS^c - CS^b \tag{37}$$

$$= \underbrace{CS^c - CS^h}_{\text{warm glow } \Delta WG} + \underbrace{CS^h - CS^b}_{\text{consumption utility } \Delta CU} \tag{38}$$

$$\Delta E = \boldsymbol{q}^c \cdot \boldsymbol{\phi}^c + n^c \phi_n - \left(\boldsymbol{q}^b \cdot \boldsymbol{\phi}^c + n^b \phi_n\right) \tag{39}$$

$$= \underbrace{\left(\boldsymbol{q}^c - \boldsymbol{q}^b\right) \cdot \tilde{\boldsymbol{\phi}} + \left(n^c - n^b\right) \phi_n}_{\text{consumption externalities } \Delta CE} - \underbrace{\nu \boldsymbol{q}^c \cdot \boldsymbol{d}^c}_{\text{donation } \Delta D} \tag{40}$$

$$\Delta\Pi = \boldsymbol{q}^c \cdot (\tilde{\boldsymbol{p}}^c - \boldsymbol{c}^c) - \left(\boldsymbol{q}^b \cdot \left(\tilde{\boldsymbol{p}}^b - \boldsymbol{c}^b\right)\right) \tag{41}$$

F.3 Consumer Surplus

Consumer surplus during the campaign week is

$$CS(\boldsymbol{q}, \boldsymbol{p}, \boldsymbol{\alpha}) = \sum_j \sum_{t=0}^{6} \int_0^{q_{jt}} (D_{jt}(x, \alpha_{jt}) - p_{jt}) dx \tag{42}$$

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

$$D_{jt}(q_{jt}, \alpha_{jt}) = \alpha_{jt} \left(\frac{C_{jt}}{q_{jt}}\right)^{\frac{1}{\sigma_c}} \tag{43}$$

Hence, consumer surplus is

$$CS(\boldsymbol{q},\boldsymbol{p},\boldsymbol{\alpha}) = \sum_j \sum_{t=0}^{6} \int_0^{q_{jt}} \alpha_{jt} \left(\frac{C_{jt}}{q_{jt}}\right)^{\frac{1}{\sigma_c}} - p_{jt} dx \tag{44}$$

$$= \sum_j \sum_{t=0}^{6} \alpha_{jt} C_{jt}^{\frac{1}{\sigma}} \frac{(q_{jt})^{1-\frac{1}{\sigma_c}}}{\left(1-\frac{1}{\sigma_c}\right)} - p_{jt} q_{jt} \tag{45}$$

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:

$$CS^b := CS\left(\boldsymbol{q}^b, \boldsymbol{p}^b, \boldsymbol{\alpha}^b\right) \tag{46}$$

$$= \sum_j \sum_{t=0}^{6} \tilde{\alpha}_{jt} \frac{\left(q_{jt}^b\right)^{1-\frac{1}{\sigma_c}}}{\left(1-\frac{1}{\sigma_c}\right)} - p_{jt}^b q_{jt}^b \tag{47}$$

$$CS^c := CS\left(\boldsymbol{q}^c, \boldsymbol{p}^c, \boldsymbol{\alpha}^c\right) \tag{48}$$

$$= \sum_j \sum_{t=0}^{6} \alpha_j^c \tilde{\alpha}_{jt} \frac{\left(q_{jt}^c\right)^{1-\frac{1}{\sigma_c}}}{\left(1-\frac{1}{\sigma_c}\right)} - p_{jt}^c q_{jt}^c \tag{49}$$

$$CS^h := CS\left(\boldsymbol{q}^h, \boldsymbol{p}^c, \boldsymbol{\alpha}^b\right) \tag{50}$$

$$= \sum_j \sum_{t=0}^{6} \tilde{\alpha}_{jt} \frac{\left(q_{jt}^h\right)^{1-\frac{1}{\sigma_c}}}{\left(1-\frac{1}{\sigma_c}\right)} - p_{jt}^c q_{jt}^h \tag{51}$$

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:

$$u\left(\boldsymbol{\nu}_{gkrw}, n_{krw}; \boldsymbol{\alpha}_{krw}, m\right) = n_{krw} + \left(\sum_g \alpha_{gkrw} \nu_{hkrw}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{m\sigma}{\sigma-1}} \tag{52}$$

where

$$\nu_g\left(\boldsymbol{\mu}_{ckrw}; \boldsymbol{\alpha}_{krw}^g\right) = \left(\sum_c \alpha_{ckrw} \mu_{ckrw}^{\frac{\sigma_g-1}{\sigma_g}}\right)^{\frac{\sigma_g}{\sigma_g-1}} \tag{53}$$

and

$$\mu_c\left(\boldsymbol{q}_{ckrw}; \boldsymbol{\alpha}_{krw}^c\right) = \left(\sum_j \alpha_{jkrw} q_{jkrw}^{\frac{\sigma_c-1}{\sigma_c}}\right)^{\frac{\sigma_c}{\sigma_c-1}} \tag{54}$$

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 (54) 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

$$q_{jkrw}^* = \left(\frac{\alpha_{jkrw}}{p_{jrw}}\right)^{\sigma_c} \frac{y_{ckrw}}{D_{ckrw}} \tag{55}$$

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

$$\mu_c = y_c D_c^{\frac{1}{\sigma_c - 1}} \tag{56}$$

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

$$\sum_{c \in C_g} y_{ckrw} = \sum_{c \in C_g} \mu_{ckrw} D_{ckrw}^{\frac{1}{1-\sigma_c}} = \sum_{c \in C_g} \mu_{ckrw} P_{ckrw} \tag{57}$$

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 (53) subject to $y_{gkrw} = \sum_{c \in C_g} \mu_{ckrw} P_{ckrw}$.

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

$$\mu^*_{ckrw} = \left(\frac{\alpha_{ckrw}}{P_{ckrw}} \right)^{\sigma_g} \frac{y_{gkrw}}{D_{gkrw}} \tag{58}$$

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

Expenditure in category c is given by

$$y_{ckrw} = \mu^*_{ckrw} P_{ckrw} = \alpha_{ckrw}^{\sigma_g} P_{ckrw}^{1-\sigma_g} \frac{y_{gkrw}}{D_{gkrw}} \tag{59}$$

Indirect utility from category consumption choices in group g is

$$v_{gkrw} = y_{gkrw} D_{gkrw}^{\frac{1}{\sigma_g - 1}} \tag{60}$$

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

$$\sum_{g \in G} y_{gkrw} = \sum_{g \in G} v_{gkrw} D_{gkrw}^{\frac{1}{1-\sigma_g}} = \sum_{g \in G} v_{gkrw} P_{gkrw} \tag{61}$$

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 (52) 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

$$v^*_{gkrw} = \left(\frac{\alpha_{gkrw}}{P_{gkrw}} \right)^{\sigma} \frac{y_{krw}}{D_{krw}} \tag{62}$$

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

$$y_{gkrw} = v_{gkrw} P_{gkrw} = \alpha^{\sigma}_{gkrw} P^{1-\sigma}_{gkrw} \frac{y_{krw}}{D_{krw}} \tag{63}$$

From these expressions, we can link the three nests of the problem. Specifically, by plugging equation (63) in (58), we can obtain category-level demands as a function of total expenditure in the inside goods:

$$\mu^*_{ckrw} = \left(\frac{\alpha_{ckrw}}{P_{ckrw}} \right)^{\sigma_g} \left(\frac{1}{D_{gkrw}} \right) \left(\frac{\alpha_{gkrw}}{P_{gkrw}} \right)^{\sigma} \left(\frac{I_{krw}}{D_{krw}} \right) P_{gkrw} = \left(\frac{\alpha_{ckrw}}{P_{ckrw}} \right)^{\sigma_g} \left(\frac{\alpha_{gkrw}}{P_{gkrw}} \right)^{\sigma} \left(\frac{I_{krw}}{D_{krw}} \right) P^{\sigma_g}_{gkrw} \tag{64}$$

Plugging equation (63) in (59) allows to compute category-level expenditures as a function of total expenditure in the inside good:

$$y_{ckrw} = \alpha^{\sigma_g}_{ckrw} P^{1-\sigma_g}_{ckrw} \frac{1}{D_g} \left(\alpha^{\sigma}_{gkrw} P^{1-\sigma}_{g} \frac{I_{krw}}{D_{krw}} \right) \tag{65}$$

By plugging equation (65) in (55), we can derive a final expression for product-level demand as a function of inside goods expenditure I_{krw}:

$$q_{jkrw} = \left(\frac{\alpha_{jkrw}}{p_{jrw}} \right)^{\sigma_c} \left(\frac{\alpha_{ckrw}}{P_{ckrw}} \right)^{\sigma_g} \left(\frac{\alpha_{gkrw}}{P_{gkrw}} \right)^{\sigma} \frac{y_{krw}}{D_{krw}} P^{\sigma_g}_{gkrw} P^{\sigma_c}_{ckrw} \tag{66}$$

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

$$v(\boldsymbol{q}_{krw}, y_{krw}) = n_{krw} + I^{m}_{krw} D^{\frac{m}{\sigma - 1}}_{krw} \tag{67}$$

Hence, marginal utility from expenditure on the inside goods bundle is

$$\frac{\partial v}{\partial I_{krw}} = m I_{krw}^{m-1} D_{krw}^{\frac{m}{\sigma-1}} \tag{68}$$

Equating equation (68) to 1, it follows that expenditure on the bundle of inside goods in equilibrium is given by

$$I_{krw} = \left(\frac{1}{m D_{krw}^{\frac{m}{\sigma-1}}} \right)^{\frac{1}{m-1}}. \tag{69}$$

G.2 Structural Model Estimation

Taste parameter identification. Following equation (55), optimal demand for product j is given by (omitting other subindices for brevity):

$$q_j^* = \left(\frac{\alpha_j}{p_j} \right)^{\sigma} \frac{y}{D} \tag{70}$$

Rearranging:

$$\frac{D}{y} = \frac{\alpha_j^{\sigma} p_j^{-\sigma}}{q_j} \tag{71}$$

Since the left hand side of equation (71) is constant across products, for any two products j and k, it follows that

$$\frac{\alpha_j^{\sigma} p_j^{-\sigma}}{q_j} = \frac{\alpha_k^{\sigma} p_k^{-\sigma}}{q_k}, \tag{72}$$

which can be rewritten as

$$\alpha_k = \alpha_j \left(\frac{q_k p_j^{-\sigma}}{q_j p_k^{-\sigma}} \right)^{\frac{1}{\sigma}}. \tag{73}$$

Taking the sample mean over all product categories k in the group:

$$\frac{1}{\mathscr{J}_c} \sum_k \alpha_k = \frac{1}{\mathscr{J}_c} \sum_k \alpha_j \left(\frac{q_k p_j^{-\sigma}}{q_j p_k^{-\sigma}} \right)^{\frac{1}{\sigma}} \tag{74}$$

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:

$$\alpha_j = \mathscr{J}_c \varphi \frac{q_j^{\frac{1}{\sigma}} p_j}{\sum_k q_k^{\frac{1}{\sigma}} p_k}. \tag{75}$$

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

Inside goods expenditure. Equation (69) 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 (66). 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.

G.3 Stockpiling

Table A13: **Campaign Price and Demand Shift, Stockpiling**

	ln(Quantity)			
	(1)	(2)	(3)	(4)
ln(Price)	-2.001	-2.050	-2.613	-2.806
	(0.013)	(0.014)	(0.016)	(0.017)
ln(Price) (w-1)			0.608	0.498
			(0.014)	(0.014)
ln(Price) (w-2)			0.455	0.367
			(0.013)	(0.013)
ln(Price) (w-3)			0.215	0.157
			(0.013)	(0.013)
ln(Price) (w-4)			0.043	0.019
			(0.013)	(0.013)
ln(Price) (w+1)				0.217
				(0.014)
ln(Price) (w+2)				0.355
				(0.013)
ln(Price) (w+3)				0.160
				(0.013)
ln(Price) (w+4)				0.035
				(0.013)
Consumer group x chain x product category x week FE	✓	✓	✓	✓
Consumer group x chain x product FE	✓	✓	✓	✓
Observations	665,692	563,015	563,015	563,015
AIC	1,511,830.4	1,267,867.2	1,258,980.7	1,256,328.3
BIC	1,903,840.7	1,617,531.7	1,608,690.1	1,606,082.7

Notes: This table shows the results from regressions to assess the incidence of stockpiling. Column (1) is analogous to equation (17), with a common price coefficient for all categories (i.e., σ instead of σ_c). Column (2) estimates the same specification as column (1), but restricts the sample to observations with non-missing price leads and lags for the four weeks before and after. Columns (3) and (4) add weekly lags and leads of the price coefficient. "AIC" and "BIC" report the Akaike Information Criterion and Bayesian Information Criterion, respectively.

H Counterfactual Simulations Appendix

In this section, we outline some implementation details about the counterfactuals.

Cross-subsidy. We operationalize the revenue-neutral cross-subsidy in the following way: for each category, and for the retailer r that implements the policy, prices under the cross-subsidy are given by $p^{CS}_{jrt} = p_{jrt} + \lambda^{ext}\phi_{jt} - \psi$, where λ^{ext} scales the magnitude of the externality charge implemented and ψ is a common rebate applied to all categories. We set ψ to minimize the distance between pre- and post-subsidy revenues. A larger externality charge increases the value of the rebate, and thus the price decrease of the

low-externality categories. Because low-externality categories tend to be among the highest demanded ones, large externality charges adversely impact total surplus by reducing retailer profits. We solve for the optimal rebate for a grid of externality charges $\lambda^{ext} = [0.01, 0.02, ..., 0.1]$ and implement the value that maximizes total surplus gains. In the counterfactual, the cross-subsidy is in place for the entire year.

True Cost Campaign. We implement an "extended" true cost campaign, in which Penny treats the same products as in the real world campaign, for an entire year. We identify the campaign products in the AiMark data by matching barcodes in the home scanner data with those for the treated products in the actual campaign. We simulate two versions of the campaign. In the first version, treated products are charged their uninternalized externalities, and the retailer donates the proceeds of this surcharge efficiently, but consumers do not derive warm glow from consuming the treated categories. In the second version, we add warm glow. Specifically, we scale the taste parameters obtained in Section 6 by the product-specific campaign effects identified in the real-world campaign in Section 5. In the real-world campaign, the recovered effects are a combination of demand shift due to warm glow and retailer substitution effects into Penny. In our structural model, retailer and product choice are separate (but interdependent) decisions. To adjust for the difference between the two exercises, we scale all product-specific campaign effects in the reduced form by a common factor such that the effect of the campaign on total weekly kcal consumption of campaign products in the structural models is is within 10% of the effect estimated in Section 5, estimated using equation (28). We convert the per-household quantities in the model to overall quantities using the ratio of baseline quantities q_j^b estimated in Section 5 and quantities in the AiMark data in the week before the campaign.