# How Do Shoppers Respond to Noisy Signals on Price Changes? Evidence from a Field Experiment in Online Supermarket Shopping*

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What is the effect on the demand for both discounted and non-discounted products, when promotional material informs shoppers that some product categories feature discounts? We address this question by conducting a field experiment on a website for online grocery shopping. We find that shoppers who had purchased in a certain food category prior to the experiment responded to noisy promotional information by purchasing items in the discounted category that they had already purchased in the past, regardless of whether the item purchased was currently discounted. Our results suggest that coarse information on discounts increases both consumer spending and seller revenue.

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# I Introduction

A consumer in the modern marketplace is often faced with the problem of repeatedly choosing the best bundle of goods or services in an environment where prices are constantly changing. This is particularly true for grocery shopping, where consumers repeatedly purchase bundles containing many diverse products including food items, household goods, and health and beauty products. Even if the consumer found and purchased the cheapest brand in a particular category during her previous shopping trip, this brand may no longer be the cheapest brand in the category during the current shopping trip.

How do shoppers then cope with frequent price changes across many relevant product categories? One possibility is that on each new shopping trip, they compare prices of all brands in each and every product category. Another possibility is that they learn about categories with discounts through promotional announcements. While this can potentially save them time and effort by alerting them to categories with price decreases, shoppers may still be facing additional uncertainty regarding price changes. First, promotional announcements typically do not inform shoppers that some items they bought on their previous shopping trip are no longer on sale, and consequently may now be more expensive than alternative substitutes. Second, promotional announcements often provide only coarse information on discounts - for instance, "Up to 30% off on select vitamins" or "40% off on vegan snacks" – in that they do not specify the exact items that are on sale or the precise discount on each item. Thus, shoppers who are faced with such promotional announcements need to exert effort and search for the specific items that are discounted in order to enjoy the savings that they offer.

The above discussion raises the following natural question: when shoppers are

informed that some product categories feature discounts, what is the effect on the demand of both discounted and non-discounted products? Addressing this question empirically is challenging as it requires the analyst to know exactly what promotional announcements shoppers were exposed to during their entire shopping trip, to control for the variability in the precision and framing of the promotional announcements, and to control for the possible endogeneity of fluctuations in prices. Since this is difficult to accomplish with purely observational data, we partnered with a platform for online grocery shopping that conducted a series of randomized controlled trials over a three-month period.

In our field experiment, a subset of shoppers on the site were randomly assigned to either a treatment or a control group. Both groups received a weekly email offering an immediate rebate (given at checkout) for buying at least one unit from a certain category (e.g., bread), which changed each week. However, the email to the treatment group included *additional* information: it announced that some food items were on sale that week and listed the food categories with the biggest discounts in percentages. The website displayed only the final prices (i.e., after applying the discounts) without prominently announcing the discounts (hence, all shoppers faced the same final prices). The only difference is that treatment shoppers were given some information about the discounts, while control shoppers could learn about the discounts only by comparing prices on the website (prior to the experiment, prices were fixed and there were no sales offered on the website).

The discounted items were not chosen at random but were selected such that each had an obvious, (weakly) more expensive substitute of equal or lower perceived quality (e.g., organic fruits were priced the same or lower than their non-organic counterparts), and each month there was a new set of discounted items. In addition to varying the set of discounted items during the course of the experiment, we also varied

the precision and framing of the information provided to the treatment shoppers. In the first five weeks of the experiment, the promotion listed only the four categories with the biggest percentage of discounts, while in weeks $6-13$ the treatment shoppers were also alerted to the fact that organic items were on sale. In addition, during these later weeks of the experiment, each treatment shopper who previously bought a non-discounted item received a personalized message notifying her that she might want to consider some cheaper alternatives that were on sale that month. Figure 1 displays the outline of the experiment.

Place Figure 1 about here.

Our main finding is that shoppers who received information on discounts (treatment shoppers) increased consumption of the discounted target product *without* decreasing their demand for the substitute products in that category, while shoppers who did not receive information on discounts (control shoppers) purchased *less* of the substitute product when the target product in that category was on sale. While demand for the discounted products in a category doubled among both treatment and control shoppers during the intervention, the demand for non-discounted products *within that same category* increased by 44 percent for treatment shoppers, which translates to increased profits for the retailer. This response is observed for substitute items that have lower perceived quality and weakly higher prices (e.g., non-organicly grown produce that is more expensive than its organic counterpart). In addition, more precise information on sales, together with a personalized nudge, seems to reduce the purchasing rate of the non-discounted substitute. This suggests that the effect on non-discounted items is driven by mistakes rather than preferences.

*Related literature.* It is instructive to compare our findings with related results in the literature. One of our main observations is consumer inertia that manifests itself

in the form of shoppers with a history of purchasing a specific item within a category, who continue to buy that item, even when they could have purchased a (weakly) higher-quality alternative at a (weakly) lower price. Similar inertia is described by Clerides and Courty [2017], who use scanner data from a supermarket chain to show that during periods in which the price of a discounted box of detergent was lower than the corresponding price of a larger ('economy-size') box (of the same product), consumers still bought the larger, and more expensive box. This could be partly explained by the fact that shoppers are used to seeing lower prices on economy-size packages and, hence, do not check the price per unit when making their purchasing decisions. Our experiment (which focuses on product categories where the weakly more expensive/higher-quality product's price is exogenously reduced) provides an opportunity to examine whether this "product inertia" can be convincingly explained by consumer preferences.

Our finding that information on product categories with discounts affects the demand for non-discounted items in those categories is related to several recent studies that document indirect effects of promotional announcements. Using field experiments on online retail websites, Fong et al. [2016] and Fong [2017] show that targeted promotions that are based on individual purchase histories can have negative spillover effects: they reduce search on the seller's website for other non-promoted items and consequently lower sales of such items. Janakiraman et al. [2006] provide evidence from lab experiments that when consumers shop for a bundle of goods (as in a supermarket or pharmacy), encountering unexpected price changes in one product has an effect in the opposite direction on their purchases of other products: when the price increases (decreases), they reduce (increase) their purchases of other products. Anderson and Simester [2013] demonstrate that sending customers of some retailer advertisements of the retailer's competitor actually leads to an increase in the sales

of the retailer who does not engage in advertising.

Other studies have shown that promoting a particular brand (either by advertising or by offering coupons) can increase the sales of other non-promoted brands. Sahni [2016] shows that advertising a particular restaurant on a restaurant-search website leads to an increase in page visits and sales of competing restaurants that offer the same cuisine. A similar effect was reported by Sahni et al. [2017], who show that when a website selling tickets to sporting events offers discounted tickets to some events, its revenues increase, but only a small proportion of this rise is due to the sale of the discounted tickets. The authors interpret this finding as suggesting that promotional emails divert attention to the promoting firm (i.e., the website) and this may increase the traffic to it. Gopalakrishnan and Park [2021] also conduct a field experiment on an online retailing platform to study the effect of coupons on purchasing behavior. They find that coupons are effective in increasing revenue, primarily by attracting customers who then purchase products unrelated to the coupons. In all these studies shoppers are made aware of a discount on *one* particular product, but choose to purchase an alternative product. The interpretation is that promotional information brings attention to a category, and then the shopper makes a choice based on her preferences.

In our experiment, coarse information on discounts in a particular food category may divert attention to that category (e.g., remind shoppers that they need to buy items in that category). The reason that this leads to more purchases of non-discounted items may be partly due to the fact that these are products shoppers were more likely to purchase in the past. However, in contrast to the aforementioned studies, it is not clear that this increase in purchases can be attributed to a pure preference for the non-discounted items over the discounted ones, for the following reasons. First, in our intervention we lower the price of the weakly higher-quality

product in a category, while keeping the price of the substitute product constant. We find that the promotion increases the purchase rate of *weakly more expensive and lower-quality substitutes* for the discounted products. Second, we show that the spillover effect on the non-discounted items diminishes when the promotional announcements become more precise (i.e., they specify the discounted items and not just the discounted category), and when shoppers are alerted to the fact that discounts have expired on items that they bought on their previous shopping trip. These findings suggest that the mechanism driving the increase in sales of the non-discounted substitutes may be more complex than the combination of saliency and brand loyalty documented in previous research.

*Outline of paper.* The remainder of the paper is organized as follows: Section II explains the design of the randomized control trials; Section III provides summary statistics on the sample; and Section IV discusses the results. Section V discusses the responses to a post-experiment survey regarding consumer preferences. Section VI concludes.

## II Experimental design

In this section we outline the different design components of our intervention. The intervention took place over three months and consisted of both exogenously determined price changes on specific products and weekly emails that were sent out to shoppers in both treatment and control groups. The following are the main components of the intervention.

*The platform.* We partnered with a website (whose name is not disclosed for confidentiality) that offers a purchase and next-day delivery service from a large American supermarket in a university city. The website includes roughly 3,000 items

that are sold in the supermarket. These items are divided into several product categories to help shoppers perform an intuitive search (e.g., produce, dairy, etc.). Shoppers need to add the items that they want to purchase to their basket, and at checkout they pay for the products, plus a flat delivery fee of $2.99 for each order. During the period of the experiment there was no option to re-order previous baskets or to add items from previous orders. Additionally, all prices were fixed and there were no promotional sales. Shoppers were required to choose a delivery date and a two-hour delivery window. The cutoff time for next-day delivery was midnight every day. The shoppers were mainly students (80 percent) with some professors (10 percent). Only 10 percent of the shoppers were unaffiliated with the university.[1]

The website was interested in both encouraging its registered customers to increase the frequency and volume of their purchases, and learning how different promotional tactics affect shopping behavior. To achieve this goal, they planned to conduct a series of randomized controlled trials. They agreed to allow us to influence the design of these trials in a way that would also enable us to address our questions. Hence, the experimental design was somewhat constrained by the objectives of the website.

*Temporary discounts.* The experiment was conducted over a period of thirteen weeks during which the website offered temporary discounts so that the prices of some select items fluctuated, dropping during the sale and rising to pre-sale levels when the sale expired. Discounted items were marked on the website with two asterisks (**), and a footnote at the bottom of the screen explained that the marked item was on sale and specified the original, higher price. We used this method of marking discounts for the following reasons. First, we did not want discounts to be too salient because we wanted there to be an advantage to receiving an email that provided information on which items were discounted. Second, we wanted to allow

any shopper who accessed the website to find out about the temporary sale if she exerted some effort in noticing fine details.[2]

The experiment focused on items in twenty-eight product categories that were popular with shoppers in the pre-experiment period (see Table I).[3] Each of these product categories (e.g., milk, tomatoes, water, etc.) included at least two items that could be considered close substitutes. Each month a different set of categories were discounted so that a discount on an item would be valid for one month. The items whose prices were manipulated during the experiment are defined as *target items*, and their alternatives are defined as *substitute items*.

Place Table I about here.

The levels of discounts were varied during the experiment, so that shoppers would face uncertainty regarding the benefit of exerting effort to search for the lowest price. The average discount on an item was 20 percent, but could be as low as 5 percent or as high as 75 percent. The discounts were set so that the discounted *target item* would be priced either the same or lower than the *substitute item*.

The discounted target items fell into four general categories: (i) organic versus non-organic items, (ii) same items that are offered in different sizes (e.g., jumbo avocado versus regular avocado) or bulk quantities (e.g., apples that are offered individually versus apples that come in 3-lb bags, or milk that is offered in 0.5-gal versus 1-gal containers), (iii) brand names versus generic store brands (e.g., Aunt Millie's breads versus generic supermarket whole wheat bread), and (iv) two competing brands of the same product (e.g., Dasani versus Ice Mountain mineral water in bottles of the same size). See Tables II and III for a full list of the relevant target and substitute items as well as the discounts given during the experiment period.

Place Table II and Table III about here.

There are two motivating factors behind the choice of target items. First, we

tried to select target items that had "near perfect" substitutes and low levels of brand loyalty. Recent evidence suggests that consumers display relatively low brand loyalty to supermarket items compared to clothing and appliances (Nielsen [2013]), and their choice of food brands is most affected by price considerations (Byron [2008]). Within the food and beverage category, consumers tend to exhibit more brand loyalty to breakfast cereals, carbonated drinks, and snacks (Chidmi and Lopez [2007]; Nielsen [2013]). *None* of these items with high levels of brand loyalty were included as target items in the experiment; therefore we assume that price sensitivity is stronger than brand loyalty in deciding between a target item and its substitute.[4]

The second motivating factor is the public perception of organic items. Studies have indicated that consumers generally express positive attitudes toward organic foods, perceiving them as tastier and friendlier to the environment (Roddy et al. [1996]; Magnusson et al. [2001]; Perkovic and Orquin [2017]). While there may be disagreement among researchers about whether this perception is backed by scientific evidence (see Baransky et al. [2014] for a meta-analysis that organic food is healthier), what is important for this study is public perception.[5]

An important feature of the discounted items was the variation in their display. Some close substitutes (where one was discounted and the other was not) appeared next to each other on the screen, while others appeared in different rows and required scrolling down to notice both items.[6] Whether a pair of substitutes was displayed next to each other is independent of their prices, or of the difference between their prices, and there was no option on the site to sort by price.[7] We used the variation in location as a proxy for the cost involved in comparing the price of a target item with its substitutes.

*Rebates.* In weekly emails, shoppers were offered an immediate rebate applied at checkout if they spent at least $20 and also bought at least one unit of an item from

a given group of eligible items that changed every week. During the first three weeks of the study, the rebate was equal to the flat delivery fee of $2.99 (it was presented to shoppers as free delivery), and in the last three weeks it was raised to[8] $10. Between the fourth and tenth weeks, the rebate was $2.99 for the control group and $10 for the treatment group (the difference between these two groups is explained below). While it would have been ideal to keep the size of the rebate equal across the two groups, we were constrained by the website's wish to offer a higher incentive to shop to the treatment group.[9] Table IV lists the rebate category offer for each week as well as the prices of the target and substitute items in the category alongside the refund when purchasing the rebate item for individuals in both the treatment and control groups.

Place Table IV about here.

*Treatment and control.* The 355 shoppers who made purchases in the second half of 2015 were randomly divided into two groups: 178 in treatment and 177 in control.[10] Treatment shoppers received additional information on categories with discounted items in the weekly email. In order to measure the effect of the email announcement separately from a general salience effect or compliance effect, both groups were sent weekly promotional emails with information on the rebate category.[11] But during the entire period of the study, the email to the control group did not mention any price discounts.

By contrast, the email to the treatment group included the following information: four product categories (e.g., milk, eggs, fruit, bread) that were on temporary sale that month; the biggest discount available in each of the four product categories expressed in percentage points; and a link to the relevant page of each product category. The treatment group was also informed that discounted items were marked

by "**."

In the later part of the study (from the sixth week on), shoppers in the treatment group began to receive a more detailed weekly email. For these weeks, the email alerted shoppers that many organic items were now on sale and even cheaper than non-organic items. Additionally, those who had purchased a substitute item in a category that was now on sale received a personalized email alerting them to this fact (e.g., 'Don't forget to consider some alternatives to your last purchase of eggs that we have on sale this month'). Figures 2 and 3 depict examples of the email formats for both the treatment and control groups.

Place Figure 2 and Figure 3 about here.

## III The data

The customer base of the website were randomly allocated to treatment and control, such that 177 shoppers were assigned to control, and 178 to treatment. Over the thirteen weeks of the experiment, we tracked the purchasing decisions of these shoppers in 28 product categories (see footnote 3). In total, 130 shoppers made 1,046 category purchases on 338 shopping trips during the experiment period: 66 shoppers made 167 shopping trips in the control group, and 64 shoppers made 171 shopping trips in the treatment group.

Table V provides summary statistics for the pre-experiment period (December 2014-January 2016) for both the full sample and a subset of 305 shoppers who had a history of purchasing in at least one of the 28 product categories (152 in control and 153 in treatment). This subset is important as it turns out that past purchases within the product category are a strong predictor of current purchases with differential effects between those allocated to the control and treatment groups. Not surprisingly,

since individuals were randomly allocated to treatment and control, there are no significant differences in shopping trends between the treatment and control groups during the pre-experiment period. Generally, shoppers had shopped on the site five times prior to the experiment, with trips averaging roughly $70. Importantly, when we condition on shoppers who made purchases of either the target or substitute items, the control and treatment groups continue to look very similar. In the pre-experiment period, the substitute items were generally purchased more frequently than the target items by all shoppers (prior to the experiment, they were cheaper than the target items).

Place Table V about here.

Recall that when a shopper browses through items, some discounted target items are displayed right next to their substitutes (or in the same row), while others may require scrolling down. In light of this, we say that a target item and its substitute are 'neighbors' if they appear on the same line on the website, and we refer to a category as a "neighboring" category if it includes a target and a substitute that are "neighbors." Figure 4 displays an illustrative screenshot from the website. The target item that is shown, organic bananas, was on sale for $0.24 per unit (regular price $0.49), while the two corresponding – and neighboring – substitutes are 'banana ripe' and 'banana mild green,' whose prices remained constant at $0.39 per unit. Six out of the twenty-eight product categories included neighboring items (avocados, bananas, kiwis, lemons, raspberries, and water).[12] These neighboring categories made up roughly a quarter of purchases of target items and almost one-third of substitute item purchases (as is evident from Tables II and III, there were no significant differences between the prices of neighboring and non-neighboring items). If comparing prices among neighboring items is simpler, we would expect shoppers to be more price sensitive in neighboring categories.

Place Figure 4 about here.

## IV Findings

We begin this section by examining the response of all shoppers to the (exogenous) price changes made in the experiment. We then measure the impact of information on this response by differentiating between shoppers in the treatment and control groups.

### IV.i How do shoppers respond to sales?

Measuring how shoppers respond to price changes in a real-world setting is usually complex due to the many factors that impact price changes and the concern that these factors may be correlated with demand. This experiment provides an opportunity to measure this response in an environment where prices were lowered for a specific group of (target) items while the prices of substitute products in that product category remained constant. Figure 5 graphs the evolution of target-item prices relative to substitute-item prices in the 6 months leading up to the intervention (period 0) through the last week of the intervention (week 13). It illustrates how the average price of a target item decreased by roughly 20 percent during its discount period while substitute products in the same product category remained at an average price of about $2.50 (see Tables II and III for a list of all products included in each of the 3 discount periods).

Place Figure 5 about here.

The exogenous shift in prices created by the intervention provides an opportunity to measure price elasticities. We ran the following analysis on all products ($p$) included in the intervention using monthly ($m$) purchase rates ($q$):

$$\log(q_{pm}) = \lambda_1 \log(price_{pm}) + \gamma_p + \eta_m + \varepsilon_{pm} \quad (1)$$

The coefficient $\lambda_1$ on $\log(price_{pm})$ estimates the price elasticity of shoppers when we control for differences in demand across time and products using product ($\gamma_p$) and month ($\eta_m$) fixed effects. Since the changes in $price_{pm}$ were unrelated to any unobserved factors impacting monthly demand $\left(\varepsilon_{pm}\right)$, $\widehat{\lambda}_1$ provides an unbiased estimate of how consumer demand shifts in response to price changes.

We find that demand increases in response to a sale (see Table VI). The average measured price elasticity is -1.649 (s.e. 0.249), with shoppers exhibiting the highest price sensitivity to changes in fruit prices and the smallest sensitivity to changes in the price of perishable items (eggs, milk, and yogurt). Specification (5) of Table VI allows price elasticity to differ for products when their substitute appears on the same line of the website (those categories with the lowest search costs). The magnitude of the price elasticity increases in these low search cost categories by 1.655 (s.e. 0.776), which suggests that price elasticity depends not only on product characteristics, but also on the ease with which shoppers are able to compare prices across alternatives in different product categories.

Place Table VI about here.

Familiarity with products in a category is another factor that could impact price elasticities if shoppers tend to focus on a particular group of product categories and do not pay much attention to prices or products outside of this group. We can look more closely at this issue by differentiating across shoppers based on whether they had made a purchase of any item in a product category in the period prior to the intervention. In specification (6) of Table VI, we find that shoppers with a

purchase history in a product category are more likely to both purchase products in this category and exhibit higher price elasticities.

Our intervention introduced an additional degree of heterogeneity across shoppers. If shoppers do not respond to price changes because they are unaware of existing discounts, one might expect that treatment shoppers who received information on product categories with discounted items may exhibit higher price elasticities. However, in column (7) of Table VI, we find that treatment shoppers fail to exhibit a significant difference in price elasticities relative to control shoppers (a change of 0.102 (s.e. 0.088). Interestingly, despite the fact that in Table V we observed no significant difference in shopping patterns between shoppers in the treatment and control groups during the pre-experiment period, Table VI suggests that treatment shoppers exhibit a higher demand for products regardless of price. In other words, providing the treatment group with sale information seems to have increased demand across all products, as opposed to increasing price sensitivity for discounted products.

Figure 6 further examines the aggregate change in consumer purchases between the month during which target products in the category were on sale and the month leading up to the sale for shoppers in both the treatment and control groups. For treatment shoppers, the sale increased demand in the product category where the sale was offered from 9 to 15 products. Interestingly, this increase in demand was roughly evenly split between target and substitute purchases even though only the target products were discounted during this period. Conversely, shoppers in the control group increased their demand for discounted target products during the sale period by two units but did not exhibit any increase in demand for substitute products.

Place Figure 6 about here.

Figure 7 demonstrates the impact of this differential change in demand on con-

sumer spending. Treatment shoppers spent 35 percent more on products in categories where the target item was on sale than they had in the month leading up to the sale, while we observe almost no change in spending among control shoppers. The fact that some shoppers in the treatment group chose the substitute product during the target sale raised the supermarket's revenue relative to the results observed in the control group. In the next section we look more carefully at the purchasing decisions made by shoppers in the treatment versus the control group and examine why more information seems to have increased supermarket revenue and made shoppers worse off.

Place Figure 7 about here.

### IV.ii Estimating the 'Information Effect'

To estimate the 'information effect,' we focus on how the treatment impacted three different monthly decisions of shoppers: $buy_{icm}$ – how many total purchases are made within each of the relevant categories in our intervention (e.g., tomatoes), $target_{icm}$ – how many items were purchased that were sometimes discounted during the intervention (when this item was organic produce, it could also be perceived as being of weakly higher quality than its non-organic substitute), and $substitute_{icm}$ – how many of the never-discounted substitutes for the target item were purchased within the category (e.g., non-organic tomatoes). We estimate a model – where each of these decisions is a function of whether the target item was on sale ($tsale_{cm}$), and its interaction with being a shopper in the treatment group ($treat_i \times tsale_{cm}$).

Following our results from the elasticity estimates in Table VI where we found that shoppers with a history of purchasing products in category ($hist_{ic}$) were more price sensitive than other shoppers, we also include the interaction terms ($tsale_{cm} \times hist_{ic}$) and ($treat_i \times tsale_{cm} \times hist_{ic}$).[13] These interaction terms allow us to account for

the possibility that promotional material may have a differential impact across these shopper groups. On the one hand, a higher price elasticity among shoppers who have purchased in this category before might suggest that they will react more to the 'information effect.' Alternatively, the 'information effect' may be most important for shoppers without a history, who otherwise would not bother to consider items in the category. Indeed, we show below that the effect of the intervention is concentrated among shoppers with a history of purchasing within the category. We also control for shopper fixed effects ($\gamma_i$), shopping month ($\rho_m$), product category ($\eta_c$), rebate eligibility ($e_{im}$), rebate size ($r_{im}$), and the interaction rebate eligibility and rebate size ($e_{im} \times r_{im}$).

$$
\begin{aligned}
(2) \qquad \ln(Y_{icm}) = {} & \beta_1 treat_i \times tsale_{cm} \times hist_{ic} + \beta_2 treat_i \times tsale_{cm} + \beta_3 tsale_{cm} \\
& + \beta_4 tsale_{cm} \times hist_{ic} + \beta_5 hist_{ic} + \beta_6 e_{im} + \beta_7 r_{im} + \beta_8 e_{im} \times r_{im} \\
& + \gamma_i + \rho_m + \eta_c + \varepsilon_{icm}.
\end{aligned}
$$

Our full sample consists of 355 shoppers ($i$) over four months ($m$) in each of the 28 product categories[14] ($c$). We measure the impact of the sale in a difference-in-differences framework. While ($\beta_3$) captures the response of shoppers in the control group to a sale on the target item, ($\beta_2$) captures the differential response of the treatment group, and ($\beta_3$) captures the additional response of shoppers who have a history of purchasing products in that category. Each specification controls for shopper, month, and category fixed effects, as well as the size of the rebate offered to a shopper purchasing the rebate item ($r_{im}$). We also include controls for rebate eligibility ($e_{im}$) and its interaction with rebate size ($e_{im} \times r_{im}$) because receiving a large rebate when reaching the \$20 minimum basket value may impact shoppers' purchasing decisions. All shoppers from the original sample are included in our

analysis in each of the 4 months observed, including months where they did not make a shopping trip. For these shoppers, $buy_{icm}$, $target_{icm}$, and $substitute_{icm}$ are equal to zero for all product categories in that month.[15] We focus on intention-to-treat outcomes as opposed to limiting the sample to shoppers who made purchases or read the promotional email, as such limitations could introduce selection concerns.

Suppose that shoppers were not aware of all available discounts, and the only effect of the promotional material on the shoppers was to raise their awareness of prices. Then we might expect treatment shoppers to be more likely to purchase discounted target products and decrease their consumption of substitutes. This would imply a positive estimate of $\beta_2$ when the outcome variable is $target_{icm}$ and negative estimate when the outcome variable is $substitute_{icm}$. If the only effect of sales was to cause shoppers to replace a substitute item with a discounted target item, then we would expect the estimate of $\beta_2$ to be zero when the outcome variable is $buy_{icm}$.

In Table VI we already observed that shoppers with a history of purchasing products in category ($hist_{ic} = 1$) exhibit higher demand for products in that category at any given price. Additionally, we observed higher price elasticities for shoppers in this group. In equation (2) we take a closer look at the role of the promotional material provided to the treatment group in driving these results. On the one hand, the higher price elasticity might suggest that the 'information effect' will be strongest for those shoppers with a history of purchasing products in that category ($\beta_1 > 0$) when the outcome variable is $target_{icm}$. Alternatively, the 'information effect' may be most important for shoppers without such a history, who otherwise would not bother to consider items in the category ($\beta_1 < 0$).

The first three columns of Table VII estimate equation (2) using the *full* sample, demonstrating that the effect of treatment is concentrated among shoppers purchas-

ing in a discounted category in which they have a history of purchasing products. Control shoppers with no history of purchasing in a category respond to a sale primarily by purchasing the target product (see columns (1) to (3) of the 'Target Sale' row), while those with a history of purchasing in a category significantly decrease their purchase of substitute products (see column (3) of the 'Target Sale × Hist' row). Treatment shoppers with no history of purchasing in a category respond very similarly to shoppers in the same category from the control group (see columns (1) to (3) of the 'Treat × Target Sale' row).

Place Table VII about here.

The increased price sensitivity observed for shoppers with a purchase history in the elasticities table is being driven by treatment shoppers as observed in column (2) of the 'Treat × Target Sale × Hist' row. Treatment shoppers with a history of purchasing products in a category are 3 percent (s.e. 1.7) more likely than control shoppers to purchase the target product when it is on sale. Interestingly, these treatment shoppers who had already made a purchase in this category in the pre-experiment period also increased their purchase rate of the *substitute* item by 9 percent (s.e. 2.2), relative to shoppers in the control group during this same period (see coefficient appearing in column (3)). Thus, the effect of promotional material was primarily to increase purchase rates for products that shoppers had purchased in the past in a category where a sale was offered.

*Explaining the increased demand for substitutes.* It may seem that a rational shopper with a purchase history in a category would be more likely to purchase products in that category if she were told that items in that category are on sale. However, it seems less plausible that a fully rational shopper would respond to the sale (i.e., increase her purchase rate in that category) *not* by buying the discounted

items, but by buying *the item she was likely to have bought before*. Thus, our results suggest that coarse promotional material may have an important interaction with past shopper behavior. Namely, promotional material may draw shoppers to a discounted category, but the product they choose may be strongly dependent on products that they purchased in the past.

Our results on the demand for substitute products are puzzling. Why did treatment shoppers who received information on category sales *increase* the probability of purchasing a substitute item when the target item was of equal or higher quality and also offered at a lower price? Without a control group, one might be concerned that shoppers suspected that an item on sale was of lower quality (e.g., close to expiration date).[16] However, this cannot explain the differential behavior between the randomly allocated treatment and control groups, as they both should have the same priors regarding the quality of discounted items.[17] One possible explanation is that the email to the treatment group impacted two separate shopping decisions: what product categories to purchase in, and whether to purchase the substitute or the target item. In other words, receiving an email that notifies a shopper that vegetables are on-sale may increase the probability of purchasing vegetables on the website. This increase could be driven by the shopper's interest in the sale and/or a salience reminder that the shopper would like to buy vegetables. This salience reminder is unique to the treatment group and could lead to an increase in purchases of the substitute item. Shoppers who have a history of purchasing products in a given category are more likely to be familiar with the substitute items, which were purchased three to four times more frequently than the target items in the pre-experiment period.

Another alternative explanation for the differential information effect we just described is one of differential incentives. Recall that in week 4 the size of the rebate increased from \$2.99 to \$10 for the treatment group, and that this difference in in-

centives remained until week 11 when the control group rebate was also increased to $10. A higher rebate amount could cause shoppers to fill their basket with substitute products in order to reach the $20 minimum necessary to qualify for the rebate. However, we control for this in our analysis and while we do find that shoppers who spent at least $20 on their basket were more likely to purchase in all product categories regardless of whether or not they were on sale (see coefficient on 'Rebate Eligibility'), the added effect of the higher rebate incentive was to increase the purchase rate of the target products (see coefficient on 'Eligibility x High Rebate').

In order to make sure that our results are not driven by self-selection where certain types respond to a $2.99 versus $10 rebate offer, in columns (4) – (6) of Table VII we re-run our analysis including only purchasing decisions made prior to week 4, so that shoppers in both the treatment and control groups received the same rebate offer. Constraining the sample in this way leaves our results unchanged. Thus, it seems unlikely that the observed differences in behavior between the treatment and control groups are a result of differential incentives.

*The effect of search costs.* Recall that some product categories had high search costs, where the target and substitute items appeared on different lines of the website, whereas others appeared on the same line (see Tables II and III). These neighboring categories provide an opportunity to examine whether treatment shoppers were more likely to take advantage of purchasing the discounted target product as opposed to the substitute product in categories where the comparison required less effort. To do this, we include an interaction term between the variables driving our main coefficient of interest ($treat_i \times tsale_{cm} \times hist_{ic}$) in equation (2) and whether this was a low search cost category ($low\_search_c$).

We summarize our results from this specification in the first three columns of

Table VIII. Generally, the added effect in the low search cost categories is very noisily measured and not statistically different from zero (see 'Treat × Target Sale × Hist × Special' row). The magnitude of our estimates in column (2) suggest that the increased price sensitivity observed for treatment shoppers in Table VI may be driven by neighboring categories. Treatment shoppers with a history of purchase in high search cost categories increase their purchase rate of target products in that category by 2 percent when they are on sale relative to control shoppers. The gap between treatment and control shoppers increases to 5 percent when examining low search cost categories. However, the lower search cost in neighboring categories does *not* reduce the increased consumption of substitute products by treatment shoppers observed in high search cost categories (see column (3) of Table VIII).

Place Table VIII about here.

*The effect of information precision and nudges.* Recall that in the last two months of the intervention (weeks 6 – 13), the email to the treatment group included a line alerting shoppers to the fact that many organic items were on sale and in some cases, even cheaper than the non-organic substitute. Additionally, if a treatment shopper purchased a substitute item on her previous trip, these personalized emails included the line "you may want to consider some alternatives to your last purchase in this category — that are now on sale." This later period with more detailed emails provides an opportunity to examine the differential response of treatment shoppers to a sale when they have more precise information on the *products* (in addition to the categories) that are on sale. To do this, we include an interaction term between the variables driving our main coefficient of interest ($treat_i \times tsale_{cm} \times hist_{ic}$) in equation (2) and whether this was a period where treatment shoppers received a more detailed email ($detailed_{im}$).

Our estimate in columns (4) to (6) of Table VIII illustrate that treatment shoppers are significantly more likely than control shoppers to purchase the substitute product in categories where a weakly higher-quality target item is discounted during non-detailed email weeks. Specifically, shoppers in the treatment group are 19 percent (s.e. 5) more likely than shoppers in the control group to purchase a substitute product during a target item sale (see column (6) of the 'Treat × Target Sale × Hist' row). However, these large differences between treatment and control shoppers disappear during detailed email weeks (see the coefficients on 'Treat × Target Sale × Hist × Special' in columns (4) to (6) of Table VIII, which are roughly the same size as those estimated for the coefficient on 'Treat × Target Sale × Hist' but of the opposite sign). During these weeks with more detailed emails, shoppers in the treatment group had a similar response to target items as shoppers in the control group. Thus, the effect of more detailed information was primarily a reduction in purchasing 'mistakes' of the substitute item for treatment shoppers. This suggests that 'mistakes' were avoided by simply not purchasing in the category, as opposed to purchasing the discounted item.

## V Discussion

Our main finding is that providing shoppers with information on categories with discounted items increases the purchase rate within the category for the undiscounted substitutes. This behavior may be viewed as anomalous if the following are true:

1. Shoppers prefer organic items if they are not more expensive than their non-organic counterparts.

2. Shoppers would switch brands if a competing brand is reduced to, or below, the price of the regular brand they usually purchase.

To verify these assertions, we conduct two follow-up surveys. The first was sent only to the participants in our study and had a response rate of only 24 percent (55 shoppers). The vast majority of respondents (91 percent) answered that they would choose an organic item if it was weakly cheaper than its non-organic alternative. Eighty percent of the respondents reported that they would switch brands for a discount of 20 percent.

Because of the low response rate to our first follow-up survey, we conducted an additional survey using the Qualtrics platform on 378 American participants ranging from 18 to 30 years of age, with at least some college education. Over 70 percent of the respondents reported that they would choose an organic product if it was the same price as the non-organic alternative for prices ranging between \$1.00 – \$3.50. This climbs to close to 90 percent when the organic product is cheaper than the non-organic substitute. Lastly, 68 percent of the respondents replied that they would switch brands if the alternative brand was discounted to the same price as the item they usually purchased. This climbs to 80 percent when the discounted alternative becomes cheaper than the item they usually purchase.

These survey results lend support to our interpretation of the data as reflecting shopping behavior under limited attention. The behavior of our participants stands in stark contrast to the vast majority of the survey responses. While our finding that promotional materials on sales increases consumption of regularly priced alternatives is not dependent on assumptions (1) and (2), these assumptions have important implications for consumer welfare.

## VI Concluding remarks

Comparing prices across a large variety of products is a non-trivial task, especially when prices are constantly changing. Despite this, mainstream economic models of consumer behavior are based on the premise that consumers are attuned to all price fluctuations and perfectly process signals of these price changes. By contrast, our findings reveal that not only do consumers miss opportunities to save, but that bringing these opportunities to their attention does not necessarily decrease spending.

Furthermore, our experiment yields some novel results that contribute to the growing literature on consumer response to signals on price changes. First, we show that announcements of category-level discounts primarily affect shoppers with a history of purchasing products in the discounted category. Second, while discounting a product generally leads to an increase in demand for that product and a decrease in demand for its lower-quality substitute, receiving information on these discounts at the category level results in an increase in demand for the discounted product *and* its more expensive substitute. While previous studies have shown that advertising an item may increase the demand for other items on the same website or in the same category, we provide evidence of increased sales for items that are close substitutes and are weakly dominated (e.g., increased purchases of a non-organic fruit when its organic version is priced lower). This spillover effect is diminished when the announcements include more information on the types of items that are discounted and when shoppers receive a personalized 'nudge' that alerts them to the fact that previous items they bought are no longer on sale. This suggests that the source of the increased demand for the more expensive substitutes is a combination of inertia (continuing to buy what the shopper is used to) and the cost of acquiring more information (looking for which specific items are discounted in the category).

The above findings hint at implications for retailers that are deciding which products to discount and how to announce these discounts to shoppers. If retailers are interested in boosting overall sales, they may benefit from announcing discounts only at the category level ('select fruits are on sale'), and targeting these announcements to shoppers with a history of purchasing products in that category. If, on the other hand, a retailer is interested in increasing the sales of a promoted brand, then more precise information at the item level may be preferred.

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## Notes

[1]This information was obtained from responses to an optional survey conducted at checkout during the first month of the experiment period. Eighty percent of the shoppers who made a purchase during the experiment period responded to the survey.

[2]We operated under the constraint that all shoppers must face the same set of prices.

[3]The twenty-eight product categories are: bananas, kiwis, lemons, raspberries, apples, bulk apples, blueberries, pineapples, avocados, broccoli, cucumbers, kale, onions, green onions, peppers, lettuce, limes, tomatoes, bread, organic bread, eggs, brown eggs, organic eggs, milk, bulk milk, organic milk, yogurt, and water.

[4]In a post-experiment questionnaire of the participants, 80 percent of 55 individuals who responded answered that they would switch brands for a discount of 20 percent. We found a similar response when surveying an additional 378 US respondents in the same age and education categories. See Section F for more detail.

[5]In our post-experiment questionnaire, 91 percent of 55 respondents said they would buy an organic item if its price was weakly cheaper than the conventional version of the same item. This result also held in an additional follow-up survey with 378 participants. See Section F.

[6]The display of items on the screen was determined by the developer and remained constant throughout the experiment. The relative display of items – i.e., whether items were adjacent or not – remained the same whether the shopper used a computer or a mobile device.

[7]Buying a substitute item was on average 28 percent more expensive than the discounted target item for non-neighboring items, and 25 percent more expensive than the discounted target item for neighboring items.

[8]Starting with free delivery before moving to the high rebate was also intended to give credibility to the promotional offer.

[9]Table VII also includes analysis run only on weeks where shoppers in the treatment and control groups were offered identical rebates to ensure that what drives the difference in results between these two groups is the difference in promotional information.

[10]Although we have data on shoppers beginning in December 2014 (over a year before we ran the experiment), we only include shoppers who had made a purchase within the previous six months in the treatment and control groups. We expected these shoppers to be the ones most likely to make

purchases during the period of the experiment.

[11]As noted above, for roughly half of the experiment both the treatment and control emails provided the same rebate amount for item in the rebate category. The observed differential effect of the sale on the treatment and control groups is robust to running the analysis only on the same rebate weeks.

[12]The twenty-two non-neighboring product categories are: apples, bulk apples, blueberries, pineapples, broccoli, cucumbers, kale, onions, green onions, peppers, lettuce, limes, tomatoes, bread, organic bread, eggs, brown eggs, organic eggs, milk, bulk milk, organic milk, yogurt. For a detailed explanation see Tables II and III.

[13]In Table VIII we control for the interaction between neighboring categories and and the target sale to account for the higher price sensitivity observed among neighboring categories.

[14]We focus our analysis on monthly purchases occurring in the month leading up to the intervention and each of the 3 months of discounts.

[15]Our results remain very similar when we exclude shopper-months when a purchase was not made on the website. We include all shopper-months in our main specification as excluding shoppers during months when they chose not to shop on the website could introduce selection concerns if different sales draw different types of consumers.

[16]We look into this explanation in our post-experiment questionnaire and find that only three out of twenty-seven respondents said that they did not buy an item on sale because they thought it was of lower quality or close to its expiration date.

[17]Indeed, we show in Table V that there are no significant differences in characteristics of shoppers between the treatment and control groups for both the full sample and the sample of shoppers who had purchased products in the category in the past.

Figure 1: The Experiment

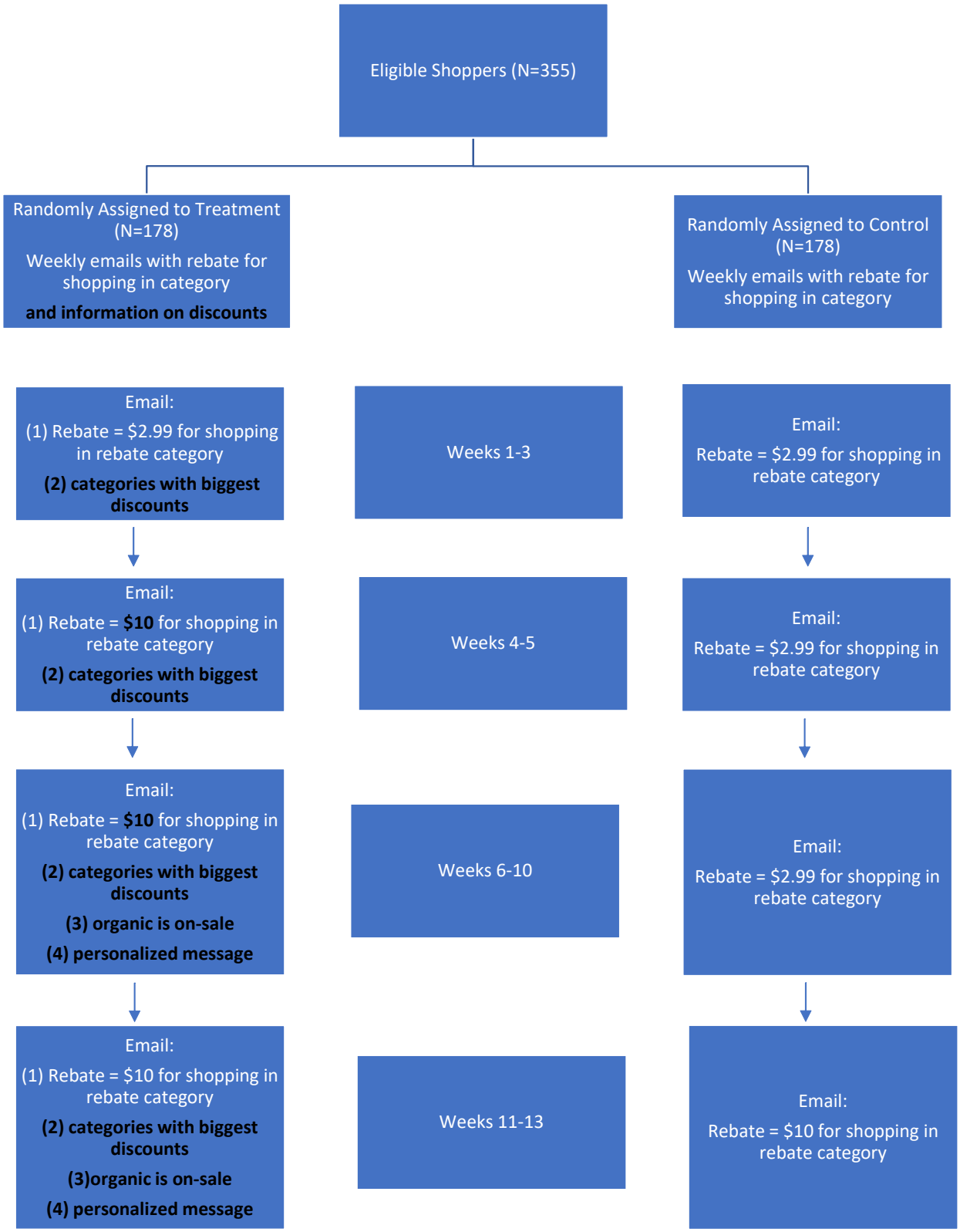


Figure 2: Examples of Email Format during Non-Detailed Email Weeks

**Control** (email title: Free Shipping on ---- if you Buy a Banana!!!)

## Greetings from ----, your local grocery delivery service!

Got a banana? Get a one-time refund on shipping for a purchase of over $20 if you buy one banana or more![1](Click here)

[1] Offer valid on all bananas. Use this email address when placing your purchase and a refund of $2.99 will be applied within 24 hours of purchase. Valid until ---

**Treatment** (email title: Free Shipping on ---- if you Buy a Banana!!!)

## Greetings from ----, your local grocery delivery service!

Got a banana? Get a one-time refund on shipping for a purchase of over $20 if you buy one banana or more![1] (Click here)

… and if that's not enough, make sure you check our discounts for the month of February (discounted items are marked by **).

**Our biggest discounts are in the following categories:**

1. Vegetables – up to 45% off select items (Click here)

2. Milk – up to 40% off select items (Click here)

3. Fruits – up to 30% off select items (Click here)

4. Eggs – up to 20% off select items (Click here)

[1] Offer valid on all bananas. Use this email address when placing your purchase and a refund of $2.99 will be applied within 24 hours of purchase. Valid until ---

Figure 3: Examples of Email Format during Detailed Email Weeks

**Control:** (email title: Click for $10 off your ---- purchase!!)

**Greetings from ----, your local grocery delivery service!**

Got apples? Get a $10 refund by simply purchasing at least one apple and inserting the coupon code dcash at checkout! [1] (Click here)

[1] Offer valid on all apples. Use this email address and the dcash coupon code when placing your purchase and you will receive a $10.00 one-time refund on your purchase of $20 or more. The refund will be applied within 24 hours. Valid until ---.

**Treatment:** (email title: Click for $10 off your ---- purchase!!)

**Greetings from ----, your local grocery delivery service!**

We are devoted to helping our customers get the "best bang for the buck".

So don't miss out on our April discounts! Our April sale prices are so low that organic sale items are often even cheaper than the non-organic alternative! (discounted items are marked by **)

**Don't forget to consider some alternatives to your last purchase of eggs that we have on sale this month.**

*To use your $10 refund - simply click on one of the links below to the site, purchase at least one apple and insert the coupon code found below.*

Our biggest discounts are on the following products:

1. Milk – up to 33% off select items (Click here)

2. Eggs – up to 49% off select items (Click here)

3. Fruit – up to 51% off select items (Click here).

4. Vegetables – up to 75% off select items (Click here)

Make sure to purchase one or more apples and enter coupon-code dcash at checkout![1]

[1] Offer valid on all apples. Use this email address and the dcash coupon code when placing your purchase and you will receive a $10.00 one-time refund on your purchase of $20 or more. The refund will be applied within 24 hours. Valid until ---.

Figure 4: Example of Target versus Substitute Item during Sale Period

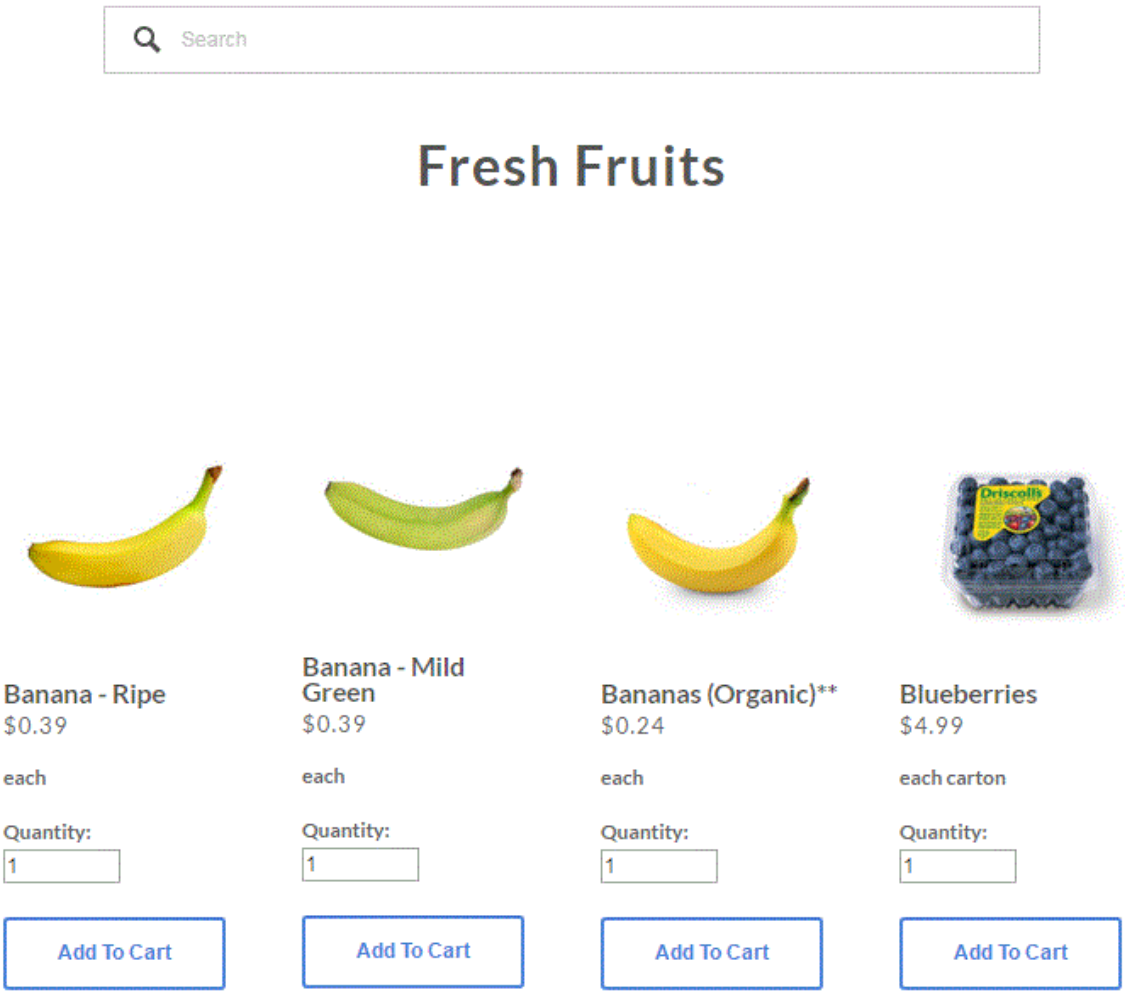
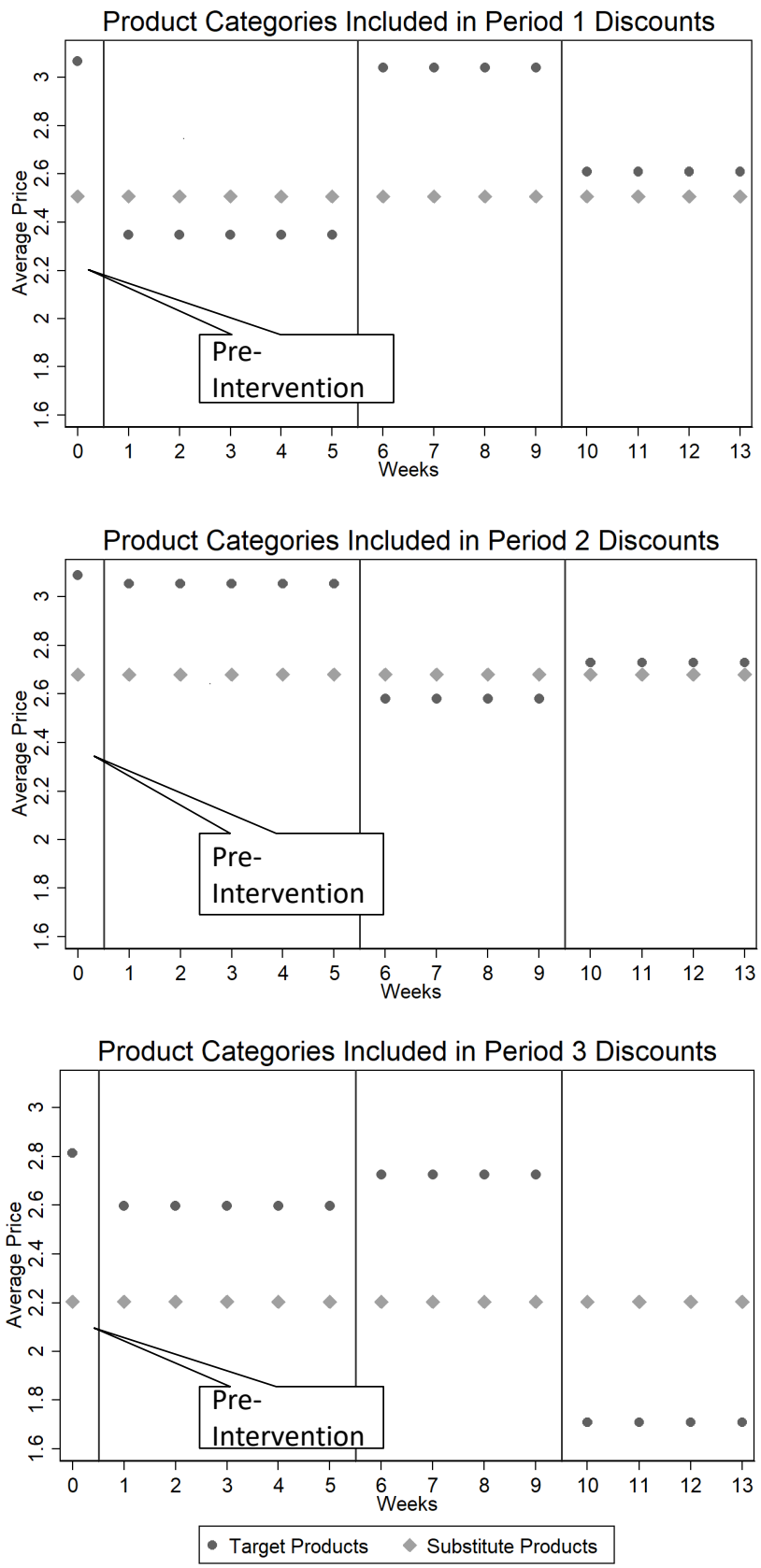


Figure 5: Price Variation in Target versus Substitute Items



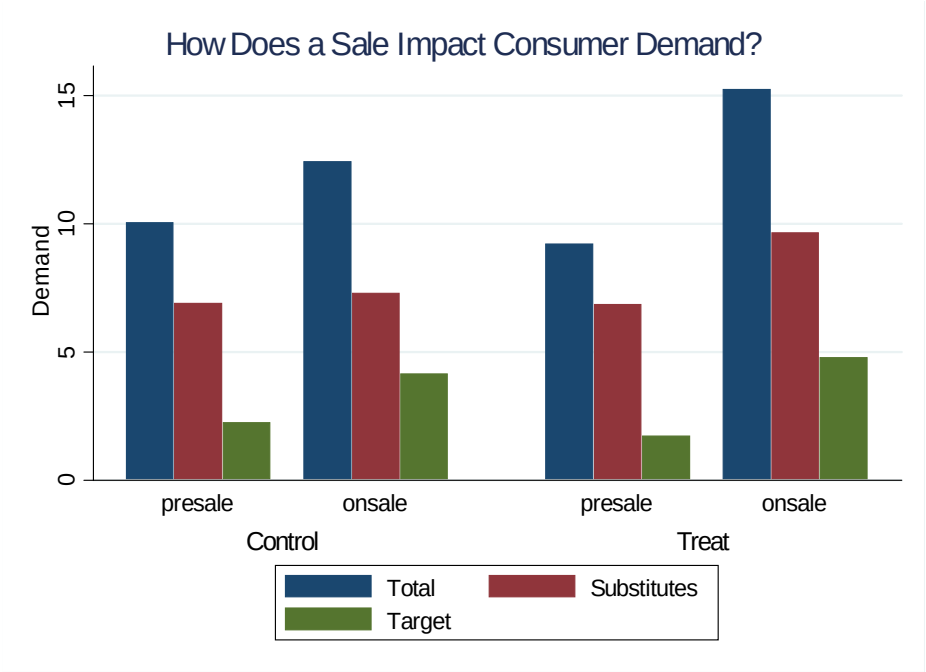



Figure 6: This figure summarizes mean categor- level purchases for total, target, and substitute products in the presale period (one month before the price of the target product was reduced) and during the one-month sale.

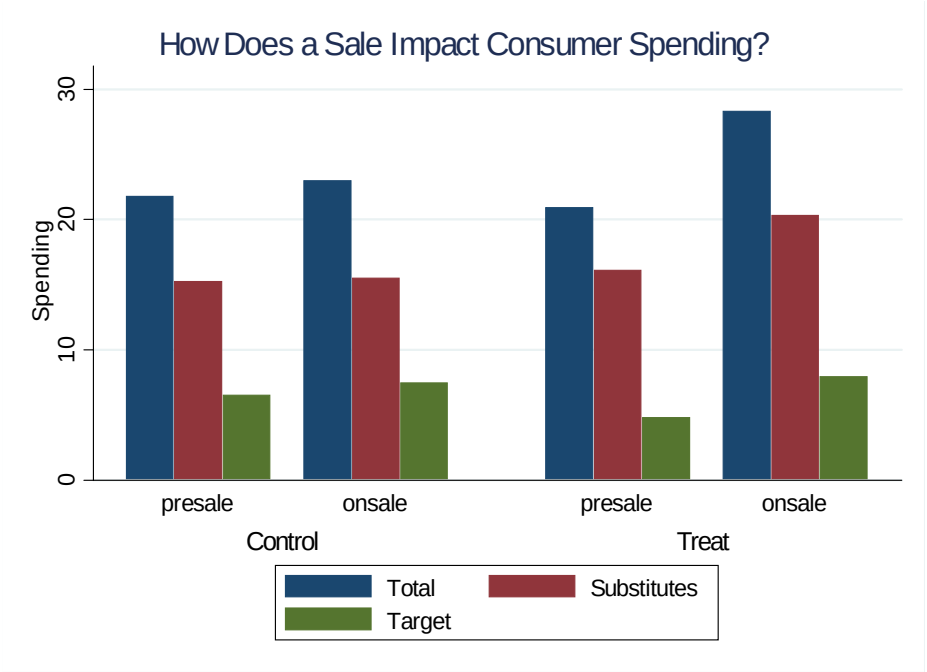



Figure 7: This figure summarizes mean category-level spending for total, target, and substitute products in the presale period (one month before the price of the target product was reduced) and during the one-month sale.

Table I: Purchasing Frequency of Target and Substitute Items Prior to Experiment

| Product Name | Quantity Purchased |
|---|---|
| ***Bananas*** | ***357*** |
| Bananas (Organic) | 72 |
| ***Onions*** | ***191*** |
| Onions (Organic) | 42 |
| ***Kroger: Bread*** | ***139*** |
| Aunt Millie's Bread | 56 |
| ***Kroger: Eggs - 12ct*** | ***134*** |
| Egg-Lands Best: Cage Free Large Brown Eggs - 12ct | 14 |
| Kroger: Grade A Large Brown Eggs - 12ct | 19 |
| Simple Truth: Natural Cage Free Large Brown Eggs - 12ct | 78 |
| ***Kroger: Milk (1gal)*** | ***114*** |
| Kroger: Milk (0.5gal) | 96 |
| Horizon: Organic Milk (0.5gal) | 22 |
| Simple Truth Organic: Milk (0.5gal) | 43 |
| ***Apple (Lg)*** | ***103*** |
| Apple (Organic) | 69 |
| Apple Bag - 3 lb bag | 65 |
| ***Bell Pepper*** | ***99*** |
| Bell Pepper (Organic) | 15 |
| ***Blueberries*** | ***94*** |
| Blueberry (Organic) | 11 |
| ***Avocado*** | ***76*** |
| Jumbo Avocado | 28 |
| ***Cucumber*** | ***75*** |
| Cucumber (Organic) | 15 |
| ***Ice Mountain: Water - 24pk*** | ***74*** |
| Kroger: Purified Drinking Water - 24pk | 11 |
| Dasani: Water - 24pk | 20 |
| Aquafina - 24pk | 11 |
| ***Chobani: Greek Yogurt*** | ***71*** |
| Fage: Greek Yogurt | 55 |
| ***Raspberries*** | ***62*** |
| Raspberries (Organic) | 10 |
| ***Roma Tomato*** | ***41*** |
| Roma Tomato (Organic) | 4 |
| ***Romaine Lettuce*** | ***33*** |
| Romaine Lettuce (Organic) | 3 |

The most popular substitute item within each category appears first and in bold. Broccoli, Kiwi, Kale, Pineapples, Lemons, Limes, Green Onions, Organic Bread, and Organic Eggs were excluded from this table for lack of space.

Table II: Target and Substitute Produce Items

| Weeks | Target Item | Price | Sale Price | Substitute Item | Price |
|---|---|---|---|---|---|
| 1-5 | Organic Banana **(N)** | 0.49 | 0.39 | Regular Banana | 0.39 |
| 1-5 | Organic Blueberries | 5.49 | 4.99 | Regular Blueberries | 4.99 |
| 1-5 | Organic Kiwi **(N)** | 0.99 | 0.79 | Regular Kiwi | 0.79 |
| 1-5 | Organic Apple (Fuji) | 1.49 | 1.25 | Regular Apple (Fuji) | 1.25 |
| 1-5 | Organic Apple (Gala) | 1.49 | 1.25 | Regular Apple (Gala) | 1.25 |
| 1-5 | Organic Apple (Granny Smith) | 1.49 | 1.25 | Regular Apple (Granny Smith) | 1.25 |
| 1-5 | Organic Lime | 1.29 | 0.89 | Regular Lime | 0.89 |
| 1-5 | Organic Broccoli | 3.49 | 3.25 | Regular Broccoli | 3.25 |
| 1-5 | Organic Romaine Lettuce | 3.29 | 2.59 | Regular Romaine lettuce | 2.59 |
| 1-5 | Organic Cucumber | 1.89 | 0.99 | Regular Cucumber | 0.99 |
| 1-5 | Jumbo Ripe Avocado **(N)** | 2.25 | 1.49 | Jumbo Unripe Avocado | 2.25 |
| 6-9 | Organic Tomato | 0.79 | 0.59 | Regular Tomato | 0.59 |
| 6-9 | Organic Red Bell Pepper | 2.79 | 2.59 | Regular Red Bell Pepper | 2.59 |
| 6-9 | Organic Onion | 2.59 | 1.99 | Regular Sweet Onion | 1.99 |
| 6-9 | Organic Kale | 2.19 | 1.99 | Regular Kale | 1.99 |
| 6-9 | Organic Green Onion | 0.99 | 0.95 | Regular Green Onion | 0.95 |
| 6-9 | Apples 3 lb bag (~4 ct.) | 5.39 | 4.49 | Regular Apple | 1.25 |
| 6-9 | Organic Lemon **(N)** | 1.49 | 1.29 | Regular Lemon | 1.29 |
| 6-9 | Organic Pineapple | 6.49 | 5.49 | Regular Pineapple | 5.49 |
| 10-13 | Organic Banana **(N)** | 0.49 | 0.24 | Regular Banana | 0.39 |
| 10-13 | Organic Blueberries | 5.49 | 4.00 | Regular Blueberries | 4.99 |
| 10-13 | Organic Apple | 1.49 | 1.00 | Regular Apple | 1.25 |
| 10-13 | Organic Apple (Fuji) | 1.49 | 1.00 | Regular Apple | 1.25 |
| 10-13 | Organic Raspberries **(N)** | 5.49 | 3.89 | Regular Raspberries | 3.99 |
| 10-13 | Organic lemon **(N)** | 1.49 | 0.99 | Regular Lemon | 1.29 |
| 10-13 | Organic Broccoli | 3.49 | 2.00 | Regular Broccoli | 3.25 |
| 10-13 | Organic Cucumber | 1.89 | 0.75 | Regular Cucumber | 0.99 |
| 10-13 | Roma Tomato Organic | 0.79 | 0.20 | Regular Tomato | 0.59 |
| 10-13 | Red Bell Pepper Organic | 2.79 | 1.99 | Regular Red Bell Pepper | 2.59 |
| 10-13 | Sweet Onion Organic | 2.59 | 1.00 | Regular Sweet Onion | 1.99 |
| 10-13 | Organic Green Onion | 0.99 | 0.50 | Regular Green Onion | 0.95 |

**(N) –** refers to neighboring categories where the target and substitute appear on the same line of the website.

Table III: Target and Substitute Dairy, Egg, and Durable Items

*Dairy*

| Weeks | Target Item | Price | Sale Price | Substitute Item | Price |
|---|---|---|---|---|---|
| 1-5 | Kroger: Milk (0.5gal) | 2.99 | 1.75 | Kroger: Milk (1gal) | 3.99 |
| 1-5 | Horizon Organic: 0% fat free Milk (0.5gal)) | 5.45 | 4.49 | Simple Truth Organic: Fat Free Milk | 4.49 |
| 1-5 | Fage: 0% and 2% fat Yogurt (plain and cherry) | 1.89 | 1.50 | Chobani: Yogurt, Fage: Yogurt (Other) | 1.89 |
| 6-9 | Fage: 0% and 2% fat Yogurt (plain and cherry) | 1.89 | 1.50 | Chobani: Yogurt, Fage: Yogurt (Other) | 1.89 |
| 10-13 | Simple Truth Organic: Milk (0.5gal) | 4.49 | 2.99 | Horizon Organic: Milk | 5.45 |

*Eggs*

| Weeks | Target Item | Price | Sale Price | Substitute Item | Price |
|---|---|---|---|---|---|
| 1-5 | Kroger: Grade A large Brown Eggs-12ct | 3.69 | 2.89 | Kroger Grade A Large Eggs-12ct | 2.99 |
| 1-5 | Egg-Land's Best: Cage Free Large Brown Eggs-12ct | 5.49 | 4.35 | Simple Truth: Natural Cage Free Grain Fed Large Brown Eggs-12ct | 4.45 |
| 10-13 | Kroger: Grade A Large Brown Eggs-12ct | 3.69 | 1.89 | Kroger Grade A Large Eggs-12ct | 2.99 |
| 10-13 | Simple Truth: Natural Cage Free Grain Fed Large Brown Eggs-12ct | 4.45 | 2.50 | Kroger Grade A Large Eggs-12ct | 2.99 |

*Durables*

| Weeks | Target Item | Price | Sale Price | Substitute Item | Price |
|---|---|---|---|---|---|
| 6-9 | Kroger: Multigrain Bread | 2.59 | 1.99 | Kroger: 100% Whole Wheat Bread | 2.59 |
| 6-9 | Kroger: Wheat Bread | 2.45 | 1.99 | Kroger: Buttermilk Bread | 2.19 |
| 6-9 | Dasani: Water **(N)** | 6.99 | 5.49 | Ice mountain: Water | 5.99 |
| | | | | Aquafina: Water | 6.99 |
| | | | | Kroger: Water | 5.49 |
| | | | | Niagara: Water | 5.99 |
| 12-13 | Aunt Millie's Bread: 100% Whole Wheat | 3.65 | 2.19 | Aunt Millies: 12 Whole Grain, Honey Oat, Honey Wheat, Multi Grain | 3.65 |
| | | | | Kroger Whole Wheat | 2.59 |
| 12-13 | Aunt Millie's Bread: Butter Top White | 3.65 | 2.19 | Kroger: Buttermilk Bread, Wheat Bread | 2.45 |
| 12-13 | Aunt Millie's Bread: Whole Grain White | 3.65 | 2.19 | Aunt Millies: Italian | 3.65 |
| | | | | Kroger: White, Italian | 2.19 |

**(N) –** refers to neighboring categories where the target and substitute appear on the same line of the website.

Table IV: Offered Rebate Categories by Week

| Week | Rebate Category | Rebate Item Price Target (in $'s) | Rebate Item Price Substitute (in $'s) | Rebate Item Refund Control Group | Rebate Item Refund Treat Group |
|---|---|---|---|---|---|
| 1 | Bananas | 0.39 | 0.39 | 2.99 | 2.99 |
| 2 | Blueberries | 4.99 | 5.49 | 2.99 | 2.99 |
| 3 | Apples | 1.25 | 1.25 | 2.99 | 2.99 |
| 4 | Broccoli | 3.25 | 3.25 | 2.99 | 10 |
| 5 | Bananas, Blueberries, Apples, or Broccoli | See Prices Above | See Prices Above | 2.99 | 10 |
| 6 | Tomatoes | 0.59 | 0.59 | 2.99 | 10 |
| 7 | Red bell pepers | 2.59 | 2.59 | 2.99 | 10 |
| 8 | Bread | 1.99 | 2.59 | 2.99 | 10 |
| 9 | Yogurt | 1.5 | 1.89 | 2.99 | 10 |
| 10 | Bananas | 0.24 | 0.39 | 2.99 | 10 |
| 11 | Apples | 1 | 1.25 | 10 | 10 |
| 12 | Bread | 2.19 | 2.59 | 10 | 10 |
| 13 | Eggs | 2.5 | 2.99 | 10 | 10 |

Table V: Sample Characteristics in Pre-Experiment Period

| | Full Sample | | | Target or Substitute History | | |
|---|---|---|---|---|---|---|
| | Control[a] | Treat[a] | Diff[b] | Control[a] | Treat[a] | Diff[b] |
| Number of Shopping Trips | 4.373 | 4.264 | -0.097 | 4.829 | 4.732 | -0.097 |
| | (5.814) | (5.678) | (0.693) | (6.122) | (5.988) | (0.693) |
| Number of Items Purchased | 12.544 | 13.039 | 0.856 | 13.529 | 14.385 | 0.856 |
| | (7.157) | (8.553) | (0.883) | (7.017) | (8.337) | (0.883) |
| Number of Target Items Purchased: | 2.198 | 2.758 | 0.65 | 2.559 | 3.209 | 0.65 |
| (28 Categories) | (4.856) | (6.372) | (0.689) | (5.153) | (6.769) | (0.689) |
| Neighboring Categories: | 0.599 | 0.702 | 0.103 | 0.697 | 0.817 | 0.120 |
| (6 Categories) | (1.683) | (2.397) | (0.220) | (1.798) | (2.569) | (0.254) |
| Non-Neighboring Categories: | 1.599 | 2.056 | 0.457 | 1.862 | 2.392 | 0.530 |
| (22 Categories) | (3.900) | (4.989) | (0.475) | (4.151) | (5.308) | (0.546) |
| Number of Substitute Items Purchased: | 8.565 | 8.360 | -0.205 | 9.974 | 9.725 | -0.248 |
| (28 Categories) | (11.585) | (12.901) | (1.302) | (11.929) | (13.433) | (1.455) |
| Neighboring Categories: | 2.904 | 2.427 | -0.477 | 3.382 | 2.824 | -0.558 |
| (6 Categories) | (6.555) | (5.125) | (0.624) | (6.961) | (5.428) | (0.714) |
| Non-Neighboring Categories: | 5.661 | 5.933 | 0.272 | 6.592 | 6.902 | 0.310 |
| (22 Categories) | (7.341) | (8.624) | (0.850) | (7.525) | (8.937) | (0.946) |
| Number of Categories Purchased | 4.260 | 4.500 | 0.240 | 4.961 | 5.235 | 0.275 |
| | (3.587) | (3.690) | (0.386) | (3.390) | (3.462) | (0.392) |
| Total $ Amount Spent on Purchase | 66.186 | 65.198 | -0.988 | 70.957 | 70.166 | -0.791 |
| | (38.556) | (40.119) | (4.177) | (38.403) | (39.833) | (4.481) |
| Number of Shoppers | 177 | 178 | | 152 | 153 | |

[a]Standard deviations are presented in parenthesis

[b]Standard errors are presented in parenthesis

Our analysis focuses on 28 product categories. Six of these are classified as Neighbor Categories - categories where the substitute and target items appear on the same line of the webpage (avocados, bananas, kiwis, lemons, raspberries, and water). The remaining 22 non-neighboring categories are the following: apples, bulk apples, blueberries, pineapples, broccoli, cucumbers, kale, onions, green onions, peppers, lettuces, limes, tomatoes, bread, organic bread, eggs, brown eggs, organic eggs, milk, bulk milk, organic milk, yogurt. Target or Substitute History is a sample that includes only shoppers who made at least one purchase of a target or substitute good during the pre-experiment period.

*Significant at 10%; **significant at 5%; ***significant at 1%

Table VI: Price Elasticities

| | All | Vegetable | Fruit | Perishable | All | All | All |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Log Price | -1.649*** | -1.619*** | -3.096*** | -1.224*** | -1.496*** | -1.119*** | -1.179*** |
| | (0.249) | (0.438) | (0.756) | (0.260) | (0.269) | (0.266) | (0.221) |
| Log Price x Same Line | | | | | -1.655** | | |
| | | | | | (0.776) | | |
| Log Price x History | | | | | | -0.347** | |
| | | | | | | (0.155) | |
| History | | | | | | 1.300*** | |
| | | | | | | (0.157) | |
| Log Price x Treatment | | | | | | | -0.102 |
| | | | | | | | (0.088) |
| Treatment | | | | | | | 0.138* |
| | | | | | | | (0.082) |
| Item Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Month Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Number of Items | 1,089 | 243 | 225 | 423 | 1,089 | 2,178 | 2,178 |

Standard errors are presented in parenthesis and clustered at the item level.
An observation is defined by month and item (121 items tracked from 6 months prior to intervention until the end of intervention (a total of 9 months)). Same Line refers to item categories where the substitute and target items appear on the same line of the website. History refers to shoppers who made a purchase in this category of products (e.g. milk) prior to the intervention.

*Significant at 10%; **significant at 5%; ***significant at 1%

Table VII: Measuring the Effect of Promotional Information on Customer Purchase Decisions

| | All Weeks | | | Identical Rebate Weeks | | |
|---|---|---|---|---|---|---|
| | **Category** | **Target** | **Substitute** | **Category** | **Target** | **Substitute** |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Treat X Target Sale X Hist | 0.114*** | 0.03* | 0.09*** | 0.129*** | 0.022 | 0.112*** |
| | (0.025) | (0.017) | (0.022) | (0.039) | (0.021) | (0.038) |
| Treat X Target Sale | -0.002 | -0.0004 | -0.002 | 0.0001*** | 0.0024 | -0.002*** |
| | (0.003) | (0.002) | (0.002) | (0.003) | (0.002) | (0.003) |
| Target Sale X History | -0.07*** | 0.00008 | -0.072*** | -0.104** | -0.01523 | -0.089* |
| | (0.018) | (0.011) | (0.018) | (0.029) | (0.015) | (0.027) |
| Target Sale (TS) | 0.005** | 0.004** | 0.001 | 0.01*** | 0.002*** | 0.008*** |
| | (0.002) | (0.002) | (0.001) | (0.004) | (0.002) | (0.003) |
| Treat X Hist | -0.046 | -0.009 | -0.039 | -0.088*** | -0.019*** | -0.072*** |
| | (0.038) | (0.012) | (0.034) | (0.043) | (0.015) | (0.037) |
| History of Purchase | 0.16*** | 0.03*** | 0.133*** | 0.196*** | 0.04*** | 0.16*** |
| | (0.027) | (0.008) | (0.024) | (0.034) | (0.012) | (0.028) |
| Rebate Eligibility | 0.087*** | 0.022*** | 0.066*** | 0.086*** | 0.022*** | 0.065*** |
| | (0.006) | (0.003) | (0.005) | (0.006) | (0.003) | (0.006) |
| High Rebate Period | 0.001 | -0.002 | 0.003* | | | |
| | (0.002) | (0.001) | (0.002) | | | |
| Eligibility x High Rebate | 0.008 | 0.012*** | -0.003 | | | |
| | (0.006) | (0.004) | (0.005) | | | |
| Item Category FE's | X | X | X | X | X | X |
| Month FE's | X | X | X | X | X | X |
| N Items x Months | 40,115 | 40,115 | 40,115 | 19,880 | 19,880 | 19,880 |
| Mean of Dependent Variable: | 0.038 [0.245] | 0.01 [0.121] | 0.028 [0.207] | 0.036 [0.223] | 0.009 [0.104] | 0.027 [0.194] |

Standard errors are presented in parenthesis and clustered at the shopper and category levels. Standard deviations appear in brackets. An observations is defined by a shopper, month, and item category. History of Purchase is equal to 1 if the shopper purchased a relevant item in the pre analysis period. Rebate Eligiblity implies that the consumer made a purchase of at least $20 during this month, High Rebate period implies that if purchasing the rebate product (either from the subsitute or target group) the shopper was eligible for a high rebate during this period ($10 off his/her purchase) .

Table VIII: The Role of Search Costs and Information in Determining the Effect of Promotional Information on Shopping Behavior

| | ***Special*** ="Same Line" Category | | | ***Special*** =Detailed Period | | |
|---|---|---|---|---|---|---|
| | **Category** | **Target** | **Substitute** | **Category** | **Target** | **Substitute** |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Treat X Target Sale X Hist X ***Special*** | 0.029 | 0.034 | -0.005 | -0.183*** | -0.016 | -0.178*** |
| | (0.048) | (0.035) | (0.047) | (0.057) | (0.034) | (0.058) |
| Treat X Target Sale X Hist | 0.107*** | 0.02 | 0.092*** | 0.207*** | 0.032 | 0.186*** |
| | (0.028) | (0.016) | (0.024) | (0.049) | (0.024) | (0.046) |
| Treat X Target Sale | -0.002 | -0.001 | -0.001 | -0.0032 | 0.0014 | -0.004 |
| | (0.003) | (0.002) | (0.002) | (0.004) | (0.003) | (0.003) |
| Target Sale X History | -0.077*** | 0.00042 | -0.079*** | -0.094** | -0.00334 | -0.092* |
| | (0.02) | (0.008) | (0.02) | (0.032) | (0.016) | (0.029) |
| Target Sale (TS) | 0.004* | 0.003** | 0.001 | 0.005*** | 0.001*** | 0.003*** |
| | (0.002) | (0.002) | (0.002) | (0.004) | (0.002) | (0.003) |
| Treat X Hist | -0.038 | -0.004 | -0.034 | -0.095*** | -0.022*** | -0.077*** |
| | (0.033) | (0.012) | (0.029) | (0.047) | (0.015) | (0.042) |
| History of Purchase | 0.144*** | 0.03*** | 0.117*** | 0.213*** | 0.043*** | 0.176*** |
| | (0.025) | (0.009) | (0.022) | (0.037) | (0.012) | (0.032) |
| Rebate Eligibility | 0.087*** | 0.022*** | 0.066*** | 0.086*** | 0.022*** | 0.065*** |
| | (0.006) | (0.003) | (0.005) | (0.005) | (0.003) | (0.005) |
| High Rebate Period | 0.001 | -0.002 | 0.003* | -0.001 | -0.003** | 0.002 |
| | (0.002) | (0.001) | (0.002) | (0.002) | (0.001) | (0.002) |
| Eligibility x High Rebate | 0.008 | 0.012*** | -0.003 | 0.01* | 0.012*** | -0.002 |
| | (0.006) | (0.004) | (0.005) | (0.006) | (0.004) | (0.005) |
| Item Category FE's | X | X | X | X | X | X |
| Month FE's | X | X | X | X | X | X |
| N Items x Months | 40,115 | 40,115 | 40,115 | 40,115 | 40,115 | 40,115 |
| Mean of Dependent Variable: | 0.038 [0.245] | 0.01 [0.121] | 0.028 [0.207] | 0.038 [0.245] | 0.01 [0.121] | 0.028 [0.207] |

Standard errors are presented in parenthesis and clustered at the shopper and category levels. Standard deviations appear in brackets. An observations is defined by a shopper, month, and item category. "Same Line" (columns (1)-(3)) refers to the product categories where both the substitute and target products appear on the same line of the webpage. Detail (columns (4)-(6)) refers to weeks where the treatment email provided personalized nudges towards onsale items and specifically mentioned that some organic items are on sale. History of Purchase is equal to 1 if the shopper purchased a relevant item in the pre analysis period. Rebate Eligiblity implies that the consumer made a purchase of at least $20 during this month, High Rebate period implies that if purchasing the rebate product (either from the subsitute or target group) the shopper was eligible for a high rebate during this period ($10 off his/her purchase) . All specifications include additional controls for "Special" interacted with Target Sale, Treat, and Hist.

*Significant at 10%; **significant at 5%; ***significant at 1%