Title

Can Information Costs Confuse Consumer Choice?---Nutritional Labels in a Supermarket Experiment

Authors

Kiesel, Kristin
Villas-Boas, Sofia B.

Publication Date

2009-12-16

Can Information Costs Confuse Consumer Choice? —Nutritional Labels in a Supermarket Experiment—

Kristin Kiesel[1] and Sofia B. Villas-Boas[2*]

December 16, 2009

[1]California State University, Sacramento—Department of Economics

[2]University of California, Berkeley—Department of Agricultural and Resource Economics

email: kiesel@csus.berkeley.edu

*We thank Hayley Chouinard, Jill McClusky and Joshua Berning for their suggestions and involvement in an early stage of this research. The study is influenced by interventions originally proposed to the National Research Initiative at the USDA by those researchers. We would like to thank Jay Variyam, Aviv Nevo, and participants at the FTC-Northwestern University microeconomics conference, Guido Imbens, participants at the economics lunch in Harvard, Jeff Perloff, Michael Anderson, Jeremy Magruder, and the participants of the ERE seminar in Berkeley for helpful comments. We are also thankful to Eric Hallstein and Barruch Ben-Zekry for their help in implementing the shelf labels and the excellent research assistance Barruch provided. And finally, we are thankful to Michelle Scizak, Kaushik Subramanian, and Steve Flamming for coordination of the experiment and data access. The authors gratefully acknowledge financial support received from the Giannini Foundation.

Abstract

This paper investigates whether information costs prevent consumers from making healthier food choices under currently regulated nutritional labels in a market-level experiment. Implemented nutritional shelf labels reduce information costs by either repeating information available on the Nutritional Facts Panel, or providing information in a new format. We analyze microwave popcorn purchases using weekly store-level scanner data from both treatment and control stores in a difference-in-differences and synthetic control method approach. Our results suggest that information costs affect consumer purchase decisions. In particular, *no trans fat* labels significantly increase sales, even though this information is already available on the package. *Low calorie* labels significantly increase sales, while correlated *low fat* labels significantly decrease sales, suggesting that labeling response may also be influenced by consumers' taste perceptions. Finally, combining multiple claims in a single label reduces the effectiveness of the implemented labels. Our results provide direct implications for changes to the format and content of nutritional labeling currently considered by the Food and Drug Administration.

1 Introduction

Existing research consistently confirms that consumers understand the link between nutrition and health. However, consumers cannot verify nutritional content at any point from purchase to consumption. Instead, they base their purchase decisions solely on subjective beliefs, arrived at by way of a labyrinth of information. These beliefs may differ due to heterogeneity in consumers' individual time constraints and ability to process relevant information. In this paper, we investigate this relationship between information costs and healthy food choices by taking advantage of a supermarket-level experiment.

While required to display the Nutrition Facts Panel (NFP), firms have an incentive to exploit differences in consumers' subjective beliefs. We describe this market setting in a theoretical model and derive comparative statics tested in real-world purchasing decisions. Our nutritional shelf labels either repeat information already available on the NFP, or provide information in a new format, allowing consumers to compare each product on a relative scale of nutritional characteristics. Using *low calorie*, *low fat* and *no trans fat* claims, we investigate the following questions: (i) Are consumer purchases affected by nutritional shelf labels? (ii) Do effects differ depending on nutrients displayed (e.g. calories versus fat content)? (iii) Do effects differ depending on disclosure of a source (Food and Drug Administration, FDA)? (iv) Do effects differ depending on display of a single versus multiple nutrients on a label? (v) Do we find evidence consistent with consumers making inferences about the nutritional content of unlabeled products? Although our empirical design incorporates previous findings in the literature on consumer response to labeling information, it is to our knowledge the first study that provides direct tests and specifically focuses on information costs at the point of purchase. By including claims for several nutrients, including the *low fat* claim discussed extensively in the literature, our empirical results also serve as a comparison and validation of previous findings.

We implemented nutritional shelf labels for one product category, microwave popcorn, in cooperation with a major supermarket chain. Five stores were treated over a period of four weeks in the fall of 2007. We obtained weekly store-level scanner data from these treatment stores and 27 comparable control stores for a total of 14 weeks. Estimations of average treatment effects are based on difference-in-differences (DD) and triple-difference (DDD) specifications identified by random assignment of treatment stores, as well as a cross-sectional and time-series control structure. In addition, we use the available control stores to apply a non-parametric synthetic control method. This approach addresses uncertainty about the ability to reproduce the counterfactual of product sales in the absence of our labeling treatments.

Consumer response to our labels suggests that information costs prevent consumers from making healthier food choices. A divergent effect of *low fat* versus *low calorie* labels further suggests that labeling response may be influenced by consumers' taste perceptions. In particular, we find that a shelf label of *no trans fat*–a claim already advertised on many of the products, and an NFP requirement–significantly increases sales of targeted products. *Low calorie* labels also significantly increase sales of treated products in aggregated regression specifications. While correlated, *low fat* labels do not result in the same effect and reduce quantity sales of targeted products. Adding an FDA approval[1] reduces sales of labeled *low fat* products even further. And with the exception of this treatment, we find no evidence that consumers make inferences about unlabeled products and their relatively inferior nutritional quality. Finally, combining multiple claims in one label treatment does not significantly affect purchases. These results are further supported by trends displayed in the graphical synthetic control method analysis. This approach further detects the biggest impact immediately following the initial implementation. For the *low calorie* and *low fat* treatments, labeling effects dissipate after the treatment period, but persist for the *no trans fat* treatment.

The Nutrition, Labeling, and Education Act (NLEA) of 1990 gave the FDA the authority to require nutritional labeling for most food products. In 1994, the NFP was implemented in order to improve consumers access to nutritional information and promote healthy food choices. Despite a national health objective to reduce obesity rates to less than 15% by 2010, recent trends suggest that the prevalence of overweight and obesity has increased sharply (from 15.0% in 1976 to 32.9% in 2004 among adults, and from 5.0% to 18.8% among children).[2] In response to a simultaneous decline in label use by consumers, the FDA is currently considering changes to the format and

[1]In addition to displaying the nutritional claim, this treatment states that the displayed claim is consistent with FDA labeling guidelines.

[2]The U.S. Department of Health and Public Services has declared this reduction as one of the national health objectives for 2010 as being obese increases the risk of health conditions, such as type 2 diabetes, coronary heart disease, stroke and some cancers. These rates are reported in the National Health and Nutrition Examination Survey (NHANES). For children, the term overweight is used rather than obesity (CDC, 2008).

content of nutrition labels (Todd and Variyam, 2008). Our results provide direct policy implications to promote increased label use.

The next section discusses the related literature in detail. Section 3 provides a simple theoretic motivation for our empirical analysis. The experimental design, data, and descriptive statistics are described in section 4. Section 5 introduces the empirical difference-in-differences specifications, identification strategy, and reports estimation results. The synthetic control method approach and findings are discussed in section 6. The paper concludes in section 7.

2 Labeling Use in Real-Life Shopping Situations

Nutritional labeling has become of increasing interest to both consumers and policy makers. In a review of existing research on consumer response to health claims and nutritional information, Grunert and Wills (2007) document widespread consumer interest in nutritional information on food packages and consumers general understanding of the link between food and health. Blitstein and Evans (2006) further report that about 50% of consumers claim to use the NFP labels when making food purchasing decisions. Using the National Longitudinal Survey of Youth 1979, Mandal (2008) finds greater use of food labels by those who are trying to lose weight as well as a greater likelihood of weight loss for those consumers. In addition, Variyam and Cawley (2006) find that the use of nutrition labels is associated with a decrease in body weight and the probability of obesity as reported in the National Health Interview Survey. However, Todd and Variyam (2008) find that self reported consumer use of nutrition labels declined from 1995-2006. The decline seems most severe for the age group of 20-29 years and for individuals with a lower educational background. These trends might be a result of consumers inability to perform label use tasks and math identified in Levy and Fein (1998). In addition, a number of studies suggest that consumers prefer short front-label claims to lengthy back label explanations, or a combination of both (e.g. Levy and Fein, 1998; Williams, 2005; Wansink, et al., 2004; Grunert and Wills, 2007). Wansink et al. (2004) further find that the presence of shorter health claims on the front of package in combination with complete back claims leads a person to generate a more positive image of the product attribute. Looking at GMO-claims, Roe and Teisl (2007) find that simple claims are viewed as most accurate, labels certified by the US Food and Drug Administration (FDA), and in some cases, USDA certified claims are perceived as more credible than third party and consumer organization certification. Using simple claims and generating a positive image, can potentially be problematic, however and poses the question if nutrition labels can actually lead to weight gain. Wansink and Chandon (2006) contend that low fat claims can increase food intake through perceptions of an increased acceptable serving size and a reduction in consumption guilt. This effect can possibly be enhanced when combining *low fat* claims with suggestive health references (Geyskens et al., 2007). Other studies emphasize a possible perceived tradeoff between nutritional considerations and taste preferences. Yeomans et al. (2001) report that *low fat* food labels result in lower taste expectations for soup. Stubenitsky et al. (2000)report that when faced with the choice between full and reduced-fat meals, adding nutritional information further decreased the selection of reduced fat meals in randomized trials. French et al. (1999) reports similar findings in the context of snack choices among adolescents and adults. Our experimental design considers these findings. It provides insight into how labeling information is used in real-world shopping situations, and how content and format affects actual consumption choices, a current shortcoming highlighted in Grunert and Wills (2007). Conducting the experiment in a real market setting further eliminates possible bias generated in these hypothetical experiments and survey responses.[3]

The limited number of market-level empirical studies exhibit mixed results regarding effectiveness of nutritional information provision. Russo et al. (1986) find that displays of lists of information on vitamins and minerals as well as sugar content in supermarkets prior to the NLEA and implementation of NFP are successful in increasing information use. Ippolito and Mathios (1990) found significant effects of voluntary labels on consumer choices prior to the NLEA, but Mojduszka and Caswell (2000) argue that information provided by firms voluntarily prior to the NLEA was incomplete and not reliable. Mathios (2000) employed pre- and post-NLEA scanner data to investigate the effects of mandatory disclosure laws on consumer

[3]While careful design and statistical analysis in survey responses can minimize strategic and hypothetical bias, it might not eliminate it. Hypothetical experimental studies rely on a much more limited range of items than available in actual retail stores. In addition, participants of those studies may exhibit what is called the Hawthorne effect, an adjusted response to please the experimenter.

choice of salad dressing. He finds that despite voluntary disclosure of low-fat products, mandatory guidelines resulted in a significant decline in sales of high fat products. In a similar study, Teisl, Bockstael and Levy (2001) find that consumer behavior was significantly altered, but purchases of "healthy" products increased only in some of the product categories. In these studies, little attention has been paid to the effects and interdependencies of regulation and alternative information sources. Yet, experimental research (Cain, Loewenstein, and Moore, 2005) suggests that when evaluating information, people do not sufficiently take the incentives and motives of the information source into account, even after disclosure of conflicts of interest. The extent to which product quality information can affect consumer behavior has been documented on a variety of aspects: branding (Montgomery and Wernerfelt, 1994), mandatory disclosure (Jin and Leslie, 2003), introduction of uniform standards (Kiesel and Villas-Boas, 2007), expert opinion (Sorensen and Rasmussen, 2004; Reinstein and Snyder, 2005; Hilger, Rafert and Villas-Boas, 2007).[4] Advertising and manufacture claims could play an important role in spreading nutritional information as highlighted by Ippolito and Mathios (1995), yet Ippolito and Pappalardo (2002) suggest that regulatory rules and enforcement policy in the nutritional context might have induced firms to move away from reinforcing nutritional claims. Critical news coverage of regulatory challenges (Nestle, 2002), and the "Food News Blues" in general (Newsweek, 2006) might be another possible explanation for decreased labeling use detected in Todd and Variyam (2008). Our experimental design allows controlling for these confounding factors and therefore identifies the labeling effect more precisely.

3 A Simple Model of Nutritional Labeling

While consumers are aware of the existence of different nutritional qualities, they might not know which product offers a higher nutritional value. Nutritional quality can be defined as a credence attribute as consumers cannot verify the nutritional content of a good they have purchased even after consuming it. [5] Providing labeling information in this context can help con-

[4] Empirical studies of consumer level responses to advertising further find that consumers adjust their purchasing decisions (e.g. Ackerberg, 2001, 2003)

[5] Credence goods vary significantly from search and experience goods in that reputation and signaling can rarely be used to alleviate information asymmetries in this case (see

sumers make an informed choice, but might not restore a full information outcome.

3.1 Market Settings

Following Bonroy and Constantatos (2008), we consider a simplified duopoly market setting with two versions of a good, g_h (denoting the higher nutritional content) and g_l (denoting the lower nutritional content), produced at constant marginal costs (with $c_h > c_l$). We further assume that the good produced by firm 2 corresponds to the high quality good ($g_2 = g_h$). All consumers are assumed to buy one unit of either good or none, and to have identical tastes in that they derive a higher utility from consuming the higher nutritional quality good ($U_h > U_l$).[6] Consumers are further assumed to be: (i) aware of two qualities and consequences of consuming either one, (ii) ignorant about production costs, (iii) able to identify whether product is made by firm 1 or firm 2, and (iv) uncertain which firm sells high quality. Using all information available (including advertisement and labels). They form subjective beliefs $\alpha \epsilon$ [0,1] over the event E: firm 1 sells the high quality good, and firm 2 sells the low quality good.[7] Bonroy and Constantos (2008) show that sufficiently dispersed beliefs might give neither firm an incentive to reveal their quality. Trivially, the low quality firm will not have an incentive to reveal its quality, but information provision might decrease profits for the high quality firm as well. To provide an intuition for this counterintuitive result for the high quality firm, it helps to divide this outcome in two components: 1. Imperfectly revealing its quality might allow firm 2 to capture a greater market share by changing consumers beliefs. 2. Firm 2 implicitly also reveals the quality of firm 1, by narrowing the distribution of beliefs. Firm 2 therefore puts pressure on firm 1 to lower its price and effectively creates pressure for itself to lower its price as consumer choice depends on

Nelson (1970), Darby and Karni (1973) and Roe and Sheldon (2007)for this classification.

[6]This abstracts from possible taste preferences and perceived trade-offs between taste and nutritional qualities. It is a simplifying assumption on nutritional quality only, keeping all else (including taste) equal.

[7]It is assumed that the firm knows the distribution of beliefs, while consumers do not. This assumption excludes the possibility of price signaling in this model. We further take differentiation based on product characteristics as given and focus on differentiation based on initial beliefs.

the expected utility difference as well as on the price difference.[8] This result has a strong lemons flavor (Akerloff, 1970), but the credence character prevents firms from building a reputation or offer some kind of warranty to signal their superior quality in this market setting.

Perfect labels would restore a full information equilibrium, in which α =0 for all consumers and result in survival of the efficient firm only.[9] Labels might be imperfect however. Low quality firms wish to avoid labeling, and have an incentive to make the label signal less clear and publicized. High quality firms might find themselves in a status quo, as an additional effort to signal their higher quality might intensify price competition. While required to display the NFP, firms can focus their advertising claims on certain attributes, and "shroud" others in the Gabaix and Laibson sense (2006). In a market with some myopic or uninformed consumers, these firms can shroud some attributes—for instance sugar content when promoting candy as a *low fat* food—and portray their product more favorably. Another alternative relates to making information less salient (Chetty, Looney and Kroft, 2007).[10]

Our data supports this setting as none of the product alternatives display the NFP on the front of the package, but feature select manufacture claims regarding nutritional content. Information provision further does not seem salient, considering that serving sizes across product alternatives vary significantly (displayed in Figure 1). Combined with significant variation in targeted nutrients indicated in Figures 2-4, consumers would need to invest time and quantitative skills in order to compare information on nutritional content currently provided under the NFP. In this context, labeling L can be defined as a continuous variable, increasing towards perfect labels and full information outcomes.

[8] One such case arises if imperfect information provision would mainly affect the higher end of the beliefs distribution (higher value of α indicating a more incorrect belief). By changing the beliefs of these consumers and forcing firm 1 to reduce its price, firm 2 could might find its profits reduced after revealing additional information. Firm 2 might therefore be better off to target well informed consumers and leave less informed consumers to be exploited by firm 1.

[9] Which firm is efficient depends both on the difference in production costs as well as the utility difference. If the utility difference is greater than the cost difference, firm 2 would be efficient as all consumers would prefer it's product when priced at marginal costs.

[10] Salience in this context is defined as the simplicity and transparency of information that allows consumers to compare nutritional content across product alternatives.

3.2 Consumer Choice

Consumers might not be able to make full use of the currently implemented labels due to differences in their time constraints and ability to access and process the information provided. We define consumer information search within a random utility household production function model.[11]

$$\begin{array}{ll} Max & U(\mathbf{x}, g; \alpha) \\ s.t. & \sum p_i x_i + p_j g_j = w(T - T_x + T_g) + Y. \end{array} \tag{1}$$

Consumers maximize utility over all other goods (or attributes) $\mathbf{x}$ as well as a good or attribute g characterized by its nutritional quality or content over which consumers form subjective beliefs α.[12] We only consider two versions of this good, g_1 or g_2, in which g_2 corresponds to the high nutritional quality good ($j = 1, 2$). Consumers further optimally choose search time over all other goods or attributes, T_x (either search or experience goods), as well as the nutritional character, T_g. Consumers are constrained by their income, defined as full income. A consumer is able to spend non-wage income, Y or allocate time to generate income in the labor force at wage rate w. This constraint specifies the costs of information search as opportunity costs of time. The time spend searching and processing relevant information cannot be used to generate income or allocate it to other uses such as leisure.[13]

Nutritional labeling, L, enters this framework as a parameter affecting a consumers optimal search time T_g, and formed beliefs α. Consumers base their beliefs on all available information including labels, manufacture claims, media coverage, word-of-mouth, etc. but differ in their ability to access and process this information. For simplicity, and due to our focus on labeling changes, we define T_g as a function of L only, and beliefs α as a function of T_g.

Given that second-order derivatives are satisfied for this constrained maximization problem, the choice of either g_1 or g_2 depends on the expected

[11]This model is similar to the model described in Kiesel, Buschena, and Smith (2005), but focuses on consumers subjective beliefs and expected utility differences formed over these beliefs.

[12]For simplicity, we assume that nutritional content is one dimensional, and consumers form subjective beliefs α about this credence attribute only, such that the expectation is formed over these beliefs only.

[13]Leisure can be thought of as one of the goods demanded, with a price equal to the forgone income.

indirect utility formed over the subjective beliefs of those two stochastic consumption options in this framework. The expected indirect utility derived from consuming either g_1 or g_2 can be defined as:

$$\begin{array}{rl} EV_1^* = & \alpha(T_g^*)V_h(Y,w,p_i,p_1,L) + (1-\alpha(T_g^*)V_l(Y,w,p_i,p_1,L) \\ EV_2^* = & (1-\alpha(T_g^*))V_h(Y,w,p_i,p_2,L) + \alpha(T_g^*)V_l(Y,w,p_i,p_2,L) \end{array} \quad (2)$$

As the choice of either product is determined by the expected indirect utility difference, the probability that g_2 is chosen can be defined as follows:

$$P(V_2^* - V_1^* > 0) = P(g_2 > 0) \quad (3)$$

The optimal amount of T_g chosen depends on the marginal productivity of time allocated to nutritional information search relative to other possible time uses. We assume that additional information search on nutritional content potentially improves beliefs, but does not worsen beliefs under a given information structure. An increase in labeling (defined as a move towards perfect labels) increases the marginal productivity of time potentially allocated to nutritional information search by making information more readily available and easier to process. In other words, an increase in labeling reduces the relative price of nutritional information search and might therefore make it optimal for consumers to allocate additional time to nutritional information search who previously had a binding constraint with regards to their time and information processing costs. The following equation summarizes this results:

$$\frac{\partial \alpha}{\partial L} = \frac{\partial \alpha}{\partial T_g} * \frac{\partial T_g}{\partial L} \leq 0. \quad (4)$$

A possible reduction in α will in turn increase V_2^* and decrease V_1^* and thus unambigiously increase the probability of choosing g_2 for some consumers:

$$\frac{\partial P(g_2 > 0)}{\partial L} = \frac{P(V_2^* - V_1^* > 0)}{\partial L} \geq 0 \quad (5)$$

One of the difficulties in the nutritional debate is that consumers might perceive trade-offs between nutritional quality and taste. Once we would allow for these tradeoffs, the net labeling effect can be defined as a change in consumers inference about all product characteristics and can potentially go in the opposite direction. Our experimental design allows us to test these partial equilibrium results. If none of the consumers were constrained by information costs under currently implemented labels, we should not see a change in the demand for targeted products in either direction, as we do not provide the new information. In our interpretation of results, we will further have to address possible changes in product demand due to general attention or nuisance effects of added labels.

4 The Supermarket Experiment

In collaboration with a major supermarket chain, we were able to display nutritional shelf labels that make information more salient and easier to process. We implemented five differentiated labeling treatments for one product category, microwave popcorn, in randomly assigned stores over a period of four weeks.

4.1 Experimental Design

The selection of microwave popcorn as the treated product group was based on a number of considerations. First of all, in compliance with the supermarket chain, we had to focus our intervention on a relatively small product category.[14] We further wanted to target a product category that can be potentially healthy and offers enough variation in nutrients to result in sufficient variation in labels. Also, we wanted to target a product that is appealing to families with children, as healthy or unhealthy eating patterns develop during childhood.[15] And finally, to increase the feasibility of cross-product comparisons, we wanted to pick a product category that is comparable in taste and appearance across brands.

Our initial labeling proposal focused on calorie content, as the amount of calories consumed has been determined to be the main contributor to weight gain and obesity.[16] The categorical character and initial design was further

[14]This restriction is supposed to minimize possible losses in sales due to our intervention.

[15]Overweight children are more likely to be overweight as adults. Successfully preventing and treating overweight in children can reduce the risk of overweight in adults and therefore help to reduce the risk of related health conditions (American Health Association 2008).

[16]Depending on daily calorie allowance according to gender, age and activity level, an extra 100 calories a day amounts to a weight gain of 10 pounds a year for instance (CDC, 2008).

based on the *Traffic Light Colour Signpost Labelling* successfully introduced by the Food Standards Agency in the UK in 2007 (FSA, 2007). But, we also wanted to contrast disclosure regarding calorie content to fat content. The World Health Organization (WHO) endorses the promotion of *low fat* products as one strategy to reduce obesity rates for instance (WHO 2004). In addition, *low fat* claims have received increased attention in the recent literature as well (see section 2). Finally, we wanted to compare possible information effects for these treatments to trans fats labeling information. Health concerns related to trans fats received a lot of media attention, and *no trans fat* advertisement was readily adapted by food manufacturers. Consumers might therefore be well informed about this nutrient and be able to more readily incorporate easier to process information with regards to this nutrient.

In combining multiple nutrient claims in one label, the information content potentially increases as several aspects are addressed at the same time. Yet, information costs increase as well as compared to the display of a single claim. By varying our treatments with regards to the number of nutrients displayed, we were able to address this potential trade-off. The supermarket (and possibly consumers as well) further viewed these labels as in-store nutritional advertisement. We therefore wanted to add an FDA approval to some of our label treatments to investigate if it increases the credibility of the information provided on the label and affects consumer deand differently(e.g. Roe and Teisl, 2007).

The information needed to construct categorical nutritional claims was collected using the NFP displayed on all microwave popcorn varieties available at local area stores. Figures 2-4 summarize the distribution of nutrients targeted in our intervention. Label classifications as low, high, and medium were created based on relative nutritional content within the overall product category of microwave popcorn, categorizing the lowest (highest) 25% of the products as *low fat* or *low calorie* (*high fat* or *hight calorie*). Figure 5 displays the initially proposed labels for calorie content. This originally proposed experimental design had to be revised and highlights possible discrepancies between policy objective and incentives of firms or supermarkets. The supermarket only permitted positive claims that would potentially increase sales, and favored a very basic design. We therefore were only able to treat products that fell within the *low calorie*, *low fat* and *no trans fat* category. The supermarkets primary interest was further in investigating response to fat claims, possibly motivated by increasing market shares of *low* *fat* snacks and recent findings suggesting *low fat* claims might increase food intake and hence purchase of targeted products. Finally, we were restricted to a total of 5 randomly assigned treatment stores. Taking these restrictions into account, Figure 6 presents the design of implemented labels in our five treatment stores, while Figure 7 shows how the labels were placed on the grocery shelf. We implemented: (1) *low calorie* labels, (2) *low fat* labels, (3) *low fat* labels with FDA approval, (4) combined *low calorie/low fat* labels, and (5) *low calorie/low fat/no trans fat* labels.[17] These differentiated treatments allow us to address the following questions: (i) Are consumer purchases affected by nutritional shelf labels? (ii) Do effects differ depending on nutritional facts (e.g. calories versus fat content) displayed? (iii) Do effects differ depending on disclosure of source (Food and Drug Administration, FDA)? (iv) Do effects differ depending on displaying single versus multiple nutrients on a label? (v) Do we find evidence consistent with consumers making inferences about the nutritional content of non-labeled products?

4.2 Data and Summary Statistics

We implemented the labeling treatments during four weeks in the fall of 2007, starting on October 10th. This implementation was in accordance with "promotional" weeks—weeks beginning Wednesday and ending Tuesday the following week—defined by the supermarkets price cycle and data organization. Labels were attached during low traffic hours every Wednesday night and after possible changes in product prices went into effect. In addition to the five randomly selected treatment stores, we received weekly product sales within the microwave popcorn product category for 27 additional stores within the same price division. [18] Data are available for a total of 14 weeks, spanning five weeks prior and post treatment period. In addition, we matched the zip code a store is located in with socio-economic statistics provided by the United States Census Bureau (2000 Census).

The original scanner data provided by the grocery chain included 93 products and 18785 product-week-store observations for the relevant product category. Sampling local area stores in order to record nutritional information resulted in a total of 68 products. For these products, we have detailed

[17] For combined label treatments, we display a variety of labels, e.g. *low calorie* labels, *low fat* labels, and *low calorie/low fat* labels.

[18] The randomization of the treatment stores and selection of the control stores was implemented by the supermarket. We were not able to provide feedback on this process.

nutritional information, with 43 of those products subject to our labeling intervention. The number of products included in the scanner data for which we do not have nutritional information amounts to 25 products. For a given week, that translates to excluding 0-12 products per control store, with a mean of 3 products.[19]

Table 1 summarizes descriptive characteristics for the labeling interventions. The reported statistics for the control stores indicate how many products would have been treated if products in these stores were labeled. With the exception of one smaller treatment store, treatment and control stores seem fairly similar regarding product assortment and potential treatment sample of products.

Table 2 provides descriptive statistics regarding store characteristics of treatment and control stores (e.g. store size, year opened, number of available products within category, category sales, and product sales) as well as socio-economic characteristics by zip code. Treatment stores vary somewhat in size, and although selected randomly, category sales seem somewhat higher compared to average category sales for the control stores. They generally are within one standard deviation, and are no larger or smaller than the observed maximum or minimum observed among the control stores, however. Table 2 also includes demographic descriptive statistics of potential shoppers in a given zip code. Here again, treatment and control stores seem similar and furthermore representative of national averages.[20]

Table 3 summarizes the variables included in the final regression analyses. The quantity variable reported here corresponds to the net total number of units of a given product sold during a promotional week. Zero or negative sales, resulting from returns of as many or more items than purchased are excluded from the analysis. In addition, the price variable is constructed as net revenue divided by product quantity.

[19] Regression specifications were also estimated including these observations as a robustness check.

[20] The median income nationwide is reported as 42.000, median household size amounts to 2.52, and percentage of white is reported at 75% according to the US Census 2000.

5 Econometric Difference-in-Differences Specifications

To estimate the effect of the labeling intervention, we compare sales of the "treatment" product group to sales of control product groups, serving as the counterfactual of product sales in the absence of our intervention. Treatment in this context refers to adding a shelf label for products targeted depending on their nutritional content. As we cannot observe what the sales of these microwave popcorn products would have been in the absence of labeling at the treated stores and during the treated weeks, identification of treatment effects depends on the definition of relevant control groups. Estimation of average treatment effects (ATE) rests on the assumption that average differences in outcomes for treated and control groups are attributable to the treatment, which is satisfied when treatment assignment and the potential outcomes are independent (Imbens, 2004). This condition is satisfied by random assignment of our treatments across stores.

We observe repeated cross sections—weekly store-level product sales– and therefore follow a difference-in-differences approach commonly used in the policy evaluation literature (see Meyer, 1995; Bertrand, Duflo, and Mullainathan, 2004) to identify the ATE. This approach allows for comparisons of means of the outcome of interest with or without treatment while certain observable covariates are held constant. Given that we also observe sales of products that will not be treated (products with higher calorie and fat content, and trans fats), we can potentially compare the treatment to three dimensions of counterfactuals (stores, time, and products). Depending on the chosen control structure, we estimate both, difference-in-differences (DD) and triple difference specifications (DDD). These are variants of the following linear model:

$$log(Y_{i,s,t}) = \alpha * \mathbf{T}_{i,s,t} + \beta * \mathbf{C}_{i,s,t} + \gamma * \mathbf{X}_{i,s,t} + \mu_j + \nu_s + \tau_t + \epsilon_{i,s,t}, \quad (6)$$

Let the outcome of interest— quantity sold or weekly revenue of a given product i, in a certain store s, and during a certain time t—be denoted by $Y_{i,s,t}$. We transform quantity measures into logs as this functional form allows interpretation and comparison of regression results in terms of average percentages rather than differences in sales in levels.[21] The parameter α de-

[21] A comparison in levels would be affected by variation of store size and resulting variation in sales across stores.

notes the treatment effect and corresponds to either the DD or DDD estimate depending on the level of interactions (twofold or threefold) in the treatment effect **T** and included control structure **C** that defines this effect. Let the variables *label*, *store*, and *time* serve as indicators whether the observation corresponds to the treated product group, the treated store, or the treatment period. In a DD specification, we can estimate the ATE on the treated by only including products that were subject to a treatment assignment across stores and time in the following specification:

$$\begin{aligned} log(Y_{i,s,t}) &= \alpha * store_s * time_t * + \beta_1 * store_s + \beta_2 * time_t + \\ &+ \gamma * \mathbf{X}_{i,s,t} + \mu_j + \nu_s + \tau_t + \epsilon_{i,s,t}, \end{aligned} \tag{7}$$

The same specification can be used to estimate the ATE on the untreated by only including products that are not labeled. Additionally including a comparison of potentially labeled products versus products that would not be subject to treatment, we can combine both product groups in a DDD specification:

$$\begin{aligned} log(Y_{i,s,t}) &= \alpha * label_i * store_s * time_t * + \\ &+ \beta_1 * label_i * store_s + \beta_2 * label_i * time_t + \beta_3 * store_s * time_t + \\ &+ \beta_4 * label_i + \beta_5 * store_s + \beta_6 * time_t + \\ &+ \gamma * \mathbf{X}_{i,s,t} + \mu_j + \nu_s + \tau_t + \epsilon_{i,s,t}, \end{aligned} \tag{8}$$

The vector **X** in these specifications denotes possible additional covariates that may affect sales, such as price and manufacture claims.

As retailers consider all product characteristics, and account for changes in demand when setting prices, one might be concerned about possible endogeneity regarding quantity measures. However, all included stores are selected from the same price division, such that price promotions are universal across stores. While we do observe some variation in initial (non-promotional) price levels, these differences do not vary over time and are controlled for by the inclusion of store fixed effects. Timing of price promotions, on the other hand is controlled for by the inclusion of week fixed effects. An additional related concern is possible endogeneity of price changes and labeling treatment. Price promotions are implemented across all stores, independent of treatment. To provide further support and test this argument, we regress prices on the treatment, resulting in a small positive and insignificant effect of the treatment on price. And finally, the inclusion of price as an additional covariate is motivated by the fact that price is measured as an average price across all units sold at a given store at a given week. It is therefore also influenced the number of people that bought products on sale or promotions. Price sensitivity among shoppers across stores might vary and affects sales independently of our treatment.

Manufacture claims might further affect sales of specific products and while some of them address the same nutrients as our labels they are common across stores and uncorrelated with the treatment assignment by store. We further include brand j, store s and time t fixed effects to account for any unobservables that cause some brands, stores and weeks to on average have higher or lower sales. Brand fixed effects allow capturing time-invariant brand preferences, store fixed effects account for unobserved time-invariant differences across stores and week fixed effects account for changes in quantity due to unobserved seasonal effects that are assumed to affect all stores and products equally. And finally $\epsilon_{i,s,t}$ represents and unobserved disturbance. The identification assumption underlying these specifications is that there are no unobserved factors that differentially affect treated products before and after the implementation of our labels.

We begin the regression analysis of labeling effects by estimating the average treatment effect across all labeling treatments in order to address hypothesis (i). We then estimate specific ATE for each treatment store separately. In addition, we test hypotheses (ii) to (iv) by estimating specific labeling effects differentiated by displayed nutrient, FDA approval, and number of nutrients targeted. As our interventions are limited to products of favorable nutritional quality, we also estimate the average treatment effect on the unlabeled products to test (v). We finally combine both labeled and unlabeled products in a triple difference specification. Additional regression diagnostics and robustness checks are presented before discussing our findings. Our treated product category is characterized by relatively low volume sales and high fluctuations in sales across weeks. In order to address this possible power limitations of our analysis, we provide result for a variety of specifications and focus on displayed consistent trends across specifications as well statistical significance of the estimated coefficients.

5.1 Average Treatment Effects on the Treated

We first start by pooling all labeling interventions to investigate whether nutritional shelf labels affected purchases of targeted products. Regression results for this overall average effect across treatments are reported in Table 4. From column 1-6, we keep adding price, manufacturer claims, brand, store, and time fixed effects as additional covariates. In addition, standard errors are clustered at the product and store level.[22] While adding these additional covariates improves the R^2 of our regression specification (including all additional covariates allows as to explain 34% of the variation in sales), they do not affect the magnitude or significance of our estimated treatment effect.

In all estimated regression specifications, we fail to reject the null hypothesis of no effect of labeled products on sales in the treatment stores and treatment weeks relative to sales of these products in the control stores. Consistently throughout these regression specifications, we find a small negative but insignificant effect on sales ranging from -2.8% to -3.1%. This suggests that just posting nutritional shelf labels did not significantly affect sales of treated products *per se*. The reported regression results further indicate that consumers are responsive to price changes. A one dollar decrease in average weekly prices is estimated to result in a 24.2% to 28.6% increase in quantity sales of a product on average. Furthermore, as suggested by descriptive store characteristics presented in Table 2, these specifications confirm that sales of products targeted by our interventions were on average 11.9% to 32.7% higher in the treatment stores relative the control stores. Including information on manufacturer claims recorded while collecting information on nutritional content at local stores, also indicates that products featuring a calorie-related claim such as "100 calories" or "12.5% less calories" have significant higher sales on average (13.1%), and products carrying the USDA organic seal have significantly lower sales. In addition, products advertising whole grains have significantly, but only slightly lower sales on average.

In Table 5, we further report regression results for estimating the ATE for each implemented treatment separately, addressing question (ii). Treatment stores other than the one analyzed in the specified regression were excluded from the control stores, resulting in varying sample sizes depending on the regression specification. Furthermore, brand, store, and week fixed effects were included in all regressions, such that indicators for treated stores are not included in these specifications. Standard errors again are clustered at the product-store level.

[22]Clustering at the product level only does not change the results qualitatively, and results in smaller standard errors for some regressions. Due to limited observations and high fluctuations in product sales, clustering at the product level does not provide us with enough degrees of freedom for the analysis of specific labeling treatments in some cases.

The reported results suggest that the estimated effects vary depending on the nutrients displayed on the label. For instance, the coefficient on the *low calorie* label treatment is positive although insignificant, while the coefficients on the *low fat* label and the *low fat* label in combination with FDA approval are negative, although only statistically significant for the *low fat* (FDA approval) treatment, indicating a reduction of sales by 28.4% in this specification. The same qualitative effect is displayed for the combined *low calorie*, *low fat* label, indicating a 15.4% and statistically significant (10%) average decrease of quantity sales for the products labeled at that store. For the fifth treatment–all three nutrients in various combinations depending on the nutrient characteristics of the product–we again find a positive, but insignificant effect for labeled products in general. In this specification, effects of manufacture claims on sales are consistent with earlier findings, with fat claims such as "50% less fat" and "94% fat free" resulting in higher sales in some specifications as well.

In three of the treatment stores, we further observed a pink ribbon label placed on the shelf for some products at some of the treatment weeks.[23] We include these identifiers in the regression specification. These labels were observed for up to two weeks during the treatment period at three different stores, even though for one of the stores, none of our treatment products were carrying a pink ribbon label. These labels allow us to compare the effect of our information treatment to an alternative information treatment.[24] The treatment effect for this label is statistically significant at the 10% level in both regressions and results in a 17.9 or 52.0% increase in sales.

For the treatments displaying combined labels, the specifications presented in columns 4 and 5 estimate an average effect across implemented combined labels addressing question (iv). We therefore further differentiate between the type of label for these combined treatments by interacting the treatment variable with dummies for the specific labeling type (e.g. *low calorie* label *treated store*treated week) and report regression results in Table 6. We find that the significant average decrease in sales for the *low calo-*

[23]Pink Ribbon Inc. is a New York based, internationally operating charity organization aimed to create a global community to support breast cancer patients, survivors and their families all over the world. Proceeds of the sale of those products were donated to this charity.

[24]We do not know, if pink ribbon labels were placed in the control stores, however. Having only some of the treatment stores display the pink ribbon label might be an indication that they were not.

rie/low fat treatment is attributable to the *low fat* label rather than to the *low calorie* label, and that a significant decrease or increase in sales is not detected for the combined label. This differentiated regression suggests a statistically significant (10%) average decrease of 27.5% for products labeled with the *low fat* label in the treated store relative to the control stores in the treatment period. Even the *low calorie* label results in negative, but insignificant effect on sales in this treatment, a contrary result to the *low calorie* treatment effect reported in Table 5. When further differentiating between the nutrients and combination of nutrients displayed on a label in the fifth treatment, regression results reported in column 2 suggest that consumers respond positively to the *no trans fat* label.[25] The display of a *no trans fat* label increases average sales of these products during the treatment period by 23.0% compared to sales in the control stores, statistically significant at the 10% level. The *no trans fat* claim in combination with other claims (*low fat*, or *low calorie*, or both) does not, however, result in a positive and significant increase in sales. The combination of *no trans fat/low calorie* results in a reduction of sales by 31.9%, significant at the 10% level. However, this result might be interpreted with caution as at most 3 products received this treatment during any given week of the treatment period. More importantly, the treatment that combines all three claims and has the highest information content, but might also be associated with the highest information costs, does not result in a significant increase or decrease in sales, and displays a coefficient close to zero.

5.2 Average Treatment Effects on the Untreated

Although we are primarily interested in estimating the average effect on the treated or labeled products, investigating whether consumers make inferences about the untreated products provides potentially valuable insights for question (v). Our labels provide nutritional information about these products implicitly. However, information costs for consumers are potentially higher, as they need to infer the relatively inferior nutritional quality of unlabeled products. The regression specifications reported in Table 7 presents this additional treatment effect. The first column in Table 7 refers to the pooled

[25] Treatment effect for *low fat* and *low calorie* labels are not included in this specification, since in both cases, only one product was treated. The effect would therefore only reflect a product specific preference. Coefficients and significance of the other regressors are robust to this exclusion.

labeling effect, while columns 2-6 target the treatment stores individually.

The pooled treatment in column 1 suggests that sales of the unlabeled products in the treatment stores during the treatment period were not significantly higher than in control stores. The small point estimate of 0.063 is not statistically different from zero. The only sizable and statistically significant(at the 5% significance level) effect is the increase in sales of 16.2% for unlabeled products for the *low fat*, FDA approval treatment. It mirror images the negative effect of this treatment of a 28.4% decrease for labeled products and suggests that consumers simultaneously increased purchases for the unlabeled products. Also note, that some of the manufacture claims drop out of these equations. Our labels and correlated manufacture claims do not perfectly match, but the number of products that do portray a claim and would not be treated under our intervention is small. Our labels are based on FDA guidelines for such claims, and the FDA requires manufacture claims to be in compliance with these guidelines under the NLEA.[26]

5.3 Combining Treated and Untreated Products in Triple Difference Estimations

An alternative way of analyzing the effect on the treated and untreated products is to combine both products in triple difference specifications. Table 8 summarizes the results for regression specifications defined in equation 8. This specification is estimated for the pooled labeling effect as well as across the five alternative treatments separately. In general, the estimated effects seem consistent in direction in the above presented DD estimates. Only the *low fat* (FDA approval) labeling treatment is statistically significant in these regressions, however. It indicates that labeled products experienced a significant 42.8% decrease in sales during the treatment period relative to unlabeled products. This effect represents the combined effect of both the average treatment effect on the treated and untreated products in the DD specifications above. Further differentiating by the type of label for the combined treatments in Table 9 again reproduces the DD results, but affects the significance levels. The average decrease in sales for products labeled as *low fat* in the *low calorie/low fat* treatment is not statistically significant in this specification. This is furthermore the only specification in which the *no trans*

[26]We do observe variation regarding manufacture claims for labeled products, however, in that we label products that chose not to advertise our targeted nutrient.

fat treatment fails to be statistically significant with a p-value of 0.29. We do detect a decrease in sales for *low calorie/no trans fat* label of 33.9%,which is significant at the 10% level. Again, this effect needs to be interpreted with caution, as only up to 3 products receive this treatment at a given treatment week. Similar to the DD regressions, we also find a significant increase in sales due to the pick ribbon label in the store where we labeled all three nutrient claims. Products exhibiting the pink ribbon label increased in sales by 45% (54% in the aggregated regression in Table 8). This labeling effect is greater in magnitude and statistical significance than the treatment effects estimated for our implemented labels. Adding a pink ribbon to the shelf labels does not result in a significant effect for the other two stores in which we also observe these labels, however. This might be due to fact that the number of products labeled was smaller in those stores, and we did only observe the pink ribbon label during one week for one of those stores.

To address limitations regarding sales volume and statistical power, we further aggregate our data to three time periods: Pre-treatment, treatment and post-treatment.[27] Regression results for these aggregated triple difference specifications are summarized in Tables 10 and 11. The directions of the estimated effects are again consistent with the previously described specifications, and we observe an increase in statistical significance. The effect of the *low calorie* treatment increases in magnitude and becomes statistically significant at the 5% significance level. The estimated regression coefficient for this aggregated specification indicates that quantity sales of labeled *low calorie* products relative to unlabeled products in alternative stores, as well as the same store in non-treatment periods, increased by 28.8%. In addition, the *low fat* labeling treatment again significantly (at the 10% significance level) decreases sales by 42.6%. Separating the effects of labels for the combined treatments in (Table 11) reproduces a significant (5% significance level) increase in sales due to the *no trans fat* label of 39.6%. The pink ribbon label could not be included in these specifications as these labels were not observed for the entire treatment period.

[27]Aggregation of data is commonly used to circumvent data limitations in similar studies (e.g. Chetty, Looney, and Kroft, 2007, Hilger, Rafert and, Villas-Boas 2007).

5.4 Additional Robustness Checks

We further investigate the time-series characteristics of our data. We perform Dickey-Fuller tests (1979) for stationarity on both, the price and the quantity time series used in our regression specifications. Such tests allowed rejecting the null hypothesis of a unit root process for all price series and quantity series. An additional concern when employing DD estimations to time series data relates to possible bias due to serially correlated outcomes and treatment (Bertrand, et al., 2004). We replicate all regression specification with Newey-West corrected standard errors, employing a maximum lag structure, as well as shorter possible lag structures. This procedure corrects for serial correlation of unknown form in the error terms (Newey and West, 1987). In addition, aggregating the data into a treatment period and non-treatment periods in our triple difference estimations corresponds to a suggestion made in Bertrand, et al. (2004) to eliminate the time-series character of the data and focus on cross-sectional variation. As an additional robustness check, we restrict regression specifications to utilizing the time-series control structure and compare treated and untreated products at a given treatment store over time. Just focusing on time-series variation in sales in the treatment stores, or alternatively focusing on cross-sectional variation across treatment and control stores only, results in the similar effects in terms of magnitude and significance. We also re-estimate the above specifications clustering at the product level rather than the product-store level.[28] In a number of regression specifications, we do detect a statistically significant decrease in sales due to the *low fat* treatment. Even though, significance levels vary across a number of specifications, we find very consistent average treatment effects in direction and in magnitude. The adopted synthetic control method approach presented in the next section further serves as a robustness check for these consistent trends portrayed in our DD and DDD analyses.

[28]We report the alternative product-store cluster in the interest of consistency across reported regression specifications. Clustering at the product level does not provide us with enough degrees of freedom to investigate the differentiated treatment effects within a given store, however.

5.5 Size of Labeling Effects, Overall Category Sales, and Explanations

Overall, this analysis provides evidence that implemented nutritional shelf labels affected product sales of microwave popcorn in the treated stores and during the treatment period. To summarize:

1. We fail to detect an overall pooled effect of labeling.

2. The implemented *low calorie* label increases sales of treated products. This positive labeling effect is only present when focusing the treatment on a single claim. In combined treatments, this effect is not detected.

3. The implemented *low fat* label decreases sales. This negative labeling effect is most significant when focusing the treatment on a single claim and adding an FDA approval. It is also detected for combined treatments in some cases.

4. The implemented *no trans fat* labels increase sales of treated products. This positive effect is only present when the *no trans fat* claim promoted by itself and not combined with other claims.

These findings are consistent with information costs mattering. Failure to detect an effect of pooled labels suggests that the effect on sales is not attributable to increased attention to labeled products without considering information provided on labels. This is further supported by the fact that treating products that are almost identical based on calorie content increases sales, while focusing on fat content decreases sales. And with regards to the *no trans fat* treatment, merely displaying information in a uniform and standardized format results in a positive and significant increase in sales. This effect dissipates, however, when combining the *no trans fat* claim with additional nutritional claims. Throughout the specifications, we find that a combination of claims into a single label—while improving the information content—does not result in an increased or more significant labeling effect on sales. But targeting several nutrients at the same time also increases the information costs for consumers relative to just focusing on one nutrient and might deter some consumers from incorporating this information into their purchase decisions altogether.

Furthermore, the negative effect of *low fat* labels on sales confirms previous findings in the literature (e.g. French et al., 1999, Yeomans et al., 2001, Stubenitsky et al., 2000), indicating that consideration of nutritional information can trigger negative taste perceptions. In this regard, it is also worth nothing that average sales of labeled (potentially treated products) are lower on average throughout all DDD regressions. In addition, products portraying a manufacture claim that addresses fat content further seem lower in sales in most regression specifications, while portraying a calorie claim significantly increases sales in some regression specifications. With regards to adding the FDA approval, our results are somewhat inconclusive. They seem to suggest that the FDA approval strengthens the dislike of *low fat* products and could therefore be interpreted as making information more reliable. This result could possibly also be driven by the smaller size and more limited product assortment of this store. Adding the FDA approval does not seem to promote these healthier alternatives due to increased credibility, however, as we detect an even larger negative effect on sales. These results reject the argument put forth by Wansink and Chandron (2006) that nutritional labels might induce consumers to increase consumption, or purchase. We actually detect a decrease in sales due to our labeling treatment when additionally testing whether the implemented labels have an effect on overall category sales for the treated stores in a specification similar to the one employed for pooled labeling effects. In fact, overall category sales significantly decrease for the treatment stores during the treatment period by 3.7%. This effect might also be an indication that consumers incorporate the labeling information, but are not willing to switch to healthier product alternatives due to perceived taste tradeoffs. [29]

And finally, we are interested in how sizable these detected effects are. In some of the regression specifications, we can directly compare our estimated treatment effects to the pink ribbon labeling treatment. As the pink ribbon treatment will not affect taste perceptions, we would expect this labeling treatment to have a higher impact for consumers placing a value on this characteristic.[30] Indeed, we find that the effect of the pink ribbon label seems larger in magnitude than our estimated labeling effects. An additionally interesting comparison is provided by looking at price promotions. Similarly to our intervention, price promotions are advertised through shelf labels. The total mark down amount for individual products ranges from 79 cents to $3.70, most commonly in the form of a "buy one/ get one free promo-

[29]Whether consumers substitute away from this product category to alternative categories that do not provide this nutritional information is an extension of this study that we would like to investigate using additional data.

[30]As we are using stores in the same price division and only observe the pink ribbon label in some stores, these products were not sold at a price premium during the investigated time period.

tion". We regress quantity sales (in logs) on an indicator whether a product was on promotion, controlling for store, brand, and week fixed effects, as well as clustering standard errors at the product-store level. This allows us to capture initial differences in price levels due to unobserved time-invariant characteristics across stores, and brand preferences due to unobserved characteristics across brands. In this regression specification, we estimate the effect of posting a price promotion to increase sales by 86.8% on average (statistically significant at the 1% significance level). Compared to this effect, the estimated effects of nutritional shelf labeling are sizable, but considerably smaller. The difference in the size of the effect might again indicate that consumers might be hindered by negative taste perceptions when considering healthier food alternatives. These relatively smaller effects, as well as the negative effect of *low fat* labels, could further be specific to our product category. Previous research has found that consumers are less likely to incorporate nutritional information into their product choice for products viewed as treats (Grunert and Wills, 2007). Microwave popcorn might be viewed as a treat, rather than a snack, when buying it for a movie night, for instance. In that case, consumers might be particularly reluctant to substitute away from "movie theater butter flavor" to a potentially less tasty *low fat* variety.

6 Synthetic Control Method Analysis

Difference-in-differences estimation can be a powerful tool for evaluating treatment effects, especially in the case of random assignment of treatment effects, as in our experimental set up. However, uncertainty remains about the ability of our control stores to reproduce the counterfactual of what sales would have been in treatment stores in the absence of our intervention. Furthermore, significance of the estimated treatment effects might depend on our assumed error structure, and ambiguity about the validity of the chosen approach might remain. The synthetic control method (Ababie et al., 2007) addresses both of these issues. It can be thought of as a non-parametric combination of DD and matching approaches. A (synthetic) control unit is constructed based on how closely it resembles the treated unit in a pre-treatment period. This method further allows evaluating statistical significance of the estimated treatment effect based on constructing placebo effects for units that were never treated. In the above regression specifications our standard errors are influenced by the uncertainty about how well average sales across control stores are able to reproduce the counterfactual of how sales would have evolved in our treatment stores in the absence of our intervention. This additional approach allows us to validate the results found in the DD, and possibly improve the statistical power by reducing this uncertainty. It uses data-driven procedures to construct a single control store closely resembling the treatment store in the pre-treatment period. Any weighted average of control units is considered as a potential single (synthetic) control, choosing the one that minimizes the mean square error of the specified estimator. We consider a variety of variables as matching criteria, including pretreatment sales of the treated product group, additional store characteristics, and zip code level social-economic variables. Statistical significance of detected differences in sales between the treatment and synthetic control unit can be evaluated by testing if this difference in sales could potentially be driven by chance. We do so by applying the same procedure to all control stores, rather than the treatment stores as placebo studies, and compare the outcome to our actual derived treatment effect. We can run 27 of such tests as we have data on 27 control stores. And finally, this approach provides us with a graphical representation of our estimated treatment effects and the trend of sales over time.

One limitation of this approach is that it only allows analyzing a single unit treatment variable, such that we cannot directly compare the DD results. Rather than looking at individual product sales, we therefore aggregate sales by treatment. We, for instance, add sales of all treated *low calorie* products for this treatment store, such that our outcome variable of interest is defined as total weekly sales of products treated (labeled) at a particular store.

6.1 Synthetic Control Method Results

To draw inference on how our label treatment affects product sales of treated products, we construct how sales would have evolved in the absence of our intervention in the selected stores. We start this analysis by considering possible matching criteria for the relevant treatment store and synthetic counterfactual. Using zip code demographics as well as store characteristics as criteria for the synthetic control store actually decreases the fit of sales prior to our implemented treatment. Table 12 reports the store as well as zip code characteristics for the *low calorie* treatment stores and synthetic control store to illustrate this effect. As our primary interest is a close fit of pre-treatment sales, the final graphs are constructed by focusing on store characteristics only. The weights of each control store in the single synthetic control store created for alternative treatments are reported in Table 13. The synthetic control stores for the reported 3 treatments are constructed by a weighted average of 2 to 5 control stores depending the treatment.[31]

Figure 8 displays the weekly total sales of products treated with the *low calorie* treatment and its synthetic control. The vertical line indicates the implementation of the treatment. Total sales of the products that were treated in the synthetic control store reproduce the sales observed in the treatment store prior to treatment fairly well. After implementing the labels, actual sales clearly exceed the sales of the synthetic control. This gap converges for the post-treatment period again, however. Furthermore, the biggest increase seems to occur right after implementation of the treatment, with an 18.7 units increase in the second week. Table 14 reports these exact differences in sales by week. This increase corresponds to a 19.57% increase in sales compared to overall average sales across the entire time period. Figure 9 displays the results for the placebo tests. The background gray lines represent the difference in sales associates with each of the 27 tests. Each gray line shows the difference in sales between each control store and its synthetic version if we would have randomly chosen that store. The red line compares those results to the effect of the intervention in the actual treatment store. Figure 9 indicates that the difference in sales seems large relative to the distribution of the random differences for the control stores. The spike of sales in the second week for instance is not matched by any other placebo run. Furthermore, the ability of this method to produce a well fitting synthetic control varies for the placebo runs as indicated by a deviation from the 0 reference line prior to the intervention.

Figure 10 summarizes the results for the *low fat* treatment. Contrary to the *low calorie* treatment, and consistent with the estimates in the DD and DDD specifications, the treatment store experiences a steep drop in sales compared to the synthetic store after the implementation of the treatment. Again, the effect seems most significant in the early weeks. Sales drop by 27.7 units in the second week, corresponding to a 68.03% decrease in sales. Figure 11 displays the corresponding results for the placebo tests once more. These graphs indicate that this difference in sales due to our treatment seems

[31]Results are only reported for the three significant treatments in the DD and DDD estimations. Applying the same method to the remaining treatments further confirmed insignificant treatment effects as described above.

relatively large compared to the distribution of random differences. The steep drop by the end of the second week is not matched by any other placebo run.

And finally, Figures 12 and 13 summarize the results for the *no trans fat* treatment. Here, we are only evaluating the partial treatment effect of the combined labeling treatment. We cannot simultaneously compare this effect to the other labels implemented in the combined labeling treatment due to the single unit treatment restriction. This treatment effect is less pronounced as compared to the *low calorie* and *low fat* treatment, possibly because it is based on fewer products in this treatment. Interestingly, response to this treatment is delayed for a week as compared to the two treatments above. In this treatment store, we faced difficulties implementing the labels in the first week, having the labels removed and replaced after interactions with the supermarket headquarters.[32] The effect is less obvious in the graphical analysis as our control stores do not provide a well fitting convex combination to create a synthetic control prior to the treatment. Starting with considerably lower sales than the created synthetic control store at the beginning of the treatment period, the trend in sales goes in the opposite direction than in the synthetic control store, and eventually rises above the total sales for the synthetic control. This treatment also experiences the biggest increase in sales in the week right after the treatment and stays above the sales constructed for the synthetic control. It might be possible that the store kept the labels in place after the last treatment week. Furthermore, as we are merely repeating information already available and advertised with manufacture claims, this information might be especially easy to take into account when making purchase decisions, even after labels disappear. The information provided for the *low calorie* and *low fat* treatment cannot be as easily recalled in the post treatment period, however, and sales trends in those treatments seem to converge back to the synthetic control after our treatment period.[33] Figure 13 displays the results for the placebo tests. As we were not able to achieve a very good fit for the synthetic control, the statistic significance for this treatment also seems weaker as compared to the previous two treatments. Compared to placebo tests that start similarly low on the distribution of differences, the initial increase seems larger, however, and the increase in sales following the last week of treatments seems significantly larger compared to

[32]Previously reported regressions are robust to excluding the first week from the regressions.

[33]These nutrients might also be advertised in manufacture claims, but a variety of terms and claims are used in this context.

the distribution of random differences.

The synthetic control function approach supports our results estimated in econometric difference-in-differences and triple difference specifications and adds insight into how these treatment effects evolve over time.

7 Conclusions

This paper analyses whether information costs could prevent consumers from fully optimizing their purchase decisions with regards to available nutritional information. Utilizing a market-level experiment in collaboration with a major supermarket chain, we estimate the effect of making nutritional information more salient and easier to process. Posted nutritional shelf labels allow consumers to make direct comparisons regarding nutrient content for three nutrients–calories, fat and trans fat—on a relative scale. Our intervention either focuses on one nutrient or a combination of these nutrients in a single label. In addition, one treatment adds FDA approval of the *low fat* claim. These interventions were implemented for one product category (microwave popcorn) in five stores over a time period of four weeks in the fall of 2007. Store-level scanner data for these treatment stores and 27 control stores within the same price division were available for a period of a total of 14 weeks.

Building on the exiting literature of credence good labeling, we provide a theoretical motivation to our experimental approach and empirical analysis. Our labeling treatment aims at reducing information costs by either providing information in a standardized and uniform format, or displayed quantitative information in a categorical format (e.g. *low fat* rather that 5 grams of fat per serving). Observed variation in serving size in combination with considerable variation of nutrient content in our treated category suggests that currently implemented labels provide information in a less salient matter. While our empirical design incorporates previous findings in the literature on consumer response to labeling information, it is to our knowledge the first study that provides direct tests and specifically focuses on information costs under the NFP in a market setting.

Estimations of average treatment effects of our labeling intervention are based on difference-in-differences and triple-difference approaches identified by random treatment assignment in a cross-sectional and time-series control structure. In addition, we draw inference about the effect of our labeling treatments on product sales in a synthetic control method approach. Our analysis suggests that consumer purchases are affected by the implemented labels and our results are consistent with information costs preventing some consumers from incorporating nutritional information into their purchasing decisions under currently implemented labeling regulations. To summarize our main findings:

1. A shelf label of *no trans fat*–a claim already advertised on some of the products, and required to be displayed on the NFP–significantly increases sales of targeted products.

2. A shelf label of *low fat* significantly reduces quantity sales of targeted products in some treatments.

3. While correlated, a *low calorie* label does not result in the same effect, and significantly increases sales of treated products in aggregated regression specifications.

The *no trans fat* treatment presents information already available on the NFP in a more uniform and standardized matter. Transforming information about caloric and fat content into a categorical statement also significantly affects sales. Yet, we do not detect an overall labeling effect and the *low calorie* and *low fat* labeling effect go in the opposite direction, allowing us to rule out a general attention or nuisance effect of our implemented labels. And while combining individually significant claims in one label treatment increases the information content, it also increases information costs. These labels do not significantly alter purchases in our data. In addition, we find only very limited evidence that consumers make inferences about unlabeled products and their relatively inferior nutritional quality. Such inferences would be more costly once more. Finally, our analysis suggests that the most sizable impact is observed right after the label implementation, with effect dissipating after the treatment period for the *low calorie* and *low fat* treatment. For the *no trans fat* treatment, the treatment effect seems to persist even after the treatment period, possibly due to the fact that consumers can more easily verify their product choice in this regard using advertised manufacture claims.

The divergent effect of *low fat* versus *low calorie* labels further highlights an important challenge with regards to promoting healthier food choices in this context: Consumer response to nutritional labeling may be influenced by consumers taste perceptions. While our results confirm perceived tradeoffs between taste and nutritional content previously found in the literature with regards to *low fat* claims(e.g. French et al., 1999, Yeomans et al., 2001, Stubenitsky et al., 2000), we do not observe a similar negative response to the *low calorie* treatment. This seems especially relevant as the assignment of these two treatments exhibits a fairly large overlap across products.

Labeling regulations under the Nutritional Labeling and Education Act have been implemented for over a decade, yet obesity rates keep rising. The FDA is currently considering a change to the format and content of food nutrition labels to promote increased label use. Our results have important implications in this context and add insight the the existing literature. Our results suggest that a focus on calorie content only, and provision of categorical statements instead or in addition to detailed quantitative statements can enable consumers to more effectively incorporate nutritional information into their purchasing choices. This strategy is particularly desirable as calorie content has been determined as the most relevant nutrient in relation to weight gain and obesity prevention (CDC, 2008). A focus on *low-fat* claims as an alternative promoted by the World Health Organization might, on the other hand, trigger negative taste perceptions in some consumers and inhibit healthier food choices.

8 References

Abadie, A., A. Diamond, and J. Hainmueller, 2007. "Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program," NBER Technical Working Papers 0335.

Ackerberg, D. 2003. "Advertising, Learning, and Consumer Choice in Experience Good Markets: A Structural Empirical Examination. *International Economic Review* 44: 1007-1040.

Ackerberg, D.A.2001. "Empirically Distinguishing Informative and Prestige Effects of Advertising." *RAND Journal of Economics* 32: 316-333.

American Heart Association. 2008. Overweight in Children. http://www.americanheart.org/presenter.jhtml?identifier=4670 (accessed April 2008).

Bertrand, M, E. Duflo, and S. Mullainathan 2004. "How much should we trust differences-in-differences estimates? *Quarterly Journal of Economics*

119: 249-275.

Blitstein, J.L., W. D. Evans. 2006. "Use of Nutritional Facts Panels among Adults Who Make Household Food Purchasing Decisions. *Journal of Nutrition Education Behavior* 38: 360-364.

Bonroy, O. and C. Constantatos, 2008. "On the use of labels in credence goods markets. *Journal of Regulatory Economics* 33: 237-252.

Cain, D., G. Loewenstein, and D. Moore 2005. "The Dirt on Coming Clean: Perverse Effects of Disclosing Conflicts of Interest. *Journal of Legal Studies* 34: 1-25.

Center of Disease Control. Obesity and overweight. http://www.cdc.gov/nccdphp/dnpa/obesity/ (accessed April 2008)

Chetty, R. 2008. "Sufficient Statistics for Welfare Analysis: A Bridge between Structural and Reduced-Form Methods." NBER Working Paper No. W14399.

Chetty, R. , A. Looney, and K. Kroft. 2007. "Salience and Taxation: Theory and Evidence. NBER Working Paper 13330.

Consumer Reports. 2006. When it pays to buy organic. http://www.consumerreports.org/cro/food/organic-products-206/overview/ (accessed January 2007).

Dickey, D.A. and W.A. Fuller. 1979. "Distribution of the estimators for autoregressive time series with a unit root, *Journal of the American Statistical Association* 74: 427-431.

Food Standards Agency 2007. "Signing up to make healthier eating an easier option.' http://www.food.gov.uk (accessed April 2008)

French, S. M., M. Story, P. Hannan, K.K. Breitlow, R. W. Jeffrey J. S. Baxter, and M. P. Snyder. 1999. "Cognitive and demographic correlates of low-fat vending snack choices among adolescents and adults." *Journal of the American Dietetic Association*: 471-475.

Gabaix, X. and D. Laibson 2006. "Shrouded Attributes, Consumer Myopia, and Information Suppression in Competitive Markets." *Quarterly Journal of Economics* 121: 505-540.

Geyskens, K., M. Pandelaere, S. Dewitte, and L. Warlop. 2007. "The Backdoor to Overconsumption: The Effect of Associating "Low Fat" Foods with Health References." *Journal of Public Policy and Marketing* 26: 118-125.//

Grunert, K.G., J.M. Wills.2007. "A review of European research on consumer response to nutritional information on food labels. *Journal of Public Health* 34: 1-25.

Hilger,J, G. Rafert, S. Villas-Boas 2007. "Expert Opinion and the Demand for Experience Goods: An Experimental Approach. CUDARE working paper 1049.

Imbens, G.W. 2004. "Nonparametric Estimation of Average Treatment Effects under Exogeneity: A Review. *The Review of Economics and Statistics* 86: 4-29.

Ippolito P.M., J.K. Pappalardo.2002. "Advertising, Nutrition & Health. Evidence from Food Advertising." Washington, DC: Federal Trade Commission, Bureau of Economics Staff Report.

Ippolito, P.M., and A.D. Mathios. 1995. "Information and Advertising: The Case of Fat Consumption in the United States. *American Economic Review* 85: 91-95.

Ippolito, P.M., and A.D. Mathios. 1990. "Information, Advertising and Health Choices: A Study of the Cereal Market. *Rand Journal of Economics* 21: 459-80.

Jin, G. Z. and P. Leslie. 2003. "The Effects of Information on Product Quality: Evidence from Restaurant Hygiene Grade Cards. *Quarterly Journal of Economics* 118: 409-451.

Kantrowitz B. and C. Kalb.2006. "Food News Blues. *Newsweek*. March 13, 2006: 44-55.

Kiesel, K. 2008. “A Definition at Last, but What Does It All Mean? Newspaper Coverage of the USDA Organic Seal and its Effects on Milk Purchases.” AAEA Selected Paper presented at the AAEA & ACCI Joint Annual Meetings in Orlando, July 27-29, 2008.

Kiesel, K. and S. B. Villas-Boas. 2007. “Got Organic Milk? Consumer Valuations of Milk Labels after the Implementation of the USDA Organic Seal. *Journal of Agricultural & Food Industrial Organization* 5: 1-38.

Levy, A.S, S.B. Fein. 1998. “Consumers’ ability to perform tasks using nutrition labels. *Journal of Nutrition Education* 30: 210-217.

Mandal, B. 2008. “Foods Labels and Weight Loss: Evidence from the National Longitudinal Survey of Youth.” AAEA Selected Paper presented at the AAEA & ACCI Joint Annual Meetings in Orlando, July 27-29, 2008.

Mathios, A.D. 2000. “The Impact of Mandatory Disclosure Laws on Product Choices: An Analysis of the Salad Dressing Market. *Journal of Law and Economics* XLII: 651-676.

McCluskey, J. J., M. L. Loureiro. 2003. “Consumer Preferences and Willingness to Pay for Food Labeling: a Discussion of Empirical Studies. *Journal of Food Distribution Research* 34: 95-102.

Meyer, B. 1995. “Natural and Quasi-Experiments in Economics.*Journal of Business and Economic Statistics* 33: 151-161.

Mojduszka, E. M., and Caswell, J. A. 2000. “A Test of Nutritional Quality Signaling in Food Markets Prior to Implementation of Mandatory Labeling. *American Journal of Agricultural Economics* 82: 298-309.

Montgomery, C. and B. Wernerfelt. 1994. “Risk Reduction and Umbrella Branding. *Journal of Business* 65: 31-50.

Nestle, M. 2000. “Food Politics: how the food industry influences nutrition and health. Berkeley: University of California Press.

Nevo, A. 2003. “New Products, Quality Changes and Welfare Measures Computed from Estimated Demand Systems. *Review of Economics and Statistics* 85: 266-275.

Nevo. A. 2000. "A Practitioners Guide to Estimation of Random-Coefficients Logit Models of Demand. *Journal of Economics & Management Strategy* 9 : 513-548.

Newey, W. K. and K. D. West. 1987. "A Simple, Positive Semi-definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix." *Econometrica* 55: 703-708.

Reinstein, D. and C. Snyder. 2005."The Influence of Expert Reviews on Consumer Demand for Experience Goods: A Case Study of Movie Critics. *Journal of Industrial Economics* 53: 27-51.

Roe, B. and I. Sheldon. 2007. "Credence Good Labeling: The Efficiency and Distributional Implications of Several Policy Approaches. *American Journal of Agricultural Economics* 89: 1020-1033.

Roe, B. and M. F. Teisl. 2007. "Genetically Modified Food Labeling: The Impacts of Message and Messenger on Consumer Perceptions of Labels and Products. *Food Policy* 32: 49-66.

Russo, J. E., R. Staelin, C. A. Nolan, G. J. Russell, and B. L. Metcalf. 1986. "Nutrition Information in the Supermarket. *Journal of Consumer Research* 13: 48-70.

Sorensen, A. and S. Rasmussen. 2004. "Is Any Publicity Good Publicity? A Note on the Impact of Book Reviews." Stanford University Working Paper.

Stubenitsky, K., J.I. Aaron, S.L. Catt, and D.J. Mela. 2000 "The influence of recipe modification and nutritional information on restaurant food acceptance and macronutrient intakes." *Public Health Nutrition*, 3: 201-209.

Teisl, M. F., N. E. Bockstael, and A. Levy. 2001. "Measuring the Welfare Effects of Nutrition Labeling. *American Journal of Agricultural Economics* 83: 133-49.

Todd, J. E. and J. N. Variyam. 2006. "The Decline in Consumer Use of Food Labels, 1995-2006." Economic Research Report Nr. 63, http://www.ers.usda.gov. (accessed April 2008)

Variyam J. N. and J. Cawley. 2006. "Nutrition Labels and Obesity." NBER Working Paper No. W11956

Wansink, B. and P. Chandon. 2006. " Can "Low-Fat" Nutrition Labels Lead to Obesity?" *Journal of Marketing Research*, 43: 605-17.

Wansink, B., S. T. Sonka, and C. M. Hasler. 2004. "Front-label health claims: when less is more. *Food Policy* 29: 656-667.

Williams, P.G. 2005. "Consumer understanding and use of health claims for foods. *Nutrition Reviews* 63: 256-264.

World Health Organization. 2004. "World Health Assembly: Global Strategy on Diet, Physical Activity and Health." http://www.who.int/gb (accessed March 2007)

Wooldridge, J. M. 2002. *Econometric Analysis of Cross Sectional and Panel Data.* Cambridge: MIT Press.

Wooldridge, J. M. 2003. *Introductory Econometrics. A Modern Approach.* Mason: South Western.

Yeomans, M.R., S. Lartamo, E.L. Procter, M.D. Lee, and R.W. Gray. 2001. "The actual, but not labeled, fat content of a soup preload alters short-term appetite in healthy men." *Physiology and Behavior* 73: 533-540.

9 Figures and Tables

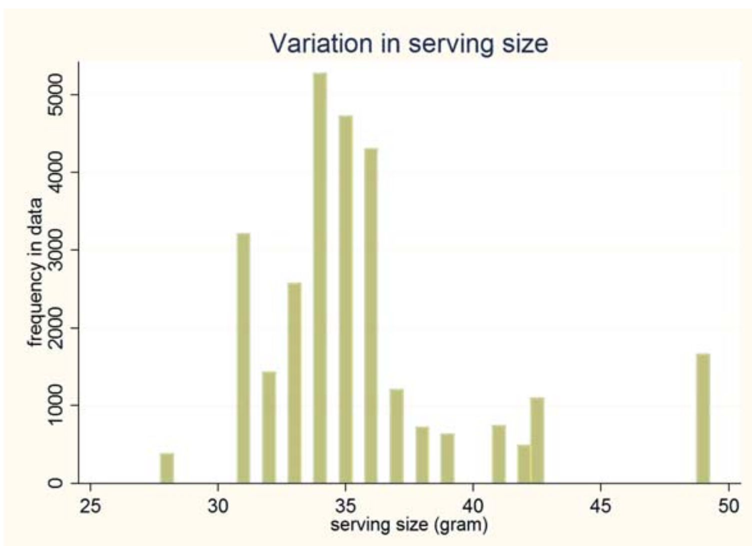


Figure 1: Observed variation in serving size across products in treated category

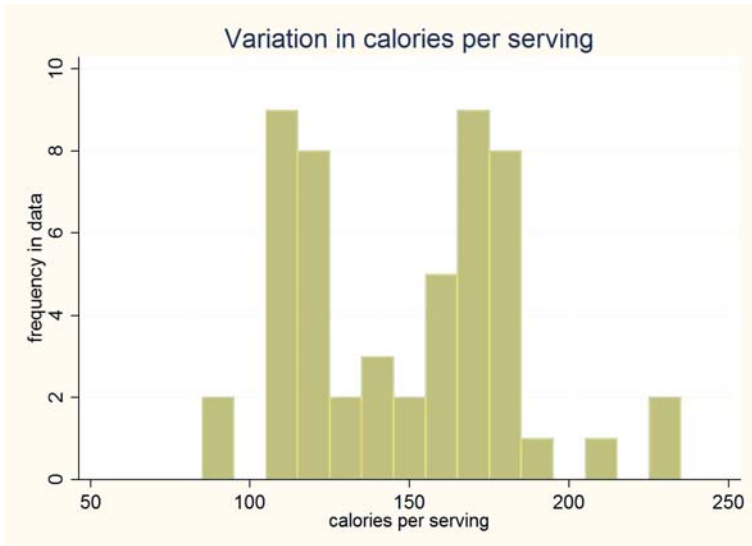


Figure 2: Observed variation in calories per serving across products in treated category

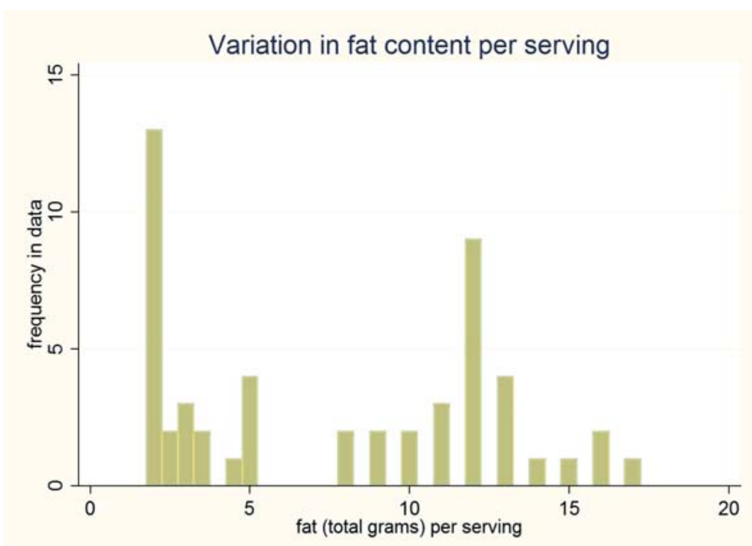


Figure 3: Observed variation in fat content per servings across products in treated category

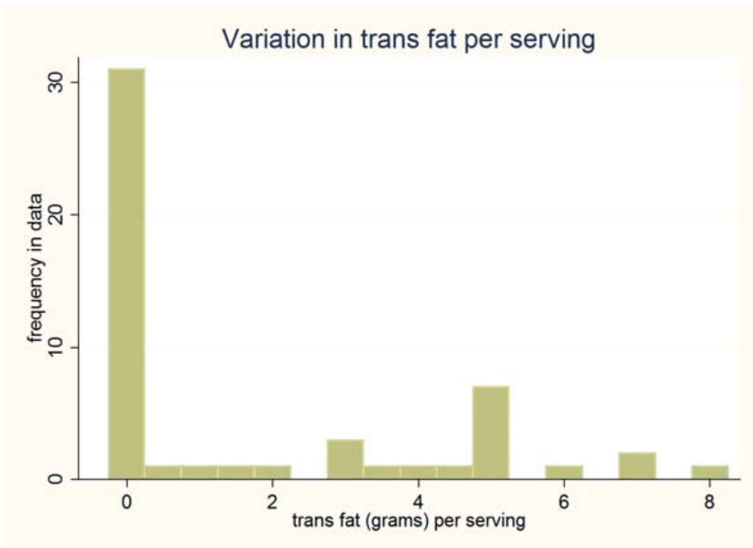


Figure 4: Observed variation in trans fat content per servings across products in treated category

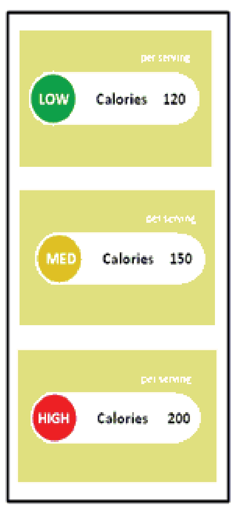
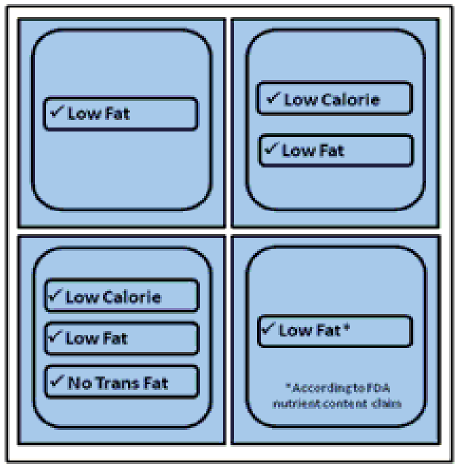


Figure 5: Initially proposed labels (illustrated for the calorie treatment)



Note: Individual *low calorie*, and *no trans fat* labels as well as combined *low calorie/no trans fat* and *low fat/ no trans fat* labels are not shown

Figure 6: Implemented labels

Figure 7: Implementation of shelf labels

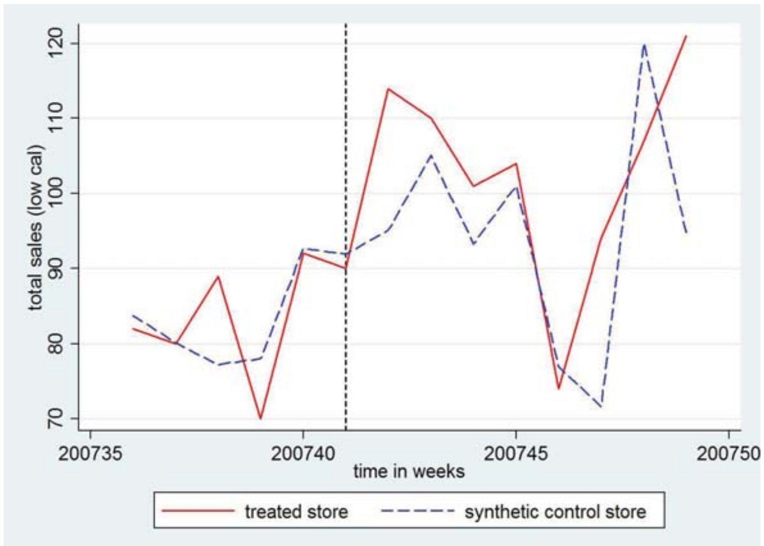


Figure 8: Trends in total sales of low calorie labeled products: Treatment vs. synthetic control store

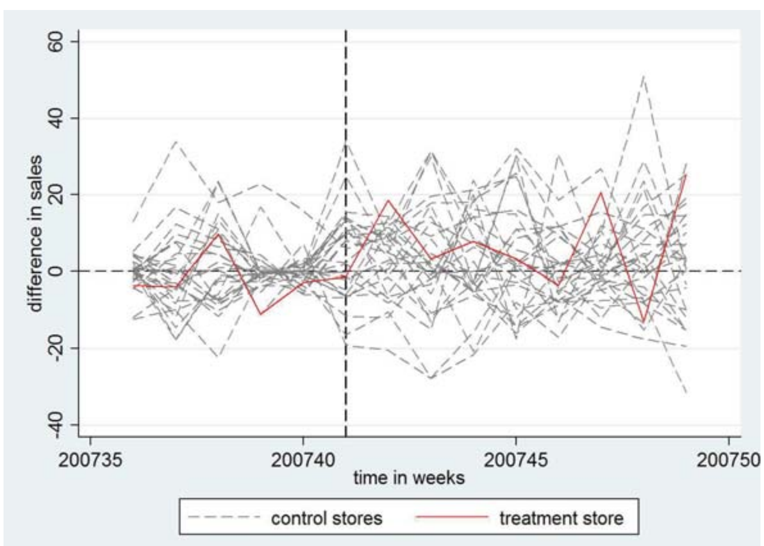


Figure 9: Differences and placebo differences in sales of labeled low calorie products

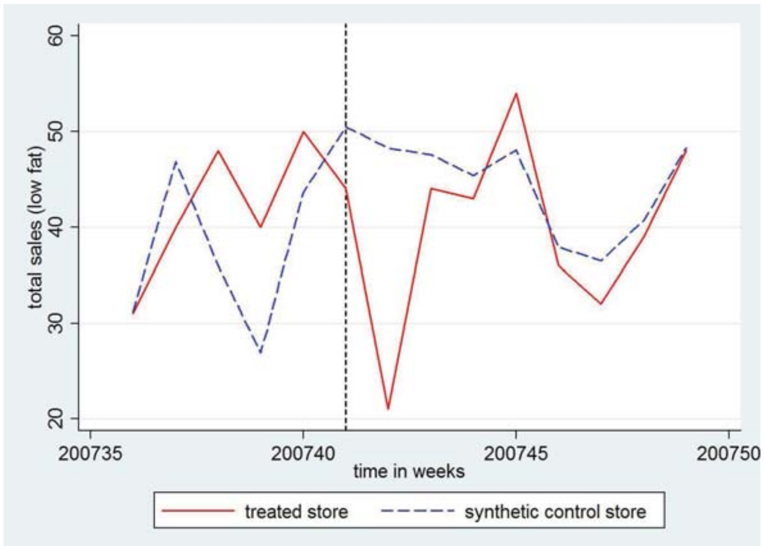


Figure 10: Trends in total sales of low fat labeled products: Treatment vs. synthetic control store

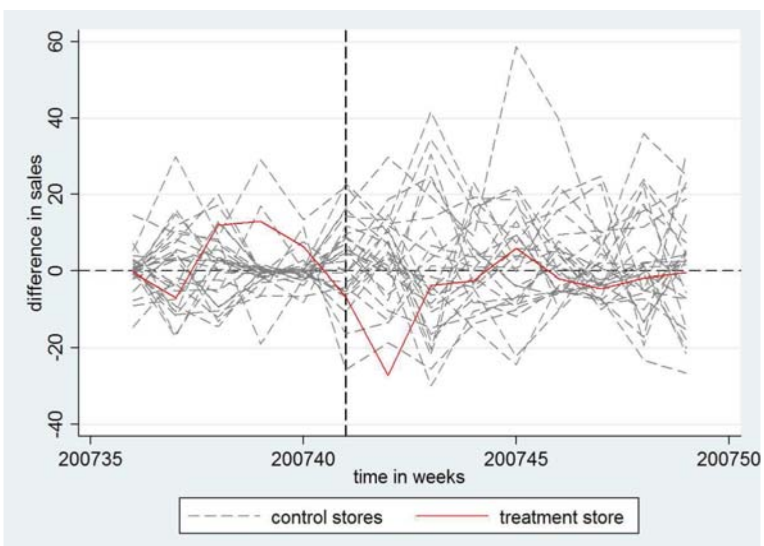


Figure 11: Differences and placebo differences in sales of labeled low fat products

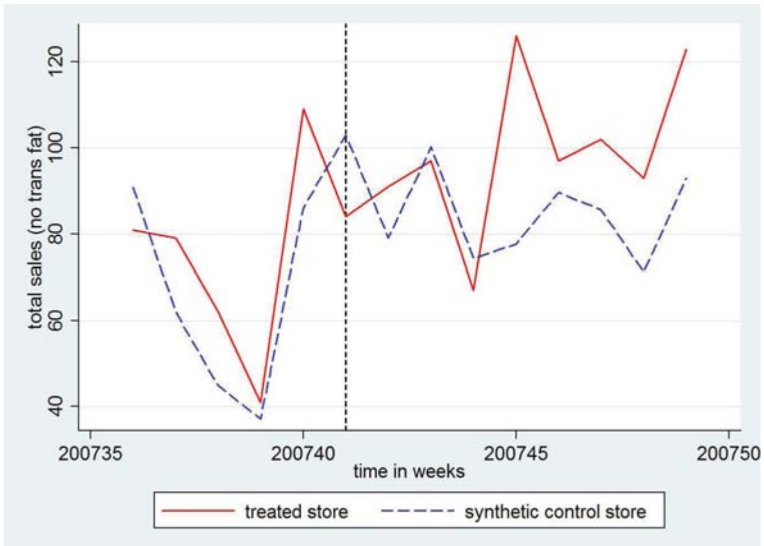


Figure 12: Trends in total sales of no trans fat labeled products: Treatment vs. synthetic control store

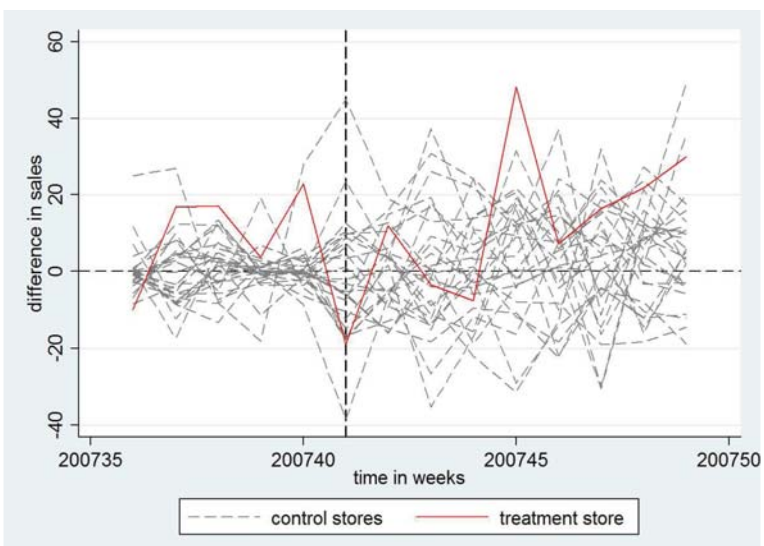


Figure 13: Differences and placebo differences in sales of labeled no trans fat products

Descriptive statistics : Treatments

A. Treatments	
1	low calorie label
2	low fat label
3	low fat label and FDA disclaimer
4	low calorie and low fat label
5	low calorie, low fat, and low trans fat label

B. Treatment Characteristics

	treatment stores					control stores				
	1	2	3	4	5	1	2	3	4	5
Low Calorie Labels	22	-	-	5	1	21.83 (2.04)	-	-	4.71 (0.59)	1 (.031)
Low Fat Labels	-	21	-	4	1	-	21.01 (1.94)	-	3.91 (0.39)	0.971 (.167)
Low Fat/FDA Labels	-	-	15	-	-	-	-	21.01 (1.94)	-	-
No Trans fat Labels	-	-	-	-	12	-	-	-	-	15.22 (1.19)
Low Calorie/Low Fat Labels	-	-	-	12	2	-	-	-	17.11 (1.67)	1.86 (0.34)
Low Calorie/No Trans fat Labels	-	-	-	-	3	-	-	-	-	2.90 (0.52)
Low Fat/ No Trans fat Labels	-	-	-	-	3	-	-	-	-	3.74 (0.52)
Low Calorie/Low Fat//No Trans fat Labels	-	-	-	-	16	-	-	-	-	15.24 (1.51)
Total Labels	22	21	15	21	38	21.83 (2.04)	21.01 (1.94)	21.01 (1.94)	24.92 (2.25)	40.99 (3.19)

Note: For the control stores, we report the mean number of products that would have been treated as well as the standard deviation in parenthesis.

Table 1: Descriptive statistics for labeling treatment

Descriptive Statistics: Grocery Stores

	Treatment Stores					Control Stores			
A. Store Characteristics	1	2	3	4	5	Mean	Std. Dev.	Min	Max
Total Floor Space	30440	27178	19348	26425	30168	26983.07	8008.21	16530	43639
Opening Year	1984	1970	1975	1978	1986	1981.63	12.82	1954	1999
Mean Weekly Category Revenue ($)	116.18	167.47	137.78	344.69	295.27	196.72	76.35	44	411
Mean Weekly Product Revenue ($)	11.32	9.71	11.33	16.97	15.00	11.32	9.18	1	112.58
Mean Weekly Product Quantity	4.19	3.63	4.20	6.14	5.44	4.19	4.34	1	44
Mean Number of Products (by week)	39.8	47.6	26.36	56.47	54.34	44.94	8.28	19	60
B. Zip Code Characteristics									
Population	36190	72702	14075	36190	19790	48979.48	21091.66	15809	98215
Median Income	41002	49452	50300	41002	57214	41908.11	11098.97	21893	69614
Mean Household Size	2.85	3.22	2.6	2.85	2.85	2.83	0.55	1.63	3.69
Percent White	0.59	0.41	0.49	0.59	0.52	0.51	0.17	0.16	0.84

Table 2: Descriptive statistics for store characteristics

Summary Statistics: Regression variables					
variables	Obs	Mean	Std. Dev.	Min	Max
quantity	18,785	4.3853	4.3270	1	49
log quantity	18,785	1.1015	0.8564	0	3.8918
price	18,785	3.1959	1.5239	0.332	7.29
product	18,785	33.6023	19.8040	1	68
brand	18,785	2.5577	1.6855	1	9
store	18,785	16.9638	9.1300	1	32
week	18,785	200742.5	3.9878	200736	200749
treatment week	18,785	0.2970	0.4570	0	1
labeled products	18,785	0.6386	0.4804	0	1
labeled products (low cal)	18,785	0.3467	0.4759	0	1
labeled products (low fat)	18,785	0.3316	0.4708	0	1
labeled products (low cal/low fat)	18,785	0.4092	0.4917	0	1
labeled products (low cal/low fat/ no trans fat)	18,785	0.6386	0.4804	0	1
treatment 1 (low cal)	18,785	0.0041	0.0639	0	1
treatment 2 (low fat)	18,785	0.0073	0.0849	0	1
treatment 3 (low fat, FDA)	18,785	0.0029	0.0535	0	1
treatment 4	18,785	0.0034	0.0578	0	1
treatment 4 (low cal)	18,785	0.0007	0.0273	0	1
treatment 4 (low fat)	18,785	0.0005	0.0231	0	1
treatment 4 (low cal/low fat)	18,785	0.0019	0.0434	0	1
treatment 5	18,785	0.0071	0.0842	0	1
treatment 5 (low cal)	18,785	0.0005	0.0217	0	1
treatment 5 (low fat)	18,785	0.0005	0.0232	0	1
treatment 5 (no trans fat)	18,785	0.0024	0.0492	0	1
treatment 5 (low cal/low fat)	18,785	0.0004	0.0206	0	1
treatment 5 (low cal/no trans fat)	18,785	0.0005	0.0231	0	1
treatment 5 (low fat/no trans fat)	18,785	0.0005	0.0219	0	1
treatment 5 (low cal/low fat/no trans fat	18,785	0.0030	0.0545	0	1
manufacture claims:					
organic claim	18,785	0.0472	0.2120	0	1
low cal claim	18,785	0.1619	0.3684	0	1
low fat claim	18,785	0.2417	0.4281	0	1
no trans fat claim	18,785	0.4609	0.4985	0	1
whole grain claim	18,785	0.3541	0.4783	0	1
pink ribbon (treatment store 2)	18,785	0.0020	0.0449	0	1
pink ribbon (treatment store 4)	18,785	0.0062	0.0783	0	1
pink ribbon (treatment store 5)	18,785	0.0007	0.0273	0	1

Table 3: Summary statistics for variables included in the regression analysis

Average Treatment Effect on Treated (Differences-in-Differences)

dependent variable: (log) quantity microwave popcorn (by week, by store)

independent variables:	1		2		3		4		5		6	
treated stores * treated weeks	-0.030		-0.029		-0.031		-0.030		-0.028		-0.031	
(treatment effect)	0.035		0.034		0.034		0.033		0.032		0.032	
treated stores	0.119	**	0.142	***	0.143	***	0.139	***	-0.329	***	-0.327	***
	0.052		0.045		0.043		0.040		0.121		0.120	
treated weeks	0.042	***	-0.017		-0.016		-0.021		-0.027		-0.026	
	0.015		0.014		0.014		0.014		0.013		0.031	
price	-		-0.248	***	-0.242	***	-0.266	***	-0.286	***	-0.282	***
			0.009		0.009		0.010		0.008		0.008	
organic claim	-		-		-0.160	**	-0.726	***	-0.857	***	-0.863	***
					0.064		0.108		0.061		0.062	
low calorie claim	-		-		-0.038		0.020		0.142	***	0.131	***
					0.037		0.040		0.037		0.037	
low fat claim	-		-		-0.111	***	-0.004		-0.003		-0.016	
					0.031		0.036		0.059		0.059	
no trans fat claim	-		-		0.274	***	0.038		-0.009		-0.009	
					0.046		0.071		0.030		0.030	
whole grain claim	-		-		-0.102	**	-0.091		-0.083	**	-0.088	**
					0.048		0.058		0.038		0.038	
brand fixed effects	no		no		no		yes		yes		yes	
store fixed effects	no		no		no		no		yes		yes	
week fixed effects	no		no		no		no		no		yes	
Number of observations	11997		11997		11997		11997		11997		11997	
R2	0.003		0.184		0.206		0.229		0.332		0.34	

Note: Robust and clustered standard errors at product-store level) are reported and *, **, *** denote statistical significance at the 10%, 5% and 1% significance level.

Table 4: Regression results for pooled average treatment effects on labeled products

Store-Specific Average Treatment Effect on Treated (Differences-in-Differences)

dependent variable: (log) quantity microwave popcorn (by week, by store)

independent variables:	Low calorie		Low fat		Low fat (FDA)		Low cal/fat		Low cal/fat/trans fat	
treated store*treated weeks	0.086		-0.101		-0.284	***	-0.155	*	0.004	
(treatment effect)	0.083		0.085		0.095		0.089		0.068	
treated weeks	0.020	*	0.127	***	-0.010		-0.018		0.060	*
	0.044		0.044		0.043		0.040		0.031	
price	-0.249	***	-0.278	***	-0.283	***	-0.264	***	-0.282	***
	0.010		0.010		0.010		0.009		0.009	
organic claim	0.011		0.002		0.027		0.020		-0.803	***
	0.082		0.077		0.081		0.080		0.064	
low calorie claim	0.135	**	0.114	***	0.108	***	0.197	**	0.111	***
	0.052		0.041		0.041		0.042		0.039	
low fat claim	-0.008		0.198	***	0.215	***	0.062	*	-0.050	
	0.068		0.035		0.036		0.063		0.066	
no trans fat claim	-0.219	***	-0.439	***	-0.231	***	-0.176	**	-0.004	**
	0.040		0.067		0.056		0.036		0.032	
whole grain claim	0.035		0.236	***	-		0.053	*	-0.087	***
	0.036		0.067				0.035		0.039	
pink ribbon	-		-		-		0.179	*	0.520	*
							0.097		0.074	
brand, store, week fixed effects	yes		yes		yes		yes		yes	
Number of observations	5768		5434		5381		6663		9810	
R2	0.331		0.305		0.335		0.332		0.339	

Note: Robust and clustered standard errors (at product-store level) are reported and *, **, *** denote statistical significance at the 10%, 5% and 1% significance level.

Table 5: Regression results for treatment specific average treatment effects on labeled products

Differentiated Average Treatment Effect on Treated (Differences-in-Differences)

dependent variable: (log) quantity microwave popcorn (by week, by store)

independent variables:	low cal/fat		low cal/fat/trans fat	
interacted treatment effects				
low calorie	-0.168		-	
	0.104			
low fat	-0.275	*	-	
	0.160			
no trans fat	-		0.230	*
			0.135	
low cal/fat	-0.126		-0.333	
	0.106		0.328	
low cal/trans fat			-0.319	*
	-		0.179	
low fat/trans fat			-0.246	
			0.279	
low cal/fat/trans fat	-		0.009	
			0.110	
treated weeks	-0.023		0.065	**
	0.040		0.031	
price	-0.268	***	-0.280	***
	0.010		0.009	
organic claim	-0.029		-0.800	***
	0.077		0.064	
low calorie claim	0.107	***	0.104	***
	0.031		0.040	
low fat claim	0.135	***	-0.059	
	0.032		0.066	
no trans fat claim	-0.344	***	-0.005	
	0.088		0.032	
whole grain claim	0.186	***	-0.083	**
	0.062		0.040	
pink ribbon	0.196	**	0.465	***
	0.091		0.085	
brand, store, week fixed effects	yes		yes	
Number of observations	6663		9810	
R2	0.331		0.336	

Note: Robust and clustered standard errors (at product-store level) are reported and *, **, *** denote statistical significance at the 10%, 5% and 1% significance level.

Table 6: Regression results for differentiated average treatment effects of labeled products

Average Treatment Effect on Untreated (Differences-in-Differences)

dependent variable: (log) quantity microwave popcorn (by week, by store)

independent variables:	pooled labels		low calorie		low fat		low fat (FDA)		low cal/fat		low cal/fat/trans fat	
treated stores*treated weeks	0.063		0.066		0.022		0.162	**	0.048		0.079	
(treatment effect)	0.043		0.070		0.056		0.068		0.060		0.096	
treated weeks	-0.002		0.008		-0.09	***	0.004		0.031		-0.077	
	0.042		0.032		0.034		0.032		0.034		0.050	
price	-0.244	***	-0.262	***	-0.253	***	-0.252	***	-0.252	***	-0.255	***
	0.010		0.009		0.009		0.009		0.009		0.011	
organic claim	-		-0.872	***	-0.592		-0.584	***	-0.515		-	
			0.103		0.101		0.101		0.146			
low calorie claim	-		-0.256	***	-0.349	***	-0.358	***	-		-	
			0.083		0.044		0.046					
low fat claim	-		0.110		-		-		-		-	
			0.080									
no trans fat claim	-		-0.062		0.229	***	0.220	***	0.285		-	
			0.079		0.079		0.079		0.132			
whole grain claim	-		-0.094		-0.106		-0.106		-0.110		-	
			0.065		0.067		0.067		0.067			
pink ribbon	-		-		-0.201		-		-0.069		-	
					0.172				0.176			
brand, store, week fixed effects			yes		yes		yes		yes		yes	
Number of observations	6788		10752		10968		10744		9632		5447	
R2	0.374		0.352		0.360		0.360		0.347		0.385	

Note: Robust and clustered standard errors (at product-store level) are reported and *, **, *** denote statistical significance at the 10%, 5% and 1% significance level.

Table 7: Regression results for average treatment effects of unlabeled products

Triple Difference for Store-Specific Average Treatment Effects

dependent variable: (log) quantity microwave popcorn (by week, by store)

independent variables:	pooled labels	low calorie	low fat	low fat (FDA)	low cal/fat	low cal/fat/trans fat
label*treated store*weeks	-0.075	0.178	-0.038	-0.428 ***	-0.060	0.030
(treatment effect)	0.054	0.134	0.101	0.133	0.127	0.092
treated weeks*label	0.065 ***	-0.020	0.026	0.026 *	0.031	0.051
	0.023	0.025	0.024	0.024	0.024	0.026
treated weeks*treated store	0.050	0.008	-0.004	0.165 **	-0.005	0.139
	0.043	0.074	0.056	0.064	0.062	0.084
treated store*label	0.070	-0.114	-0.001	0.028	0.038	0.018
	0.057	0.123	0.090	0.125	0.139	0.062
label	-0.291 ***	-0.171 ***	-0.255 ***	-0.261 **	-0.218 ***	-0.292 ***
	0.029	0.026	0.026	0.025	0.024	0.031
treated weeks	0.005	-0.029	-0.065 **	-0.063	-0.071 *	-0.078 **
	0.029	0.020	0.032	0.032	0.032	0.032
price	-0.260 ***	-0.265 ***	-0.262 ***	-0.266 ***	-0.260 ***	-0.265 ***
	0.007	0.007	0.007	0.007	0.007	0.007
organic claim	-0.662 ***	-0.994 ***	-0.941 ***	-1.002 ***	-0.974 ***	-0.610 ***
	0.084	0.088	0.066	0.088	0.089	0.087
low calorie claim	-0.091 ***	-0.178 ***	-0.218 ***	-0.186 ***	-0.106 ***	-0.090 **
	0.029	0.030	0.039	0.030	0.030	0.031
low fat claim	0.030	0.144 ***	-0.019	0.155 ***	0.108 ***	0.036
	0.025	0.031	0.052	0.031	0.029	0.027
no trans fat claim	0.125 **	-0.143 *	-0.109 ***	-0.165 ***	-0.143 **	0.011
	0.055	0.061	0.037	0.061	0.061	0.033
whole grain claim	-0.154 ***	-0.013	-0.026	-0.011	-0.045	-0.157 ***
	0.047	0.052	0.042	0.052	0.050	0.048
pink ribbon	-	-	-0.180		-0.041	0.540 ***
			0.175		0.171	0.067
brand, store, week fixed effects	yes	yes	yes	yes	yes	yes
Number of observations	18785	16520	16402	16125	16295	15591
R2	0.340	0.332	0.32	0.324	0.337	0.340

Note: Robust and clustered standard errors (at product-store level) are reported and *, **, *** denote statistical significance at the 10%, 5% and 1% significance level.

Table 8: Regression results for triple difference specifications

Triple Difference: Differentiated Average Treatment Effects				
dependent variable: (log) quantity microwave popcorn (by week, by store)				
independent variables:	low cal/fat		low cal/fat/trans fat	
interacted treatment effects				
low calorie	-0.045			
	0.122			
low fat	-0.165			
	0.175			
no transfat			0.171	
			0.162	
low cal/fat	-0.037		-0.332	
	0.151		0.331	
low cal/trans fat			-0.339	*
			0.185	
low fat/trans fat			-0.322	
			0.323	
low cal/fat/trans fat			-0.054	
			0.142	
treated weeks*label	0.031		0.062	**
	0.024		0.026	
treated weeks*treated store	-0.005		0.052	
	0.062		0.092	
treated store*label	0.037		0.236	**
	0.139		0.108	
label	-0.218	***	-0.241	**
	0.024		0.117	
treated weeks	-0.071	**	0.003	
	0.032		0.031	
price	-0.260	***	-0.264	***
	0.007		0.007	
organic claim	-0.973	***	-0.610	***
	0.089		0.088	
low calorie claim	-0.106	***	-0.086	***
	0.062		0.031	
low fat claim	0.108		0.034	
	0.029		0.027	
no transfat claim	-0.136	**	0.124	**
	0.062		0.058	
whole grain claim	-0.045		-0.149	***
	0.050		0.049	
pink ribbon	-0.038		0.450	***
	0.173		0.108	
brand, store, week fixed effects	yes		yes	
Number of observations	16295		15591	
R2	0.344		0.344	

Note: Robust and clustered standard errors (at product-store level) are reported and *, **, *** denote statistical significance at the 10%, 5% and 1% significance level.

Table 9: Regression results for differentiated triple difference specifications

Triple Difference for Store-Specific Average Treatment Effects
(aggregated by treatment and pre-treatment period)

dependent variable: (log) quantity microwave popcorn (by 4 weeks, by store)

independent variables:	pooled labels	low calorie	low fat	low fat (FDA)	low cal/fat	low cal/fat/trans fat
label*treated store*period	-0.128	0.289 **	-0.166	-0.426 *	0.024	0.043
(treatment effect)	0.088	0.125	0.179	0.224	0.141	0.102
treatment period*label	0.130 **	-0.014	0.055	0.053	0.063	0.111 ***
	0.040	0.037	0.037	0.037	0.037	0.037
treatment period*treated store	0.035	-0.107 **	-0.051	0.053	-0.052	-0.080
	0.067	0.053	0.053	0.037	0.054	0.057
treated store*label	0.009	-0.131 *	-0.086	-0.075	-0.102	-0.051
	0.079	0.072	0.073	0.072 *	0.075	0.074
label	-0.449 ***	-0.266 ***	-0.389 ***	-0.398 ***	-0.346 ***	-0.433 ***
	0.049	0.037	0.037	0.037	0.035	0.049
treatment period	-0.076 **	0.020	-0.028	-0.026	-0.033 *	-0.062 **
	0.032	0.031	0.030	0.030	0.030	0.031
price (average across 4 weeks)	-0.267 ***	-0.267 ***	-0.273 ***	-0.273 ***	-0.269 ***	-0.266 ***
	0.011	0.011	0.011	0.011	0.011	0.011
organic claim	-0.788 ***	-1.210 ***	-1.359 ***	-1.364 ***	-1.347 ***	-0.796 **
	0.127	0.128	0.131	0.129	0.130	0.127
low calorie claim	-0.159 ***	-0.180 ***	-0.306 ***	-0.313 ***	-0.184 ***	-0.164 **
	0.045	0.045	0.045	0.045	0.045	0.046
low fat claim	0.102 ***	0.189 **	0.284 ***	0.297 ***	0.231 ***	0.109 ***
	0.037	0.041	0.044	0.044	0.041	0.037
no trans fat claim	0.258 ***	-0.061 ***	-0.145 *	-0.160 *	-0.137	0.231 ***
	0.081	0.083	0.084	0.084	0.084	0.082
whole grain claim	-0.212 ***	-0.102	0.002	0.008	-0.042	0.082 ***
	0.066	0.067	0.070	0.070	0.067	0.068
brand and store fixed effects	yes	yes	yes	yes	yes	yes
Number of observations	4000	3856	3843	3835	3840	3854
R2	0.440	0.437	0.445	0.446	0.443	0.439

Note: Robust and clustered standard errors (at product-store level) are reported and *, **, *** denote statistical significance at the 10%, 5% and 1% significance level.

Table 10: Regression results for triple difference specifications aggregated across treatment period

Triple Difference: Differentiated Average Treatment Effects (aggregated by treatment and pre-treatment period) dependent variable: (log) quantity microwave popcorn (by 4 weeks, by store)				
independent variables:	low cal/fat		low cal/fat/transfat	
interacted treatment effects				
low calorie	0.119		-	
	0.130			
low fat	-0.171		-	
	0.249			
no transfat	-		0.396	**
			0.158	
low cal/fat	-0.018		-0.182	
	0.165		0.278	
low cal/trans fat	-		-0.169	
			0.180	
low fat/trans fat	-		0.227	
			0.186	
low cal/fat/trans fat	-		-0.183	
			0.162	
treatment period*label	0.063	*	0.112	***
	0.037		0.037	
treatment period*treated store	-0.052		-0.077	*
	0.054		0.057	
treated store*label	-0.102		-0.049	
	0.075		0.074	
label	-0.346	***	-0.432	***
	0.035		0.049	
treatment period	-0.033		-0.063	**
	0.030		0.031	
price (average across 4 weeks)	-0.269	***	-0.265	***
	0.011		0.011	
organic claim	-1.347	***	-0.801	***
	0.130		0.127	
low calorie claim	-0.185	***	-0.164	***
	0.045		0.046	
low fat claim	0.231	***	0.113	***
	0.041		0.037	
no transfat claim	-0.137		0.225	***
	0.084		0.082	
whole grain claim	-0.041		-0.191	***
	0.067		0.067	
brand, store, week fixed effects	yes		yes	
Number of observations	3840		3854	
R2	0.443		0.440	

Note: Robust and clustered standard errors (at product-store level) are reported and *, **, *** denote statistical significance at the 10%, 5% and 1%significance level.

Table 11: Regression results for differentiated triple difference specifications aggregated across treatment period

Descriptive Statistics: Treatment Store and Synthetic Control Store (low cal treatment)

A. Store Characteristics	**Treatment store**/Synthetic control store		
Sales of labeled products (week 36)	**82**	92.945	85.425
Sales of labeled products (week 39)	**70**	89.661	80.995
Sales of labeled products (week 40)	**92**	98.984	94.682
Total Floor Space	**26425**	32501.19	28512.52
Mean Weekly Category Sales	**354**	272.34	279.75
Mean Number of Products (by week)	**56.60**	52.36	52.81
Mean Price of Treated Products	**3.76**	3.50	3.74
Mean Total Treatment Sales	**17**	19.37	17.03
B. Zip Code Characteristics			
Population	**36190**	43016.67	-
Median Rent	**751**	732.8	-
Median Income	**41002**	47792.8	-
Median House Value	**156300**	223886.8	-
Number of Households	**12660**	17127.41	-
Number of Family Households	**7899**	9977.75	-
Percent White	**0.592**	0.638	-
Percent Black	**0.042**	0.059	-
Percent Indian	**0.009**	0.006	-
Percent Asian	**0.076**	0.137	-
Percent Hispanic	**0.395**	0.221	-
Percent 65 years+	**0.086**	0.106	-

Table 12: Predictor Means for Low Calorie Label Treatment

Synthetic control method: Weights for synthetic control stores (by treatment)

A. Treatments			
	low calorie label		
	low fat label		
	no trans fat label		

	Weights (by treatment)		
	low calorie	low fat	no trans fat
B. Control stores			
1	0	0	0.037
2	0	0.248	0
3	0	0	0.188
4	0	0	0
5	0	0	0
6	0	0	0
7	0	0	0
8	0	0	0
9	0.257	0	0.378
10	0	0	0
11	0	0	0
12	0	0.392	0
13	0.743	0	0.066
14	0	0	0
15	0	0	0
16	0	0	0
17	0	0	0
18	0	0	0
20	0	0.125	0
21	0	0	0
22	0	0	0
23	0	0	0
24	0	0.062	0
25	0	0	0
26	0	0	0.332
27	0	0.173	0

Table 13: Store Weights in Single Synthetic Control Stores

Results for synthetic control method
(Difference in sales treatment vs. control)

Weeks	Sales by Treatment/synthetic Control		
	low calorie	low fat	no trans fat
200736	-3.425	-0.15	-9.813
200737	-3.911	-6.879	16.945
200738	9.832	12.015	17.122
200739	-10.995	13.12	3.8
200740	-2.682	6.364	22.919
200741	-1.257	-6.507	-18.918
200742	18.659	-27.268	11.981
200743	3.262	-3.569	-3.28
200744	7.972	-2.4	-7.305
200745	3.313	5.933	48.297
200746	-3.453	-1.898	7.358
200747	20.659	-4.505	16.417
200748	-12.832	-1.693	21.862
200749	25.402	-0.298	30.052

Note: Treatment weeks are in bold font.

Table 14: Differences in Total Sales of Treatment vs. Synthetic Control Store by Label Treatment