International Journal of Industrial Organization xxx (2010) xxx–xxx

Contents lists available at ScienceDirect

International Journal of Industrial Organization

journal homepage: www.elsevier.com/locate/ijio

Can information costs affect consumer choice? Nutritional labels in a supermarket experiment

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ARTICLE INFO

Article history:
Received 7 January 2010
Received in revised form 26 August 2010
Accepted 16 November 2010
Available online xxxx

JEL classification:
L15
M31
D83
C93

Keywords:
Information
Consumer behavior
Field experiment
Nutrition

ABSTRACT

This paper investigates whether information costs under currently regulated nutritional labeling prevent consumers from making healthier food choices. We implement five nutritional shelf label treatments in a market-level experiment. These labels reduce information costs by highlighting and summarizing information available on the Nutritional Facts Panel. Following a difference-in-differences and synthetic control method approach, we analyze weekly store-level scanner data for microwave popcorn purchases from treatment and control stores. Our results suggest that consumer purchases are affected by information costs. Implemented *low calorie* and *no trans fat* labels increase sales. In contrast, implemented *low fat* labels decrease sales, suggesting that consumer response is also influenced by consumers' taste perceptions. A combination of these claims into one label treatment increases information costs and does not affect sales significantly.

1. Introduction

Existing research documents consumers' general understanding of the link between food consumption and health, and widespread interest in the provision of nutritional information on food labels (e.g. Williams, 2005; Grunert and Wills, 2007). However, consumers cannot verify this information at any point from purchase to consumption.[1] Instead, they base their product choice on beliefs arrived at by way of a labyrinth of information printed on food packages. In such markets, firms might not have an incentive to fully reveal their product quality (Bonroy and Constantos, 2008), might try to highlight certain attributes in their advertising claims while shrouding others (Gabaix and Laibson, 2006), or provide information in a less salient fashion (Chetty et al., 2007).

The Nutrition, Labeling, and Education Act (NLEA) of 1990 gave the Food and Drug Administration (FDA) the authority to require nutritional labeling for most food products. In 1994, the Nutrition Facts Panel (NFP) was implemented in order to improve consumer access to nutritional information and to promote healthy food choices. This paper uses a supermarket-level experiment to address the relationship between information costs and healthy food choices under these labeling regulations.

About 50% of consumers claim to use the NFP when making food purchasing decisions (Blitstein and Evans, 2006). Consumers trying to lose weight are more likely to read the NFP (Mandal, 2008), and NFP use can result in weight loss and a decrease in obesity (Variyam and Cawley, 2006). However, self reported consumer use of nutrition labels declined from 1995 to 2006, with the largest decline for younger age groups (20–29 years) and less educated consumers (Todd and Variyam, 2006). This decline could be a result of consumers' inability to perform quantitative tasks (Levy and Fein, 1998), and preferences for short health claims and short front label claims instead of NFP's lengthy back label explanations (e.g. Levy and Fein, 1998; Williams, 2005; Wansink, et al., 2004; Grunert and Wills, 2007).[2] Yet, simple claims, such as *low fat* labels could potentially mislead consumers and increase their caloric food intake through perceptions of an increased acceptable serving size and a reduction in consumption guilt (Wansink and Chandon, 2006), especially when combined with a positive image

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[1] Nutritional characteristics can be defined as credence attributes. Credence attributes vary significantly from search and experience goods in that reputation and signaling can rarely be used to alleviate information asymmetries (see Nelson, 1970; Roe and Sheldon, 2007).

[2] Looking at GMO claims, Roe and Teisl (2007) found that simple claims are viewed as most accurate, and labels certified by the FDA and, in some cases, USDA are perceived as more credible than third party and consumer organization certification.

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doi:10.1016/j.ijindorg.2010.11.002

and suggestive health references (Geyskens et al., 2007). Conversely, perceived tradeoffs between nutritional considerations and taste preferences could prevent consumers from choosing reduced-fat alternatives if they are labeled as such (Yeomans et al., 2001; Stubenitsky et al., 2000, and French et al., 1999).

The limited number of market-level empirical studies exhibits mixed results regarding consumer use of nutritional information. Displaying lists of information on vitamins and minerals as well as sugar content in supermarkets resulted in increased nutritional information use (Russo et al., 1986), and voluntary labels had significant effects on consumer choices prior to the NLEA (Ippolito and Mathios, 1990). Still, Mojduszka and Caswell (2000) argue that information provided by firms voluntarily prior to the NLEA was incomplete and not reliable. Mathios (2000) finds that mandatory guidelines resulted in a significant decline in sales of high fat products, despite prior voluntary disclosure of low-fat products, and Teisl et al. (2001) find that consumer behavior was significantly altered by the NLEA, but purchases of “healthy” products increased only in some of the product categories.

Less attention has been paid to interdependencies of regulation and alternative information sources in these studies. This is important because experimental research (Cain, et al., 2005) suggests that people do not sufficiently take motives of the information source into account when evaluating information, even after disclosure of conflicts of interest. In this context, Ippolito and Pappalardo (2002) suggest that regulatory rules and enforcement policy induced firms to move away from reinforcing nutritional claims. Critical news coverage of regulatory challenges (Nestle, 2000), and the “Food News Blues” in general (Kantrowitz and Kalb, 2006) could have also contributed to decreased labeling use over time.

Our experimental design adds to this literature by focusing on information costs under current NFP labeling. Conducting our experiment in a real market setting eliminates possible bias generated in hypothetical experiments and survey responses, and controls for potential confounding factors such as marketing claims and media coverage.

We implemented nutritional shelf labels for one product category (microwave popcorn) in cooperation with a major supermarket chain in five treatment stores over a period of four weeks. The supermarket chain also provided store-level scanner data for a total of 32 stores, covering a time period before and after our labeling implementation. Our collected NFP information indicated substantial variation in nutrient content and suggested serving size across products included in the data. Consumers trying to compare products based on their nutritional characteristics might therefore face significant information costs. We reduce information costs by either repeating or summarizing NFP information and providing it a new format. Using *low calorie*, *low fat*, and *no trans fat* claims, we address 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 depend on disclosure of information source (FDA)? (iv) Do effects differ depending on display of a single versus multiple nutrients on a label? and (v) Do we find evidence consistent with consumers making inferences about the nutritional content of unlabeled products?

Following a difference-in-differences and synthetic control method approach, we find results consistent with information costs mattering and conclude that nutritional information is not provided effectively under current labeling guidelines. In particular, we find that a shelf label of *no trans fat* significantly increases sales of treated products, even though this information is already provided in a less uniform format. *Low calorie* labels also significantly increase sales of treated products. *Low fat* labels, on the other hand, significantly reduce quantity sales of targeted products, especially when adding an FDA approval to our labeling treatments. We attribute this effect to consumers having less favorable taste perceptions of *low fat* foods than of *low calorie* foods. When combining claims in a single label, we do not detect significant purchase responses because this treatment increases information costs for the consumer. Finally, we find no consistent evidence that consumers make inferences about unlabeled products and their relatively inferior nutritional quality. The synthetic control method further detects the largest labeling effect immediately following our initial implementation. Labeling effects dissipate quickly after our treatment period for the *low calorie* and *low fat* treatment, but persist for the *no trans fat* label. *No trans fat* products are highlighted in manufacturer claims and are easier to identify by consumers under the current NFP labeling.

In the next section, we describe our experimental design and the main features of our data. We introduce our empirical specification, report estimation results, and test the robustness of our findings in Section 3. In Section 4, we conclude by discussing our results and their relevance for regulatory changes.

2. The supermarket experiment

In collaboration with a major supermarket chain, we were able to design and implement nutritional shelf labels in order to make information more salient and easier to process. Our labeling treatments either repeat information already available on the NFP in a more uniform format (e.g. *no trans fat*), or transform quantitative statements into relative statements (e.g. *low fat*, *low calorie*). They reduce information costs by allowing consumers to directly compare alternatives on a relative scale within our targeted product category. If consumers already incorporated the NFP information in their purchases, our labels should not affect purchases as we are not providing additional nutritional information.[3] We implemented five differentiated labeling treatments over a period of four weeks in each of five stores, targeting microwave popcorn products.

2.1. Experimental design

The selection of microwave popcorn as the treated product category was based on a number of considerations. We had to focus our intervention on a relatively small product category that could potentially be healthy and offered enough variation in nutrients to result in sufficient variation for the implemented labeling treatments. Microwave popcorn further allows us to target a product that is appealing to families with children, as healthy or unhealthy eating patterns develop during childhood.[4] Lastly, product alternatives within this category are similar in taste and appearance across brands, allowing for cross-product comparisons in our analysis.

The information needed to construct our treatment product group was collected from the NFP displayed on all microwave popcorn varieties available at local area stores, complemented by online searches. We observed significant variation in serving size and nutrients per serving before classifying each microwave popcorn product on a categorical scale (low, medium, and high) for a certain nutrient.[5] The supermarket chain permitted positive claims only, favored a very basic design, and expressed a primary interest in fat related claims, possibly motivated by research findings suggesting that *low fat* claims increase food intake (e.g. Wansink and Chandon,

[3] This statement is especially valid for the *no trans fat* treatment. For the *low fat* and *low calorie* treatment, one could argue that the ranking of products is new information. As this ranking is based on the information already provided on the NFP, we argue that we are decreasing information costs rather than providing new information.

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

[5] We for instance categorized the lowest 25% of products within the overall product category of microwave popcorn as *low fat* or *low calorie*. These categories are based on the *Traffic Light Color Signpost Labeling* introduced by the Food Standards Agency in the UK in 2007 (FSA, 2007). For more details on label design and distribution of serving size and nutrients per serving targeted in our treatments see Kiesel and Villas-Boas (2009).

Please cite this article as: Kiesel, K., Villas-Boas, S.B., Can information costs affect consumer choice? Nutritional labels in a supermarket experiment, Int. J. Ind. Organ. (2010), doi:10.1016/j.ijindorg.2010.11.002

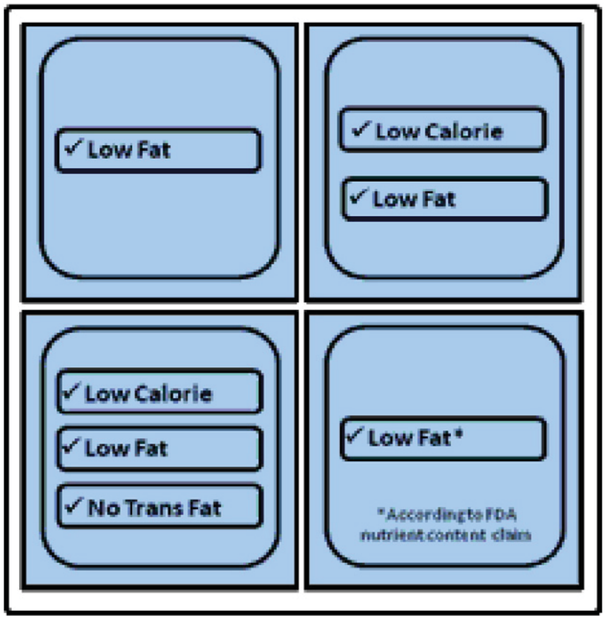

Fig. 1. Label treatments. Note: We implemented five labeling treatments. These examples display single nutrients, combined nutrients, and FDA approved *low fat* labels. We also implemented single nutrient *low calorie* and *no trans fat* labels, and combined *low fat*, *no trans fat* and *low calorie*, *no trans fat* labels.

2006). We were provided with five treatment stores, but with no additional information on the selection process of these stores. Fig. 1 shows the labeling design, while Fig. 2 shows how the following five label treatments were placed on the grocery shelf in one of the five treatment stores each: (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. We added the FDA approval to increase the credibility of our labeling claim, especially since consumers were not able to otherwise identify the information source of our labels. For combined label treatments, we displayed a variety of labels (e.g. *low calorie* labels, *low fat* labels, and *low calorie*/*low fat* labels for treatment (4)). By combining several claims in one treatment, we increased the nutritional information content, but also the information costs for the consumer. They now had to compare

Fig. 2. Implementation of shelf labels. Note: Our labels were attached to the price tag placed on the shelf.

products based on labels about different nutrients. Because we were only able to treat products within the *low calorie*, *low fat* and *no trans fat* categories, it might also be more costly for the consumer to make inferences about the nutritional value of unlabeled products.

2.2. Data and summary statistics

We implemented the labeling treatments during a four week period 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 supermarket chain's price cycle and data organization. Labels were attached to shelves during low traffic hours every Wednesday night and after possible changes in product prices went into effect (see Fig. 2). In addition to data from the five treatment stores, we received data for 27 stores within the same pricing division. The store-level data include weekly quantities, net revenue, gross revenue, and mark-down amounts for each product sold in the microwave popcorn category. Different products are identified by the Universal Product Code (UPC). In addition, we constructed a price variable by using net revenue divided by product quantity reported.[6] The quantity variable reported in our data 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. 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-demographic statistics provided by the United States Census Bureau (2000 Census).[7]

The scanner data provided by the grocery chain include 93 products for 18785 product-week-store observations. Sampling all treatment stores and local area stores as well as conducting online searches for nutritional information resulted in a total of 68 matches of products. 43 of those products were subject to the labeling interventions.[8]

In Table 1, Panel A defines the five different treatments corresponding to our five treatment stores. Panel B1 provides descriptive statistics of treatment and control stores (e.g. store size, year opened, number of available products within our category, category sales, and product sales), while Panel B2 summarizes socio-demographic characteristics by store zip code. Panel C presents the number of labeled products for each store, as well as the number of products that would have been labeled on average in the control stores. These statistics suggest that our treatment stores vary in size, with store 3 being the smallest. Category sales of microwave popcorn in the treatment stores seem somewhat higher than mean sales in the control stores, but fall within one standard deviation, and are no larger or smaller than the observed maximum or minimum for the control stores. In addition, treatment and control stores seem similar and representative of national socio-demographic averages.[9] Finally, control stores have a comparable number of treatment eligible products, with the exception of store 3. We would have treated 21 products on average rather than the 15 products we did treat in this smaller store (indicated in Panel C).

As an additional summary statistic, Table 2 reports the average treatment effect of our labels when using raw means. We aggregate sales for treated and untreated products into a four week period before and during our treatment period. We then compute differences

[6] This price corresponds to the average product price across all transactions for a given product, store, and week.

[7] See Kiesel and Villas-Boas (2009) for a complete summary of all variables included in our data.

[8] The 25 products included in the scanner data for which we do not have nutritional information translate into an exclusion of 0–12 products per control store, with a mean of 3 products. Regression specifications were also estimated including these observations as a robustness check.

[9] The median income nationwide is reported as 42,000, median household size amounts to 2.52, and percentage of whites in the U.S. is reported at 75% (US Census, 2000).

Table 1
Descriptive statistics: store characteristics.

Descriptive statistics: stores						
A. Treatments						
1						Low calorie label
2						Low fat label
3						Low fat label and FDA approval
4						Low calorie and low fat label
5						Low calorie, low fat, and low trans fat label
	Treatment stores					Control stores
	1	2	3	4	5	
B1. Store characteristics						
Total floor space	30440	27178	19348	26425	30168	26983.07 (8008.21)
Opening year	1984	1970	1975	1978	1986	1981.63 (12.82)
Mean weekly category revenue ($)	116.18	167.47	137.78	344.69	295.27	196.72 (76.35)
Mean weekly product revenue ($)	11.32	9.71	11.33	16.97	15.00	11.32 (9.18)
Mean weekly product quantity	4.19	3.63	4.20	6.14	5.44	4.19 (4.34)
Mean weekly product price	3.39	3.31	3.26	3.19	3.36	3.18 (1.46)
Mean number of products (by week)	39.8	47.6	26.36	56.47	54.34	44.94 (8.28)
B2. Zip code characteristics						
Population	36190	72702	14075	36190	19790	48980 (21091)
Median income	41002	49452	50300	41002	57214	41908 (11099)
Mean household size	2.85	3.22	2.6	2.85	2.85	2.83 (0.55)
Percent white	0.59	0.41	0.49	0.59	0.52	0.51 (0.17)
C. Label characteristics						
Number of labeled products	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: Descriptive statistics of store, zip code, and label characteristics for all stores. Mean values are reported when applicable and standard deviations are reported in parentheses for the control stores. For C, numbers reported for the control store correspond to the number of products eligible for treatment 1 to 5 (defined in A).

Table 2
Summary statistics: average treatment effects for single claim labels.

Descriptive statistics: average treatment effects	Average over all stores			Store 1			Store 2			Store 3		
	Labeled	Unlabeled	Diff	Low cal	Unlabeled	Diff	Low fat	Unlabeled	Diff	Low fat (FDA)	Unlabeled	Diff
Treatment stores												
Pre-treatment	463.93	437.59	23.8	331	1041	−710	178	492	−314	157	344	−187
(week 37–40, 2007)	(183.65)	(207.5189)	(110.65)									
	[531]	[373]	[5]	[69]	[156]		[62]	[132]		[42]	[67]	
Treatment	538.54	346.07	171	415	919	−504	152	453	−301	162	344	−220
(week 41–45, 2007)	(226.25)	(126.46)	(112.56)									
	[549]	[369]	[5]	[77]	[143]		[54]	[131]		[46]	[67]	
DD_{TS}			**147.2**			**206**			**13**			**−33**
			(147.01)									
			[5]									
Control stores												
Pre-treatment	390.88	333.92	45	210.9	507.69	−278.89	199.9	516.82	−296.22	199.9	516.82	−296.22
(week 37–40, 2007)	(156.47)	(116.27)	(88.38)	(90.69)	(185.97)	(137.80)	(84.01)	(188.76)	(137.28)	(84.01)	(188.76)	(137.28)
	[2838]	[1706]	[27]	[1586]	[2889]	[27]	[1513]	[2962]	[27]	[1513]	[2962]	[27]
Treatment	505.83	284.24	200.77	251.95	530.05	−265.26	242.78.78	538.88	−282.074	242.78.78	538.88	−282.074
(week 41–45, 2007)	(203.54)	(100.14)	(145.99)	(100.13)	(202.61)	(142.38)	(95.23)	(206.77)	(145.27)	(95.23)	(206.77)	(145.27)
	[3009]	[1739]	[27]	[1630]	[3050]	[27]	[1555]	[3125]	[27]	[1555]	[3125]	[27]
DD_{CS}			**155.78**			**13.63**			**14.15**			**14.15**
			(88.03)			(57.96)			(62.41)			(62.41)
			[27]			[27]			[27]			[27]
DDD			**−8.58**			**192.37**			**−1.15**			**−47.15**

Note: We report mean quantities sold at each store, aggregated by treatment and treatment period as well as for 4 weeks prior. Standard deviations are reported in parentheses, and number of observations are reported in square brackets. *Labeled* refers to the pooled effect for all labeling treatments, and separate treatments are indicated. For control stores, these specifications denote the corresponding placebo effects. DD_{TS} and DD_{CS} denote the difference-in-differences for the treatment and control stores, while *DDD* combines those in a triple difference, denoting the average treatment effect.

in sales for treated versus untreated products within each treatment and control store as well as triple differences across treatment and control stores. Table 3 follows the same approach and reports results for the two stores in which we implement differentiated labels.[10] The first three columns in Table 2 compare sales of all treated products, independent of treatment type, against unlabeled products. Labeled products have higher sales during the treatment period as compared to the unlabeled products in the treated and control stores. Adding the third difference indicates that sales of treated products are actually slightly lower on average (8.58 units). If we compare the *low calorie* treatment against untreated products, we find a triple difference in mean quantity sales of 192.37 units, indicating that sales of our

[10] We only report the differences and triple differences for these treatments.

Table 3
Summary statistics: average treatment effects for multiple claim labels.

Descriptive statistics: average treatment effects (differentiated treatments)						
Labels	Store 4			Store 5		
	Low cal/low fat			Low cal/low fat/trans fat		
	DD_{TS}	DD_{CS}	DDD	DD_{TS}	DD_{CS}	DDD
Labeled	−31	42.07 (61.17)	**−73.07**	123	155.78 (88.03) [27]	**−32.78**
Low cal	−44	2.11 (48.38)	**−46.11**	57	54.75 (52.89) [24]	**2.25**
Low fat	−40	2.37 (52.40)	**−42.37**	64	50.96 (42.60) [25]	**13.04**
No trans fat				382	101.9259 (64.80) [27]	**280.07**
Low cal/fat	−35	14.04 (57.51	**−49.04**	49	41.85185 (42.40) [27]	**7.15**
Low cal/trans fat				59	57 (47.54) [27]	**2.00**
Low fat/trans fat				79	56.15 (49.21) [27]	**22.85**
Low cal/fat/trans fat				67	74.11 (52.90) [27]	**−7.11**

Note: Mean aggregated sales by treatment and time period are suppressed in this table. DD_{TS} and DD_{CS} denote the difference-in-differences for treated versus untreated in the treatment and control stores, while DDD combines those in a triple difference, denoting the average treatment effect. Standard deviations are reported in parentheses, and number of observations are reported in square brackets.

treated products during our treatment period are substantially higher. For the *low fat* treatment, a comparison of means suggests a decrease in sales of treated products by 1.15 units. Adding the FDA approval decreases sales by 47.15 units.

In the differentiated labeling treatment, we compare sales within each labeling alternative to sales of untreated products. Here, the most pronounced effect is observed for our *no trans fat* label; sales of labeled products increase by 280.07 units on average. Table 3 also shows that there are no large differences for products that are labeled as *no trans fat* and *low calorie*. In summary, these mean differences suggest that our label treatments had an effect on consumer purchases, but effects differ based on the nutrients displayed and the number of nutrients displayed.

3. Econometric specifications

Building on this first comparison of mean sales, we estimate the effect of our labeling intervention by comparing sales of the treatment product group to sales of control product groups. The defined control product group serves as a counterfactual of product sales in the absence of our intervention, but we also include additional controls such as price. Our estimation of average treatment effects (ATE) of nutritional shelf labeling rests on the assumption that treatment assignment and the potential outcomes are independent (Imbens, 2004). This condition is satisfied by a random assignment of treatments across stores.

As we observe repeated cross sections—weekly store-level product sales—we follow a difference-in-differences approach commonly used in the policy evaluation literature (see Meyer, 1995; Bertrand et al., 2004) to identify the ATE. 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) in a triple difference specification (DDD). A DDD also allows to control for potential time-variant differences across treatment and control stores.

We specify and estimate a difference-in-differences specification for the ATE on the treated as differences in sales of labeled products in the treated store ($store_s = 1$) and treatment period ($time_t = 1$) to sales of the same products in the control stores and earlier periods. 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 so we can compare regression results in terms of average percentages rather than differences in levels of sales. In these regression analyses of labeling effects, we estimate the average treatment effect across all labeling treatments first and then estimate specific ATEs for each treatment store, and label separately. These specifications can be summarized by the following equation:

$$\begin{aligned} log\left(Y_{i,s,t}\right) = {} & \alpha * store_s * time_t + \\ & + \beta_1 * store_s + \beta_2 * time_t + \\ & + \gamma * \mathbf{X}_{i,s,t} + \mu_j + \nu_s + \tau_t + \epsilon_{i,s,t}, \end{aligned} \tag{1}$$

where the parameter α denotes the average treatment effect on the treated, when we only include labeled products in the regression.[11] The vector $\mathbf{X}$ denotes possible additional covariates that may affect sales, such as price and manufacture claims. We further include brand j, store s and time t fixed effects to account for any unobservable factors that cause some brands, stores, and weeks to on average have higher or lower sales. Brand fixed effects capture 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 affect all stores and products equally. Finally $\epsilon_{i,\ s,\ t}$ represents an unobserved disturbance term. The identification assumption underlying these DD specifications is that no unobserved factors differentially affect treated products before, during, or after the implementation of our labels.

We can also combine both product groups (labeled and unlabeled) for a DDD specification where we compare the changes in treated and control stores of labeled products ($label_i = 1$) versus changes in unlabeled products. We do this by estimating the equation:

$$\begin{aligned} log\left(Y_{i,s,t}\right) = {} & \alpha * label_i * store_s * time_t + \\ & + \beta_1 * label_i * store_s + \beta_2 * label_i * time_t + \beta_3 * store_s * time_t + \\ & + \beta_4 * label_i + \beta_5 * store_s + \beta_6 * time_t + \\ & + \gamma * \mathbf{X}_{i,s,t} + \mu_j + \nu_s + \tau_t + \epsilon_{i,s,t}, \end{aligned} \tag{2}$$

where α now denotes the ATE on sales of labeled products relative to those without labels at treated stores versus control stores, in the treatment period versus periods prior to treatment.

3.1. Triple difference results

We begin by discussing our results from the DDD regression specification as they directly relate to the comparisons of means reported in Tables 2 and 3. Table 4 presents results for the triple difference specifications for which we aggregated our data into two time periods (pre-treatment and treatment period) in order to address the low frequency of product sales and improve the statistical power of our regressions.[12]

The first of the six columns in Table 4 reports the ATE across treatments resulting from pooling all labeling interventions. The remaining columns focus on the specific labeling treatments implemented at each of the stores. The number of observations varies across specifications because the remaining treatment stores are not included in the controls. The reported results are robust to an inclusion of several

[11] By only including products that are not labeled, this same specification can also be used to estimate the ATE on the untreated.

[12] Aggregation of data is commonly used to circumvent data limitations in similar studies (e.g. Chetty et al., 2007). Specifications without aggregation produce similar results are reported in Kiesel and Villas-Boas (2009).

Table 4
Regression results for triple difference specifications aggregated across treatment period.

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)						
	Average over all stores	Store 1	Store 2	Store 3	Store 4	Store 5
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
Brand, store, week fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	4000	3856	3843	3835	3840	3854
R^2	0.440	0.437	0.445	0.446	0.443	0.439

Note: Due to the inclusion of store fixed effects, indicators for treated stores are not included in these specifications. Robust and clustered standard errors (at product-store level) are reported and *, **, *** denote statistical significance at the 10%, 5% and 1% significance levels. The reported results are robust to an inclusion of additional controls such as manufacturer claims and pink ribbon labeling.

controls in X such as price, manufacturer claims, brand, store, and time fixed effects as additional covariates. Due to the inclusion of store fixed effects, indicators for treated stores are not included in these specifications. And finally the reported standard errors are clustered at the product-store level and are heteroskedasticity robust.

In addressing question (i), the reported overall results suggest that consumer purchases are affected by nutritional shelf labels, but that effects differ across labeling treatments in important ways. The ATE of pooling all treatments indicates lower sales, but the differences are not significantly different from zero. This suggests that just posting nutritional shelf labels in order to attract consumer attention did not significantly affect sales of treated products. The *low calorie* treatment increased sales of labeled products by 28.8% relative to unlabeled products in the same store, to control stores and to non-treatment periods. The estimated *low fat* labeling treatment is −16.6% but not statistically significant. Adding an FDA disclaimer, however, results in a significant decrease in sales of 42.6%. Relating these results to question (ii), we find that purchase response does differ depending on the nutrient displayed on the label. In addition, our results suggest that the FDA approval increases the magnitude of the negative ATE for the *low fat* treatment (question (iii)).[13]

The negative effects of *low fat* labels could be an indication that consumers are hindered by negative taste perceptions when considering healthier alternatives. Interestingly, these perceptions seem stronger for *low fat* labels than low calorie labels as the products labeled in either store 1, 2, and 3 (stores with either a *low calorie* or *low fat* treatment) are almost identical. Preferences for high fat products are also confirmed by the negative and significant coefficient on treated products, with a slightly larger coefficient for products included in the *low fat* treatments. These strong taste preferences could be specific to our product category, however, as previous research has found that consumers are less likely to incorporate nutritional information into their product choice when purchasing treats (Grunert and Wills, 2007). Consumers might be particularly reluctant to substitute away from "movie theater butter flavor" to a potentially less tasty *low fat* variety when, for instance, buying microwave popcorn as a treat for a Friday night movie.

Table 5 further separates the overall labeling effects for stores 4 and 5 to address question (iv). While the ATE for the combined labeling effect in store 4 and 5 is not statistically significant (Table 4, column 5 and 6), we do find significant labeling effects when we further differentiate the type of nutrients displayed on these combined treatments. To do so, we interacted dummies for the label type with a treatment store indicator and treatment week indicator (e.g. low calorie label *treated store*treated week). Separating the treatment effect shows statistically significant increase in sales of 39.6% due to the *no trans fat* label. However, once the *no trans fat* claim is combined with the *low calorie* or *low fat* claim, or both, we are not able to detect a significant effect.[14] In addition, while the labeling effects for the combined *low calorie*/*low fat* treatment in store 4 are consistent in sign to our previous results, they are not statistically significant.

These estimated treatment effects are consistent with our observed differences in the comparison of means, and the reported regression results also indicate that consumers are responsive to price changes. A one dollar decrease in average prices resulted in a 26.5 to 27.3% increase in quantity sales of a product on average.

3.2. Difference-in-differences results

We also estimate treatment effects in a DD specification for labeled products only. The results for individual treatment effects are consistent with the reported DDD results, but may be affected by power limitations.[15] When estimating an overall ATE pooling all labeling interventions, we again find no statistically significant effect of labeled products on sales in treatment stores and treatment weeks relative to sales of these products in control stores. The effect of the *low calorie* label treatment is positive while the effect of the *low fat* label is negative, although insignificant. When adding the FDA approval, the effect of the *low fat* label becomes significant once

[13] This result could also be influenced by the smaller size and more limited product assortment of this treatment store.

[14] The model was not able to provide an estimate for the labeling effects of the *low calorie* and *low fat* labels because only one product falls into each of these categories.

[15] See Kiesel and Villas-Boas (2009) for complete estimation results.

Table 5
Regression results for differentiated 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)		
	Store 4	Store 5
Independent variables:	Low cal/fat	Low cal/fat/trans fat
Interacted treatment effects		
Low calorie	0.119	–
	0.130	
Low fat	−0.171	–
	0.249	
No trans fat	–	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
Brand, store, week fixed effects	Yes	Yes
Number of observations	3840	3854
R^2	0.443	0.440

Note: Due to the inclusion of store fixed effects, indicators for treated stores are not included in these specifications. Robust and clustered standard errors (at product-store level) are reported and *, **, *** denote statistical significance at the 10%, 5% and 1% significance levels. The reported results are robust to an inclusion of additional controls such as manufacturer claims and pink ribbon labeling.

more, indicating a reduction of sales by 28.4%. For treatments of combined labels, we again separate treatment effects. These differentiated regressions suggest a statistically significant average decrease of 27.5% for products labeled *low fat* in store 4 relative to the control stores in the treatment period. When differentiating labels for store 5, our results suggest once more that consumers respond positively to the *no trans fat* label. The display of a *no trans fat* label significantly increases average sales of these products during the treatment period by 23.0%. The *no trans fat* claim in combination with other claims (*low fat*, or *low calorie*, or both) does increase sales significantly.

Although we are primarily interested in estimating the average effect on the treated or labeled products, investigating whether consumers make inferences about the unlabeled products provides potentially valuable insights (question (v)). Information costs for consumers may potentially increase if they need to infer the relatively lower nutritional quality of unlabeled products. Table 6 reports the ATE for untreated products. The first column in Table 6 refers to the pooled labeling effect, while columns 2–6 address the treatment stores individually.

The pooled treatment suggests that sales of the unlabeled products in the treatment stores during the treatment period were not significantly higher than in control stores. The point estimate of 0.063 is not statistically different from zero. The only statistically significant (at the 5% significance level) effect is the 16.2% increase in sales of for unlabeled products for the *low fat* label with FDA approval. This effect is the mirror image of the negative effect for labeled products in the DD regression, suggesting that consumers replaced purchases of labeled products with unlabeled products. Whether this effect is attributable to information costs remains somewhat unclear. However, we do not observe it for the *low fat* treatment without the FDA disclaimer (the 0.02 point estimate is not statistically significant) or any other treatments. This may indicate that the FDA approval strengthened consumers' dislike of low fat varieties.

3.3. Additional robustness checks

Because we found that consumers are responsive to price changes, we further investigate our identification assumptions with regards to the prices in our data set. There is variation in initial (non-promotional) price levels, but these differences are time-invariant and thus absorbed by store fixed effects. Weekly price promotions are absorbed by including week fixed effects in the regressions. Additionally, one might be concerned about possible endogeneity of price promotions and the labeling treatment. However, price promotions were simultaneously implemented across treatment and control stores, as all stores are in the same pricing division. To test this argument, we regress prices (including promotions) on our labeling treatments. As expected, there is no statistically significant effect on price. Finally, we include price as a covariate since price is measured

Table 6
Regression results for average treatment effects of unlabeled products.

Average treatment effect on untreated (differences-in-differences)						
Dependent variable: (log) quantity microwave popcorn (by week, by store)						
Independent variables:	Average over all stores	Store 1	Store 2	Store 3	Store 4	Store 5
	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
Brand, store, week fixed effects	yes	yes	yes	yes	yes	yes
Number of observations	6788	10752	10968	10744	9632	5447
R^2	0.374	0.352	0.360	0.360	0.347	0.385

Note: Only unlabeled products are included in these regressions such that the ATE for unlabeled products is identified by a treatment store dummy interacted with the treatment weeks. Due to the inclusion of store fixed effects, indicators for treated stores are not included in these specifications. Robust and clustered standard errors (at product-store level) are reported and *, **, *** denote statistical significance at the 10%, 5% and 1% significance levels. The reported results are robust to an inclusion of additional controls such as manufacturer claims.

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as an average price across all transactions for a specific product in a given store and week. It could thus influence the number of people that bought products during promotions. Price sensitivity among shoppers across stores might vary and could affect sales independent of our treatment.

Price promotions also provide us with an interesting comparison in terms of the size of our estimated labeling effects. Similar to our intervention, price promotions are advertised using shelf labels. Total mark-down amounts for individual products range from 79 cents to $3.70 in our data, most commonly in the form of a "buy one/get one free promotion". We regress quantity sales (in logs) on an indicator of 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. We estimate that posting a price promotion increases sales by 86.8% on average (statistically significant at the 1% significance level). Our estimated nutritional labeling effects are considerably smaller than these price effects.

We further investigated the time-series nature of our data with performed Dickey-Fuller tests (1979) for stationarity on price and quantity. We reject 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 treatments (Bertrand et al., 2004). We replicate all regression specifications with Newey–West corrected standard errors, employing various lag structures. This procedure corrects for serial correlation of unknown form in the error terms (Newey and West, 1987). Furthermore, aggregating the data into a treatment period and pre-treatment period in our reported DDD specification essentially eliminates the time-series character of the data (Bertrand et al., 2004). As an additional robustness check, we restrict regression specifications to compare treated and untreated products at a given treatment store over time. Focusing on time-series variation in sales in treatment stores, or cross-sectional variation across treatment and control stores results in similar signs and magnitudes of effects. We also re-estimate the above specifications by clustering at the product level rather than the product-store level. Significance levels vary slightly, mainly due to power limitations in our product category, but we find very consistent results in all regression specifications.

Finally, we do not find support for the argument by Wansink and Chandon (2006) that simple nutritional labels could induce consumers to increase consumption. We find an overall significant decrease in total category sales of microwave popcorn for the treatment stores during the treatment period of 3.7%.

3.4. 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. 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, the significance of our estimated treatment effects depends on our assumed error structure. The synthetic control method (SCM) (Abadie et al., 2007) addresses these concerns and allows us to test our assumption of random assignment of treatment stores. It can therefore validate and strengthen our DD and DDD results.

SCM can be thought of as a non-parametric combination of the DD and matching approaches as it constructs a (synthetic) control unit that resembles the treated unit in a pre-treatment period. It uses data-driven procedures and considers any weighted average of control units as a potential single (synthetic) control, ultimately choosing the one that minimizes the mean square error of the specified estimator. We consider a variety of variables as matching criteria, including pre-treatment sales of the treated product group, additional store characteristics, and zip code level socio-demographic variables. This method further allows for an evaluation of statistical significance of the estimated treatment effect based on a number of placebo interventions in our control stores, pretending that eligible products had been labeled. We apply a placebo treatment to all 27 control stores and compare the estimated effects to our actual treatment effects. This approach also provides a graphical representation of our estimated treatment effects and trends in sales over time.

One limitation of this approach is that it only allows analysis of a single treatment, and we cannot directly compare it to the DD and DDD results. These results relate to the comparisons of means, however, since we aggregate sales by treatment. Our outcome variable of interest is defined as total weekly sales of products treated (labeled) at a particular store. Here, we look at weekly sales instead of sales over four week periods before and during treatment. We are also able to incorporate the four weeks post treatment to investigate if labeling effects persist.

We start this analysis by considering possible matching criteria for the relevant treatment stores and synthetic counterfactual. Using zip code demographics in addition to store characteristics actually decreases the fit of our model of sales prior to the treatment. As our primary interest is a good prediction of pre-treatment sales, we decided to focus on store characteristics only. Table 7 reports store and zip code characteristics for the *low calorie* treatment stores and the synthetic control store to illustrate this effect. The synthetic control stores for the three analyzed treatments are a weighted average of 2 to 5 control stores depending on the treatment.[16]

Fig. 3 compares weekly total sales of products treated with the *low calorie* label to the synthetic control. The sales trend in the treatment store is indicated by the red line, while the sales trend for the synthetic control is indicated by the dashed blue line. The vertical line

Table 7
Means of explanatory variables for *low calorie* label treatment.

Descriptive statistics: treatment store and synthetic control store (low cal treatment)			
	Treatment store/synthetic control store		
A. Store characteristics			
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	–

Note: Store and zip code characteristics for the *low calorie* treatment stores and its synthetic control store illustrate a better fit when focusing on store characteristics only. The synthetic control store for this treatment is a weighted average of 5 control stores.

[16] See Kiesel and Villas-Boas (2009) for control store weights for alternative treatments.

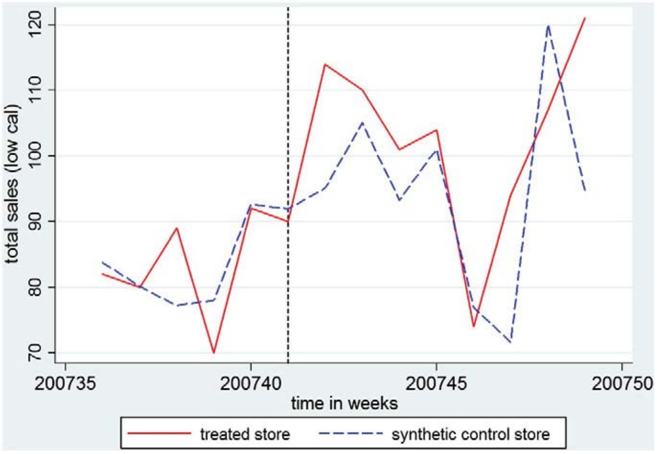

Fig. 3. Trend in total sales of *low calorie* labeled products: Treatment vs. synthetic control store. Note: This figure compares weekly total sales of products treated with the *low calorie* label to the synthetic control. The sales trend in the treatment store is indicated by the red line, while the sales trend for the synthetic control is indicated by the dashed blue line. The vertical line indicates the timing of our labeling treatment. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

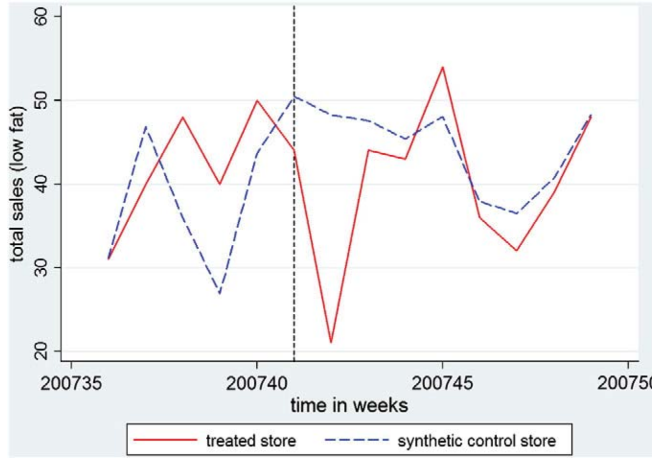

Fig. 4. Trend in total sales of *low fat* labeled products: Treatment vs. synthetic control store. Note: This figure compares weekly total sales of products treated with the *low fat* label to the synthetic control. The sales trend in the treatment store is indicated by the red line, while the sales trend for the synthetic control is indicated by the dashed blue line. The vertical line indicates the timing of our labeling treatment. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

indicates the timing of our labeling treatment. Total sales of treated products in the synthetic control store closely reproduce the sales observed in the treatment store prior to our treatment. After implementing the labels, actual sales clearly exceed sales in the synthetic control. This gap converges for the post-treatment period. The largest increase seems to occur right after implementation of the treatment, with an 18.7 units increase observed in the second week (reported in Table 8). This corresponds to a 19.57% increase in sales compared to average sales across the entire time period and is smaller than the estimated increase of 28.9% in the DDD regressions. The overall difference in sales relative to the synthetic control of 28.64 units is significantly lower than the difference in absolute means. It highlights the improved fit of a synthetic control versus a simple average of all control stores.

Fig. 4 provides the same graphical representation for the *low fat* treatment, which resulted in a steep drop in sales. This trend is consistent with our DD and DDD estimates and comparisons of means. Sales drop by 27.7 units in the second week, corresponding to a 68.03% decrease in sales. Fig. 5 also provides an illustration of the statistical significance of this negative treatment effect. The red line shows the difference in sales in the treatment store relative to changes in sales its synthetic control store. The dashed gray lines represent the difference in sales associated with each of the placebo tests for the 27 possible controls. Each gray line shows the difference in sales between each control store and its synthetic version. Comparing placebo effects (in gray) to the effect of the intervention in the actual treatment store (in red), we conclude that difference in sales observed in the treated store seems large relative to the distribution of the random (placebo) differences for the control stores. The drop in sales in the first and second week for instance is not matched by any other placebo run.

Finally, we conduct this analysis for the *no trans fat* treatment. Here, we are only evaluating the partial treatment effect of the combined labeling treatment for store 5. We cannot simultaneously

Table 8
Differences in total sales of treatment vs. synthetic control store by label treatment.

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: Total weekly sales of treated products in the treatment and synthetic control store are reported. Treatment weeks are highlighted in bold font.

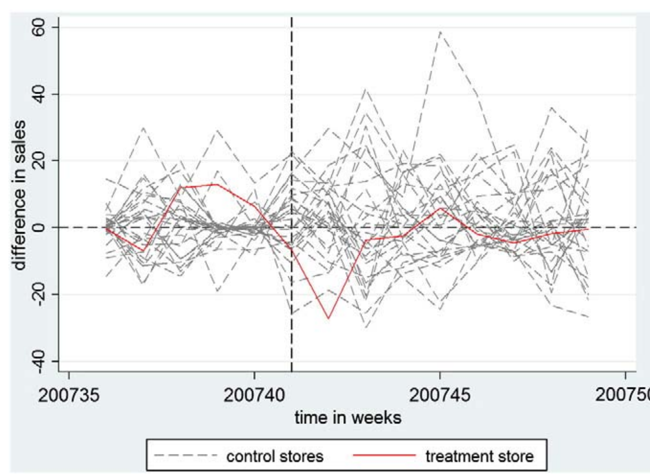

Fig. 5. Differences and actual and placebo labeling effects on sales for *low fat* products. Note: This figure illustrates the statistical significance of the *low fat* treatment effect. The red line shows the difference in sales in the treatment store relative to changes in sales in the synthetic control store. The dashed gray lines represent the difference in sales associated with each of the placebo tests for the 27 possible controls. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

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compare this effect to the effects of other labels in the combined labeling treatment due to the single unit treatment restriction of the SCM. These results are included in Table 8. The effect of the *no trans fat* label is less pronounced than the *low calorie* and *low fat* treatment effects, possibly because the synthetic control does not provide as good a fit to the treated store. The created synthetic control store has considerably higher sales that the treated store and the trend in the treated store's sales goes in the opposite direction, eventually rising above total sales for the synthetic control. This treatment also increases sales most in the weeks right after the treatment and the treatment effect persists after our treatment period. As we repeat information already available and advertised for this treatment, consumers can easily take this information into account, even after our labels disappear. In contrast, the information provided for the *low calorie* and *low fat* treatment cannot be as easily recalled in the post-treatment period. Sales trends in those treatments converge back to the synthetic control after our treatment period.

4. Conclusions

In this paper, we analyzed whether information costs prevent consumers from fully optimizing their purchase decisions with regards to currently available nutritional information. Focusing on consumer information costs under the NFP, we use a market-level experiment to estimate the effect of making nutritional information more salient and easier to process. Our implemented nutritional shelf labels allow consumers to make direct comparisons regarding nutrient content by either repeating available information in a more uniform format (*no trans fat* label), or translating quantitative information into categorical statements (*low calorie* and *low fat* label). Our interventions focus on one nutrient or a combination of nutrients in a single label. Combining multiple nutrient claims in one label increases the label's information content, but information costs also increase. We also analyze whether unlabeled products were affected, as we implicitly provide information about the superior nutritional content of these product alternatives.

Our empirical design further allows us to incorporate and test previous findings in the literature on consumer response to labeling information. We were able to address potential differences in consumer purchase response based on the nutrient displayed. We tested *low calorie* labels because calorie content has been determined as the most relevant nutrient in relation to weight gain and obesity prevention (CDC, 2008).[17] The World Health Organization (WHO), in contrast, endorses the promotion of *low fat* products as one strategy to reduce obesity rates (WHO, 2004). Yet, simple *low fat* claims might increase overall food intake due to reduced consumption guilt (e.g. Wansink and Chandon, 2006), or trigger negative taste perceptions (e.g. Yeomans et al., 2001). We further wanted to compare possible information effects for these nutrients to *no trans fat* labeling information. Health concerns related to trans fats received a lot of media attention, and *no trans fat* advertisements were readily adopted by food manufacturers. Consumers might therefore be well informed about this nutrient and more able to readily incorporate information into their purchase decision. Finally, as consumers might view these labels as in-store nutritional advertisement, we added an FDA approval to one of our label treatments to investigate whether it increased the credibility of the provided information.

We implemented five labeling treatments for one product category (microwave popcorn) in five stores over a time period of four weeks in the fall of 2007. The supermarket chain provided weekly store-level scanner data for these treatment stores and 27 control stores within the same price division over a period of 14 weeks. By adding the information provided on the NFP for each product included in this data, we find substantial variation in nutrient content and suggested serving size in our product category. Consumers trying to compare products based on their nutritional characteristics might therefore face significant information costs.

Estimations of average treatment effects of our labeling intervention are based on difference-in-differences and triple-difference approaches identified by a cross-sectional and time-series control structure. In addition, we draw inference about the effect of our labeling treatments on product sales with a synthetic control method approach. Our analysis suggests that consumer purchases are affected by our labeling treatments. Information costs prevent some consumers from incorporating nutritional information in their purchasing decisions under currently implemented labeling regulations. Our findings are not driven by consumers simply paying more attention to labeled products, since we find no statistically significant effects of pooling all labeling treatments. However, a labeling treatment focusing on calorie content significantly increases sales, while focusing on fat content decreases sales. Displaying *no trans fat* labels also has positive and significant effects on sales, even though this information is already provided on the NFP and is highlighted in manufacturer claims. 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— an improvement in information content— does not result in a significant effect on sales. This may happen because multiple claims also increase information costs for consumers. Finally, our analysis suggests that the most sizable impact is observed right after the label implementation, with effect dissipating after the treatment period for *low calorie* and *low fat* labels. For the *no trans fat* labeling treatment, the effect persists even after the treatment period, possibly due to the fact that consumers can more easily recall their product choice in this regard using the NFP or manufacturer claims.

The observed divergent effect of *low fat* versus *low calorie* labels highlights an important challenge with regards to promoting healthier food choices. While our results confirm perceived tradeoffs between taste and nutritional content reported in the literature (e.g. French et al., 1999; Yeomans et al., 2001; Stubenitsky et al., 2000) for the *low fat* label, we do not observe a similar negative response to the *low calorie* label. This seems especially relevant since these two treatments exhibit a fairly large overlap of products. In general, treated products were significantly lower in sales as compared to the unlabeled products, potentially indicating taste preferences for high fat (high calorie) product alternatives in our product category. However, consumers seem to associate more favorable taste perceptions with the *low calorie* label than the *low fat* label. We also observe that overall category sales decreased as a result of our labeling interventions, suggesting that this substitution to healthier product alternatives was not offset by an overall increase in consumption.

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. While our study looks at only one product category, it adds a market-based approach on how nutritional shelf labeling affects purchase decisions to the existing literature. Our reduced-form approach precludes us from providing welfare estimations, but results suggest that consumers may benefit from simple shelf or front package labels that focus on calorie content. A provision of these categorical statements instead or in addition to detailed quantitative statements could enable consumers to better incorporate nutritional information into their purchasing choices. A focus on calories also seems in alignment with policy objectives since calorie intake has been identified as the main contributor to weight gain and obesity. Focusing instead on fat content, as suggested by the World Health Organization, might trigger negative taste perceptions in some consumers and prevent them from making healthier food choices.

[17] An extra 3500 calories result in a one pound weight gain (CDC, 2008).

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Acknowledgments

We thank the editor Pat Bajari, two anonymous referees, as well as Jenny Aker, Michael Anderson, Joshua Berning, Hayley Chouinard, Eric Hallstein, Guido Imbens, Joanne Lee, Jayson Lusk, Jill McClusky, Jeremy Magruder, Aviv Nevo, Jeff Perloff, Jay Variyam, participants of the FTC-Northwestern University microeconomics conference, the economics lunch in Harvard University, and the ERE seminar at UC Berkeley for helpful comments. We are also thankful to Eric Hallstein and Barruch Ben-Zekry for their help in implementing the shelf labels. 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.

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Please cite this article as: Kiesel, K., Villas-Boas, S.B., Can information costs affect consumer choice? Nutritional labels in a supermarket experiment, Int. J. Ind. Organ. (2010), doi:10.1016/j.ijindorg.2010.11.002