Consumer and Strategic Firm Response to Nutrition Shelf Labels

Sofia B. Villas-Boas, Kristin Kiesel, Joshua P. Berning, Hayley H. Chouinard, and Jill J. McCluskey

The display of nutrition facts is mandatory on virtually all packaged foods sold in the United States. Yet manufacturers and retailers add their own claims to differentiate their products and capture consumers' attention at point of sale. We implement experimental nutrition claims on shelf labels in a retail setting and test how consumers react to the display of these labels that express information reported on the Nutrition Facts Panel in a different format. We hypothesize that our labels either shift demand for the highlighted healthier products uniformly or trigger more complex demand rotations. Our estimated heterogeneous labeling effects suggest that consumers process nutrition information differently depending on which and how many claims are displayed and prefer products labeled with a single claim overall. When we simultaneously consider demand and supply responses under three price setting behaviors (competitive pricing, Bertrand-Nash pricing, and monopoly pricing), we find that consumer surplus and overall welfare is highest when our labels display multiple nutrient claims and retailers are able to adjust prices across the entire product category. Firms' profits are highest when single nutrient claims are displayed, however. We conclude that firms with market power have little incentive to voluntarily display nutrition claims that maximize welfare.

Key words: Market-level experiment, nutrition information, shelf labels, strategic price response, structural random utility demand, welfare analysis.

JEL codes: C93, D83, L15, M38, Q18.

The majority of Americans do not meet dietary guidelines and continue to consume more than the recommended values for added sugars, saturated fats, and overall calories in their diets (U.S. Department of Health and Human Services 2015). The Nutrition Labeling and Education Act (NLEA) of 1990 required the display of the nutrition facts panel (NFP) on packaged products, and recent revisions to the information requirements aim at better assisting consumers in developing healthier dietary practices (U.S. Food and Drug Administration 2018). However, food manufacturers have added additional front of package (FOP) claims, and grocery retailers are posting nutrition labels on grocery store shelves. Although the validity of these claims is monitored by the Food and Drug Administration (FDA), they are voluntary and firms selectively highlight product attributes. Nutrition FOP and shelf labels are just one of many dimensions of greater product differentiation in an increasingly concentrated retail market (Sexton 2013). Yet the impact of strategic firm response on consumer choice and overall welfare is not well understood.

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In this paper we explore revealed consumer preferences for experimental nutrition shelf labels. We apply distinct experimental labeling treatments to one product category (microwave popcorn) in select stores of a national grocery retailer. Relying on models of persuasion and information developed in the advertising literature (Ackerberg 2001, 2003; Johnson and Myatt 2006; Rickard et al. 2011), we hypothesize that our labels either shift demand for the highlighted healthier products uniformly or trigger more complex rotations of product demand. We then estimate demand for microwave popcorn using store-level scanner data in a discrete choice framework (McFadden and Train 2000; Nevo 2000) and calculate willingness to pay (WTP) estimates for the labeled products. Finally, we consider potential strategic firm responses resulting from an actual implementation of such labels under several supply scenarios. In simulations we first estimate a pure switching effect induced by our labels while keeping prices constant and then allow prices to adjust in order to estimate overall welfare changes under various degrees of market power (Small and Rosen 1981; Petrin 2002; Allenby et al. 2014).

Because strategic firm response can limit the impact of nutrition labels overall, effective regulation of information provision requires accounting for this behavior (Weil, Grahman, and Fung 2013). Moorman, Ferraro, and Huber (2012) find that some food manufacturers decreased their nutritional quality due to NFP regulations, and Mohr, Lichtenstein, and Janiszewski (2012) detect that firms manipulated serving size to make the information displayed on NFPs less salient. Although the recent revisions of the information provided on NFPs incorporate some of these findings, consumers state that they prefer simple FOP nutrition labels (Berning, Chouinard, and McCluskey 2011; Becker et al. 2015). Consumers also appear willing to pay for the customization of information to help inform their choices (Balcombe et al. 2015). Firms have experimented with FOP labels for a while (Levy and Fein 1998; Williams 2005; Grunert and Wills 2007), and a shift in regulation toward simple claims has been recommended to the FDA (Institute of Medicine 2012).

The literature already suggests that selective and strategic claims can reduce consumers' price sensitivity (Nikolova and Inman 2015). The introduction of such labels can also result in a stigma and an unintended decrease in the willingness to pay for some products (Kanter, Messer, and Kaiser 2009). Marketers may shift part of their resources from traditional media advertising to in-store marketing, and retailers may continue to employ sophisticated shelf management strategies (Chandon et al. 2009). Our analysis of experimental nutrition shelf labels adds new insights to the literature as market-based studies that allow for interactions between demand and supply responses to these types of labels have not been conducted.

All of our shelf labels highlight healthier products. They do not uniformly increase or shift demand for these products, however. Instead, they seem to rotate demand by allowing consumers to re-evaluate their purchases in more complex ways. For example, consumers are willing to pay up to \$1.54 for a "No Trans Fat" (NTF) shelf label on average, even though this information is already easily accessible and highly salient. This willingness to pay declines when we add "low fat" (LF) as well as "low calorie" (LC) claims to our labels. Overall, consumers seem to prefer single claims posted on labels and value products highlighted by a LC shelf label more than unlabeled products. Strikingly, the almost identical set of products would need to be discounted when labeled with a LF claim.

Once we allow firms to adjust their prices in response to these observed differences in consumer preferences and simulate welfare changes, we find significant consumer welfare losses when adding single claim shelf labels compared to not displaying a label. Posting a comprehensive list of claims on a shelf label instead results in an increase in consumer surplus and the largest overall welfare change. This labeling treatment does not maximize profits, and firms would not voluntarily label their products in this way.

Our most important result reported here is that voluntary nutrition FOP or shelf labels may not be a panacea when trying to inform consumers about healthier food options. Consumers react differently to nutrition shelf labels depending on which and how many claims are displayed. Our simulations of strategic firm response in concentrated markets further suggest that policy and firm incentives might not be aligned and that voluntary posting of selective claims will not necessarily benefit consumers. Our findings motivate future research to inform regulations of claims and information requirements for NFPs.

The remainder of this paper is structured as follows. In section 2 we describe our experiment, including characteristics of our label design and potential effects on consumer demand, and provide summary statistics for our data. We specify the structural demand model and the derivation of WTP measures for products highlighted by our experimental shelf labels as well as voluntary FOP claims in section 3. In section 4 we present these structural estimates. Finally, we specify alternative supply scenarios and estimate general equilibrium models to perform counterfactual simulations and present estimates of overall welfare changes in section 5. In section 6 we conclude and re-emphasize important implications of our findings.

The Labeling Experiment

The product category analyzed was deliberately chosen based on experimental considerations as well as restrictions imposed by the retailer. Microwave popcorn products are similar with respect to key attributes (size, packaging, etc.) and therefore allow comparisons across brands. Calories and fat content can vary significantly across products, and popcorn can be both a healthy snack or an unhealthy treat once butter and other flavors are added.[1] Finally, popcorn sales represent a relatively small share of retail revenue, limiting potential risks of a market-level experiment faced by the retailer.

The retailer agreed to post a selection of positively perceived nutrient claims (e.g., "Low Fat" claims but not "Medium Fat" or "High Fat" claims) on shelf labels over a four-week period and designated five stores comparable in size, product assortment, and consumer demographics as treatment stores. The retailer provided a dictionary of all products sold in the microwave popcorn category. We collected additional nutrition information for sixty-eight of these products using the information provided on NFPs via store visits and web searches. We then identified which products meet the FDA guidelines for LC and LF labels, and which products do not have trans fats.[2] The retailer was primarily interested in fat related claims and favored a plain blue label, resulting in the following five label treatments displayed in figure 1.

In the first store we added LF shelf labels. In the second store we also disclosed that the LF claim followed FDA guidelines to allow consumers to distinguish this shelf label from potentially spurious advertising claims. This treatment incorporates previous findings of consumer inattention to missing information and possible conflicts of interests when firms voluntarily disclose product attribute information (Loewenstein, Sunstein, and Golman 2014). In the third store we displayed LC shelf labels instead. Even though the primary source of calories in this product category is fat, and an almost identical set of products is being treated with labels in this store, consumer perceptions and inferences regarding other product attributes might differ depending on which nutrient is highlighted on a label. In the fourth store, we combined LF and LC claims resulting in the introduction of several label options.[3] This treatment increases search costs for consumers slightly but in potentially significant ways as consumers make decisions in less than a second and on average take 15.5 seconds to choose a product at a grocery store (Chandon et al. 2009). In our final treatment store, in addition to LF and LC claims, we also introduce a NTF claim. This means that we post seven different shelf labels in this store. The NTF claim expresses information already displayed on packages. Potentially harmful health effects of trans fats were well publicized during the time of our experiment and a number of products already highlight this claim on the front of the package, making this information highly salient already. This treatment incorporates previous findings that consumers use information selectively. Sharot et al. (2012) find that consumers are more likely to pay attention to information they are already familiar with if it supports decisions they have already made and ignore or downplay other information.

[1] Popcorn is low in calories and supplies antioxidants, protein, fiber, and polyphenol. Our experiment was conducted before concerns emerged that a chemical coating used in microwave popcorn bags breaks down into perfluorooctanoic when heated. The Environmental Protection Agency has now specified this substance as a likely carcinogen.

[2] FDA labeling guidelines allow products containing less than 0.5 g of trans fat per serving to be declared as 0 g on the NFP and state that the determination of whether a product is free of a nutrient such as fat be based on the value of the nutrient per labeled serving. Only more recently (after declaring that trans fat is no longer recognized as safe for any use in human consumption in 2013), did the FDA advise manufacturers that "No Trans Fat" claims were unauthorized nutrient content claims when products contains small amounts of trans fats and that product labels stating the amount of trans fats per serving should be used instead. We are therefore not considering possible differences in information content between trans fat listings on the NFP, our shelf labels, or front of package claims.

[3] A small number of sweetened popcorn varieties qualify for the fat but not the calorie claim, and an even smaller number of products narrowly qualify for the calorie claim but not the fat claim.

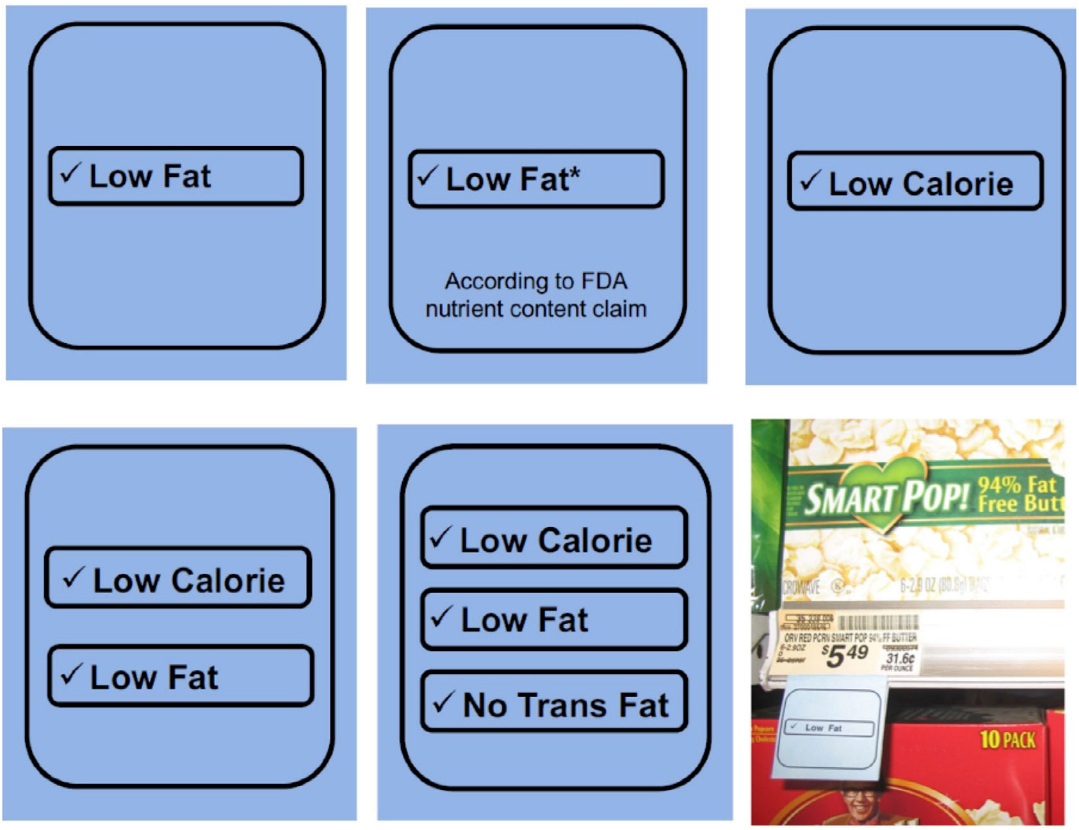

Figure 1. Label treatment implementation at stores

Note: This figure depicts the five labeling treatments implemented in five distinct stores. The label combining LF and LC claims is only one of the three types of labels displayed in that store. Similarly, the label featuring all three claims is only one of the seven possible labels displayed in the fifth treatment store. The lower right panel also shows how we displayed the labels below each eligible product and its pricing information on grocery shelves.

We placed these labels below the already posted pricing information for each eligible product on the grocery shelf as depicted in the lower right panel in figure 1. We recorded all related voluntary FOP nutrition claims already displayed on product packages (e.g. “94% Fat Free,” “100 Calories” and “No Trans Fat”).

Empirical studies on nutrition labeling that elicit consumers’ preferences for information provision via surveys and lab experiments indicate that marginal effects of additional label information on consumer choice depend on the relationship with product attributes, and the number of attributes highlighted in claims (Gao and Schroeder 2009). Our experimental shelf labels aim at reducing search costs for consumers that are trying to distinguish between healthy and unhealthy alternatives but also allow for differences in consumer perceptions and inferences about product attributes depending on the claim displayed. Our claims transform the information provided on NFPs into comparative statements (“Low Fat” and “Low Calorie”) or express information already reported (“No Trans Fat”). They further highlight select claims or combine claims in a label.

We conceptualize the potential effects of these labels on demand by referring to the advertising literature. Existing models distinguish among the persuasiveness, the informativeness, and the complementariness of advertising that assumes consumers receive utility from both the advertised product and the advertising itself (Rickard et al. 2011). If all of our labels simply draw attention to the labeled product and persuade or remind consumers that these are higher quality or healthier products, demand for labeled products would shift up uniformly. If our labels are truly informative to at least some consumers, they might trigger a re-evaluation of their choice sets. Highlighting select nutrient claims and reducing search costs could change consumer inferences about product attributes and comparisons across products. Providing nutrient information in a more salient fashion does not necessarily increase the WTP for all labeled products in this case and could even reduce sales of some labeled products (Johnson and Myatt 2006).[4] We are not making a priori assumptions of how our labels affect demand. Instead, we designed our treatments in a way that allows us to empirically distinguish between a uniform shift in the demand of all labeled products as well as a rotations in the demand of labeled product depending on the claims displayed on the label.

Store-Level Scanner Data

We posted these labels on grocery shelves for four weeks starting on October 10, 2007. In addition to providing weekly store-level scanner data for the five treatment stores, the retailer provided data for twenty-seven stores from the same pricing division that did not post nutrition shelf labels. In order to analyze label effects using a structural demand model, we requested data for an extended time period as well as for additional product categories to define an outside or no-purchase option described in more detail in section 3.1.

The data are organized by UPC and include information on units sold, net total dollar amount paid, and any retail markdown offered. Prices and promotions are similar across stores as all stores are selected from within the same pricing division. This limited cross-sectional variation in prices means that we primarily rely on time-series variation to identify price coefficients in our structural demand estimation. Given that products are infrequently purchased, we further aggregate the data by month and compute average monthly prices by dividing the net dollar amount sold during a month by the number of units sold. We then create an indicator to capture whether a product was discounted at any point during a given month.

[4] Using a slightly different approach, Ackerberg (2001, 2003) argued that one could empirically distinguish between persuasive and informative functions of advertising by observing consumer behavior of inexperienced and experienced or informed consumers. Both groups can be persuaded by advertising, but only less informed consumers should be affected by the informative function of advertising.

We received data covering a period of two years (February 2006 to February 2008) but ultimately restricted the data used in our analysis to a five month period (July 2007–November 2007). We did so to keep the choice set of consumers representative of the choices observed in our treatment stores during the treatment period. The resulting final data set includes 860 product by month and store observations from treatment stores, and 4,551 corresponding observations from twenty-seven control stores for the microwave popcorn category. The sixty-eight products for which we collected nutrition information cover all products sold in the treatment stores during this five month period. However, an additional 0 to 12 products are sold in each of our control stores, with an average of three additional products per store over the entire time period.

Summary Statistics for Implemented Labeling Treatments

Table 1 lists our assigned labels and provides summary statistics for each treatment. The first column lists each treatment store, in column (2) and (3) we describe the labeling options for these stores, and column (4) reports the number of products (unique UPCs) assigned to each option. We also report average quantity sales and product prices. Columns (5) to (7) report these averaged over all control stores, whereas columns (8) to (10) report quantities and prices for the corresponding treatment stores. Importantly, as our labels are experimental, retail prices are not affected by these labels, and we only report prices for the period prior to our labeling treatment.

The second treatment store only displayed thirty-six products of the sixty-eight products analyzed on the shelves during the treatment period, potentially due to its slightly smaller overall size. The remaining treatment stores displayed all sixty-eight products. The number of products not eligible for a label was proportionally higher than the products eligible for all but the fifth treatment store. For treatment store 1 (LF claim) and 3 (LC claim), forty-six and forty-five products were not eligible, while twenty-two and twenty-three products received a label, respectively. This ratio reverses for treatment store 5, where twenty-five products were label ineligible, while forty-three products were labeled. Only

Table 1. Summary of Treatment Eligibility, Sales, and Prices across Stores

			(4)	(5)	(6) Control Stores	(7)	(8)	(9) Treatment Stores	(10)
Store	Option	Type	Number of products (UPCs)	Quantity before	Quantity after	Price before	Quantity before	Quantity after	Price before
1	1	Shelf label ineligible	46	4.44	5.02	3.34	4.06	3.58	3.45
	2	LF claim eligible	22	3.35	4.57	3.26	2.86	3.38	3.46
		Number observations		1,113	1,150		48	46	
2	1	Shelf label ineligible	20	5.53	6.89	2.91	4.58	5.38	3.16
	2	LF (FDA) claim eligible	16	3.02	4.58	3.68	4.94	4.36	3.74
		Number observations		560	575		27	27	
3	1	Shelf label ineligible	45	4.48	5.12	3.28	7.53	6.94	3.60
	2	LC claim eligible	23	3.34	4.39	3.38	5.33	6.47	3.71
		Number observations		1,113	1,150		50	50	
4	1	Shelf label ineligible	41	4.68	5.22	3.24	2.79	3.48	3.46
	2	LF claim eligible	4	2.26	4.16	3.74	1.00	2.00	2.69
	3	LC claim eligible	5	2.48	3.32	4.18	4.00	3.00	4.50
	4	LC and LF claim eligible	18	3.56	4.66	3.17	3.33	2.89	2.67
		Number observations		1,113	1,150		35	39	
5	1	Shelf label ineligible	25	5.31	5.06	3.34	6.11	4.25	3.08
	2	LF claim eligible	1	2.59	3.65	2.67	1.01	2.00	1.71
	3	LC claim eligible	1	1.94	2.08	5.38	5.00	1.00	5.37
	4	LC and LF claim eligible	2	4.60	5.19	1.94	8.50	3.50	1.55
	5	NTF claim eligible	16	3.68	5.46	3.08	6.58	8.82	2.79
	6	LF and NTF claim eligible	3	2.14	4.40	4.15	1.50	8.00	3.63
	7	LC and NTF eligible	4	2.63	3.54	3.83	4.00	2.00	3.85
	8	LF and LC and NTF eligible	16	3.43	4.60	3.33	4.14	5.06	2.92
		Number observations		1,113	1,150		52	56	

Notes: Each section of the above table corresponds to one of our five treatment stores. The first column lists the store, the second identifies the treatment or label options for these stores with option 1 classifying products that were not eligible to receive a label. The third column lists the claims displayed on these labels. Column (4) reports the number of products in each of the label categories, and column (5) to (10) report the average weekly product quantities sold and prices in these categories for our control and treatment stores. We report product quantities for two months only, the month before (the month just before we implemented our label treatment) and after (the month during which our labels were displayed) we posted our labels in the stores. No significant differences in prices were detected for these time periods. As prices are not affected by or correlated with our label treatments, they are reported only once (before).

one product each was eligible for a single fat or calorie claim label, two for a label that combines both claims, and sixteen for a NTF claim only in this treatment.[5] We report average product sales for the month prior to our treatment as well as during the treatment month (after our labels were posted).

Average product quantities sold and prices did not vary in a detectable pattern between treatment and control stores. We observe both slightly higher sales (store 3) and slightly lower sales (store 4) for our treatment stores than for the control stores on average. Consistent with the greater number of unlabeled products offered, average quantities sold were slightly higher for these products in both treatment and control stores. This does not seem to be a result of average price differences, as average prices were not systematically lower for these products. Products under some label options were slightly more expensive on average, but labeled products were not more expensive as a whole.

Average product sales seemed to have increased for some of our label treatments. Displaying a LF claim only in the first treatment store increased average product sales (by UPC) from 2.86 to 3.38 units sold in the treatment store during the treatment period. Average quantities for unlabeled products decreased slightly in the treatment store as well. In the control stores, sales for both product groups increased instead. In the second treatment store (adding the FDA reference to the label), we observe decreased average sales for labeled products (4.95 to 4.36), whereas unlabeled products increased in sales from 4.58 to 5.38 units. Sales for both product groups increased in the control stores once more. For the third store (LC claim), we observe increased sales for the labeled products and decreased sales for the ineligible products, whereas sales increased for both groups in the control stores. The direction of the labeling effects varied for the combined labeling treatment in store 4. Average quantity sales increased for products labeled with the LF claim only and for unlabeled products, whereas sales decreased for the other two labeling treatments. All sales increased in the control stores again. Finally, we observe a decrease in average product sales for unlabeled products in the last treatment store as well as the control stores, possibly due to the increase in products eligible for labels. Product sales further decreased for the LC single claim, the combined LF and LC claim, and the combined LC and NTF claim in this treatment store. Sales for the remaining label options increased in the treatment store. In contrast, sales for all labeled products increased in the control stores.

These diverse trends are a first indication that our labels did not uniformly increase demand. They further suggest that product sales decrease for some label options.[6] Analyzing label effects in a structural demand model will provide further insights and allow us to estimate average consumer WTP for each of our experimental label treatments.

The Structural Consumer Demand Model

In order to estimate the effect of our experimental labels on consumer demand, we specify a discrete choice random utility model (McFadden 1974; McFadden and Train 2000; Train 2009), where product attributes and labels enter consumers' indirect utility linearly. Our labels were experimental and actual product attributes did not change. This specification therefore allows us to compute consumer WTP for the products highlighted by our labels in a straightforward way. We model each label as a possible demand determinant common to all products highlighted by specific nutrition claims. This means that we can estimate a potential attention or persuasion effect common to all labels introduced, as well as label-specific information effects on product demand. We can further test for changes in the price elasticity of demand as a result of the introduced labels.

If consumers already incorporated all information available on the NFP, any inferences about nutrition characteristics highlighted by our labels as well as already perceived trade-offs between these and other attributes for each microwave popcorn product available would be captured by product fixed effects or

[5] Note that not all products were sold over the analyzed time period. Our sales data only records products that had non-zero sales and therefore includes a slightly lower number of labeled products for each treatment store (21, 15, 22, 21, and 38 in the order of the listed treatment stores).

[6] Previously published research (Kiesel and Villas-Boas 2013) reports reduced form results of our label experiment estimating triple-differences using a shorter time period of scanner data. We re-estimated previously published specifications with this larger data set and found that these results replicated those reported. Due to space considerations they are not reported here.

the time-invariant determinant of the indirect utility for product *j*. We are also able to control for already displayed voluntary FOP claims on product packages. To account for any potential unobserved differences in the composition of consumers, consumer knowledge, and preferences across stores, we include store fixed effects.

A product *j* is defined as a specific popcorn UPC sold at a specific store, and we define each store as a local market. Only UPCs in the same store are assumed to be in the choice set of a consumer as stores are located in geographically distinct areas and different zip codes. We describe the utility for consumer *i*, from consuming product *j*, and in month *t* as:

$$(1) \qquad U_{ijt} = \alpha_j + \alpha_t - \beta p_{jt} + X_{jt}\beta_x + \gamma T_{jt} Nut_{jt} + \xi_{jt} + \varepsilon_{ijt}.$$

In this equation α_j denotes a product fixed effect capturing intrinsic (constant) preferences for a product based on observable attributes and perceived values, and α_t denotes a month fixed effect capturing monthly changes common to all popcorn products. The shelf price is denoted by p_{jt}, and the marginal utility of price is captured by β. The term X_{jt} includes a treatment store indicator, a treatment month indicator, an organic product indicator, as well as indicators for voluntary FOP claims already displayed on packages. The parameter γ measures consumer's average marginal utility from the added shelf label displayed for product *j* during the treatment period (captured by T_{jt}, an indicator variable equal to one for treatment stores during the treatment period, and zero otherwise). Nut_{jt} is an indicator capturing whether product *j* is eligible for a specific shelf label.[7] The term ξ_{jt} accounts for monthly changes in marketing factors observed by consumers and firms but not the researcher, such as changes in shelf space and positioning of the product at point of sale. We further assume ε_{ijt} to be an i.i.d. type I extreme value distributed error term capturing consumer idiosyncratic preferences. Finally, possible category expansions or contractions are captured by including an outside or no-purchase option indexed as $n = 0$. This no-purchase utility is normalized to zero and given by the idiosyncratic term $U_{i0t} = \varepsilon_{i0t}$.

[7] Nut_{jt} actually represents 13 different indicator variables. For instance, one indicator variable captures the eligibility for a single LF claim and label added to products in treatment store 1.

Although a more complex demand model allowing for consumer heterogeneity could provide additional insights into how our experimental labels affect demand, this simple demand specification does not limit our subsequent analysis of potential strategic response by firms. Strategic pricing decisions are typically applied across stores, for example over an entire pricing division (DellaVigna and Gentzkow 2017). In our simulation of supply responses we take advantage of the fact that our labels were experimental and exogenous to manufacturer or retailer decisions and implicitly assume that strategic decisions by either are made based on average consumer demographics and observed sales trends.

Pre-Treatment Average Market Shares and Trends for Treatment and Control Stores

We begin our structural demand analysis by computing market shares for the sixty-eight products included in our analysis. We do so for each store–month combination, dividing observed sales in each label option by a potential market share that includes an outside option. To define the outside option, we aggregate data for potato chips and other chips. Products in these two categories take up most if not all of the remaining shelve space in the aisle our analyzed products are displayed and can be viewed as close substitutes to popcorn purchases. Our defined outside or no purchase option can be visualized as entering the popcorn aisle but instead buying an item in these alternative snack categories. Due to the experimental character of our labels and selective placement, we implicitly assume that our labels do not induce substitution away from other snack foods displayed elsewhere in the store (e.g. candy bars, etc.). We therefore define a market for salty snacks and compute total sales in a certain month and store as the sum of sales in all three product categories (potato chips, other chips, and popcorn sales). The resulting sales in store *s* during month *m*, are denoted by M_{ms}, and we use the maximum of monthly total sales over the entire time period ($M_s = max(M_{ms})$) to define store specific constant market sizes.

A visual representation of market shares for label eligible and label ineligible products is depicted in figure 2. We report market shares for a specific treatment store (left graph) as well as across all control stores (right graph) in each panel, and use pre-treatment data only

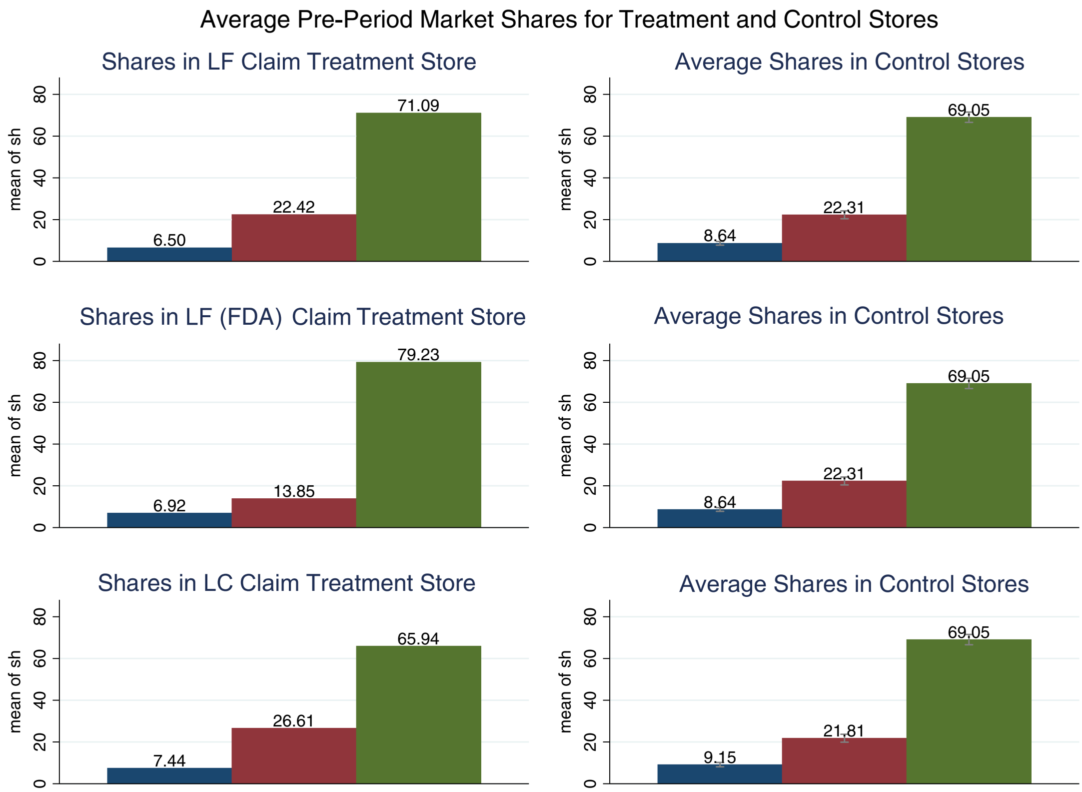

Figure 2. Average pre-period market shares of popcorn purchases by label options and no purchase options across treatment and control stores

Note: The top left graph displays shares of popcorn products eligible for a LF label in blue, of popcorn products not eligible for a label in red, and our defined outside options (potato chips and other chips) in green for the first treatment store. The top right graph displays the same information averaged across all control stores. The middle panel summarizes market shares for the LF (FDA) label treatment instead, whereas the bottom panel displays market shares for the LC label treatment. We compute market shares using pre-treatment data only and derive the market share of a product by dividing the number of units sold in a store and month by the market size. We define the market size for each store as the maximum of monthly total sales (microwave popcorn, potato chips and other chips) over the entire period in that store.

to test if treatment and control stores have similar average market shares. The top panel of figure 2 displays bar graphs for LF shelf label eligible shares in blue, label ineligible market shares in red, and outside option shares in green. The middle panel depicts the same graphs for LF label eligible products in the second treatment store for which we added the FDA explanation, and the bottom panel depicts shares for the LC shelf label treatment.

The largest market shares belong to our defined outside option (potato chips and other chips) purchases, followed by label ineligible popcorn products, and we observe no significant differences in pre-treatment average shares across treatment and control stores for each label option.[8] We formally test for similar pre-treatment trends for labeled products across treatment and control stores. Table 2 reports regression results from estimating a reduced-form triple difference specification with product market shares as our dependent variable. We use the month prior to our labeling intervention as a pseudo-treatment period and confirm that none of the estimated average pseudo-treatment effects are statistically significant. This allows us to interpret the impact of our experimental shelf labels on demand, resulting WTP estimates, and our simulated welfare changes as causal effects.

Market Shares for Products

Assuming that consumers purchase one unit of product j among all the possible products available at a certain time t that maximizes their indirect utility, the market share of

[8] Although not depicted here, the remaining two treatment stores display similar patterns.

Table 2. Reduced-Form Estimates Pre-Period Pseudo Labels in a Triple Difference Specification

	(1)	(2)	(3)	(4)	(5)
Price	–0.511***	–0.528***	–0.519***	–0.513***	–0.515***
	(0.032)	(0.033)	(0.033)	(0.032)	(0.033)
LF claim	0.157				
	(0.162)				
LF claim (FDA)	–0.275				
		(0.260)			
LC claim			0.059		
			(0.135)		
LF claim				0.372	
				(0.557)	
LC claim				0.098	
				(0.224)	
LF and LC claim				–0.009	
				(0.180)	
LF claim					0.040
					(0.180)
LC claim					0.000
					(.)
LF and LC claim					0.572
					(0.432)
NTF claim					–0.203
					(0.199)
LF and NTF claim					–0.263
					(0.173)
LC and NTF claim					–0.019
					(0.159)
LF, LC, and NTF claim					–0.042
					(0.186)
Num of obs.	2,410	2,388	2,413	2,403	2,415
R squared	0.39	0.39	0.39	0.39	0.39
Product FE	YES	YES	YES	YES	YES
Store FE	YES	YES	YES	YES	YES

Notes: Clustered errors are reported in parentheses at the product-store level. Regressions are estimated separately for each of the five treatment stores and reported in column (1) to (5). Pseudo treatment effects allow testing for similar trends relative to all 27 control stores during the month preceding our treatment implementation. The dependent variable is the market share (in percentage) per product, by store, and by month. *p < 0.10, **p < 0.05, and ***p < 0.01.

product *j* during period *t* is given by the probability that good *j* is chosen, or:

$$(2)\quad s_{jt} = \int_{(\varepsilon_{ijt})} \left(U_{ijt} > U_{int} \forall n = 1, \ldots, N\right) dF(\varepsilon)$$

which becomes:

$$(3)\quad s_{jt} = \frac{\exp\left(\alpha_j + \alpha_t - \beta p_{jt} + X_{jt}\beta_x + \gamma T_{jt} Nut_{jt} + \xi_{jt}\right)}{\sum_{n=0}^{N} \exp(\alpha_n - \beta p_{nt} + X_{nt}\beta_x + \gamma T_{nt} Nut_{nt} + \xi_{nt})}.$$

We follow Berry (1994) to construct a demand equation that is linear in the parameters. Subtracting the log of market share for each product from the log of the market share of the outside option, using:

$$(4)\quad s_{jt} = \frac{e^{\alpha_j + \alpha_t - \beta p_{jt} + X_{jt}\beta_x + \gamma T_{jt} Nut_{nt} + \xi_{jt}}}{1 + \sum_{n=1}^{N} e^{\alpha_n + \alpha_t - \beta p_{nt} + X_{nt}\beta_x + \gamma T_{nt} Nut_{nt} + \xi_{nt}}}$$

and:

$$(5)\quad s_{0t} = \frac{1}{1 + \sum_{n=1}^{N} e^{\alpha_n + \alpha_t - \beta p_{nt} + X_{nt}\beta_x + \gamma T_{nt} Nut_{nt} + \xi_{nt}}},$$

we arrive at our estimation equation:

$$(6)\quad ln\left(s_{jt}\right) - ln\left(s_{0t}\right) = \alpha_j + \alpha_t - \beta p_{jt} + X_{jt}\beta_x + \gamma T_{jt} Nut_{jt} + \xi_{jt}.$$

Prices are set at a division level and not correlated with product–month specific determinants of demand in each store. Thus, price is not endogenous in this demand equation. Importantly, our experimental shelf labels are also uncorrelated with changes in prices.

We estimate equation (6) using fixed effects panel regressions. As before, product fixed effects α_j capture (constant) consumer preferences for a given product based on observable attributes and perceived values, and month fixed effects α_t capture time varying factors (monthly) common to all products in the data. The econometric error that remains, (ξ_{jt}) accounts for changes in unobserved determinants of consumer demand for the products included in the analysis.

Results from the Structural Demand Estimation

Table 3 reports the marginal utility estimates for all label treatments. The dependent variable is the log share of a product *j* sold in a given store during month *t* minus the log of the share of the outside option in the same month and store. In column (1) we report the results for treatment store 1 that posts a single LF claim on shelf labels. The results for the LF claim and added FDA explanation are displayed in column (2). The remaining columns report results for the additional three treatment stores.[9]

The marginal utility for the LF claim in column (1) is negative but insignificant. It increases in magnitude and becomes significant in column (2) or treatment store 2. The marginal utility for posting the LC claim in store 3 is positive but insignificant once more. Products that are labeled with a single LC claim do display a positive and significant coefficient in column (4) or for the fourth treatment store. In contrast, these products display a negative and significant coefficient in store 5.[10] This might be the result of consumer's relative preference for products that were labeled with only the newly introduced NTF claim. Possible negative health effects of trans fats were frequently discussed in the media around the time of our experiment. Information about trans fats is already listed on NFPs and frequently highlighted with FOP labels. Nevertheless, we estimate a positive and significant effect on utility for the products labeled with just this claim. Although products that are labeled with this claim only are not labeled in any of the other treatments, the marginal utility received from the products that are labeled in the other treatments and now display all three possible claims on a shelf label in treatment store 5 increases significantly as well. This effect is smaller in magnitude than the effect for the products labeled with just the NTF claim, however.

Taken together, these results not only allow rejecting the hypothesis that our shelf labels uniformly increased demand, they also suggest that consumers prefer single claims and make different inferences depending on what claims are highlighted or combined. Combining LC and LF claims to provide more accurate and complete nutrition information did not increase consumer demand for these products. Demand for products labeled with a single LC claim did increase, but demand decreased when these products were labeled with a LF claim instead. In addition, adding a claim that consumers are already familiar with resulted in some consumers preferring products that display only this claim over products that display combinations of claims on a label. Relatively healthier products therefore received relatively less attention once this highly salient claim was posted.

We use the structural demand parameters to estimate the implied own and cross-price elasticities in the pre-period and treatment period for treatment as well as control stores and test for possible changes in demand substitution patterns due to shelf labels. We find that average price elasticities are not statistically different across periods and stores, however.[11]

Willingness to Pay for Nutrition Shelf Labels and Front of Package Claims

Finally, we derive average WTP estimates for nutrition shelf labels as well as for related voluntary FOP nutrition claims by following two commonly used methods described in the literature: (1) dividing the estimates for γ from

[9] We capture the marginal utility effects for all the additional controls described above but do not report these results here.

[10] Four of the five products labeled with the single calorie claim in store 4 receive a label displaying a LC and NTF claim in the fifth treatment store.

[11] The failure to reject the null that elasticities did not change, as well as estimated relatively small cross-price elasticities (0.01 and 0.02) might be a result of limited cross-sectional variation in prices in our data.

Table 3. Structural Demand Estimates for Shelf Label Treatments (Marginal Utilities)

	(1)	(2)	(3)	(4)	(5)
Price	−0.442***	−0.507***	−0.436***	−0.436***	−0.439***
	(0.030)	(0.028)	(0.030)	(0.030)	(0.030)
LF claim	−0.090				
	(0.143)				
LF (FDA) claim		−0.481**			
		(0.191)			
LC claim			0.216		
			(0.177)		
LF claim				0.291	
				(0.260)	
LC caim				0.579**	
				(0.269)	
LF and LC claim				0.223	
				(0.141)	
LF claim					−0.174
					(0.127)
LC claim					−1.265***
					(0.117)
LF and LC claim					−0.002
					(0.145)
NTF claim					0.674***
					(0.161)
LF and NTF claim					0.384
					(0.712)
LC and NTF claim					−0.584***
					(0.213)
LF, LC, and NTF claim					0.405**
					(0.176)
Num of obs.	3,843	3,878	3,856	3,840	3,796
R squared	0.552	0.522	0.548	0.551	0.547
Product FE	YES	YES	YES	YES	YES
Store FE	YES	YES	YES	YES	YES

Notes: Clustered errors are reported in parentheses at the product-store level. Regressions are estimated separately for each of the five treatment stores and reported in column (1) to (5). Triple interactions (label eligibility, treatment month and treatment store) allow estimating marginal utility changes relative to all 27 control stores. The dependent variable is the difference in the log of market share for each product and the outside option. *p < 0.10, **p < 0.05, and ***p < 0.01.

equation (6) by the average marginal utility of price β from the same equation; (2) using the demand results to estimate the change in consumer welfare (or surplus) due to the label changes in counterfactual simulations that keep prices constant. The second approach is based on simulations that remove shelf labels associated with significant WTP estimates (see Small and Rosen 1981; Allenby et al. 2014).

Table 4 reports the number of products that display voluntary FOP claims related to our labels. A few of the products that display a low fat or low calorie related FOP claim (three and four products, respectively) do not receive an experimental shelf label. Similarly, not all (twelve out of twenty-two and ten out of twenty-three, respectively) of the products that receive an experimental label displaying a LF or LC claims already display a related FOP label. In contrast, none of the products that are label ineligible for a NTF claim display a related FOP label, and thirty-one of the thirty-nine label eligible products do.

We report the average WTP results for both shelf labels and already included voluntary FOP claims in table 5. In our analysis of the FOP nutrition claims, we rely on control stores only because the average estimated parameters for FOP claims are unaffected by the experimental shelf labels in these stores. It is worth pointing out that the observed FOP claims are included as an additional reference but were not part of our market-level experiment. They are chosen voluntarily and strategically by manufacturers and in combination with other labeling and pricing decisions. Although we assign our label treatments randomly across our five

Table 4. Number of Products with Voluntary FOP Claims by Treatment Eligibility in Control Stores

(1) Type	(2) Number of products with low fat related claim	(3) Number of products without claim	(4) Total number of products
Shelf label ineligible	3	43	46
LF claim	12	10	22
Total	15	53	68
Type	Number of products with low calorie related claim	Number of products without claim	Total number of products
Shelf label ineligible	4	41	45
LC claim	7	16	23
Total	11	57	68
Type	Number of products with no trans fat claim	Number of products without claim	Total number of products
Shelf label ineligible	0	29	29
NTF claim	31	8	39
Total	31	37	68

Notes: This table focuses on products in control stores only. Each of the three panels corresponds to a front of package (FOP) claim. The first column (1) identifies the label eligibility. The second column (2) reports the number of products in each of these experimental shelf label options that also display a related FOP claim, and column (3) repeats the same for products without FOP claims. Column (4) reports the total number of products.

selected treatment stores for our experimental shelf labels, these FOP labels are not randomly assigned. The resulting WTP estimates for FOP labels are therefore observational, and we cannot interpret them as causal effects.

These limitations notwithstanding, our results suggest that consumers do not value products that display a FOP trans fat claim or calorie information on microwave popcorn packages on average, as we observe a negative and significant WTP for these products. Consumers seem to value products with “Fat Free” and related FOP labels, however. The observed very high average WTP for these products ($4.32) is likely affected by omitted variable bias. For instance, it might partially capture brand preferences as only a select number of brands use these labels.

The average additional willingness to pay for products with a LF claim posted on our shelf labels is negative, ranging from 20 cents to 95 cents (once the FDA explanation is added). It indicates that these products would need to be discounted to maintain previous sales. Although the WTP estimate for an almost identical set of products receiving LC label in treatment store 3 switches to being positive, it is not statistically significant. In treatment store 4 that features combinations of these two claims, consumers are willing to pay significantly more ($1.33) for products with a LC claim only but not for products highlighted by the remaining two labeling options. Finally, in treatment store 5 that posted all claim combinations on shelf labels, we observe a positive and significant willingness to pay for products that are highlighted by the now added NTF shelf label claim. With $1.54, it is the largest WTP estimate for our experimental labels. Once combined with both the LF and LC claim, consumers are still valuing these labels but their average WTP for products highlighted by this labeling option reduces to 92 cents. It is interesting that consumers were not willing to pay significantly more for these products when we labeled them with two claims only in treatment store 4.[12]

Rather than focusing on the surprising differences between our results for the already implemented voluntary FOP labels and our experimental shelf labels, the most important result is the dispersion of consumer valuation for these labels in both direction and magnitude, despite the fact that all of these labels try to draw consumers attention to healthier product attributes. The WTP estimates for our experimental shelf labels for instance suggest that posting a LF claim discourages

[12] We put less emphasis on the remaining claims here as very few products are labeled that way.

Table 5. Willingness to Pay for Nutrition Claims and Labels

		WTP in dollars
Front of package claims (FOP)	Fat free (and related)	4.32***
	No trans fat	−3.69**
	Calorie count (and related)	−1.85***
Experimental shelf labels		
Single claim treatments	LF claim	−0.20
	LF (FDA) claim	−0.95***
	LC claim	0.50
Two claims treatment	LF claim	0.67
	LC claim	1.33**
	LF and LC claim	0.51
Three claims treatment	LF claim	−0.40
	LC claim	−2.88***
	LF and LC claim	0.00
	NTF claim	1.54***
	LF and NTF claim	0.87
	LC and NTF claim	−1.33***
	LF, LC, and NTF claim	0.92**

Notes: WTP Estimates for FOP nutrition claims are based on control stores and demand estimates only. WTP Estimates for experimental shelf labels are based on differences reported in table 3. *p < 0.10, **p < 0.05, and ***p < 0.01.

purchases of labeled products. Related FOP claims on the other hand suggest that fat content related claims can be effectively used as strategic advertising claims. The results for our fifth labeling treatment that adds a NTF claim further echoes the findings of Sharot et al. (2012) in that consumers appear to value being reminded of information with which they are already familiar. This motivated attention might partially distract from other considerations, however, as consumers value products with a single NTF shelf label claim more than the relatively healthier products labeled with combined nutrient claims. Once more, these observed differences in WTP depending on the type of label confirm that nutrition claims do not uniformly shift demand. Instead, they seem to affect demand in more complex ways.

Welfare Changes under Different Labeling Scenarios

To investigate the potential welfare effects of our experimental labeling changes we specify a vertical supply model under three alternative assumptions regarding market structure: perfect competition, Bertrand-Nash, and monopoly. Perfect competition assumes that no margins are added throughout the supply chain. Under the Bertrand-Nash setting, manufacturers set wholesale prices equal to marginal costs, and manufacturers and retailers maximize vertical profits for each product or groups of products produced (e.g. products of a specific brand). The monopoly setting assumes that the retailer has all the market power and hence is able to jointly maximize profits by optimally adjusting prices across the entire product category. These two market power scenarios commonly used in the industrial organization literature allow us to capture increased concentration in food manufacturing and grocery retailing. Although the monopoly setting is often only included to establish upper bounds for estimates of strategic pricing, this setting could apply to our analyzed product category. Given our very small overall category sales, manufacturers may exert market power when negotiating product assortment and shelf space, but retailers (especially large national chains with private label brands) might then strategically set prices across the entire product category.

Counterfactual Simulations under Perfect Competition

Starting with an assumption of perfect competition in food manufacturing and retailing, we estimate changes in welfare by comparing choices with and without posting of our experimental shelf labels. In this setting, we assume that prices equal marginal costs and keep prices constant to estimate the pure consumption switching effect as a result of our labels. We therefore focus on changes in consumer surplus only to estimate overall welfare effects in this scenario. Using the observed consumer choices after our labels were posted, we can compute the resulting consumer surplus and simulate consumer choices if labels would have not been added. We compute the changes in consumer surplus, ceteris paribus (prices unchanged) following Small and Rosen

(1981) and Allenby et al. (2014). We first define the compensation variation or average expected consumer surplus, CS_i, as:

$$(7)\quad CS_{jt} = \frac{1}{|\beta|} ln \sum_j e^{\alpha_j + \alpha_t + X_{jt}\beta_x - \beta price_{jt}} + C,$$

where β denotes the average marginal utility of price and C is a constant. We estimate the CS for the baseline choices when shelf labels are displayed and then estimate the resulting consumer surplus for the next best alternatives consumers choose when nutrition shelf labels are no longer posted. It allows us to obtain the estimated changes in per capita consumer surplus from adding nutrition shelf labels in our treatment stores as:

$$(8)\quad \Delta CS = \sum_j \sum_t \left[CS_{jt,Labels} - CS_{jt,NoLabelsSimulation}\right],$$

differencing out the constant, C. A positive change in surplus means that our shelf labels are significantly valued by and benefit our consumers on average. For voluntary FOP claims, we follow a similar procedure and define the counterfactual as removing voluntary FOP claims from products in the control stores. However, we will have to interpret the results with caution due to the limitations already discussed.

Possible Strategic Pricing and Resulting Welfare Changes

Next, we assume that firms have market power and might strategically price their products as a result of a permanent introduction of our experimental shelf labels. We consider two types of pricing behavior, firms competing in a Bertrand-Nash setting or firms being able to set monopoly prices. Assuming that prices are derived in a Bertrand-Nash equilibrium, we subtract margins added by manufacturers or retailers from observed prices to recover marginal costs. When we assume monopoly pricing, we recover a lower bound on marginal costs by using a monopoly (larger) markup.[13] Once more, the monopoly price setting behavior captures a higher degree of market power in which the retailer can set prices for all products in a way to maximize total category or multi-product profits. We simulate the removal of our labels but now solve for new equilibrium prices under counterfactual scenarios. The final step is to perform simulations for estimated welfare changes, denoted as $Label_{No}$. Here we use the differences in nutrient information available to consumers as well as our recovered costs.

Bertrand-Nash Pricing

We simulate the equilibrium (N by 1) vector of retail prices p^* under alternative labeling scenarios ($Label_{No}$), assuming that firms play a Bertrand-Nash pricing game. We assume that wholesale prices are set equal to marginal costs, and retail prices p_j for each product j are set to maximize profits for each product, or $max\ \pi_1 = (p_1 - c_1)s_1, \ldots, max\ \pi_1 = (p_N - c_N)s_N$.

Using matrix notation and solving for profit maximizing prices, the equilibrium retail prices with labels p^0 can be expressed by an equation in which prices are equal to costs plus a Bertrand-Nash markup, given by:

$$(9)\quad p^0 = \hat{c^{bn}} - \left(T^{bn} * \delta\right)^{-1} s\left(p^0, Labels_{Yes}\right)$$

T^{bn} is a matrix with general element (j, k) = 1 if both products j and k are produced by the same firm, and equal to zero otherwise, and δ is the matrix of demand responses to price changes. Given that we observe the retail prices with labels p^0 and estimated demand, we can now estimate the markup term $-(T^{bn} * \delta)^{-1}s(p^0, Labels)$. We recover the marginal costs under Bertrand-Nash behavior, $\hat{c^{bn}}$, as shown in the Appendix.

The counterfactual equilibrium prices without labels are obtained by solving for the prices p^* that satisfy the fixed point:

$$(10)\quad p^* = \hat{c^{bn}} - \left(T^{bn} * \delta\right)^{-1} s\left(p^*, Labels_{No}\right).$$

Using these simulated counterfactual equilibrium prices p^* without labels, baseline prices p^0, and equation (8), we can compute the change in consumer surplus.

The changes in producer surplus are captured by the change in profits with and without labels (or with and without voluntary FOP claims) given baseline prices p^0 and new simulated prices p^*. Finally, we report total welfare changes as the sum of both.

[13] A derivation to recover marginal costs under both scenarios is included in the appendix.

Monopoly Pricing

This procedure is repeated considering a market setting where retailers can coordinate prices that maximize joint profits over all products, or the matrix $T^m = 1$ for all elements. Given that we observe p^0 and can estimate the monopoly markup term $-(T^m * \delta)^{-1}s(p^0, Labels_{Yes})$, monopoly costs are the difference between the two and defined as $\hat{c^m}$.

The simulations allow us to find the new equilibrium retail monopoly prices p^{**} that solve the fixed point under no labels given by:

$$(11) \quad p^{**} = \hat{c^m} - (T^m * \delta)^{-1} s(p^{**}, Label_{No}).$$

As before, using simulated prices p^{**}, baseline prices p^0, and equation (8), we compute the change in consumer surplus. The change in producer surplus is captured by changes in profits with and without nutrient information displayed, using baseline and simulated prices, and we report total welfare changes once more.

Estimated Average Welfare Changes Due to Experimental Shelf Labels

Table 6 reports the resulting monthly average price changes $p^* - p^0$, changes in consumer surplus (given by (8)), changes in producer surplus or profits, as well as overall changes in total welfare. All estimates are reported in dollars per capita and by month, and standard errors are reported in parentheses below the point estimates.

We report welfare changes for our shelf label treatments under all three pricing scenarios (competitive pricing, Bertrand-Nash pricing, and monopoly pricing) organized into four panels. The top three panels provide estimates for single nutrition claims displayed on our experimental shelf labels, and the bottom panel provides estimates for a label that combines all three claims.[14] We interpret the change given constant prices (competitive supply) to be the pure switching effect resulting from our labels. Allowing firms to adjust prices adds a strategic or imperfect competition effect to the change in welfare.

Adding a LF shelf label has no significant effect on consumer surplus, producer surplus, and overall welfare per capita if prices remain constant. If firms adjust prices and are competing in a Bertrand-Nash setting, prices increase by a very small amount, per capita consumer surplus and overall welfare per capita decrease, although by a small and economically insignificant amount. In the monopoly scenario, average prices increase by 7.5 cents, per capita consumer surplus decreases by 7.3 cents, and per capita total welfare increases by 57.6 cents. This welfare change is driven by increased per capita profits (64.9 cents). The second panel in table 6 indicates that adding a LC shelf label has no significant effect on consumer surplus, producer surplus, and overall welfare per capita if prices remain constant once more. When firms are competing in a Bertrand-Nash setting, prices increase by a relatively small amount, and consumer surplus and overall welfare per capita decline. In the monopoly scenario, average prices increase by 26.8 cents, an increase significantly larger than for LF shelf label. As a result, consumer surplus per capita decreases significantly (by 26.3 cents), and per capita welfare increases by less than before (38.5 cents rather than 57.6 cents) despite the fact that per capita profits increase by almost the same amount (64.7 cents).

Although we observe a similar pattern for the NTF shelf label in the third panel, the fourth panel shows a different pattern. When adding all three claims in a label, none of the changes are significant if prices remain unchanged. Under the Bertrand-Nash scenario, prices now decline by 2 cents on average, and consumer surplus and overall welfare per capita increases slightly as a result. When retailers are able to set monopoly prices, despite a sizable price decrease (\$1.22), both consumer surplus and profits increase, resulting in a large increase in overall welfare of \$1.58 per capita.

As we report these values in dollars per capita per month, we also extrapolate to monthly store totals to provide an additional perspective. As an approximation, we observe about 3,800 transactions over 52 weeks in each treatment store, or about 300 popcorn sales per month. The total welfare effect per month per store when retailers can strategically adjust all prices after posting all nutrition claims in one label would roughly amount to $\$1.581 \times 300 = \$473$ per store. Similarly, the increase in profits per month per store from strategically adjusting all prices after a single nutrient claim is posted on a

[14] We do not include the combined fat and calorie treatment in store 4 as the combined label did not display statistically significant results in the structural demand estimations. Other two claim combinations are also not included here as they only applied to a small number of products.

Table 6. Simulated Average Monthly Per Capita Welfare Changes for Experimental Nutrition Shelf Labels under Three Supply Scenarios

	Price change	Average CS change	Average profit change	Average welfare change
LF claim				
Competitive		0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)
Bertrand-Nash	0.001	−0.002	0.000	−0.002
	(0.000)	(0.000)	(0.705)	(0.000)
Monopoly	0.075	−0.073	0.649	0.576
	(0.003)	(0.000)	(0.087)	(0.084)
LC claim				
Competitive		0.002	0.000	0.002
		(0.002)	(0.000)	(0.002)
Bertrand-Nash	0.004	−0.007	0.000	−0.007
	(0.000)	(0.002)	(0.001)	(0.003)
Monopoly	0.268	−0.263	0.647	0.385
	(0.010)	(0.011)	(0.083)	(0.074)
NTF claim				
Competitive		0.003	0.000	0.003
		(0.003)	(0.000)	(0.003)
Bertrand-Nash	0.004	−0.008	0.000	−0.008
	(0.000)	(0.003)	(0.001)	(0.003)
Monopoly	0.294	−0.290	0.614	0.324
	(0.011)	(0.012)	(0.073)	(0.062)
LF, LC, and NTF claim				
Competitive		−0.002	0.000	−0.002
		(0.002)	(0.000)	(0.002)
Bertrand-Nash	−0.017	0.020	−0.005	0.015
	(0.001)	(0.002)	(0.001)	(0.003)
Monopoly	−1.227	1.193	0.389	1.581
	(0.075)	(0.079)	(0.038)	(0.117)

Notes: All results are reported in dollars and average consumer surplus, profits, and total welfare are measured per capita and month. Standard errors are reported in parentheses. We report welfare changes from displaying single "low fat" (top panel), "low calorie" (second panel), and "no trans fat" (third panel) claims on shelf labels, as well as a display of all three claims on a shelf label (bottom panel). All estimates are based on demand estimates and simulations using treatment and control stores during the pre- treatment period only.

label (e.g. the LC claim) is roughly $\$0.649 \times 300 = \$195$. These estimates are sizable when considering the small overall category revenue that amounts to $978 per month in this approximation.

Although our labels do not change consumer surplus and overall welfare in significant ways under the assumption of perfect competition, once we allow firms to strategically adjust prices, our simulation estimates statistically and economically significant welfare changes. Despite previously detected consumer preferences for the stand-alone calorie and trans fat claims, consumer surplus decreases once firms are able to charge monopoly prices under these preferred labeling options. In contrast, consumers surplus and overall welfare are now highest when all three claims are displayed on a label. However, profits increase by a smaller amount than in the single claim labeling scenarios. We conclude that retailers would have little incentive to implement this welfare maximizing shelf labeling option without being regulated to do so and instead would prefer to post single nutrient claims. When firms operate in a Bertrand-Nash setting, the overall increase in total welfare is still positive under the label option that posts all three claims but firms now find their profits slightly reduced. If firms instead implement a single claim label, their profits remain unchanged. In this setting, retailers might not voluntarily introduce any of our shelf labels.

Estimated Average Welfare Changes for Voluntary FOP Claims

We apply the same methodology to simulate changes in welfare for FOP nutrition claims.

We obtain these by simulating the difference between removing these labels and displaying these labels on product packages in our control stores. In table 7, we once more report estimates of changes in consumer surplus, profits, and welfare in dollars per capita by month. The top panel reports results for LC related claims, the middle panel for LC related claims, and the bottom panel for NTF claims.

The top panel suggests that adding a voluntary LF related FOP claim resulted in an increase in consumer surplus per capita under all three pricing scenarios, although by less under monopoly pricing than under the assumption of perfect competition and Bertrand-Nash pricing (33 cents versus 50 cents). Under Bertrand-Nash pricing, we also observe an increase in profits, whereas profits would have decreased under the assumption that retailers adjusted prices strategically across all products. Interestingly, once retailers are able to adjust prices across the entire product category we observe price increases of 18 cents, whereas under the Bertrand-Nash setting, they hardly change. Total welfare increased under perfect competition and Bertrand-Nash but decreased under the monopoly pricing scenario.

For LC related FOP claims, the consumption switching effect and combined effect under Bertrand-Nash are close to equal in magnitude once more, but consumer surplus actually decreases as a result of posting these claims. As per capita profits decrease as well, overall per capita welfare decreases under all pricing models. This result might point to already discussed limitations of our analysis of voluntary FOP claims as it otherwise poses the question of why firms voluntarily add these claims in the first place.

When repeating our analysis for NTF claims in the third panel, we see large drops in consumer surplus per capita once more and predict that prices decrease significantly, especially under monopoly pricing. We also predict sizable per capita profit decreases of \$1.68 under the monopoly setting and large overall welfare reductions of up to \$3.10 per capita by month.

When once more extrapolating to store-level monthly measures, the profit gain from posting a

Table 7. Simulated Monthly Per Capita Welfare Changes (with FOP Claims minus simulated no FOP Claims) under Three Supply Scenarios

	Price change	Average CS change	Average profit change	Average welfare change
LF related FOP claims				
Competitive		0.500	0.000	0.500
		(0.012)	(0.000)	(0.012)
Bertrand-Nash	0.002	0.502	0.101	0.603
	(0.000)	(0.012)	(0.003)	(0.010)
Monopoly	0.180	0.331	−0.467	−0.136
	(0.009)	(0.012)	(0.062)	(0.058)
LC related FOP claims				
Competitive		−0.339	0.000	−0.339
		(0.011)	(0.000)	(0.011)
Bertrand-Nash	−0.002	−0.336	−0.073	−0.408
	(0.000)	(0.011)	(0.003)	(0.013)
Monopoly	−0.131	−0.216	−0.760	−0.976
	(0.006)	(0.009)	(0.075)	(0.071)
NTF related FOP claims				
Competitive		−2.467	0.000	−2.467
		(0.022)	(0.000)	(0.022)
Bertrand-Nash	−0.013	−2.429	−0.563	−2.992
	(0.000)	(0.021)	(0.009)	(0.028)
Monopoly	−1.093	−1.422	−1.682	−3.104
	(0.039)	(0.035)	(0.107)	(0.079)

Notes: All results are reported in dollars and average consumer surplus, profits and total welfare are measured per capita and month. Standard errors are reported in parentheses. We report welfare changes from adding low fat related (top panel), low calorie related (second panel), and no trans fat (third panel) front of package (FOP). All estimates based on the demand estimates and simulations using control stores only during the whole sample period.

LF related FOP claim under this setting amounts to roughly $1.01 × 300 = $303 per store per month. The total welfare loss as a result of retailers setting monopoly prices after select brands display a LF related FOP claim is approximately $ −0.136 × 300 = $−41 per store per month.

To summarize our analysis of FOP labels, we only detect positive welfare changes for voluntary FOP claims that highlight information about fat content. Removing the other two claims increases overall welfare in our simulations. It is worth pointing out that food manufacturers use these labels selectively and might not make FOP labeling and pricing decisions for a single product or in one product category only. Other strategic responses by retailers not modeled here might further bias our results. For instance, we cannot incorporate considerations across product categories or across stores. Although our analysis suggests that FOP claims might not always be beneficial to consumers, additional research is needed that addresses or controls for this multifaceted strategic behavior.

Conclusion

Our nutrition label experiment suggests that consumers do not fully utilize all of the nutrition information currently reported on NFPs. When we provide this information in a more salient fashion on experimental shelf labels, consumers adjust their purchases. Our estimated heterogeneous labeling effects are not consistent with a uniform shift in demand for the highlighted healthier products, however. Consumers seem to react differently to our shelf labels depending on which and how many claims are displayed.

Our simulations of strategic pricing behavior under varying degrees of market power and estimated welfare changes further suggest that an already discussed shift in regulation toward simple claims in addition to the information provided on NFPs needs to take possible strategic firm responses into account. The estimated strategic pricing decisions in response to our experimental nutrition shelf labels suggest that in today's concentrated food retail markets, firms have little incentive to choose welfare-maximizing labels.

Our treatment stores were selected by the retailer to be comparable in size, product assortment, and consumer demographics, and as a result, we analyzed store-level data only. Future research should consider empirical settings where the heterogeneity of consumers' valuation of nutrition claims can be modeled and formally incorporated into the analysis. Such studies could experiment with targeted information provision or advertising such as smart phone ads or digital store displays to provide further policy recommendations.

Finally, our analysis was restricted to one product category with small overall sales. Experiments across a variety of product categories would not only test the robustness of the results presented here; they could also consider other strategic long-run firm responses such as new product introductions and overall changes in product assortment.

For nutrition labeling to be successful, consumers need to process the information provided and choose healthier product alternatives as a result. Heterogeneous consumer preferences, limited attention spans, and potentially biased perceptions will likely trigger strategic firm responses in a market characterized by ongoing consolidation and increased market power of large manufacturing and retailing firms. Although limited in scope, our research provides important insights for regulators and motivates further research that focuses on the interplay between demand and supply in today's complex retail environment.

Supporting information

Supplementary material is available at American Journal of Agricultural Economics online.

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Appendix

Recovering Marginal Costs under Two Market Power Scenarios

Under Bertrand-Nash Pricing, we assume that suppliers maximize profits for every product by choosing each price given the competitor prices and marginal costs c by:

$$\begin{aligned} \max\ \pi_1 &= (p_1 - c_1)s_1 \\ &\vdots \\ \max\ \pi_1 &= (p_N - c_N)s_N. \end{aligned}$$

The resulting first order conditions are:

$$\frac{\partial \pi_j}{\partial p_j} = \begin{cases} s_1 + (p_1 - c_1)\dfrac{\partial s_1}{\partial p_1} = 0 \\ \vdots \\ s_N + (p_N - c_N)\dfrac{\partial s_N}{\partial p_N} = 0 \end{cases}$$

If we define a matrix δ as:

$$\delta = \begin{bmatrix} \frac{\partial s_1}{\partial p_1} & \frac{\partial s_1}{\partial p_2} & \cdots & \frac{\partial s_1}{\partial p_{15}} \\ \frac{\partial s_2}{\partial p_1} & \frac{\partial s_2}{\partial p_2} & \cdots & \frac{\partial s_2}{\partial p_N} \\ \vdots & \vdots & \cdots & \vdots \\ \frac{\partial s_N}{\partial p_1} & \frac{\partial s_N}{\partial p_2} & \cdots & \frac{\partial s_N}{\partial p_N} \end{bmatrix}$$

and let T^{bn} be the ownership matrix defined as:

$$T^{bn} = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \cdots & \vdots \\ 0 & 0 & \cdots & 1 \end{bmatrix}$$

We know that $T^{bn}(j,k) = 1$ if both j and k are produced by the same firm, and equal to 0 otherwise, and can solve for Bertrand-Nash price cost markups as:

$$\begin{bmatrix} p_1 - C_1 \\ \vdots \\ \vdots \\ p_N - C_N \end{bmatrix} = -\begin{bmatrix} \vdots \\ T^{bn} \times \delta \\ \vdots \end{bmatrix}^{-1} \begin{bmatrix} s_1 \\ \vdots \\ \vdots \\ s_N \end{bmatrix}.$$

Here $T^{bn} \times \delta$ is an element by element multiplication. Re-arranging further, we get:

$$\begin{bmatrix} \vdots \\ T^{bn} \\ \vdots \end{bmatrix} \times \begin{bmatrix} \vdots \\ \delta \\ \vdots \end{bmatrix} \begin{bmatrix} p_1 - C_1 \\ \vdots \\ \vdots \\ p_N - C_N \end{bmatrix} = -\begin{bmatrix} s_1 \\ \vdots \\ \vdots \\ s_N \end{bmatrix}$$

$$\begin{bmatrix} p_1 \\ \vdots \\ \vdots \\ p_N \end{bmatrix} - \begin{bmatrix} \hat{C}_1 \\ \vdots \\ \vdots \\ \hat{C}_N \end{bmatrix} = -\begin{bmatrix} \vdots \\ T^{bn} \times \delta(p_1 \cdot p_N) \\ \vdots \end{bmatrix}^{-1} \begin{bmatrix} s_1(p_1 \cdot p_N) \\ \vdots \\ \vdots \\ s_N(p_1 \cdot p_N) \end{bmatrix}$$

The upper bound on marginal costs C^{bn} given Bertrand-Nash is:

$$\hat{C}^{bn} = p - m^{bn}.$$

Here m^{bn} denote the Bertrand Nash margins:

$$\begin{bmatrix} \hat{C}_1^{bn} \\ \vdots \\ \vdots \\ \hat{C}_N^{bn} \end{bmatrix} = \begin{bmatrix} p_1 \\ \vdots \\ \vdots \\ p_N \end{bmatrix} + \begin{bmatrix} \vdots \\ T^{bn} \times \delta(p_1 \cdot p_N) \\ \vdots \end{bmatrix}^{-1} \begin{bmatrix} s_1(p_1 \cdot p_N) \\ \vdots \\ \vdots \\ s_N(p_1 \cdot p_N) \end{bmatrix}$$

Repeating this analysis, but assuming monopolist or joint profit maximization instead, the first order conditions now are:

$$\begin{cases} s_1 + (p_1 - c_1)\dfrac{\partial s_1}{\partial p_1} + (p_2 - c_2)\dfrac{\partial s_2}{\partial p_1} + \ldots + (p_N - c_N)\dfrac{\partial s_N}{\partial p_1} = 0 \\ \vdots \\ s_N + (p_1 - c_1)\dfrac{\partial s_1}{\partial p_N} + (p_2 - c_2)\dfrac{\partial s_2}{\partial p_N} + \ldots + (p_N - c_N)\dfrac{\partial s_N}{\partial p_N} = 0 \end{cases}$$

Using T^m, the ownership matrix for joint profit price choices:

$$T^m = \begin{bmatrix} 1 & 1 & \cdots & 1 \\ 1 & 1 & \cdots & 1 \\ \vdots & \vdots & \cdots & \vdots \\ 1 & 1 & \cdots & 1 \end{bmatrix}$$

and the delta matrix, we can solve for monopolist price–cost markups:

$$\begin{bmatrix} p_1 - c_1 \\ \vdots \\ \vdots \\ p_N - c_N \end{bmatrix} = - \begin{bmatrix} & \vdots & \\ & T^m \times \delta & \\ & \vdots & \end{bmatrix}^{-1} \begin{bmatrix} s_1 \\ \vdots \\ \vdots \\ s_N \end{bmatrix}$$

Here, $T^m \times \delta$ is an element by element multiplication. Re-arranging, we get:

$$\begin{bmatrix} \vdots \\ T^m \\ \vdots \end{bmatrix} \times \begin{bmatrix} \vdots \\ \delta \\ \vdots \end{bmatrix} \begin{bmatrix} p_1 - c_1 \\ \vdots \\ \vdots \\ p_N - c_N \end{bmatrix} = - \begin{bmatrix} s_1 \\ \vdots \\ \vdots \\ s_N \end{bmatrix}$$

The lower bound of marginal costs c^m given monopolist pricing are:

$$\hat{c}^m = p - m^m,$$

where m^m are the monopolist margins. We get:

$$\begin{bmatrix} \hat{c}_1^m \\ \vdots \\ \vdots \\ \hat{c}_N^m \end{bmatrix} = \begin{bmatrix} p_1 \\ \vdots \\ \vdots \\ p_N \end{bmatrix} + \begin{bmatrix} & \vdots & \\ & T^m \times \delta(p_1 \cdot p_N) & \\ & \vdots & \end{bmatrix}^{-1} \begin{bmatrix} s_1(p_1 \cdot p_N) \\ \vdots \\ \vdots \\ s_N(p_1 \cdot p_N) \end{bmatrix}.$$