The impact of mandatory trans fat labeling on product mix and consumer choice: A longitudinal analysis of the U.S. Market for margarine and spreads ☆

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ABSTRACT

The impact of changes in food labeling policy on food consumption depends on how market participants—both firms and consumers—react to the changes across all products in the market. We investigate how both responded to the U.S. Food and Drug Administration's 2006 rule mandating that the quantity of trans fat in food products be separately labeled on the mandatory Nutrition Facts Panel across an entire differentiated product category. Using a longitudinal data set tracking both product offerings and consumer purchases in the market for margarine and spreads for over a decade, we analyze how product mix and consumer purchase behaviors were influenced by the new regulatory requirement. We find that the number of products bearing voluntary "trans fat free" labels increased after the labeling regulation was implemented. However, a large number of the newly introduced products exited the market within five years. As a result, the FDA's 2006 rule had a stronger short-run than long-run effect on product offerings. Even after the introduction of additional "trans fat free" labeled products, such products remained only a small percentage of margarine and spreads product offerings, increasing from a pre-regulation level of 2.3% of the market to a peak of 6.5% in 2007 before dropping to 3.1% by 2011. In addition to firm response, we examine demand-side reactions to the 2006 rule and find that consumers significantly increased their expenditures on "trans fat free" labeled products soon after the labeling changes were implemented, increasing from about 1.2% of the market in 2001 to a peak of 5.9% in 2007, before returning to 1.8% in 2011. We further explore variations in responses across different demographic characteristics. Although long-run effects are small, the market for "trans fat free" labeled margarine and spreads settled into a new equilibrium with a somewhat higher level of products in the market than prior to the 2006 rule taking effect and a somewhat higher share of expenditures in the category. Overall, our category-wide analysis of both firm and consumer behavior indicates that the effects of the labeling policy change were smaller in the longer run in this market than would be indicated by an analysis of only new product introductions in response to the policy change.

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1. Introduction

Trans fat is a type of unsaturated fat uncommon in nature but manufactured artificially as a byproduct in the production of processed vegetable fats. Starting in the 1950s, trans fat, in the form of margarine, became a popular replacement for butter. Partially hydrogenated vegetable oils have remained a significant ingredient in the U.S. diet, particularly through foods such as margarine and spreads, cookies, and French fries throughout the second half of the 20th century (Valenzuela and Morgado, 1999). By the early 1990s, mounting evidence showed that trans fat is associated with an increased incidence of coronary artery disease and is associated with 380,000 deaths and $108.9 billion in medical costs in the U.S. every year (Murphy et al., 2013; Heidenreich et al., 2011). In the absence of mandatory nutrition labeling, the amount of trans fat in food products is a credence attribute for consumers, meaning that consumers cannot evaluate the level of trans fat even after consumption. Information on trans fat content is asymmetric, with consumers being less informed than producers.

Efforts have been made in the U.S. to reduce trans fat consumption, including product liability lawsuits and banning the use of trans fat in restaurants in some jurisdictions. The U.S. Food and

Drug Administration (FDA) provides detailed information on trans fat to educate and enhance the general public's understanding of trans fat and to encourage the consumption of trans-fat-free (TFF) foods. In 1999, the FDA proposed to change labeling policy to include information on trans fat on the required Nutrition Facts Panel and to further regulate the use of voluntary TFF claims on food products (Federal Register, 1999). In its final rule, issued in 2003 and taking effect in 2006, the FDA mandated that Nutrition Facts Panels include a separate entry for trans fat, while at the same time withdrawing its proposed further regulation of voluntary TFF claims (Federal Register, 2003; FDA, 2003). Recently, trans fat once again took center stage when the FDA mandated that partially hydrogenated oils, the primary dietary source of artificial trans fat in processed foods, be removed from products entirely by 2018 (FDA, 2015).

From a policy perspective, the overall impact of changes in food labeling policy on food consumption depends on how market participants —both firms and consumers—react to the changes across all products in the market and over time. This impact may vary across product categories. Research to date on the impact of labeling changes such as adding trans fat content to the Nutrition Facts Panel has focused on changes in new product introductions. While important, this research does not capture overall movements in the supply of and demand for food products across entire, differentiated product categories. To capture these market-wide outcomes, we study the impact of the 2006 mandatory labeling of trans fat on the Nutrition Facts Panel (the "2006 rule") on an entire product category. Using a large-scale longitudinal dataset, we analyze changes in both supplier and consumer behavior in the entire margarine and spreads category from 2001 to 2011, five years before and six years after the 2006 rule.

Tracking both product introductions and existing products, we find the mandatory labeling of trans fat impacted both product offerings and consumer purchases in the market for margarine and spreads. During the sample period, product offerings with TFF claims increased, as did household consumption of these products. However, similar to effects found for other popular claims (Martinez, 2013), both effects were stronger in the short than the long run. The market for margarine and spreads reached a new equilibrium with somewhat higher levels of TFF product offerings and purchases at the end of the sample period in 2011 than in periods before labeling took effect. These results suggest that the evaluation of the impact of labeling policy changes should consider changes in firm and consumer behavior across entire product categories and over time.

2. Literature on the impact of nutrition labeling regulations on food markets

The Nutrition Labeling and Education Act (NLEA), passed by the U.S. Congress in 1990 and implemented in 1994, required the inclusion of a detailed Nutrition Facts Panel on most packaged foods. Prior to the NLEA, disclosure of nutrition information was not required unless a nutrition claim was made on the packaging, although all nutrition-related disclosure, whether voluntary or mandatory, had to follow a prescribed format. After the NLEA, all food packages were required to disclose calories, total fat, cholesterol, sodium, carbohydrates (including dietary fiber and sugars), protein, and selected vitamins and minerals. In addition, the NLEA regulates the use of voluntary nutritional claims (e.g., "low fat" or "sugar-free") as well as general health claims (e.g., "high cholesterol is a risk factor in the development of coronary heart disease").

Researchers (Capps, 1992; Caswell and Padberg, 1992; Zarkin and Anderson, 1992) have long been interested in the impact of the NLEA policy on product offerings and on household consumption. Over the years, a considerable literature on nutrition labeling has accumulated, including studies concerning the Nutrition Facts Panel as well as voluntary nutrient content and health claims (Cowburn and Stockley, 2005; Drichoutis et al., 2006).

In general, the literature suggests that nutrition labeling rules are conditionally effective in influencing both consumers and food producers in many aspects. Mandatory nutrition labeling leads to an increase in information available to consumers. Surveys conducted by the Food Marketing Institute (FMI) indicate that at least 43% and possibly as many as 78% of consumers were aware of the presence of the Nutrition Facts Panel (FMI, 1995a, 1995b) shortly after the NLEA's implementation. That awareness in some cases translates to practical consequences: more motivated and less skeptical consumers acquire more information from the label (Moorman, 1996). Caswell et al. (2003) found that the NLEA improved information quality by standardizing the usage of voluntary nutritional label claims. Mandatory nutrition labeling could potentially benefit consumers by reducing search costs and increasing product knowledge (Berning et al., 2010). Crutchfield et al. (2001) estimated the benefits of nutrition labeling rules on raw meat and poultry products that reduced intake of fat and cholesterol to be $62–$125 million annually. Variyam and Cawley (2008) estimated that the total monetary benefit of the decrease in body weight due to the NLEA is $63–$166 billion over a 20-year period—far in excess of its costs.

A large body of literature has found that nutrition labeling influences consumer valuations and perceptions of a product leading to changes in purchasing decisions if the substitution effect between nutrition and taste is small (Teisl and Levy, 1997). Drichoutis et al. (2006) argued that consumers use nutrition labels when shopping mainly to avoid negative nutrients in food products, while Mathios (2000) found salad dressings with the highest fat levels experienced a significant decline in sales following the NLEA. In line with these findings, other research has found that consumers may respond to nutritional labels by altering their food choices as a result of their increased understanding of food content (Ippolito and Mathios, 1994; Marietta et al., 1999).

Positive effects of nutrition labeling regulation on consumer behavior have recently been reported in other countries as well. For instance, Leathwood et al. (2007) argued that European legislation on nutrition and health claims implemented in January 2007 can help consumers make well-informed food choices. Studying the same set of legislation, Gracia et al. (2007) found that older and more educated consumers are more likely to consider the regulation as beneficial. Balcombe et al. (2010) found that UK consumers are willing to pay more to avoid foods with "red" nutrients, especially salt and saturated fats, in response to the UK nutritional food label Traffic Light System. Barreiro-Hurlé et al. (2010) used a multivariate Probit model to study the effect of Nutrition Facts Panels and nutrition/health claims on consumption through survey data obtained in Spain. They found that nutrition information increases consumption of healthy foods. However, the impact of nutrition labeling may be limited if, for example, it does not significantly change consumption (Mojduszka et al., 2001) or the search and recall of nutrition information by consumers (Balasubramanian and Cole, 2002).

Research on nutrition and health claims yield somewhat similar findings. For instance, Nocella and Kennedy (2012) pointed out the complexity of how consumers are influenced by health claims. After examining several potential impact factors, including personal characteristics, food features, and the wording of claims, they found that enhancing the communication of scientific evidence could reduce consumer confusion about food health claims. Wezemael et al. (2014) found that consumer preferences for nutrition and health claims on lean beef steak vary across countries.

In addition to influencing consumer demand, nutrition labeling rules encourage producers to use voluntary label claims, create new products, and reformulate existing products. For example, research focused specifically on newly introduced products with trans fat labeling has shown significant responses by food processors. Unnevehr and Jagmanaite (2008) argued that the 2006 rule created incentives for the food industry to reduce trans fat content. They showed that the number of new TFF-labeled products increased greatly from 64 in 2003 to 544 in 2006, and that the number of firms introducing TFF-labeled products increased from 139 in 2004 to 318 in 2006. Van Camp et al. (2012) suggested that the 2006 rule resulted in a decreased use of partially hydrogenated vegetable oil in newly introduced chip products, without a corresponding increase in saturated fat content. Hooker and Downs (2013, 2014) found that, while in 2006, the main fat ingredient used in cookies in the U.S. was partially hydrogenated vegetable oils, by 2012 it had shifted to palm oil, resulting in a nearly 50% reduction in trans fat used in newly introduced cookies between 2006 and 2012. Rahkovsky et al. (2012) found a decrease in trans fat and an increase in the use of TFF claims in new food products, including snacks, bakery products, and soup, from 2005 to 2010. However, the analysis of new product introductions cannot characterize developments across entire product categories in response to changes in labeling policy.

Martinez (2013) argued that as food labeling regulations take effect, competition among food manufacturers encourages the use of labels to advertise the nutritional quality of healthier products. This result does not seem to hold, however, in the earlier time period of the 1990s. Moorman et al. (2012) conducted a cross-sectional study on the effect on product offerings as a result of the 1994 NLEA during the period 1990–1996. Examining the nutritional profiles of 30 product categories, the authors found evidence that the average nutritional quality of products regulated by the NLEA decreased compared to those not regulated. They suggest that, among other potential causes, one factor driving the decrease had to do with consumer taste. Consumers select products based on their taste instead of nutrient quality; companies respond by offering products with better taste that have lower nutritional value on the margin. However, the authors also found that a subset of the new products introduced after the NLEA were more nutritional than existing products.

While Moorman et al. (2012) study is similar to our own, the authors examined only the supply side of the market by concentrating on products offered; they did not analyze demand-side effects. Such one-sided studies can be misleading, since changes to the products offered in a given category may not correspond to changes, if any, in consumer choices. In other words, while the products offered may have grown worse in nutrition in the early post-NLEA period, consumer choices may remain as healthy or become healthier than before, because consumers may still choose from the healthier foods available.

Overall, relatively little research on changes in labeling policy has focused on changes both in the supply of product offerings and on consumer demand across entire categories of food products. An exception is Mojduszka et al. (1999), who measured nutritional quality changes in product offerings in five food categories: entrees, soup, salted snacks, cookies, and processed meats and bacon in the mid-1990s. They found no significant change in the average nutritional quality of products within each category upon adoption of the NLEA. Their preliminary analysis also suggested that consumer purchases within these categories are weighted toward products with lower nutrition indexes. In our study, we focus on both supply-(product offerings) and demand-(consumer purchases) side changes in the entire product category of margarine and spreads before and after the 2006 rule. This approach addresses the overall question of the impact of labeling policy changes on food markets.

3. Market and data description

The market for margarine and spreads is predominantly comprised of sticks, spreads, and spray products. Because butter is made mainly from natural milk fat, which is free of trans fat, only margarine and spreads products, and not real butter products, were affected by the 2006 rule.

Our data set derives from two longitudinal panels, a retail panel and a household panel, both provided by Information Resources, Inc. The panels span eleven years, from the first week of 2001 to the last week of 2011, in weekly intervals. In addition, a panel on product attributes details the characteristics of each UPC (a unique universal code associated with each product-packaging combination) in each year. Furthermore, the demographics of all households in the household panel are reported. Together, these data capture not only the composition of the entire market for margarine and spreads by product attribute, but also allow for the analysis of consumer uptake of available products. Thus, our data set provides a complete picture of market changes occurring before and after the 2006 rule.

The retail panel documents weekly sales and prices from all margarine and spreads[1] sold in participating grocery stores across all major metropolitan statistical areas. Together, the sample of grocery stores (e.g., Kroger, Stop & Shop) accounts for roughly 10% of all grocery stores in the U.S. For each UPC code in each store in each week, we observe the total revenue and total quantity sold, as well as whether the product is experiencing a temporary price reduction, is on display in-store, or is otherwise featured in-store. Tracking all products sold by UPC for over a decade, we can identify introductions of new products, major reformulations of previously existing products, and product exits. In total, we observe 39,323,839 instances (UPCs on a weekly basis) in the panel.

For each product identified by its UPC code in the retail and household panels, we observe a set of attributes. These include its brand, product type (e.g. margarine), packaging (e.g. plastic tub), form (e.g. stick), main ingredient (e.g. vegetable oil), calorie level (e.g. zero calorie[2]), and most importantly fat claims (e.g. "TFF"), which identifies any claims made on the package with regard to fat. However, we do not directly observe the Nutrition Facts Panel associated with each UPC. The set of product attributes are tracked annually from 2001 to 2011, covering the entire retail panel. This allows us to observe in which year new products are introduced, their duration in the market, and their exit from the market if discontinued.

We analyze in particular fat-related claims appearing on product labels, which take a variety of forms in addition to the TFF claim on the labels of margarine and spreads, including "50% less saturated fat", and "70% less fat". Not all products in this category have labels that contain fat-related claims. In fact, 18.5% of products available have no fat-related claims. For these products, the "fat claims" variable is labeled as "missing".[3] Here we concentrate on products with TFF claims. All other label claims, including those which make no claims as to fat content, are aggregated into the group "no TFF claims".

We make use of the household panel data to analyze how households reacted to the 2006 rule. The panel documents purchases of margarine and spreads on a weekly basis for an average of 4758 households in one of two locations, one in New England and the other in the Great Lakes region. For each household in the panel, we observe the volume and price of all purchases of

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[1] We do not observe butter-only products; instead, all products in the sample are either butter substitutes or butter imitation products.

[2] We identify zero calories based on observed zero calorie claims reported in the data.

[3] All claims on a product's packaging are recorded in the data. As a result, if a product makes no claims on its packaging, it is recorded as "missing" in the data.

margarine and spreads—data comprising a total of a little over 400,000 purchases. In addition, household demographic information is observed, including annual income, education of the head of the household, family size, presence of children, and race.

Table 1 shows summary statistics of demographic variables and the number of households in the household panel by year. Nominal annual household income is observed as falling into one of twelve income brackets, the lowest denoting $0–$9999 and the highest denoting $100,000 and above. For the summary statistics provided in Table 1, we use the upper bound of each bracket in computing the average and standard deviation. The household income reported is representative of the U.S. population, with the sample average of $61,925 comparable to the 2011 U.S. average of $69,821, according to the U.S. Census. The education level of the head of the household is observed in eight levels, from "some grade school" to "post-graduate work". While we analyze how households in each education level respond to the new NLEA rules, in Table 1 we present only the percentage of households with college degrees. On average, around 24% of the heads of household sampled have completed college degrees, which conforms to the national average of 22%. Household size ranges from one to six members, with an average of 2.5, also on par with the U.S. population. The variable "presence of children" shows the percentage of households in the sample with children. Approximately 20% of all households sampled have at least one child. Households of all races are present in the sample; however, a large majority of the households are Caucasian.

One caveat regarding the household panel data is the household attrition that has occurred in recent years causing the size of the panel to decrease gradually. However, the attrition was pro rata across demographics. As a result, the distributions of demographic variables do not vary much over the sample period. A second caveat is that the sample was drawn predominantly from regions with relatively low racial diversity, and as a consequence the majority of households sampled are Caucasian. However, we are not aware of research documenting racial biases in the consumption of margarine and spreads.

4. Changes in product offerings with TFF claims before & after the 2006 rule

Using weekly retail sales data and product feature records from 2001 to 2011, we analyze supply-side changes in the market for margarine and spreads corresponding to implementation of the 2006 rule. Our analysis covers the entire product space and includes the total number of products (existing and new) offered each year.

Table 2 shows an annual breakdown of the 895 total margarine and spreads offered at some time between 2001 and 2011 based on unique UPCs. On average, there were 332 different products on the market in every year, eleven of which carry TFF claims on their labels. We find that the share of TFF-labeled products reached its peak in 2007 at 6.5% of all available products. In comparison, only between 2.0% and 2.5% of margarine and spreads carried a TFF claim prior to 2006. The number of products with a TFF claim gradually decreased after 2007, with their market share settling at around 3% of all available products—slightly above the level prior to the 2006 rule change.

Spreads dominate margarine in market share of products offered, capturing just over 60% of the market on average across the years. Furthermore, spreads experienced a more rapid increase in the number of products carrying TFF claims after implementation of the 2006 rule, from 3.1% in 2006 to 7.9% in 2007. In comparison, margarine products with TFF claims increased from 1.0% in 2006 to 3.5% in 2007. Both categories experienced a decrease in

products with TFF claims after 2008 but the market shares of products offerings in both margarine and spreads stabilized at levels above those observed at the beginning of the decade. These trends demonstrate that firms reacted to the 2006 rule by increasing products with TFF claims.

To further investigate the entry and exit of margarine and spreads across the sample period, we separate products into those that entered the market and those that exited. Furthermore, we decompose these entries and exits by the existence of TFF labels. To identify if a product has (1) entered the market, (2) continued its previous existence, or (3) exited the market, we track the presence of its UPC over time. If a UPC not observed before year x appears in that year it is counted as a product entry in year x. If a UPC seen previously continues its presence in year x, it is counted as a product continuation. And if a UPC seen previously disappears in year x and afterwards, it is counted as a product exit.[4] Table 3 displays the resulting product entry and exit by year. Because our panel starts in 2001, we do not observe product availability in 2000 or changes from 2000 to 2001. Thus, our findings start in 2002.

Table 3 shows the total number of products available in the market each year, the number of products entering that year that do and do not carry a TFF claim, and the number of products that do or do not carry a TFF claim that exited. For instance, we observe a total of 302 products available in the market in 2002, out of which 35 are newly entering products, none carrying a TFF label. Furthermore, 14 non TFF-labeled products available in 2001 exited the market and are no longer available by 2002. This implies a market expansion for products without TFF claims. Table 3 shows there is little market movement for products with TFF claims prior to the 2006 NLEA rule change. However, with the requirement that the Nutrition Facts Panels show trans fat content, more firms took the opportunity to introduce products with TFF claims in order to attract sales. The highest number of products introduced with TFF claims—seventeen—was in 2007, accounting for 58.6% of all new TFF-labeled products introduced in the entire eleven-year sample period. By 2009, the market once again saw relatively few introductions of TFF-labeled products, while a share of the TFF-labeled products continuously exited the market. This pattern suggests that the labeling policy had a significant short-run effect on the use of TFF claims in the market for margarine and spreads but less of a long-run effect. Interestingly, Table 3 also shows a significant uptick in entry and exit of products without TFF claims right after the NLEA rule change. However, as we discuss later, unlike for TFF-labeled products, prices of these products were not affected.

Overall, many products with TFF claims were introduced shortly after the 2006 rule went into effect but exited the market some time later. Table 4 shows the product life of margarine and spreads introduced with TFF claims. More than 80% of TFF-labeled products lasted five years or less before exiting the market, with 25.7% being offered in the market for one year or less. On average, products remained in the market for close to 3.6 years.

Table 5 shows changes over the sample period in the use of TFF claims on individual margarine and spreads products. Overall, sixteen products (45.7%) carried a TFF claim during all sample years in which they were offered. We would expect some of the products originally lacking a TFF claim (non-TFF labels) to have been reformulated or repackaged to carry a TFF claim after the 2006 rule.

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[4] Product introductions are recorded only when previously unobserved products come into the market. That is for a product to be considered a new entrant, it must not appear in any previous years. Similarly, we define product exits as complete discontinuations, i.e. only UPCs with no reoccurrences in any of following years are counted. For those products that changed their label claims from non-TFF to TFF, a new entry is counted at its initial appearance and once again when a TFF claim is observed for the first time in history. As a result, changes in the total number of products in the market may differ from the net entry that would be calculated from the shown entry and exits.

Table 1
Summary statistics of demographic variables in household panel data by year, 2001–2011.

Variable	Income	College degree (%)	Household size	Presence of children (%)	Caucasian (%)	Sample size
2001	52879.86 (43099.37)	21.00	2.55 (1.29)	24.23	91.08	6846
2002	53152.63 (43540.94)	20.57	2.54 (1.29)	23.92	95.17	7573
2003	55604.99 (44567.09)	23.78	2.53 (1.28)	25.07	98.85	5291
2004	56409.03 (45365.26)	22.96	2.54 (1.28)	24.48	98.86	4837
2005	57968.05 (46223.46)	23.86	2.53 (1.26)	24.69	98.92	4674
2006	58321.57 (45510.08)	23.41	2.51 (1.24)	23.84	98.98	4372
2007	59962.41 (47080.58)	24.16	2.46 (1.22)	22.79	99.04	3873
2008	60415.99 (51830.51)	23.10	2.35 (1.17)	18.35	96.19	3634
2009	61139.59 (52220.43)	24.44	2.37 (1.18)	18.97	96.35	3395
2010	60636.72 (51875.42)	25.98	2.33 (1.16)	18.80	96.10	3099
2011	61924.70 (52771.07)	26.97	2.35 (1.15)	18.56	95.95	2836

Table 2
Summary statistics of number of unique margarine/spread products in the market, 2001–2011.

Year	No. of products			Margarine			Spreads		
	All	TFF	%TFF	Total	TFF	%TFF	Total	TFF	%TFF
2001	285	6	2.1%	111	0	0.0%	174	6	3.4%
2002	302	6	2.0%	112	0	0.0%	190	6	3.2%
2003	304	7	2.3%	122	1	0.8%	182	6	3.3%
2004	303	7	2.3%	120	1	0.8%	183	6	3.3%
2005	280	7	2.5%	111	1	0.9%	169	6	3.6%
2006	264	6	2.3%	101	1	1.0%	163	5	3.1%
2007	356	23	6.5%	115	4	3.5%	241	19	7.9%
2008	392	21	5.4%	127	4	3.1%	265	17	6.4%
2009	399	17	4.3%	124	3	2.4%	275	14	5.1%
2010	377	13	3.4%	114	3	2.6%	263	10	3.8%
2011	386	12	3.1%	111	2	1.8%	275	10	3.6%
2001–2011	895	35	3.9%	287	7	2.4%	608	28	4.6%

Note: When we report the number of unique products in each market, we count the presence of every unique Universal Product Code (UPC) unconditional on its previous existence.

Table 3
Entry and exit of margarine and spreads with TFF claims, 2001–2011.

Year	No. of products in market	Entry		Exit	
		TFF	NonTFF	TFF	NonTFF
2002	302	0	35	0	14
2003	304	1	29	0	23
2004	303	0	28	0	31
2005	280	0	17	0	39
2006	264	0	11	1	29
2007	356	17	174	0	90
2008	392	9	191	11	162
2009	399	0	42	4	33
2010	377	2	26	6	47
2011	386	0	37	1	33

Note: A new product entry is counted only at its initial appearance and/or the first time when a TFF claim is observed.

Indeed, nine products (25.7%) were re-labeled from non-TFF to TFF labels during the sample period. However, ten products (28.6%) made the opposite shift resulting in products formerly labeled as TFF then being labeled non-TFF. Tables 4 and 5 suggest that the 2006 rule had a short-run effect of stimulating firms to use TFF claims on their product labels but that this effect faded over time.

As the 2006 rule on trans fat took effect and the number of TFF-labeled products increased, we would expect to see changes not only in the competition between TFF-labeled and non-TFF-labeled products but also within TFF-labeled products. Intensified competition, especially between TFF-labeled products, may result in relative price changes across products. We use the price

Table 4
Product life of margarine and spreads with TFF claims introduced from 2001 to 2011.

Life length in years	Number of products	Percentage of all products (%)
1	9	25.7
2	6	17.1
3	3	8.6
4	6	17.1
5	5	14.3
6	0	0
7	3	8.6
8	2	5.7
9	1	2.9

Table 5
TFF labeling changes to margarine and spreads, 2001–2011.

Labeling change	Frequency	Percentage (%)
Always TFF label	16	45.7
Switch from non-TFF label to TFF label	9	25.7
Switch from TFF-label to non-TFF label	6	17.1
Switch from non-TFF to TFF to non-TFF label	4	11.4

information in the data to explore possible price variations over time. First, we investigate relative price changes between products with and without TFF claims. We then extend our pricing analysis by further decomposing products by size and form.

Fig. 1 shows the nominal monthly volume weighted average prices for products by claim and whether the product is branded. Because there are no private label products with TFF claims, the figure shows the price trends for branded products with TFF claims, branded products without TFF claims, and private label products without TFF claims. Over the period 2001–2011, prices of margarine and spreads for non-TFF-labeled products were on an increasing trend, where the prices of branded products consistently exceeds that of private label products as expected. Fig. 1 shows that while the average price for branded non-TFF-labeled products were on a steadily increasing trend, the average price for TFF-labeled products experienced a substantial drop approximately one year after the NLEA rule. As a result, the price differential between national brand TFF and non-TFF products disappeared from 2006 to 2007. In fact, the average prices for branded TFF-labeled products fell below those for branded non-TFF-labeled products. The convergence in prices lasted for close to three years; by the beginning of 2009, prices of branded TFF-labeled products once again became a bit higher than branded non-TFF-labeled products. Over the next two years, prices evened out and by the end of 2011 the two types of products were offered at similar prices.

This period of intense price competition is likely driven by the substantial introductions of TFF-labeled products over the same period. As reported in Table 3, 59% of all newly introduced products carrying TFF-label claims for the entire study period were introduced in 2007 and 29% in 2008. As we discuss below, demand for TFF-labeled products substantially increased from 2007 to 2008, which would drive up prices for all TFF-labeled products holding supply constant. This implies that the drop in prices for TFF-labeled products is driven by heightened competition from the increase in TFF-labeled products.

To investigate price movements in a more detailed manner, we further decompose products by their attributes. We first decompose all unique products by size in addition to the presence of TFF labels. There are many different sizes offered in the margarine and spreads market. We bin these products into five brackets. Fig. 2 shows the nominal volume weighted average monthly price of margarine and spreads by the size of the package and by claim. Several patterns are clearly shown in this figure. First, there is clear evidence of nonlinear pricing across products of different sizes.

Prices of smaller packages are much higher than those of larger packages. Second, products that carried TFF labels did not exist for most sizes until after the NLEA rule change. In fact, TFF labels only existed for products between 0.5 and 1 lb. Lastly, the price differentials between TFF and non-TFF-labeled products differ across sizes. For some sizes, prices of products carrying TFF labels are higher, while for other sizes prices are lower. For instance, prices of products with TFF labels are lower than their non-TFF counterparts for the smallest, (0, 0.5] lb., sizes but prices with TFF labels are higher for the (0.75 1] lb. sizes. This suggests that price competition differs across different package sizes.

In a similar fashion, we also decompose all products by their forms. More specifically, margarine and spreads come in different forms, such as liquid and spread. Due to the large number of different types, we separate all unique products into solid and non-solid forms for clarity. Figs. 3 and 4 present decompositions by solid form and non-solid forms respectively. Similar to the decomposition by size and label, Fig. 3 shows that the majority of solid forms did not carry TFF labels until the NLEA rule change. The only exception is spreads, where the price differential between TFF and non-TFF-labeled products follows the same pattern as those seen in Fig. 1. Prices of TFF-labeled spreads were above those without TFF labels prior to the NLEA rule change. As the number of TFF-labeled products increases and competition becomes fiercer, prices of these products experienced a drop and became lower than those of products without TFF labels about one year after the rule change. For TFF-labeled products introduced after the rule change, prices remained fairly stable. For products in the stick form, prices of TFF-labeled products were consistently above those without TFF labels. And for products in the block form, prices of TFF-labeled products were consistently above those without TFF-labels. Similar to Fig. 3, Fig. 4 shows the price trends for all products in non-solid forms, with products decomposed by whether they carry TFF labels, if such claims are available, and form. Out of the three forms, liquid and spray carried TFF-labeled products during some periods. However, there were no overlapping periods between these two types of products: Liquid products stopped carrying TFF labels right around the NLEA rule change, while spray products started carrying TFF labels two years after the rule change. That is to say, a consumer looking to purchase a non-solid TFF-labeled item would have been restricted to only one form. And as a result, there was no direct competition between these two groups of products. In this setting, we see that while prices between TFF and non-TFF-labeled liquid products are fairly comparable, prices of TFF-labeled spray products are far below those without the claims. This suggests that price competition could differ significantly across forms.

In summary, the 2006 rule elicited a change on the supply side in the margarine and spreads market. Firms reacted to the new regulation by introducing many new products with voluntary TFF claims. In total, seventeen new TFF-labeled products were added to the market in 2007 and nine in 2008. Thus the labeling policy had a significant short-run effect on product offerings. As shown in Table 2, the share of TFF-labeled spreads increased from 3.4% of product offerings in 2001 to 7.9% in 2007, shortly after implementation of the rule, while the share of margarine product offerings with such claims increased from 0.0% to 3.5% in the same period. However, many of these newly introduced products exited the market within five years. In the long run, the market settled into an equilibrium with more TFF-labeled products than prior to the 2006 rule. By 2011, only 3.6% of spreads and 1.8% of margarine product offerings carried a TFF label. Not all TFF-labeled products remained consistently labeled, however; over 50% of products bearing TFF claims at some point in the sample period experienced changes in their labeling, either from or to a TFF-label (or in some cases, even changing back and forth). While a number of products
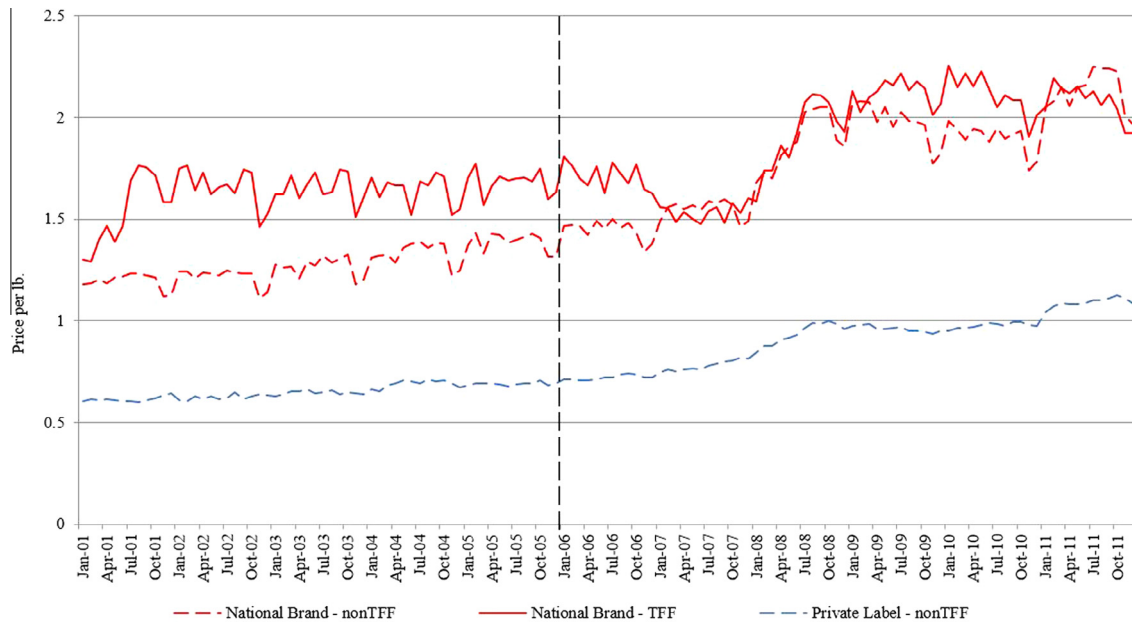
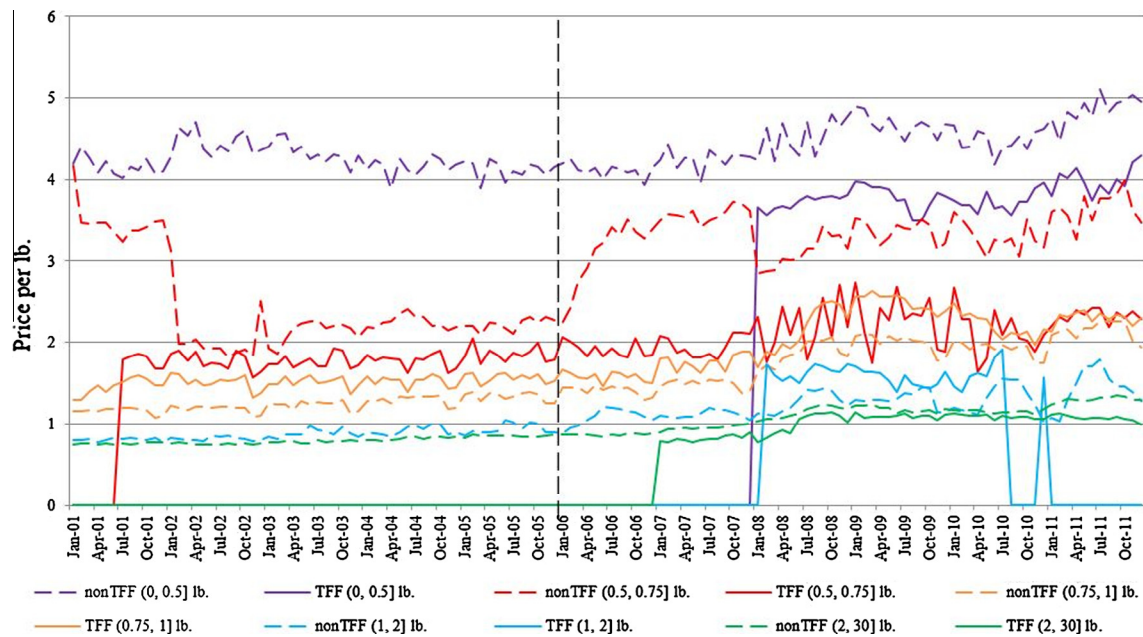**Fig. 1.** Monthly average price of margarine and spreads – by claim.

Fig. 2. Monthly average price of margarine and spreads - by label and size.

were introduced after this labeling law change, the very vast majority of products did not carry voluntary claims even after the rule's implementation. As a consequence, only a relatively small number and percentage of products were affected by the 2006 rule. Our results suggest that analysis concentrated on new product introductions in margarine and spreads in the short run after the policy change can easily overstate the effect of the 2006 rule on product offerings in the overall product category.

5. Changes in product purchases with TFF claims before & after the 2006 rule

The total effect of a labeling change is made up of the supply-side effects (mandatory labeling, changes in use of voluntary labeling, and changes in product offerings) explored in the previous section and consumer response to the labeling, which we explore in this section. Here we analyze how consumers reacted to the market changes brought about by the 2006 rule. Analyzing weekly household purchases of margarine and spreads in the same 2001–2011 period, we show that in general consumers increased consumption of products with TFF labels and decreased consumption of products without TFF labels.

Table 6 shows summary statistics of annual purchases of margarine and spreads in millions of pounds of product purchased and millions of dollars in expenditures based on the retail panel data. Over the sample time period, expenditures on margarine and spreads did not change much except in 2008 and 2009 when it increased. In contrast, the volume purchased dropped
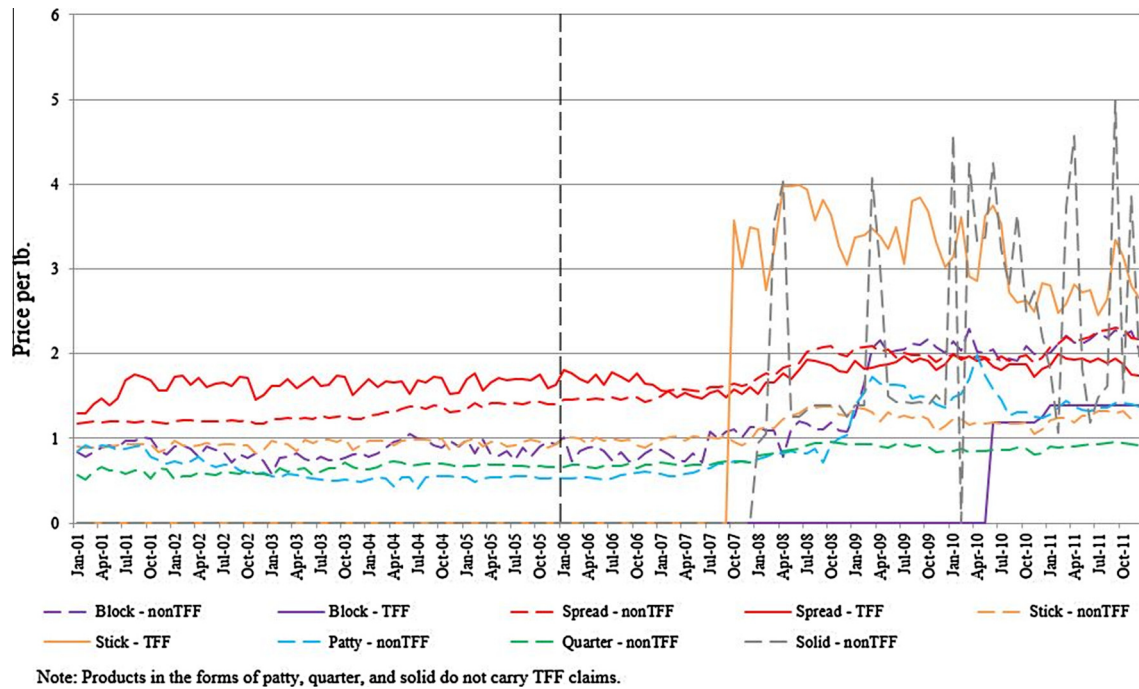
Note: Products in the forms of patty, quarter, and solid do not carry TFF claims.

Fig. 3. Monthly average price of margarine and spreads - by label and form, solid.

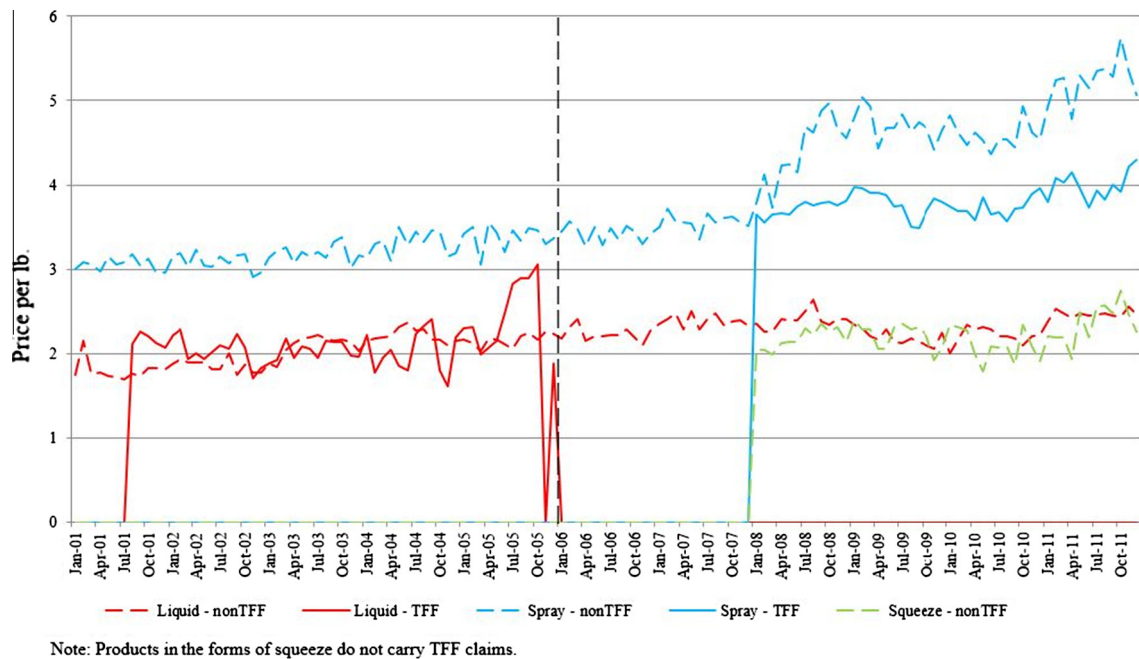Note: Products in the forms of squeeze do not carry TFF claims.

Fig. 4. Monthly average price of margarine and spreads - by label and form, non-solid.

dramatically over the period from 74.7 million pounds in 2001 to 44.5 million pounds in 2011. The proportion of purchases that were TFF-labeled products peaked in 2007, just after implementation of the 2006 rule, at nearly 6% of purchases measured both in pounds and dollars.

The volume of TFF-labeled products increased from 0.86 million pounds (1.4% of the market) in 2006 to 3.11 million pounds (5.6%) in 2007, then decreased sharply to 1.5 million pounds (2.7%) in 2008 before further declining to 0.9 million pounds (1.7%) in 2009. In 2010 and 2011, the volume purchased of TFF-labeled products was 0.73 and 0.76 million pounds, respectively.

Comparing starting and ending years, the volume of TFF-labeled product purchased increased slightly over the entire eleven-year period. TFF-labeled products comprised a growing share of the market purchase volume over the time period, starting at 0.8% in 2001, peaking at 5.6% in 2007, and falling to 1.7% in 2011. This increase in shares largely comes from an ever shrinking base, from 74.1 million lbs. in 2001 to 44.5 million lbs. in 2011. We observe a similar trend for the market share of TFF-labeled products in dollar expenditures, which began at 1.2% of the market in 2001, peaked at 5.9% in 2007, and subsequently dropped to 1.8% in 2011.

Table 6
Annual purchases of TFF-labeled and non-TFF-labeled margarine and spreads, 2001–2011.

Year	Volume			Expenditure		
	(in million lb.)			(in millions of dollars)		
	All	TFF	%TFF	All	TFF	%TFF
2001	74.7	0.62	0.8%	83.2	1.01	1.2%
2002	70.3	1.08	1.5%	79.8	1.78	2.2%
2003	68.4	1.04	1.5%	80.5	1.72	2.1%
2004	65.8	1.03	1.6%	82.0	1.68	2.1%
2005	62.0	0.92	1.5%	80.6	1.55	1.9%
2006	60.6	0.86	1.4%	82.7	1.48	1.8%
2007	55.7	3.11	5.6%	81.4	4.78	5.9%
2008	54.9	1.50	2.7%	97.0	2.82	2.9%
2009	54.1	0.90	1.7%	100.0	1.90	1.9%
2010	48.7	0.73	1.5%	87.1	1.54	1.8%
2011	44.5	0.76	1.7%	88.7	1.58	1.8%

As shown in Fig. 5, the monthly purchase probability of TFF-labeled products using the retail panel increased dramatically from 1.25% in December of 2006 to 4.65% in January of 2007 and increased further to 6.34% by late 2007, suggesting a significant short-run effect of the 2006 rule. However, after August of 2008, the purchase probability fell back to a level only slightly higher than its previous average in the years 2001–2006. This pattern further supports previous studies of popular claims (Martinez, 2013) that suggested that given the large choice sets of grocery products and limited consumer attention spans, strong effects of popular labels are typically short lived.

We further check the robustness of this overall pattern using the alternative household panel data set. We find that for the average household, the percentage of margarine and spreads purchases comprised of TFF-labeled products was 0.74% in 2001. This percentage increased to 5.8% in 2007, the period immediately after the labeling policy change, but by 2011 had dropped to 3.7%. The impact of the 2006 rule on the market was not sustained but rather stabilized at around 3% after 2007. Our household panel confirms the pattern found using the retail panel but with less of a drop-off. We emphasize the retail rather than the household panel results because the retail panel provides changes in the market at the nationwide level, which is a more comprehensive result. The short- and long-run effects are explored further in the regression analysis in the next section.

6. Analysis of the effect of policy change, time, and consumer demographics on demand for TFF labeled products

To investigate how households across different demographic characteristics responded to the labeling policy change, we analyze consumers' purchase behaviors for TFF-labeled products during the sample period using the household panel data. We concentrate on four demographic variables: income, family size, education of head of household, and presence of children. For each of the four demographic characteristics, we stratify households in the household panel into groups by income bracket, number of household members, education level, and age group of children in household. Trends in household purchases are shown in Figs. 6–9 for each of the four demographic characteristics. While different demographic groups reacted differently to the 2006 rule, one clear pattern emerges: households across all demographic groups increased their purchases of TFF-labeled products in 2007, as shown by the red reference line in each figure.

Fig. 6 plots annual average household purchases of TFF-labeled products as a percentage of all margarine and spreads product purchases over time by income level. Households in the household panel are divided into twelve income brackets by annual household income. The lowest income group is comprised of households earning $9999 or below, and the highest of households earning $100,000 or above. As noted, households across all income brackets increased their purchases of TFF-labeled products in 2007. For instance, TFF-labeled products accounted for less than 1% of all margarine and spreads product purchases in 2001 for the average household in the $20,000–$24,999 income bracket, in marked contrast to nearly 8% in 2007, a trend consistent across all income brackets. Furthermore, households across nearly all income brackets, continued to purchase TFF-labeled products at an increased level after 2007. Again taking households in the $20,000–$24,999 income bracket as an example, their purchases of TFF-labeled products decreased shortly after 2007 but remained at levels above those in 2001, settling into equilibrium around 4% at the end of 2011. The same trend holds for all other income brackets except for the top one ($100,000 and above), where TFF-product purchases at 3% exceeded those of other income brackets prior to 2007, rose, and then returned to that level by 2009.

While income may play a role in household behavior, it is also likely that education levels, which are correlated with income levels, affect how households obtain and more importantly use nutrition and health information in making their purchase decisions. Fig. 7 shows similar annual average household purchases of TFF-labeled products as in Fig. 6 with the households grouped according to the education level of the head of household.[5] Fig. 7 shows that while households across all education levels increased purchases of TFF-labeled products in reaction to the 2006 rule, households with lower education levels reacted much more strongly. For instance, households from the lowest education level, "some grade school", increased their purchases from an average of 0% in 2001–2006 to 10% in 2007. In comparison, households from the highest education level, "post-graduate work", showed much less variation over time.

While we do not have a measure of health motivation at the household level, our results provide some support for the finding of Balasubramanian and Cole (2002) that highly motivated and less knowledgeable people successfully transitioned into using the Nutrition Facts Panel and potentially benefited more from the NLEA than their counterparts. In contrast, Kiesel et al. (2011) and Shimshack et al. (2007) find contradicting results that more educated households rely on the Nutrition Facts Panel and respond as intended by the NLEA whereas less educated households do not. Our results suggest that households with less education respond more than their counterparts to front of the package TFF claims made after the 2006 NLEA rule change.

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[5] If female household education level is not available, we used male head of household education level instead.
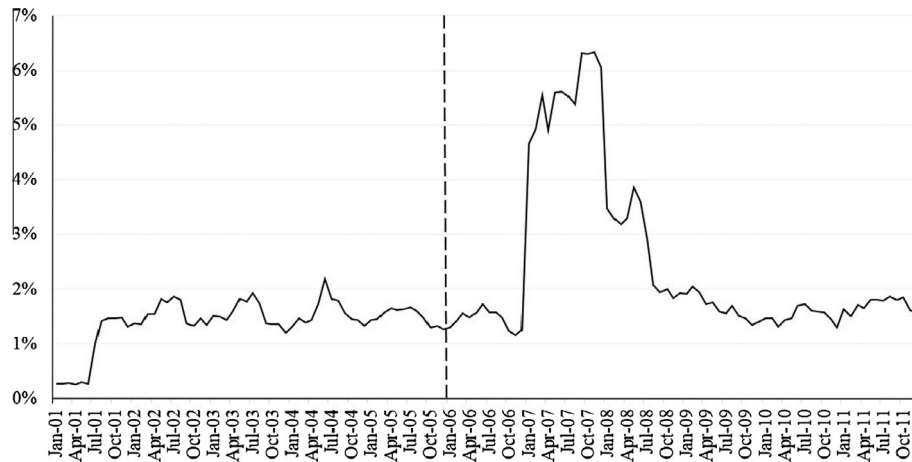
Fig. 5. Monthly U.S. market share of TFF-labeled margarine and spreads, 2001–2011.
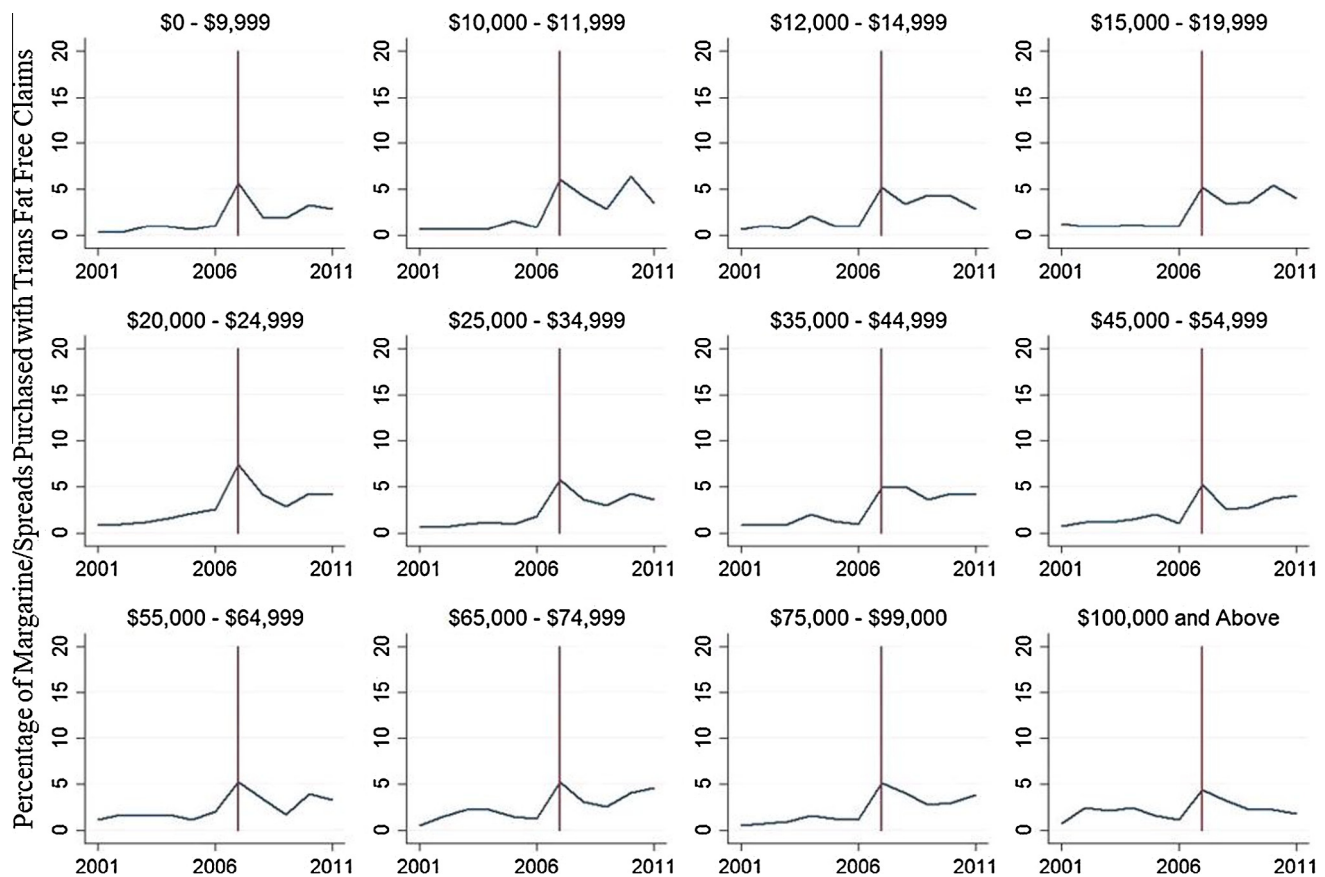

Fig. 6. Annual purchase percentage of TFF labeled margarine and spreads by household income bracket.

We find that both low income and less educated households purchased low levels of TFF products but transitioned into high levels of TFF-labeled products post 2006, suggesting that they were more strongly affected by the 2006 NLEA rule change. This is in contrast to both high income and more educated households, whose purchases of TFF-labeled products stayed relatively constant over the sample period. While the correlation between these two groups necessitates that they show similar trends, the duration and magnitude of the NLEA effects differs over all. As the regression analyses that follow show, education level does not predict statistically significant changes in a household's behavior post

the NLEA rule change. However, household income is a statistically significant predictor of households' purchase probability of TFF-labeled products.

We further investigate how household composition, namely the number of household members and the presence of children, influenced household reaction to the 2006 rule. Fig. 8 shows the percentage of TFF-labeled products over time by the number of household members, where household members range from one to "six or more". Prior to 2006, purchases of TFF-labeled products varied little by household size. However, shortly after the 2006 rule went into effect, households with fewer members (one, two, or
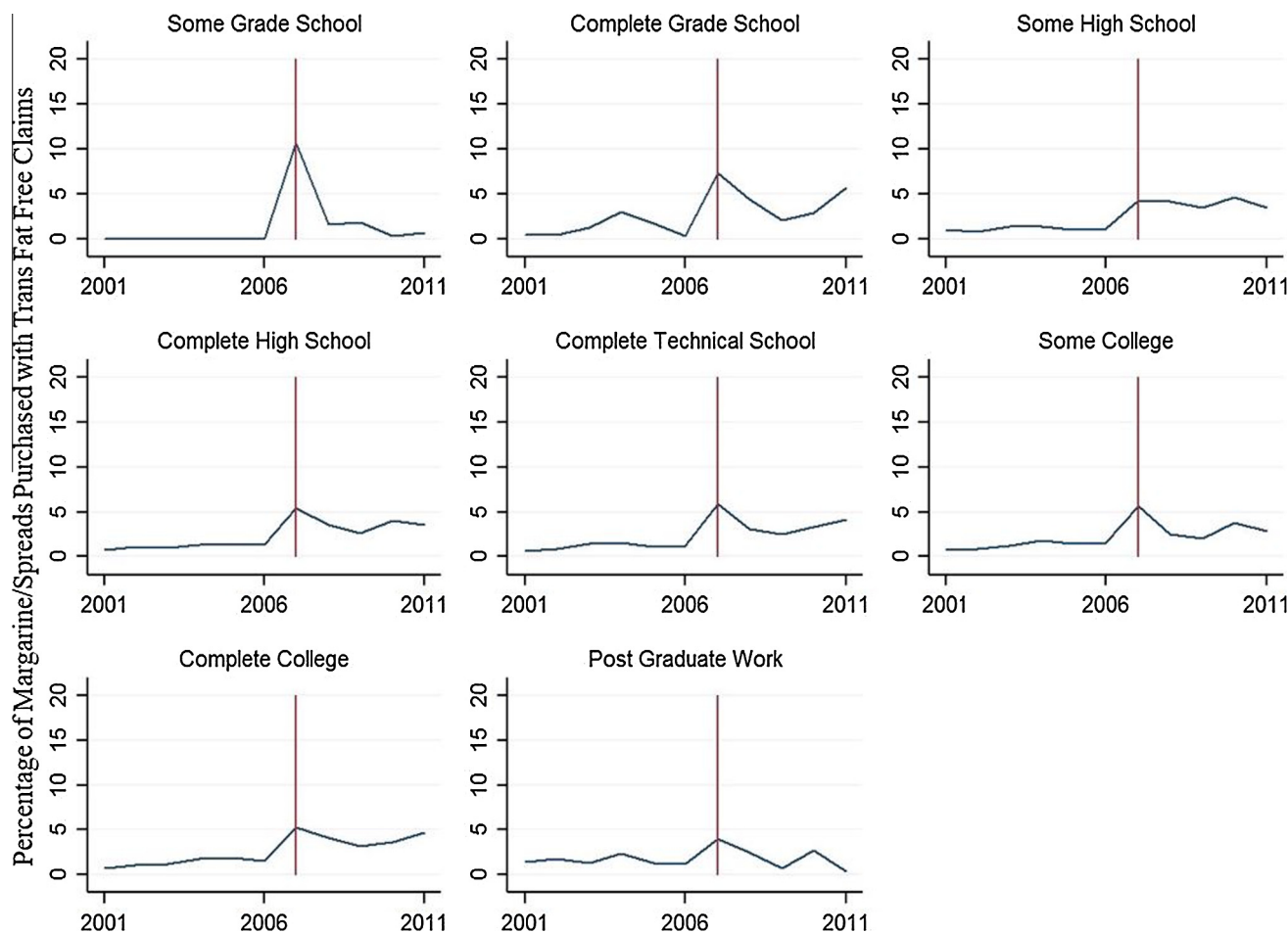
Fig. 7. Annual purchase percentage of TFF labeled margarine and spreads by education of head of household.

three) continued to purchase products with TFF claims at a substantially higher level than before. In comparison, households of larger sizes (four, five, or "six or more") did not substantially change their purchase habits in the longer run. For instance, households with six or more members increased their purchases of TFF-labeled products by only about 1%.

It is possible that the presence of children may influence changes in household purchase behavior. Fig. 9 plots the share of TFF-labeled product purchases over time for households with children across different age groups and for households with no children present. In the short run, the 2006 rule affected all households with and without children but had the largest impact on those with children in age groups 0–5 and 12–17. Overall, the short-run effect on households without children was marginally smaller than on each of the groups of households with children. In the long run, the annual average purchase of TFF-labeled products for each group of households with children varied more widely than those for the group of households with no children.

We further investigate the effect of the 2006 rule on consumer demand over time using regression analysis. Our primary interest lies in understanding how consumers reacted to this rule change in the short run and in the long run. We identify these effects by analyzing changes in consumers' purchase probability of products with TFF labels in and around 2006, when the NLEA rule changed.

Our analysis relies on the standard discrete choice framework, where we model each household's probability of purchasing a TFF-labeled product as a function of prices and time since the NLEA rule change controlling for demographic characteristics and

product attributes. Household demographics include income, education level, household size, and presence of children. Product attributes, in addition to the presence of a TFF claim, are captured by several indicator variables including brand, size of the product, what form the product comes in, whether the product has zero calories, and whether the product contains vegetable oil. Because we do not directly observe the Nutrition Facts Panel, these variables help control for additional factors that may influence consumer preferences. Table 7 defines all variables used in the analysis.

Prices in the household utility function are normalized to dollars per lb., which controls for the presence of nonlinear pricing across products of differing sizes. We model time in two different ways. First, we explicitly estimate short- and long-run effects. We exploit a natural structural break in the monthly market share of TFF-labeled products, as shown in Fig. 5, to distinguish between the short run and the long run, defining short run (SR) as an indicator variable that takes the value 1 in 2006–2007 and 0 otherwise and long run (LR) as an indicator variable that takes the value 1 in 2008–2011 and 0 otherwise. Second, we model time using a series of quarterly dummies beginning in the first quarter of 2006 and ending in the fourth quarter of 2011. Variation in household purchases in each quarter between 2006 and 2011 are compared to the average of household purchases from 2001 to 2005. In this way, we are able to flexibly capture the effect of the 2006 rule on the market for TFF-labeled margarine and spreads over time.

We include as controls the set of household demographic variables shown in the previous section. These include household
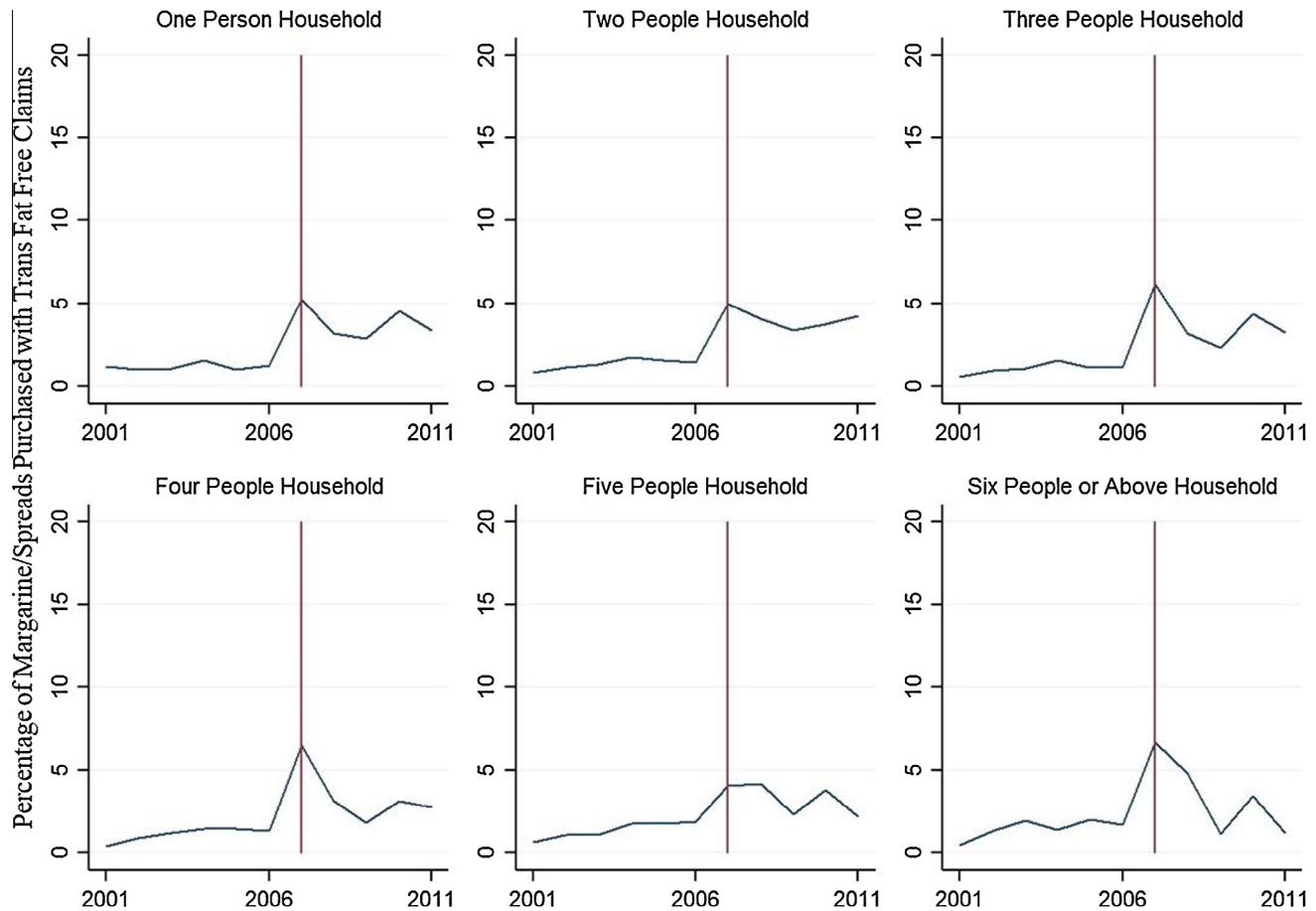
Fig. 8. Annual purchase percentage of TFF-labeled margarine and spreads by household size.

income, education level, household size, and presence of children. As discussed previously, some of the demographic variables are likely correlated. For instance, household income is likely correlated to education level and household size is likely correlated to the presence of children. However, since these characteristics each provide an interesting aspect of the household and are not perfectly correlated, which avoids collinearity problems in the regressions, we include all as controls in our analysis. We conduct robustness checks using each demographic characteristic separately, which are documented in the Appendix. Our results are not affected. In addition, we control for a large set of product attributes including brand, product size, form, whether the product has zero calories, and whether the product contains vegetable oil. Because we do not directly observe the Nutrition Facts Panel or the amount of calories per serving, these product attributes help control for product specific effects.

We model households' choice of purchasing TFF-labeled products using the standard discrete choice framework, where household utility is specified under six variations. Each variant represents a unique combination of time effects and controls, which will be discussed in detail below. The NLEA rule change does not directly affect a household's utility. Rather, households' utility for the presence of TFF labels is measured by the time variables. If households value products with TFF labels shortly after the NLEA rule change, their utility of purchasing TFF-labeled products increases in the short run and the probability of them purchasing these products increases. Likewise, if they value products with TFF labels long after the NLEA rule change, their utility of purchasing TFF-labeled products increases in the long run. Comparing households' purchase probabilities of TFF-labeled products across

the different time periods – before the 2006 rule change, shortly after, and long after – allows us to identify the effect of the 2006 NLEA rule.

In the first and second utility specifications, we model the short- and long-run effects of the 2006 rule using the variables SR and LR as defined in table 7. The two models differ in product attribute controls used. In the first, we control only for zero calories and vegetable oil. In the second model, we control for all product attributes discussed earlier. Mathematically, household i's utility for product j in period t, U_{ijt}, is expressed as the linear function below:

$$U_{ijt} = \alpha + \beta \cdot P_{ijt} + \zeta \cdot T_t + \theta_1 \cdot SR_t + \theta_2 \cdot LR_t + \gamma \cdot X_{it} + \delta \cdot Z_{jt} + \varepsilon_{ijt}$$

(1)

where P_{ijt} denotes the price of product j household i faces in week t; T denotes the year of week t and captures any aggregate time trend; SR_t denotes the weeks starting January 2006 and ending December 2007 and captures the effect of the 2006 rule on consumer demand of TFF-labeled products in the short run; LR_t denotes weeks starting January 2008 and ending December 2011 and captures the long-run effects of the 2006 rule. Household demographic variables defined above are captured in X_{it}, and product attributes are captured in Z_{jt}. Following standard notation, the household-product-time-specific error term ε_{ijt} captures any remaining idiosyncratic components in the utility and allows us to estimate the model under a discrete choice framework.

In the third and fourth specifications, the models keep the same utility specifications as above but add the interactions between SR and household demographics and between LR and household
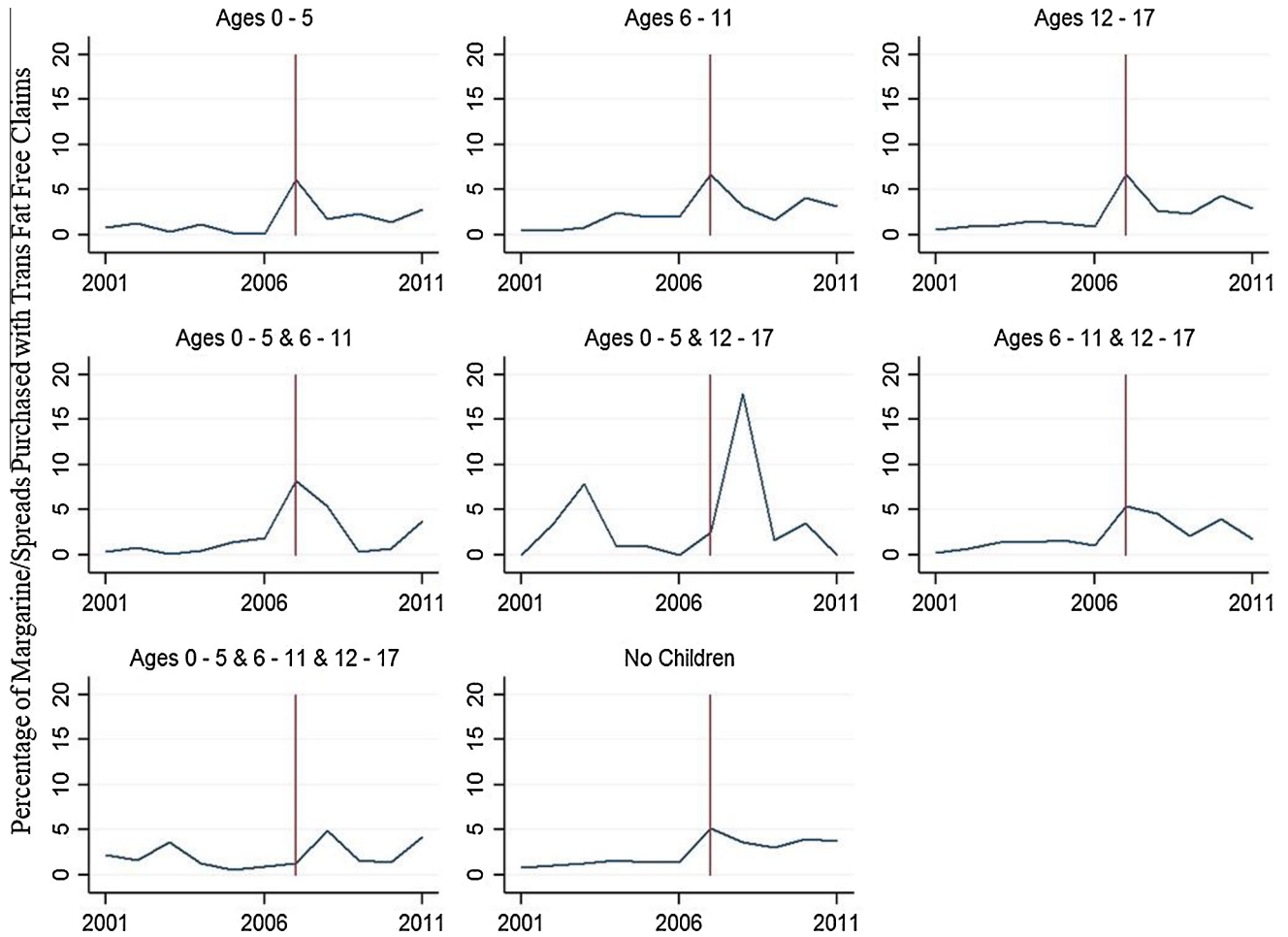
Fig. 9. Annual purchase percentage of TFF-labeled margarine and spreads by presence of children.

Table 7
Variables included in regression analysis.

Symbol	Variable	Description
P	Price per lb.	Price per lb.
T	Year	Year running from 2001 to 2011
SR	Short-run	Dummy with value of 1 in 2006 and 2007
LR	Long-run	Dummy with value of 1 in years from 2008 to 2011
Q	Quarter dummy	Dummy variables indicating quarters beginning in the 1st quarter of 2006 and ending in the 4th quarter of 2011
X	Low income	Dummy with value of 1 if the household makes less than $9999 annually
	High income	Dummy with value of 1 if the household makes more than $100,000 annually
	Education	Categorical variable with value codes:
		1 = Some grade school or less
		2 = Completed grade school
		3 = Some high school
		4 = Graduated high school
		5 = Completed technical school
		6 = Some college
		7 = Graduated from college
		8 = Post graduate work
	Household size	Categorical variable with value codes:
		1 = One person
		2 = Two people
		3 = Three people
		4 = Four people
		5 = Five people
		6 = Six or more people
	Presence of children	Dummy with value of 1 if the household has at least one child
Z	Zero calorie	Dummy with value of 1 if the product has no calories
	Vegetable oil	Dummy with value of 1 if the product contains vegetable oil
	Brand	Dummies for each brand
	Size	Dummies for each size bracket, as shown in Fig. 2
	Form	Dummies for each form the product takes, as shown in Figs. 3 and 4

demographics. This captures more precisely how households with different demographics reacted to the 2006 rule in both the short and the long run. The difference between the two models again is in the product attribute controls. Household i's utility function is expressed as:

$$U_{ijt} = \alpha + \beta \cdot P_{ijt} + \zeta \cdot T_t + \theta_1 \cdot SR_t + \theta_2 \cdot LR_t + \gamma \cdot X_{it} + \delta \cdot Z_{jt}$$
$$+ \eta_1 \cdot SR_t \cdot X_{it} + \eta_2 \cdot LR_t \cdot X_{it} + \varepsilon_{ijt} \qquad (2)$$

In the fifth and sixth specifications, the models estimate the effect of the 2006 rule on consumer purchases by using a set of quarter dummies instead of the time trend and short- and long-run dummies. Models 5 and 6, as defined below, capture the effect of the 2006 rule nonparametrically over time and represent the most flexible specifications.

$$U_{ijt} = \alpha + \beta \cdot P_{ijt} + \lambda \cdot Q_t + \gamma \cdot X_{it} + \delta \cdot Z_{jt} + \varepsilon_{ijt} \qquad (3)$$

We estimate parameters of the household utility function using a binary response framework. The outcome variable Y_{ijt} takes the value of 1 if product j that household i purchased in period t carries a TFF label, and 0 otherwise. That is,

$$Y_{ijt} = \begin{cases} 1 & \text{if } U_{ijt} \geqslant 0 \\ 0 & \text{if } U_{ijt} < 0 \end{cases}$$

We assume the idiosyncratic error term ε_{ijt} follows a Type I Extreme Value distribution which implies a standard Logit framework. That is, the probability of observing a TFF-labeled product purchase in each of the three models is:

$$Pr(Y_{ijt} = 1)$$
$$= \frac{\exp(\alpha + \beta \cdot P_{ijt} + \zeta \cdot T_t + \theta_1 \cdot SR_t + \theta_2 \cdot LR_t + \gamma \cdot X_{it} + \delta \cdot Z_{jt})}{1 + \exp(\alpha + \beta \cdot P_{ijt} + \zeta \cdot T_t + \theta_1 \cdot SR_t + \theta_2 \cdot LR_t + \gamma \cdot X_{it} + \delta \cdot Z_{jt})}$$

$$Pr(Y_{ijt} = 1)$$
$$= \frac{\exp(\alpha + \beta \cdot P_{ijt} + \zeta \cdot T_t + \theta_1 \cdot SR_t + \theta_2 \cdot LR_t + \gamma \cdot X_{it} + \delta \cdot Z_{jt} + \eta_1 \cdot SR_t \cdot X_{it} + \eta_2 \cdot LR_t \cdot X_{it})}{1 + \exp(\alpha + \beta \cdot P_{ijt} + \zeta \cdot T_t + \theta_1 \cdot SR_t + \theta_2 \cdot LR_t + \gamma \cdot X_{it} + \delta \cdot Z_{jt} + \eta_1 \cdot SR_t \cdot X_{it} + \eta_2 \cdot LR_t \cdot X_{it})}$$

$$Pr(Y_{ijt} = 1) = \frac{\exp(\alpha + \beta \cdot P_{ijt} + \lambda \cdot Q_t + \gamma \cdot X_{it} + \delta \cdot Z_{jt})}{1 + \exp(\alpha + \beta \cdot P_{ijt} + \lambda \cdot Q_t + \gamma \cdot X_{it} + \delta \cdot Z_{jt})}$$

Marginal effects implied by the parameter estimates of the models are reported in Table 8. Overall, we find that implementation of the 2006 rule is associated with increased purchases of TFF-labeled products. This result is robust across all specifications. However, the impact of this labeling rule decreased over time, with short-run effects significantly stronger than those in the long run.

Under model 1, the marginal effect of price (0.0017) indicates that, ceteris paribus, households are not very sensitive to price. In the margarine and spreads market, a one-dollar price increase leads to nearly no change (0.17% rise) in weekly purchases of TFF-labeled products. The marginal effect for the time trend, T, is estimated to be 0.0027 and is statistically significant at 1%. This implies that over time consumers would have gradually increased their purchases of TFF-labeled products by 0.27% per year, even in the absence of labeling changes resulting from the 2006 rule. However, the label changes that accompanied the 2006 rule increased this probability of purchase significantly. The marginal short- and long-run effects of the 2006 rule are estimated at 0.0111 and 0.0027 respectively, implying that after the 2006 rule took effect, households were likely to increase purchases of TFF-labeled margarine and spreads by an additional 1.11% in the short run. This effect is statistically significant at the 1% level. The long run effect is not statistically significant in this model.

For the set of demographic controls, only household income plays a statistically significant role in influencing the purchase

probability of products with TFF claims in this model. Even then, only low income households reacted substantially differently from other households. Compared to middle-income households, the purchase probability of TFF-labeled products is 0.71% lower for low-income households. For the set of product attribute controls, only zero calories shows statistically significant results. Products with zero calories decrease the likelihood of a TFF-labeled purchase by 0.84%. Containing vegetable oils does not influence purchase probabilities of products with TFF claims.

Compared to model 1, our main results – on the short and long run effects of the NLEA rule change – remain qualitatively the same as in model 2. The only difference is that the long run effect is now statistically significant at the 10% level and it suggests that even long after the 2006 NLEA rule change consumers still increased their purchases of TFF-labeled products. Most of the other variables experienced only minor changes in magnitudes. This is not surprising since the addition of more product attribute controls leads to a smaller sample size due to the collinearity between some attributes and the dependent variable. For instance, some brands only carry products with TFF labels.

The marginal effects of price and the time trend in models 3 and 4 follow the same direction and magnitude as those in models 1 and 2. The marginal short- and long-run effects of the 2006 rule, on the other hand, both increased in magnitude and are both statistically significant at the 10% level. Holding all else constant, the rule increased household likelihood of purchasing TFF-labeled products by about 1.5% in the short run and around 2% in the long run. These increases in magnitude, in comparison to the first two models, are counter-balanced by mostly negative interaction terms with household demographic variables. For instance, the marginal effect of the interaction between LR and high income is -0.0118, which indicates that households in the highest income bracket experience a lower likelihood of TFF-labeled purchases by 1.18% compared to middle-income households two years after the 2006 rule. Demographic and product attribute control variables share similar results as those for models 1 and 2.

Models 5 and 6 present a more flexible way of capturing the effect of NLEA over time. The models do not predefine a distinction between the short-run period and the long-run period. Instead we use a series of quarterly dummies to capture the changing purchase behaviors of households over time after implementation of the 2006 rule. We keep the demographic and product variables as those in models 1 and 2. As shown in the last two columns of Table 8, the marginal effects of price, demographic characteristics, and product attributes are nearly identical to those of the previous models. This shows the robustness of these effects.

The quarterly dummies from the first quarter of 2006 to the last quarter of 2011 show the quarterly changes in consumer purchases of TFF-labeled products. For instance, we see that households increased their purchases of these products by a slight margin of 0.62% in model 5 and 0.86% in model 6 immediately following the implementation of the 2006 rule. After one year, in the first quarter of 2007, households sharply increased their TFF-labeled purchases. Taking model 5 as an example, compared with the same quarter in 2006, households increased their purchases of TFF-labeled products by 3.63% (4.25–0.62). This trend continued for the rest of the year. By the end of 2007, purchase probability of TFF-labeled products with TFF claims increased another 4.11% (8.36–4.25). Household TFF-labeled purchases began to decline in the following year. By the last quarter of 2008, purchase probabilities of TFF-labeled products had decreased to 2.89%, 5.47% below the same quarter in 2007 but still 2.27% above the first quarter in 2006. Purchases of TFF-labeled products fluctuated between 2.29% and 4.73% in subsequent quarters. By the end of our sample period, in the last quarter of 2011, purchases of TFF-labeled products remained at 2.33%, still substantially above the first quarter of

Table 8
Factors affecting purchase probability for margarine/spreads with trans fat free claims, Logit model. 2001–2011.

Variable	Model 1 dy/dx	Model 2 dy/dx	Model 3 dy/dx	Model 4 dy/dx	Model 5 dy/dx	Model 6 dy/dx
Price per lb.	0.0017***	0.0008*	0.0017***	0.0008*	0.0019***	0.0009*
SR	0.0111***	0.0133***	0.0147*	0.0145*		
LR	0.0027	0.0067*	0.0210*	0.0240*		
Low income	−0.0071***	−0.0059***	−0.0073***	−0.0059**	−0.0069***	−0.0058***
Low income * SR			0.0101	0.0100		
Low income * LR			−0.0023	−0.0024		
High income	−0.0016	−0.0025	0.0108	0.0059	−0.0017	−0.0025
High income * SR			−0.0087**	−0.0074**		
High income * LR			−0.0118***	−0.0097***		
Education	0.0001	−0.0002	0.0008	0.0004	0.0002	−0.0002
Education * SR			−0.0005	−0.0002		
Education * LR			−0.0016	−0.0015		
Family size	−0.0005	−0.00003	0.0005	0.0007	−0.0005	0.00001
Family size * SR			−0.0001	−0.000009		
Family size * LR			−0.0024	−0.0018		
Child	−0.0001	0.0011	−0.0034	−0.0012	−0.00001	0.0011
Child * SR			0.0050	0.0029		
Child * LR			0.0069	0.0048		
Year	0.0027***	0.0023***	0.0027***	0.0023***		
1st Quarter 2006					0.0062**	0.0086***
2nd Quarter 2006					0.0061**	0.0076***
3rd Quarter 2006					0.0046*	0.0056**
4th Quarter 2006					0.0020	0.0022
1st Quarter 2007					0.0425***	0.0497***
2nd Quarter 2007					0.0477***	0.0569***
3rd Quarter 2007					0.0690***	0.0698***
4th Quarter 2007					0.0836***	0.0882***
1st Quarter 2008					0.0489***	0.0615***
2nd Quarter 2008					0.0598***	0.0763***
3rd Quarter 2008					0.0337***	0.0391***
4th Quarter 2008					0.0289***	0.0389***
1st Quarter 2009					0.0268***	0.0367***
2nd Quarter 2009					0.0312***	0.0413***
3rd Quarter 2009					0.0276***	0.0335***
4th Quarter 2009					0.0229***	0.0267***
1st Quarter 2010					0.0250***	0.0339***
2nd Quarter 2010					0.0440***	0.0484***
3rd Quarter 2010					0.0473***	0.0526***
4th Quarter 2010					0.0395***	0.0394***
1st Quarter 2011					0.0332***	0.0376***
2nd Quarter 2011					0.0374***	0.0385***
3rd Quarter 2011					0.0297***	0.0324***
4th Quarter 2011					0.0233***	0.0266***
Zero calorie	−0.0084***	0.0171*	−0.0083***	0.0166	−0.0085***	0.0154
Vegetable oil	−0.0022	−0.0033	−0.0022	−0.0034	−0.0020	−0.0034
Size fixed effect		✔		✔		✔
Brand fixed effect		✔		✔		✔
Form fixed effect		✔		✔		✔
PrTFF	0.0184	0.0165	0.0182	0.0163	0.0181	0.0162
Wald Chi²	586.68	1141.22	614.96	1193.6	1098.16	2072.44
Prob > Chi²	0.00	0.00	0.00	0.00	0.00	0.00
Sample size	452,035	283,191	452,035	283,191	452,035	283,191

* Statistically different from zero at the 10% level of significance.
** Statistically different from zero at the 5% level of significance.
*** Statistically different from zero at the 1% level of significance.

2006 when the 2006 rule was implemented. Results from model 6 show similar trends.

Our results illustrate that the 2006 rule requiring the inclusion of trans fat quantities on federally-mandated Nutrition Facts Panels elicited a positive and strong response from households in purchasing TFF-labeled margarine and spreads in the short run. At the peak of this response, consumers in the household panel increased their purchases of products with TFF claims by over 8% within two years of the rule's implementation. Only the demographic variable low income showed a statistically significant effect on purchases, with consumers in this group increasing their purchases to a lesser degree than middle income consumers. Analysis of the impact of the policy change over time, using two different specifications, shows that the consumer response lessened over time with purchases of products with TFF claims stabilizing at a level around 2% of the market, which is above the level in the period prior to the labeling rule taking effect.

7. Conclusions

Changes in nutrition labeling policy are targeted at improving information disclosure. As an example of such a change, the FDA's 2006 rule requiring a separate listing for trans fat on the mandatory Nutrition Facts Panel gave consumers the opportunity to quickly search for the amount of trans fat in a given product at the point of sale. In theory, increased consumer awareness due to a policy change such as this would result in changes on both the

supply and demand sides of the market. On the supply side, the policy change could lead to increases in competition and possibly result, for example in the case studied here, in firms introducing more trans-fat-free products and voluntarily placing more voluntary "trans fat free (TFF)" claims on package labels. On the demand side, the policy change could result in increased purchases by consumers of products with lower levels of trans fat, for example in the case studied here, in increased purchases of TFF labeled products.

Using comprehensive panel data that spans five years before and six years after the FDA's implementation of its rule in 2006, we find both supply- and demand-side responses in the market for margarine and spreads following closely on the heels of the rule's implementation. Our findings indicate that firms, in addition to including the line-item trans fat quantity as required on Nutrition Facts Panels, also introduced many new margarine and spreads products with voluntary TFF labels. At the same time, consumers increased their purchases of these TFF-labeled products. In the following years, however, a number of TFF-labeled products

exited the market. This decline mirrored consumer behavior: fewer households continued their purchases of TFF-labeled margarine and spreads, although responses to the changing market differed across demographic groups. Both supply-side and demand-side effects were stronger in the short run than the long run. In the long run, the market settled into a new equilibrium with only somewhat more TFF-labeled margarine and spreads product offerings than prior to the 2006 rule, and only slightly more consumer purchases of those products than before the policy change.

Earlier studies of the effects of new labeling regulations have largely focused on supply-side changes in product offerings due to new product introductions. While important, this focus yields an incomplete picture of the effects of new labeling regulations because it addresses only a portion, sometimes small, of all products offered for sale and purchased in a given food category. Our results give a much fuller picture by looking at changes in an entire product category—margarine and spreads—over an eleven-year period straddling the policy change. This before-and-after picture brings together product offerings (supply side) and consumer

Table A.1

Factors affecting purchase probability for margarine/spreads with trans fat free claims using household income and family size as demographic controls, Logit model. 2001–2011.

Variable	Model 1 dy/dx	Model 2 dy/dx	Model 3 dy/dx	Model 4 dy/dx	Model 5 dy/dx	Model 6 dy/dx
Price per lb.	0.0017***	0.0008*	0.0017***	0.0008*	0.0019***	0.0008*
SR	0.0111***	0.0133***	0.0086**	0.0117**		
LR	0.0025	0.0069**	0.0080	0.0124**		
Low income	−0.0071***	−0.0058***	−0.0079***	−0.0062**	−0.0070***	−0.0057***
Low income * SR			0.0114	0.0104		
Low income * LR			−0.0012	−0.0021		
High income	−0.0015	−0.0027	0.0125	0.0065	−0.0015	−0.0026
High income * SR			−0.0091*	−0.0075**		
High income * LR			−0.0125***	−0.0103***		
Family size	−0.0005	0.0002	−0.0003	0.0005	−0.0005	0.0002
Family size * SR			0.0009	0.0006		
Family size * LR			−0.0013	−0.0012		
Year	0.0027***	0.0023***	0.0027***	0.0023***		
1st Quarter 2006					0.0062**	0.0086***
2nd Quarter 2006					0.0061**	0.0076***
3rd Quarter 2006					0.0046*	0.0056**
4th Quarter 2006					0.0020	0.0022
1st Quarter 2007					0.0426***	0.0497***
2nd Quarter 2007					0.0478***	0.0569***
3rd Quarter 2007					0.0690***	0.0698***
4th Quarter 2007					0.0837***	0.0883***
1st Quarter 2008					0.0482***	0.0622***
2nd Quarter 2008					0.0590***	0.0771***
3rd Quarter 2008					0.0331***	0.0395***
4th Quarter 2008					0.0284***	0.0394***
1st Quarter 2009					0.0263***	0.0372***
2nd Quarter 2009					0.0307***	0.0419***
3rd Quarter 2009					0.0271***	0.0340***
4th Quarter 2009					0.0225***	0.0271***
1st Quarter 2010					0.0246***	0.0343***
2nd Quarter 2010					0.0434***	0.0490***
3rd Quarter 2010					0.0466***	0.0532***
4th Quarter 2010					0.0389***	0.0399***
1st Quarter 2011					0.0327***	0.0383***
2nd Quarter 2011					0.0368***	0.0390***
3rd Quarter 2011					0.0292***	0.0329***
4th Quarter 2011					0.0228***	0.0270***
Zero calorie	−0.0084***	0.0172*	−0.0084***	0.0171*	−0.0085***	0.0155*
Vegetable oil	−0.0022	−0.0032	−0.0022	−0.0033	−0.0020	−0.0033
Size fixed effect		✔		✔		✔
Brand fixed effect		✔		✔		✔
Form fixed effect		✔		✔		✔
PrTFF	0.0184	0.0165	0.0182	0.0164	0.0181	0.0162
Wald Chi²	579.72	1132.56	599.19	1156.41	1055.96	2040.79
Prob > Chi²	0.00	0.00	0.00	0.00	0.00	0.00
Sample size	452,035	283,191	452,035	283,191	452,035	283,191

* Statistically different from zero at the 10% level of significance.

** Statistically different from zero at the 5% level of significance.

*** Statistically different from zero at the 1% level of significance.

purchasing (demand side). This approach shows that, for the margarine and spreads market, despite robust introduction of new TFF-labeled products and corresponding increases in consumer purchases of these products following implementation of the 2006 rule, TFF-labeled products still made up a relatively small share of the overall market, in offerings and in purchases, and these shares fell from their peak in the time period further out from the policy change.

The impact of the FDA trans fat labeling policy change for other product categories, and of other nutrition labeling policy changes for all product categories, may be quite different from that found here for margarine and spreads after the implementation of mandatory trans fat labeling on the Nutrition Facts Panel. A comprehensive understanding of the impacts of nutrition labeling policy changes requires a comprehensive analysis of both supply and demand side changes across product categories and over time.

Appendix A

A.1. Regression robustness checks

Table A.1 documents regression results using only household income and family size as demographic controls. Results for the main parameters of interest are qualitatively similar to those reported in Table 8.

Table A.2 documents regression results using only education and presence of children as demographic controls. Results for the main parameters of interest are qualitatively similar to those reported in Table 8.

Table A.3 documents baseline regression results with no other demographic controls except household income. Results for the main parameters of interest remain qualitatively similar to those reported in Table 8.

Table A.2
Factors affecting purchase probability for margarine/spreads with trans fat free claims using education and presence of children as demographic controls, Logit model. 2001–2011.

Variable	Model 1 dy/dx	Model 2 dy/dx	Model 3 dy/dx	Model 4 dy/dx	Model 5 dy/dx	Model 6 dy/dx
Price per lb.	0.0017***	0.0008*	0.0017***	0.0008*	0.0019***	0.0008*
SR	0.0112***	0.0134***	0.0196**	0.0192**		
LR	0.0024	0.0064*	0.0180*	0.0217**		
Education	0.0002	−0.0002	0.0014**	0.0008	0.0002	−0.0002
Education * SR			−0.0012	−0.0008		
Education * LR			−0.0027**	−0.0023**		
Child	−0.0010	0.0011	−0.0021	0.0004	−0.0009	0.0012
Child * SR			0.0041	0.0022		
Child * LR			0.0008	0.0003		
Year	0.0028***	0.0024***	0.0027***	0.0023***		
1st Quarter 2006					0.0063**	0.0087***
2nd Quarter 2006					0.0062**	0.0076***
3rd Quarter 2006					0.0047*	0.0057**
4th Quarter 2006					0.0020	0.0022
1st Quarter 2007					0.0429***	0.0502***
2nd Quarter 2007					0.0482***	0.0575***
3rd Quarter 2007					0.0695***	0.0704***
4th Quarter 2007					0.0843***	0.0889***
1st Quarter 2008					0.0487***	0.0607***
2nd Quarter 2008					0.0593***	0.0752***
3rd Quarter 2008					0.0333***	0.0384***
4th Quarter 2008					0.0287***	0.0383***
1st Quarter 2009					0.0265***	0.0362***
2nd Quarter 2009					0.0309***	0.0407***
3rd Quarter 2009					0.0272***	0.0330***
4th Quarter 2009					0.0226***	0.0262***
1st Quarter 2010					0.0247***	0.0335***
2nd Quarter 2010					0.0436***	0.0479***
3rd Quarter 2010					0.0467***	0.0520***
4th Quarter 2010					0.0390***	0.0387***
1st Quarter 2011					0.0328***	0.0372***
2nd Quarter 2011					0.0369***	0.0379***
3rd Quarter 2011					0.0295***	0.0320***
4th Quarter 2011					0.0229***	0.0262***
Zero calorie	−0.0084***	0.0167	−0.0083***	0.0162	−0.0085***	0.0149
Vegetable oil	−0.0022	−0.0034	−0.0022	−0.0034	−0.0020	−0.0035
Size fixed effect		✔		✔		✔
Brand fixed effect		✔		✔		✔
Form fixed effect		✔		✔		✔
PrTFF	0.0185	0.0165	0.0184	0.0165	0.0181	0.0163
Wald Chi²	577.19	1114.92	577.88	1126.26	1057.96	2057.05
Prob > Chi²	0.00	0.00	0.00	0.00	0.00	0.00
Sample size	452,035	283,191	452,035	283,191	452,035	283,191

* Statistically different from zero at the 10% level of significance.
** Statistically different from zero at the 5% level of significance.
*** Statistically different from zero at the 1% level of significance.

Table A.3
Factors affecting purchase probability for margarine/spreads with trans fat free claims using only household income as demographic control, Logit model. 2001–2011.

Variable	Model 1 dy/dx	Model 2 dy/dx	Model 3 dy/dx	Model 4 dy/dx	Model 5 dy/dx	Model 6 dy/dx
Price per lb.	0.0017***	0.0008*	0.0017***	0.0008*	0.0019***	0.0008*
SR	0.0111***	0.0133***	0.0119***	0.0140***		
LR	0.0025	0.0069*	0.0043	0.0085**		
Low income	−0.0069***	−0.0059***	−0.0078***	−0.0064***	−0.0068***	−0.0058***
Low income * SR			0.0102	0.0097		
Low income * LR			−0.0006	−0.0014		
High income	−0.0018	−0.0026	0.0122	0.0065	−0.0018	−0.0025
High income * SR			−0.0088**	−0.0073**		
High income * LR			−0.0129***	−0.0106***		
Year	0.0027***	0.0023***	0.0027***	0.0023***		
1st Quarter 2006					0.0062**	0.0086***
2nd Quarter 2006					0.0061**	0.0076***
3rd Quarter 2006					0.0046*	0.0056**
4th Quarter 2006					0.0020	0.0022
1st Quarter 2007					0.0426***	0.0497***
2nd Quarter 2007					0.0479***	0.0569***
3rd Quarter 2007					0.0691***	0.0698***
4th Quarter 2007					0.0838***	0.0882***
1st Quarter 2008					0.0484***	0.0621***
2nd Quarter 2008					0.0592***	0.0770***
3rd Quarter 2008					0.0333***	0.0394***
4th Quarter 2008					0.0286***	0.0393***
1st Quarter 2009					0.0264***	0.0371***
2nd Quarter 2009					0.0309***	0.0417***
3rd Quarter 2009					0.0273***	0.0339***
4th Quarter 2009					0.0226***	0.0270***
1st Quarter 2010					0.0247***	0.0343***
2nd Quarter 2010					0.0436***	0.0489***
3rd Quarter 2010					0.0469***	0.0531***
4th Quarter 2010					0.0391***	0.0397***
1st Quarter 2011					0.0328***	0.0382***
2nd Quarter 2011					0.0370***	0.0389***
3rd Quarter 2011					0.0294***	0.0328***
4th Quarter 2011					0.0230***	0.0269***
Zero calorie	−0.0084***	0.0173*	−0.0084***	0.0176*	−0.0085***	0.0155*
Vegetable oil	−0.0022	−0.0032	−0.0022	−0.0032	−0.0020	−0.0033
Size fixed effect		✔		✔		✔
Brand fixed effect		✔		✔		✔
Form fixed effect		✔		✔		✔
PrTFF	0.0184	0.0165	0.0182	0.0164	0.0181	0.0162
Wald Chi^2	579.87	1129.29	586.62	1139.49	1051.84	2040.14
Prob > Chi^2	0.00	0.00	0.00	0.00	0.00	0.00
Sample size	452,035	283,191	452,035	283,191	452,035	283,191

* Statistically different from zero at the 10% level of significance.
** Statistically different from zero at the 5% level of significance.
*** Statistically different from zero at the 1% level of significance.

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