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THREE ESSAYS ON FOOD ECONOMICS STUDIES

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THREE ESSAYS ON FOOD ECONOMICS STUDIES

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by

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ABSTRACT

ESSAYS ON FOOD ECONOMICS STUDIES

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In this dissertation research, we first study how legislations governing nutrients in food production have influenced consumer behaviors and firm choices. Taking margarine and spreads as the product category of choice, Chapter 1 analyzes how consumers and firms responded to the 2006 implementation of the NLEA trans fats labeling guidelines. Our results show that product offerings with "trans fat free" labels increased shortly after 2006, while consumer purchases of products with "trans fat free" labels also surged promptly after the labeling policy was implemented. However, in general, we find the short-term effects of trans fat labeling to be significantly larger than the long-term effects.

In Chapter 2, we extend the previous research in estimating consumers' willingness to pay for trans fat using scanner data on purchases of microwavable popcorn from 2006 to 2014, after mandatory labeling was instituted. Product-level multinomial logit model results suggest that trans fat content on average increases consumer demand,

with significant regional preference heterogeneity. Consumers in the Northeast have a higher preference for trans fat popcorn than in the other three regions. In addition, we find evidence to show that this positive preference for trans fat has become stronger since the 2006 mandatory labeling rule, implying that consumers value the taste of trans fat over trans fat health concerns.

Chapter 3 explores the WIC infant formula rebate program, which awards a single-source contract to the firm that offers the lowest net bid price. We find different spillover patterns by comparing three types of formula: top WIC infant formula, non-WIC infant formula, and toddler formula. In particular, immediately after the contract change, there is a significant increase in market share for all three types of formula for the winning manufacturer due to greater shelf space, better product placement, and the advantages of carrying WIC labels. Our empirical results suggest that losing manufacturers still enjoy a spillover privilege in the toddler formula market from consumers' brand loyalty. Over time, the spillover effect increases the winner's share and decreases the losers' shares for all infant formula, which may reflect a combined impact of recommendations from physicians and WIC participants. Lastly, we observe that winning manufacturers increase the price of top WIC and all other infant formula and decrease the price of toddler formula over time. The spillover effect allows losing manufacturers to increase prices for all three types of formula at least 2 years after a contract change.

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CHAPTER 1

ECONOMIC IMPACTS OF TRANS FAT LABELING POLICY ON CONSUMERS AND PRODUCERS

1.1 Introduction

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 fats 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.

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 & 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, Xu, & Kochanek, 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 fats 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 fats 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 fats, while at the same time withdrawing its proposed further regulation of voluntary TFF claims (Federal Register, 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 2001-2011, 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.

1.2 Literature Review

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 & Padberg, 1992; Zarkin & 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 & Stockley, 2005; Drichoutis, Lazaridis, & Nayga, 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 and b) 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, Ning, Liu, and Mojduszka (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, Kuchler, & Variyam (2001) estimated the benefits of nutrition labeling rules on raw meat and poultry products that reduced intake of fat and cholesterol to be $62 to $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 to $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 & Levy, 1997). Drichoutis, Lazaridis, & Nayga (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 & Mathios, 1994; Marietta, Welshimer, & Anderson, 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, Loureiro, and Hayga (2007) found that older and more educated consumers are more likely to consider the regulation as beneficial. Balcombe, Fraser, and Di Falco (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, Gracia, & de-Magistris (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, Caswell, & Harris, 2001) or the search and recall of nutrition information by consumers (Balasubramanian & 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 & 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, Hooker, & Lin (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 & 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, Martinez, & Kuchler (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, Ferraro, & Huber (2012) conducted a cross-sectional study on the effect on product offerings as a result of the 1994 NLEA during the period 1990 to 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, Ferraro, & Huber's (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.

1.3 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

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

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 4,758 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 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 1.1 shows summary statistics of demographic variables and the number of

[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.

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 – $9,999 and the highest denoting $100,000 and above. For the summary statistics provided in table 1.1, 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 1.1 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.

Table 1.1 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	52,879.86 (43099.37)	21.00%	2.55 (1.29)	24.23%	91.08%	6846
2002	53,152.63 (43540.94)	20.57%	2.54 (1.29)	23.92%	95.17%	7573
2003	55,604.99 (44567.09)	23.78%	2.53 (1.28)	25.07%	98.85%	5291
2004	56,409.03 (45365.26)	22.96%	2.54 (1.28)	24.48%	98.86%	4837
2005	57,968.05 (46223.46)	23.86%	2.53 (1.26)	24.69%	98.92%	4674
2006	58,321.57 (45510.08)	23.41%	2.51 (1.24)	23.84%	98.98%	4372
2007	59,962.41 (47080.58)	24.16%	2.46 (1.22)	22.79%	99.04%	3873
2008	60,415.99 (51830.51)	23.10%	2.35 (1.17)	18.35%	96.19%	3634
2009	61,139.59 (52220.43)	24.44%	2.37 (1.18)	18.97%	96.35%	3395
2010	60,636.72 (51875.42)	25.98%	2.33 (1.16)	18.80%	96.10%	3099
2011	61,924.70 (52771.07)	26.97%	2.35 (1.15)	18.56%	95.95%	2836

1.4 Descriptive Results

1.4.1 Changes in Product Offerings

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 1.2 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.

Table 1.2 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: Products that re-enter the market after a period of absence are not counted again.

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. Table 1.3 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 1.3 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 1.3 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 Panel 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 1.3 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.

Table 1.3 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: All products are accounted for, including those that re-enter the market after a period of absence[4].

Overall, many products with TFF claims were introduced shortly after the 2006 rule went into effect but exited the market some time later. Table 1.4 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 1.5 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.

[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. 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 1.4 Product Life of Margarine and Spreads with TFF Claims Introduced from 2001-2011

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%

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.

Table 1.5 TFF Labeling Changes to Margarine and Spreads, 2001-2011

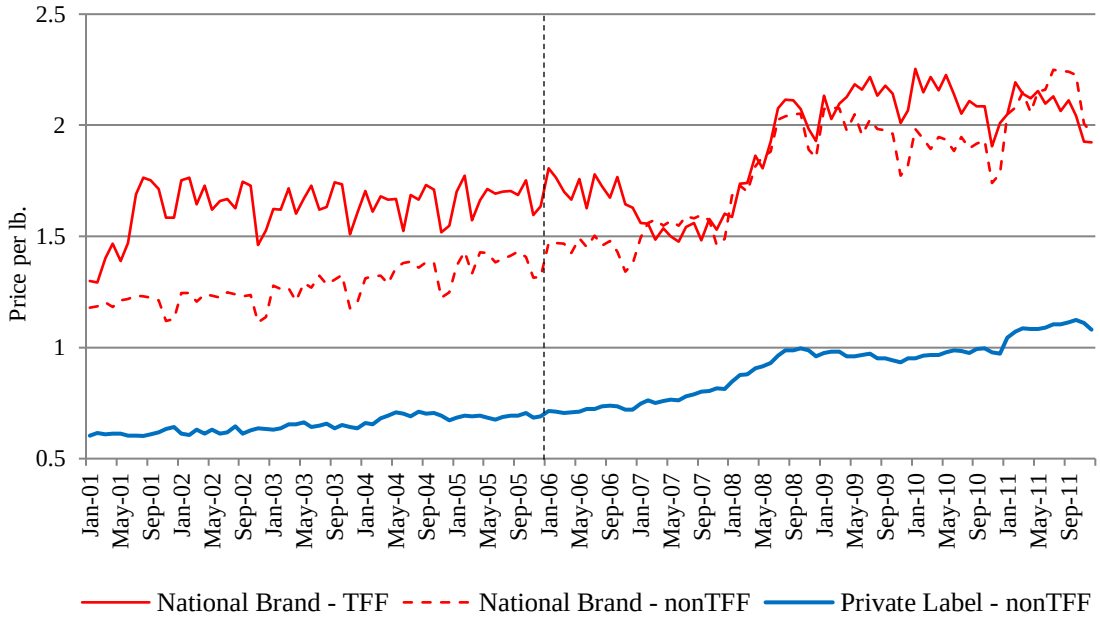
Labeling Change	Frequency	Percentage
Always TFF label	16	45.7%
Switch from non-TFF label to TFF label	9	25.7%
Switch from TFF-label to non-TFF label	6	17.1%
Switch from non-TFF to TFF to non-TFF label	4	11.4%

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 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.

Figure 1.1 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 to 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. Figure 1.1 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 1.3, 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.

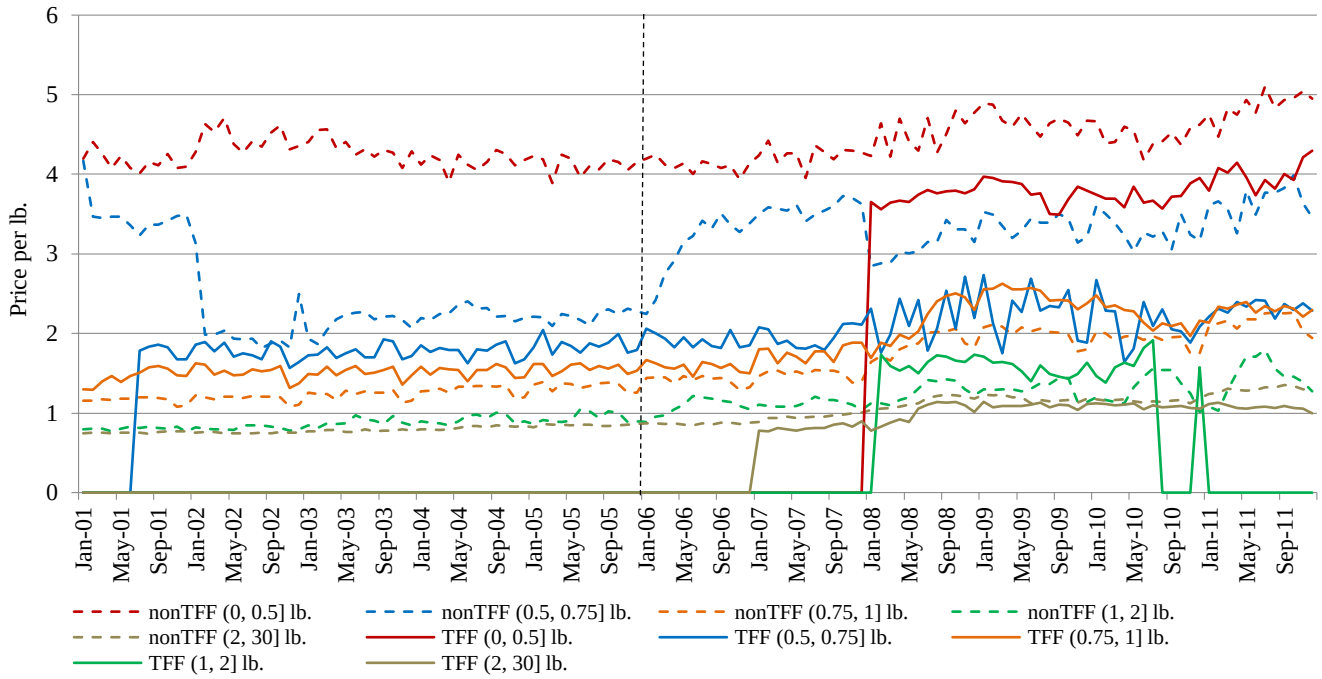
Figure 1.1 Monthly Average Price of Margarine and Spreads – by Claim



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. Figure 1.2 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.

Figure 1.2 Monthly Average Price of Margarine and Spreads – by Label and Size

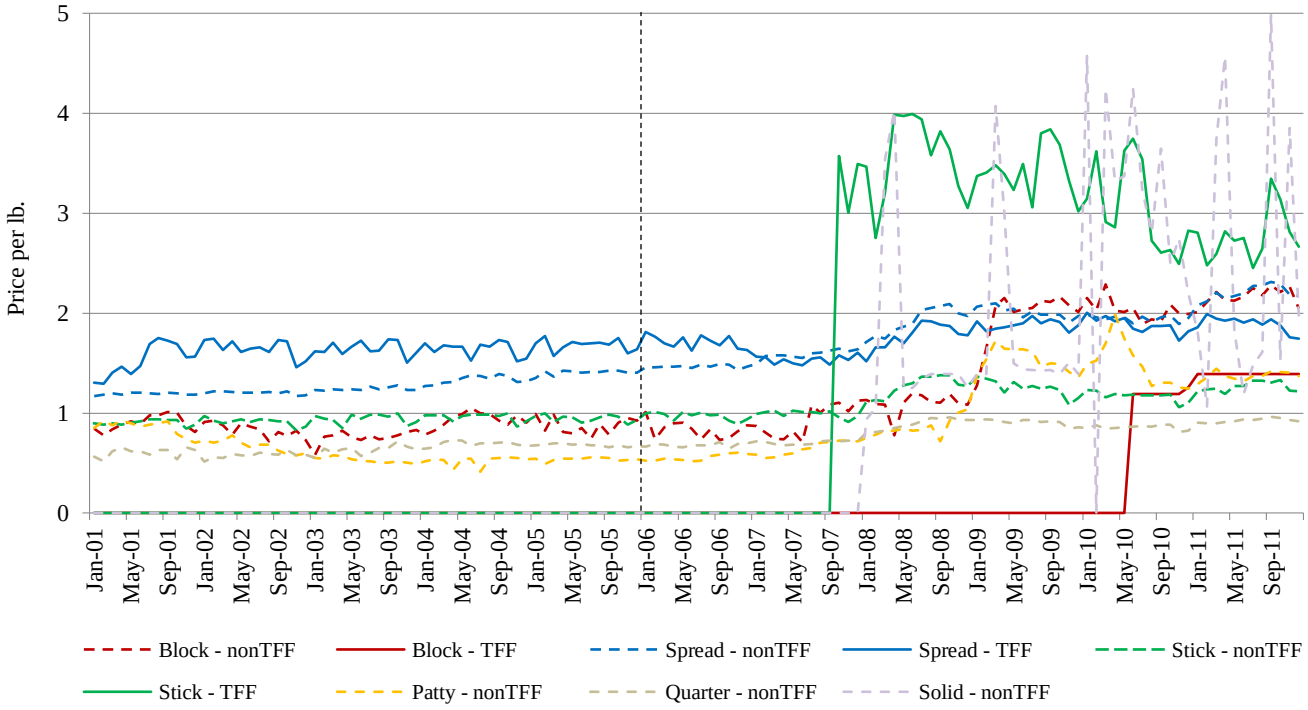


In a similar fashion, we also decompose all products by their forms. More specifically, margarine and spreads come in different forms, such as liquid and spread. Due to the large number of different types, we separate all unique products into solid and non-solid forms for clarity. Figures 1.3 and 1.4 present decompositions by solid form and non-solid forms respectively.

Similar to the decomposition by size and label, figure 1.3 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 figure 1.1. 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.

Figure 1.3 Monthly Average Price of Margarine and Spreads – by Label and Form, Solid

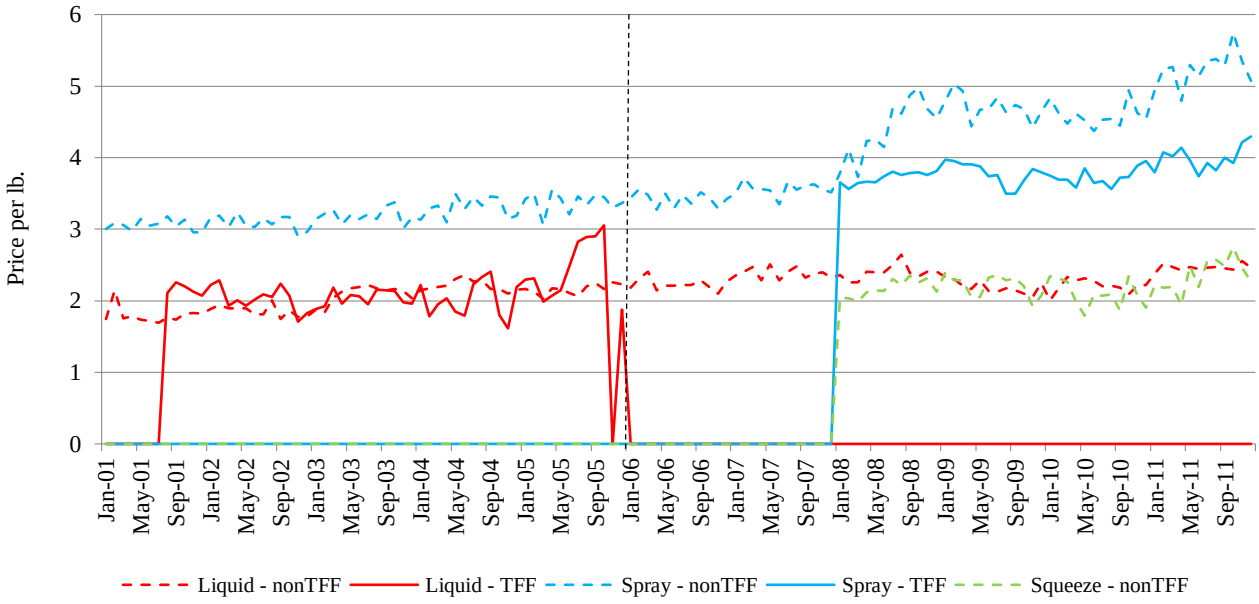


Note: Products in the forms of patty, quarter, and solid do not carry TFF claims.

Similar to figure 1.3, figure 1.4 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.

Figure 1.4 Monthly Average Price of Margarine and Spreads – by Label and Form, Non-Solid



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

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, sixteen new TFF-labeled products were added to the market in 2007 and eleven in 2008. Thus the labeling policy had a significant short-run effect on product offerings. As shown in table 1.2, 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 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.

1.4.2 Changes in Product Purchases

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 1.6 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

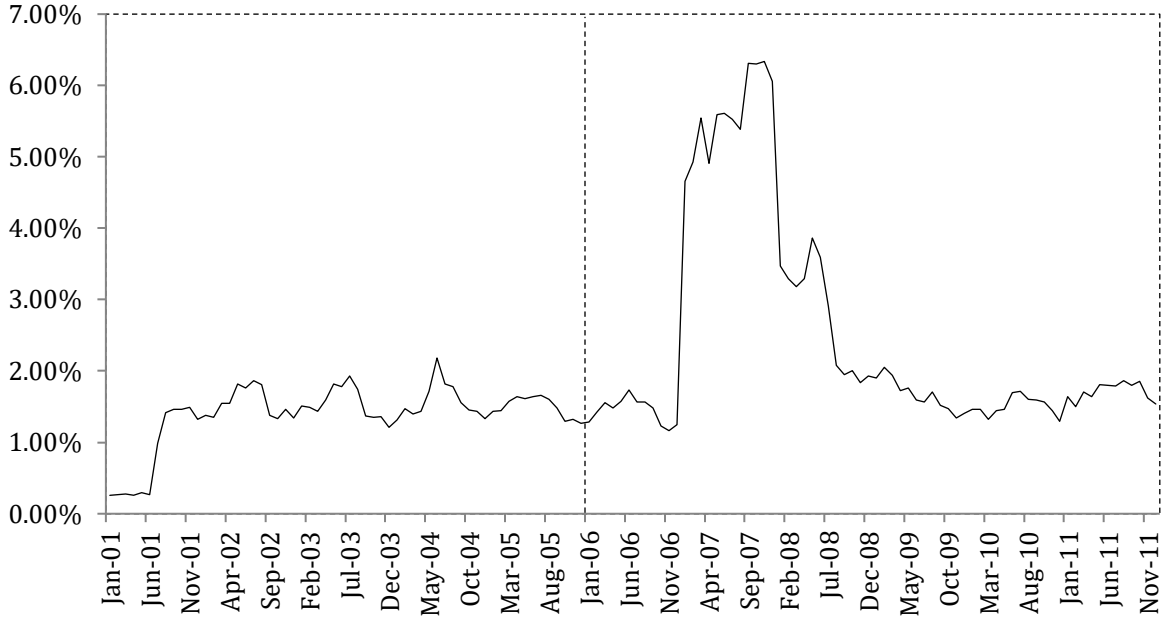
dropped dramatically over the period from 74.7 million pounds in 2001 to 44.5 million pounds in 2011. The proportion of purchases that were TFF-labeled products peaked in 2007, just after implementation of the 2006 rule, at nearly 6% of purchases measured both in pounds and dollars.

Table 1.6 Annual Purchases of TFF-Labeled and Non-TFF-Labeled Margarine and Spreads, 2001-2011

Year	Volume (in million lb.)			Expenditure (in millions of dollars)		
	All	TFF	Percentage TFF	All	TFF	Percentage 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%

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.

Figure 1.5 Monthly U.S. Market Share of TFF-Labeled Margarine and Spreads, 2001-2011



As shown in figure 1.5, 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 to 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

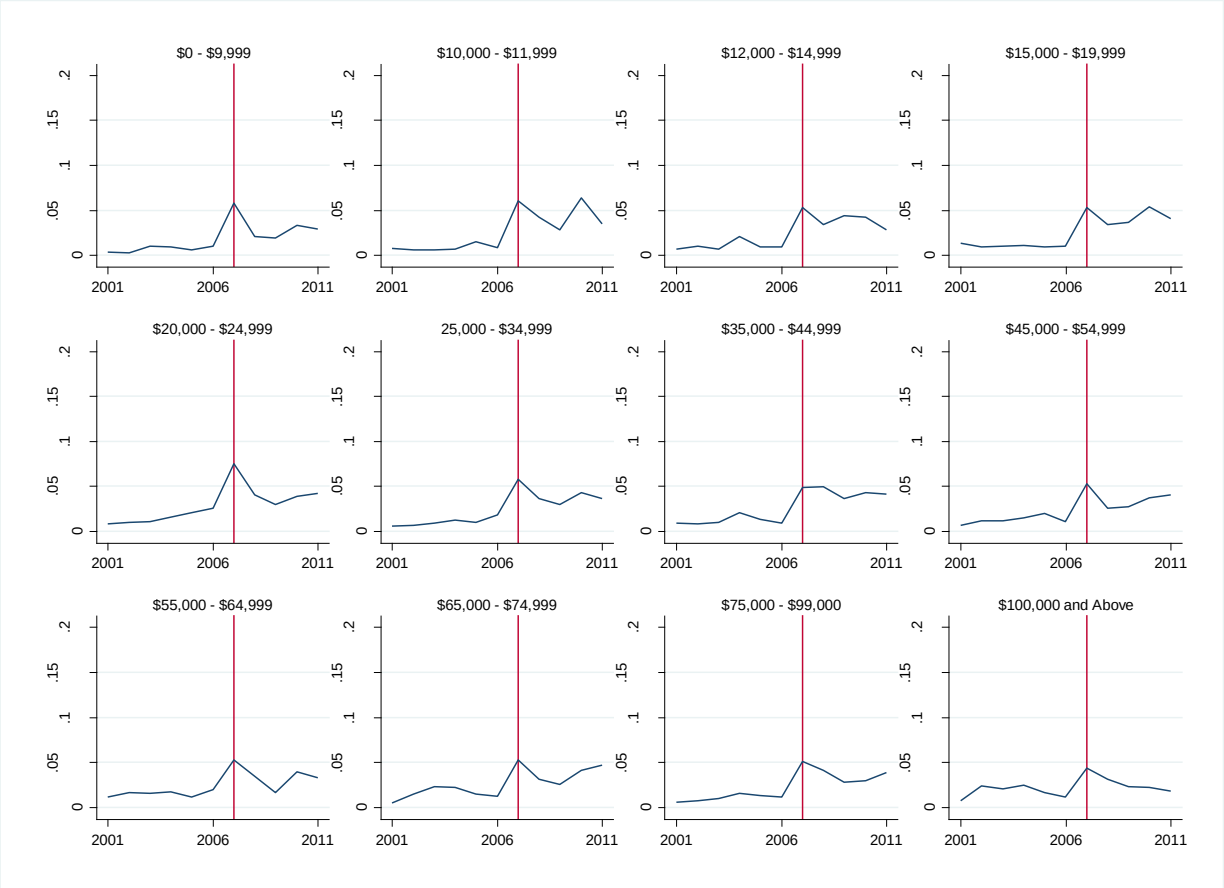
with less of a drop-off. We emphasize the retail rather than the household panel results because the retail panel provides changes in the market at the nationwide level, which is a more comprehensive result. The short- and long-run effects are explored further in the regression analysis in the next section.

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 figures 1.6 to 1.9 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.

Figure 1.6 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 $9,999 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 for the average household in the $20,000 to $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 to $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.

Figure 1.6 Annual Purchase Percentage of TFF-Labeled Margarine and Spreads by Household Income Bracket



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. Figure 1.7 shows similar annual average household purchases of TFF-labeled products as in figure 1.6 with the households grouped according to the education level of the head of household.[5] Figure 1.7 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 & 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, McClusky, & Villas-Boas (2011) and Shimshack, Ward, & Beatty (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.

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

[5] If female household education level is not available, we used male head of household education level instead.

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. Figure 1.8 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 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%.

Figure 1.7 Annual Purchase Percentage of TFF-Labeled Margarine and Spreads by Education of Head of Household

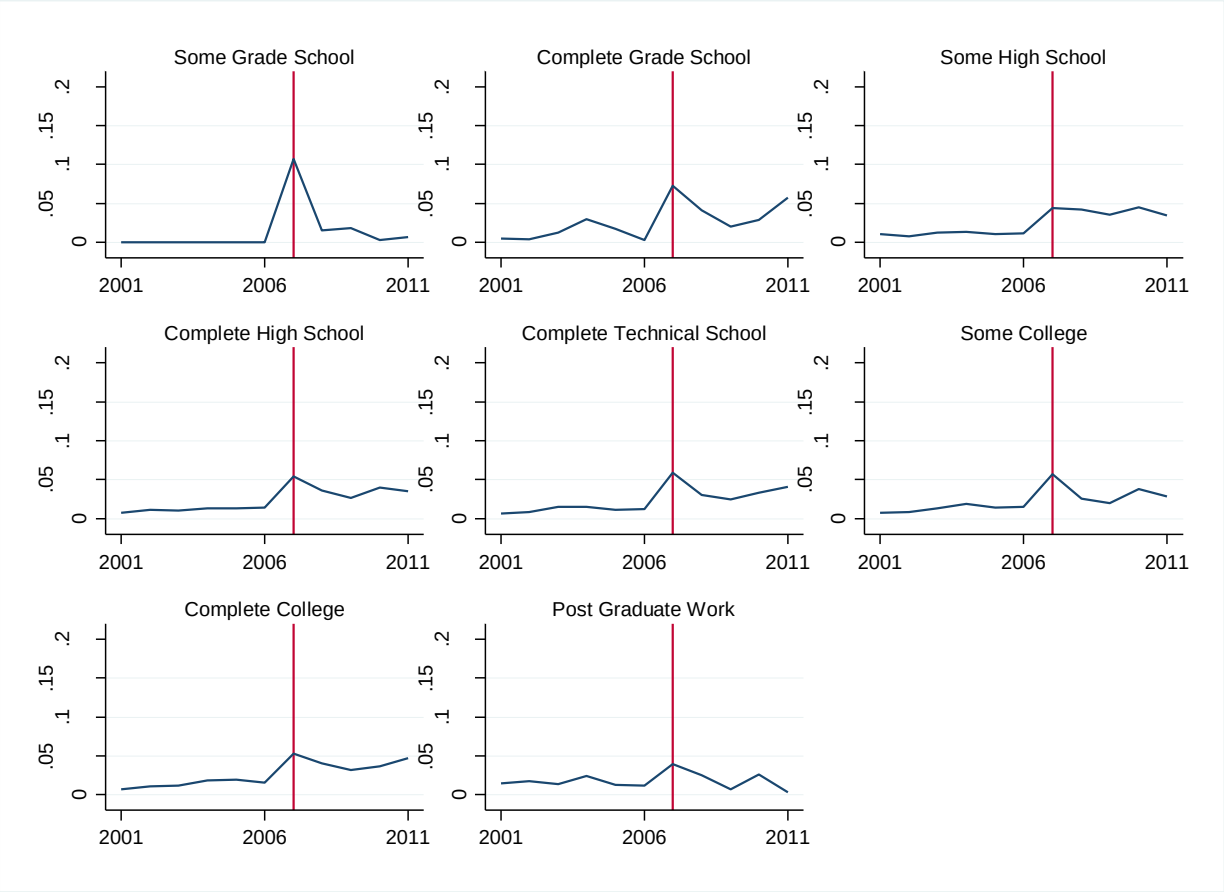
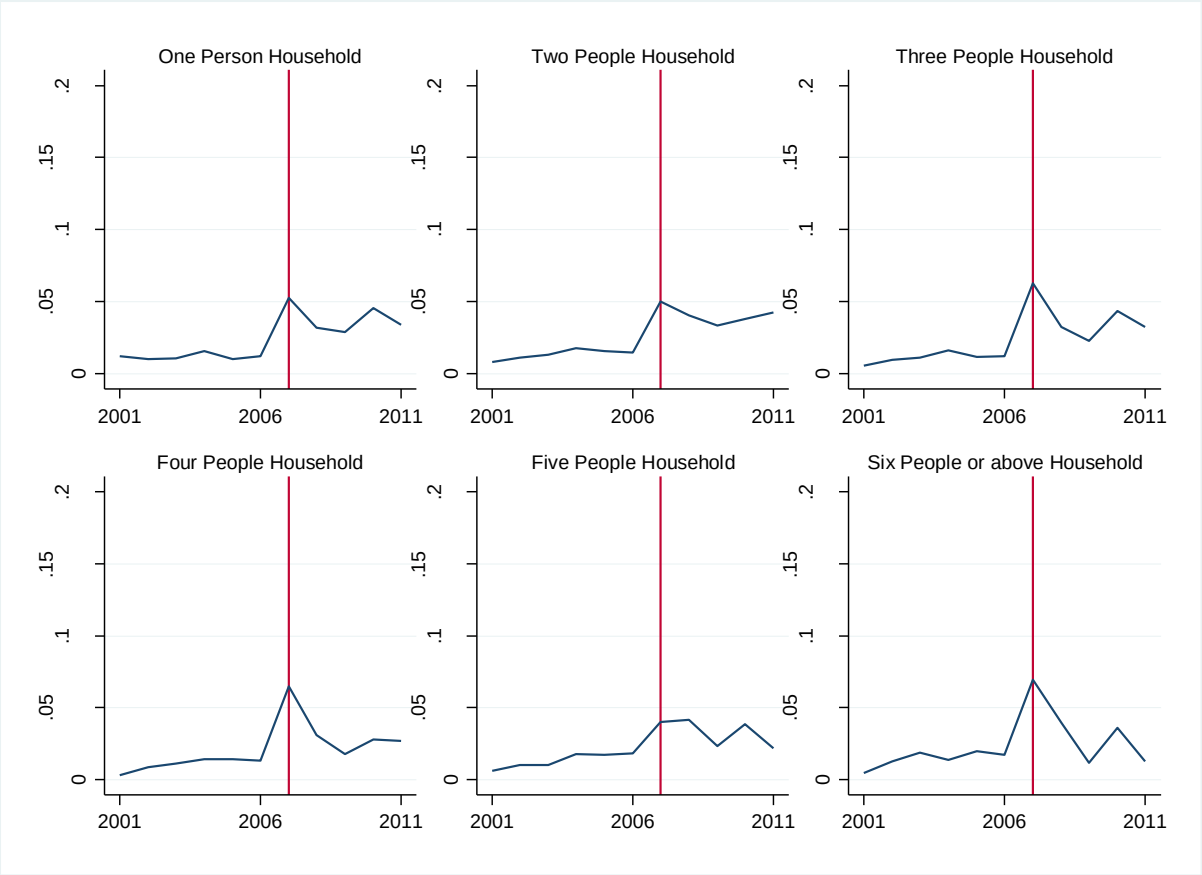
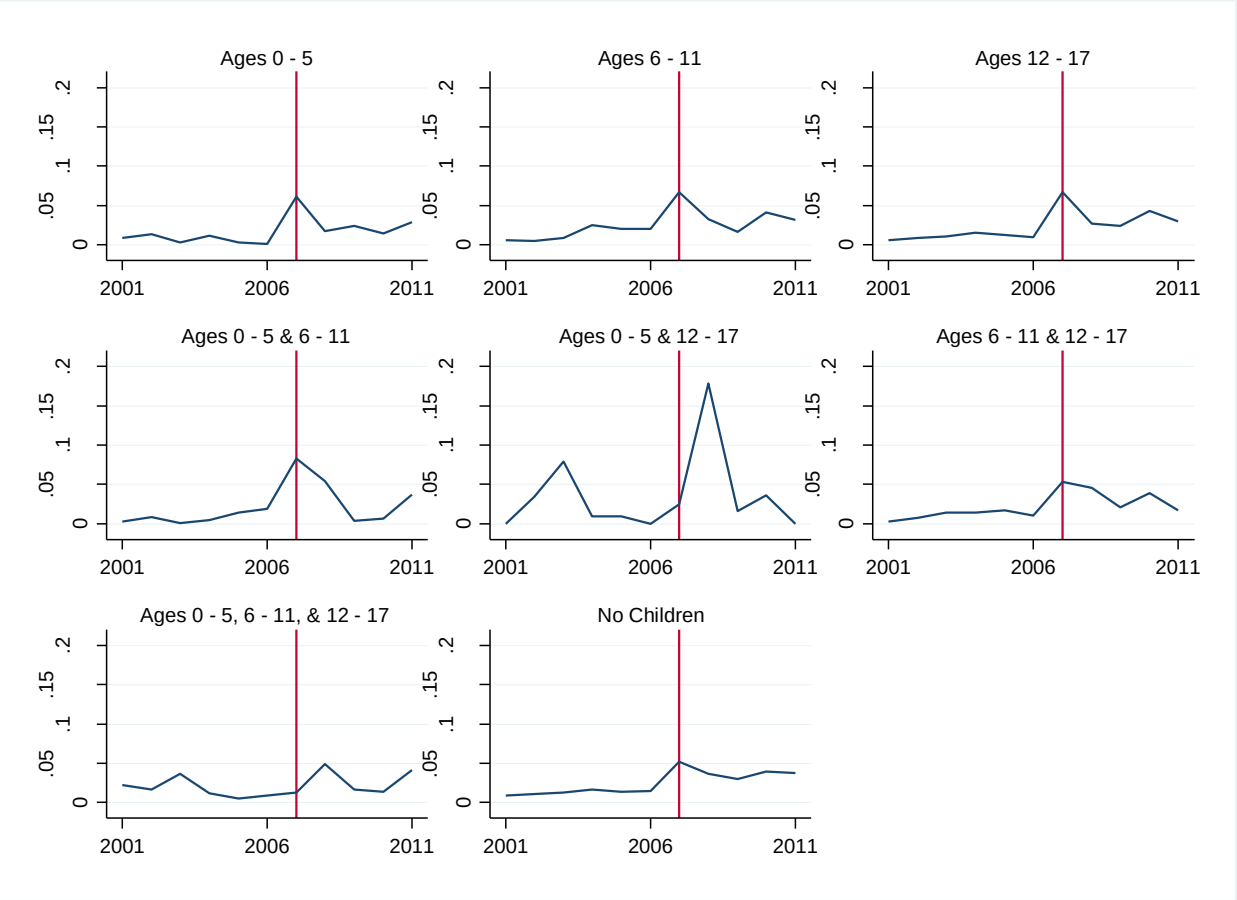


Figure 1.8 Annual Purchase Percentage of TFF-Labeled Margarine and Spreads by Household Size



It is possible that the presence of children may influence changes in household purchase behavior. Figure 1.9 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.

Figure 1.9 Annual Purchase Percentage of TFF-Labeled Margarine and Spreads by Presence of Children



1.5 Regression Model

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 1.7 defines all variables used in the analysis.

Prices in the household utility function are normalized to dollars per oz, 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 figure 1.5, 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 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.

Table 1.7 Variables Included in Regression Analysis

Symbol	Variable	Description
P	**Price per oz.**	Price per oz.
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 $9,999 annually
	High Income	Dummy with value of one 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 = 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 figure 1.2
	Form	Dummies for each form the product takes, as shown in figures 1.3 and 1.4.

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 1.7. 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:

$$U_{ijt} = \alpha + \beta \cdot P_{ijt} + \zeta \cdot T_t + \eta \cdot SR_t + \theta \cdot LR_t + \gamma \cdot X_{it} + \delta \cdot Z_{jt} + \varepsilon_{ijt} \quad \textbf{(1)}$$

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 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:

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

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.

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

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,

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

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:

$$\Pr\left(Y_{ijt} = 1\right) = \frac{e^{\left(\alpha + \beta \cdot P_{ijt} + \zeta \cdot T_t + \eta \cdot SR_t + \theta \cdot LR_t + \gamma \cdot X_{it} + \delta \cdot Z_{jt}\right)}}{1 + e^{\left(\alpha + \beta \cdot P_{ijt} + \zeta \cdot T_t + \eta \cdot SR_t + \theta \cdot LR_t + \gamma \cdot X_{it} + \delta \cdot Z_{jt}\right)}}$$

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

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

1.6 Regression Results

Marginal effects implied by the parameter estimates of the models are reported in table 1.8. 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.

Table 1.8 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 oz.	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	0.00110
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	452035	283191	452035	283191	452035	283191

*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.

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. 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 1.8, 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 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.

1.7 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 fats 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" 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 fats, 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 TFF 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 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.

1.8 Regression Robustness Checks

Table 1.9 below 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 1.8.

Table 1.9 Factors Affecting Purchase Probability for Margarine/Spreads with Trans Fat Free Claims, Logit Model. 2001-2011

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Variable	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**
Price per oz.	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	452035	283191	452035	283191	452035	283191

*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 1.10 below 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 1.8.

Table 1.10 Factors Affecting Purchase Probability for Margarine/Spreads with Trans Fat Free Claims, Logit Model. 2001-2011

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Variable	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**
Price per oz.	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	452035	283191	452035	283191	452035	283191

*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 1.11 below documents baseline regression results with no demographic controls. Results for the main parameters of interest remain qualitatively similar to those reported in table 1.8.

Table 1.11 Factors Affecting Purchase Probability for Margarine/Spreads with Trans Fat Free Claims, Logit Model. 2001-2011

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Variable	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**	**dy/dx**
Price per oz.	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 Chi2	579.87	1129.29	586.62	1139.49	1051.84	2040.14
Prob > Chi2	0.00	0.00	0.00	0.00	0.00	0.00
Sample Size	452035	283191	452035	283191	452035	283191

*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.

CHAPTER 2

ESTIMATING CONSUMERS' WILLINGNESS TO PAY FOR TRANS FAT IN THE POST MANDATORY LABELING REGIME

2.1 Introduction

Coronary heart disease is currently the leading cause of death in the United States, responsible for one in three deaths (Go et al. 2014); obesity—with an estimated prevalence of 35% in the U.S. adult population over the 2011–2012 period—imposes annual nationwide medical costs of $315.8 billion (2010 values) (Cawley et al. 2015). In this environment, both federal and state governments have introduced various policies to try to stem and reduce the prevalence and incidence of obesity, heart disease, and various co-morbidities. Trans fats—tied to increases in coronary heart disease, obesity, and insulin sensitivity (Go et al. 2014)—are one of the nutrients targeted for policy interventions in the United States. In particular, legislation enacted in 2003 required the explicit trans fat labeling for all foods beginning in 2006. In 2015, the Obama administration finalized a ban on trans fats, providing a 3-year compliance period to allow the food industry to remove all trans fats from their products.

Using Nielsen retail scanner data on microwavable popcorn purchases over the 9 years (January 2006–December 2014) following the introduction of the trans fat labeling requirement, this chapter explores consumers' willingness to pay (WTP) for trans fat. We model products as a bundle of characteristics (Lancaster 1966) that includes normalized trans fat content per 100 g and other nutrient content. We use a multinomial logit model to estimate product-level demand, which allows us to estimate how a change in trans fat content affects consumer demand for microwavable popcorn products. We allow consumer preferences to vary over time while

holding price sensitivity constant. Furthermore, we decompose retail sales data at the state level and explore whether there are regional differences in consumer preferences.

2.2 Literature Review

Trans fats, or (industrially produced) trans fatty acids, are formed when hydrogen is added to a vegetable oil through the process of partial hydrogenation to make a more solid and stable cooking fat. Trans fats are commonly used to extend food products' shelf lives and cost-efficiently modify their taste and texture. The 2006 labeling legislation led some producers to abandon the use of trans fats, but they are still commonly found in products such as cookies, cakes, margarines, baking mixes, fried foods, and snack items, particularly microwavable popcorn.

Trans fat consumption is linked to higher levels of "bad" LDL (low-density lipoprotein) cholesterol and is associated with a 23% increase in the risk of coronary heart disease (Go et al. 2014), a significant increase in adiposity (Go et al. 2014), abdominal obesity, and changes in insulin sensitivity (Kavanagh et al. 2007). Trans fat have no known health or nutritional benefits (Ascherio and Willet 1997), and most health experts recommend limiting trans fat consumption to a minimum. Many countries have therefore implemented trans fat reduction policies, ranging from nutrient labeling to complete bans on their use in food production. For example, since 2004, trans fats cannot make up more than 2% of total fat content in any food item in Denmark (Stender et al. 2006), leading to a drastic decline in trans fat consumption in that country. Producers have widely varying levels of trans fat in their products depending on local consumer preferences and legislation, and the same types of food can have very different levels of trans fat. In 2006 in Sweden and Norway, which had no bans on trans fats at that time, trans fats made up

48% and 49%, respectively, of total fat in popcorn. By contrast, the trans fat content of popcorn from Denmark (after the trans fat legislation) was below 5% (Stender et al. 2006).

Previous literature suggests that consumer preferences for the taste of trans fat are unclear. Consumer acceptance of reformulated products' taste and texture could also vary substantially across products (Eckel et al. 2007). Some have argued that trans fat bans represent unjustified limitations to consumer choice (Resnik 2010), which was somewhat validated by some consumers "mourning" their favorite foods ahead of the trans fat ban (Greatist 2015). According to the U.S. Food and Drug Administration (FDA, 2015), the 2006 trans fat labeling policy gave consumers information necessary to make heart-healthy choices, implicitly suggesting that consumers not only know the health effects of trans fats but also prefer to limit their consumption for health reasons. This assumption implies that most consumers believe trans fat to be a negative characteristic.

However, consumers might actually prefer items with trans fat content, either due to a lack of knowledge about their health effects or due to preferences for reduced saturated fat content in general (trans fats are a frequent substitute for saturated fats). Estimates of nutrient-specific elasticity in the current literature are often quite inelastic (Huang and Lin 2000, Allais et al. 2010), while studies examining consumer preferences for fat in particular suggest that fat content is often seen as a positive characteristic. Ou (2017) finds that, on average, consumers were willing to pay $0.002/oz more for the taste of trans fat based on a structural discrete choice model using data from 2 years before to 2 years after the 2006 labeling policy was instituted. Rapp et al. (2009) suggest that both consumers with heart disease and healthy consumers prefer full-fat foods over low-fat foods; using a taste experiment, Vickers and Mullan (1997) find that participants consume more cheese when the full-fat variety is available and rate full-fat cheeses

as tastier and more likable. While trans fats are just one type of fat, and high-fat products do not necessarily contain trans fats, it is possible that some consumers might actually seek out trans fat products for their flavor characteristics, particularly when trans fat content is also associated with high fat content.

However, Ou (2017) also finds evidence that a consumer with average demographic characteristics is willing to pay −$0.013/oz. for the trans fat content label, which is significantly larger in magnitude than WTP for trans fat taste. This means that consumers are willing to pay more to compensate for a loss in utility from health than for a utility gain from the taste of trans fats. WTP to pay for the label is noticeably higher among those with higher incomes, those with more education, more frequent buyers, and smokers. Many other studies suggest that fat can be perceived as a negative characteristic: Results from Lusk and Parker's (2009) choice experiment suggest that consumers would prefer reduced saturated fat content in ground beef; similarly, Krause et al. (2007) conclude that consumers perceive saturated fat content as an undesirable characteristic in butter.

Overall, some evidence indicates that companies started voluntarily limiting trans fat content in their products after the 2006 labeling regulation came into force. Unnevehr and Jagmanaite (2008) suggest that the restaurant and food service industry in particular started reformulating their products to limit trans fat content. Doell et al. (2012) look at trans fat consumption in the U.S. population using the National Health and Nutrition Examination Survey and suggest that overall trans fat consumption decreased from 4.6 g per person per day in 2003 to 1.3 g per person per day in 2013, although individuals with certain dietary habits (e.g., those who frequently consume certain brands or types of food products with at least 1 g trans fat per serving, such as refrigerated biscuits, ready-to-use frozen pizzas, and microwavable popcorn)

may still consume high levels of trans fat. Most trans fat labeling policies have led to some reductions in consumption, but their relative effectiveness varies considerably, with bans being the most effective policy option for reducing trans fat consumption.

In the United States, the 2006 trans fat labeling rule is estimated to have led to an approximately 58% reduction of trans fatty acids levels in blood plasma and reduced blood levels of LDL cholesterol, but the World Health Organization suggests that continued reductions in trans fat consumption are still required (Down et al. 2013). In particular, in the absence of national and local bans, some population sub-groups continue to consume higher-than-advisable levels of trans fats, either due to particular tastes or to the relative costliness of trans fat–free products (Down et al. 2013). Additionally, some trans fat labeling might be perceived as deceptive: Trans fats with less than 0.5 g per serving do not need to be labeled, but product labels often underestimate the size of actual consumer servings (FDA 2015).

2.3 Data Description

We choose microwavable popcorn as our product category because it can be produced with or without trans fats. According to the U.S. Popcorn Board (2018), Americans consume approximately 13 billion quarts of popped popcorn annually, 70% of which is eaten at home. Most (90%) home-prepared popcorn is purchased in un-popped form, including the microwavable popcorn we focus on here. In 1999, microwavable popcorn accounted for around 72% of all popcorn sales in the United States (Hansen and Brester 2012). As a snack item, popcorn is often considered to be a healthier alternative, endorsed by Weight Watchers as a weight-conscious snack and the American Dental Association as a sugar-free snack; the American Cancer Society recognizes popcorn for its high fiber content (Hansen and Brester 2012).

We first summarize large-scale Nielsen retail scanner datasets—consisting of weekly purchase and pricing data from more than 90 participating retail chains—from the Kilts Center for Marketing. We focus on six popcorn brands with 104 unique products, each defined by a unique combination of brand and flavor. Together, Orville Redenbacher's, Pop Secret, Act II, Jolly Time, and Cousin Willie's account for over 96% of market share; all other brands, including private-label brands, serve as the outside good. Table 2.1 presents the average and yearly market share for 2006–2014, the period of our analysis.

Table 2.1 Yearly and Average Market Shares by Brand, 2006–2014

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	Average
Orville Redenbacher's	39.52%	40.76%	42.34%	42.39%	39.92%	42.33%	41.30%	40.43%	39.36%	40.93%
Pop Secret	21.96%	22.22%	23.77%	25.93%	32.17%	33.78%	34.69%	36.85%	39.82%	30.13%
Act II	24.61%	23.43%	21.74%	19.84%	16.92%	14.91%	13.97%	13.00%	12.14%	17.84%
Jolly Time	6.37%	5.91%	4.54%	5.72%	5.58%	5.42%	5.72%	5.98%	5.62%	5.65%
Cousin Willie's	1.76%	1.56%	1.35%	1.56%	1.82%	1.71%	2.25%	2.04%	1.90%	1.77%
All Other	5.78%	6.11%	6.26%	4.55%	3.59%	1.84%	2.07%	1.70%	1.16%	3.67%

Orville Redenbacher's and Pop Secret are the clear market leaders, with the former brand enjoying a higher initial market share and the latter catching up consistently, securing a slightly higher market share by 2014. This increase in Pop Secret's market share seems to have occurred mostly at the expense of Act II (which lost slightly over 50% of its 2006 market share by 2014) and smaller brands, whose overall share declined from almost 6% in 2006 to just over 1% in 2014. Figure 2.1 provides detailed information on monthly shares by brand. The turning point for the change to the original market share distribution appears to be 2009, before which market shares remained relatively stable. Table 2.2 shows that 4 out of 5 microwave popcorn brands carry products with trans fats. Altogether, 15 products have trans fats, with a total market share of more than 30% out of all products. Pop Secret has the largest market share for products with trans fats, approximately 27.5%.

Figure 2.1 Volume Market Share by Top Brands, 2006 to 2014

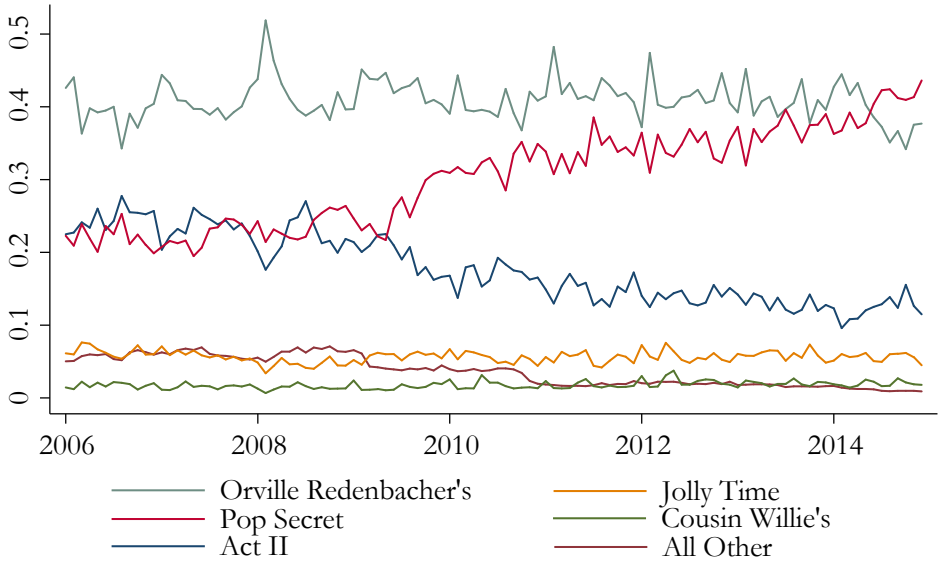


Table 2.2 Number and Market Share of Products with Trans Fat by Brand

Company	Brand	Number of products		Volume market share	
		Trans fat	Total	Trans fat	Total
Conagra Foods, Inc	Orville Redenbacher's	1	25	0.48%	38.43%
Diamond Foods, Inc	Pop Secret	4	12	27.53%	27.98%
Conagra Foods, Inc	Act II	0	19	0.00%	17.60%
American Pop Corn Company	Jolly Time	3	12	2.46%	5.58%
Ramsey Popcorn Co.	Cousin Willie's	7	9	1.28%	1.75%
Total		15	77	31.75%	91.34%

Note: These five brands have 104 products altogether. But 27 products are not included, because they are either non-microwavable popcorn or no nutrition information available. Private label products only exist in household panel data, but not in retail store date.

Table 2.3 summaries the level of each nutrition ingredient contained in all 77 sample products. It shows that the maximum amount of trans fat per 100 g of microwave popcorn is 15.2 g and the average is 2.0 g, with a standard deviation of 4.3 g.

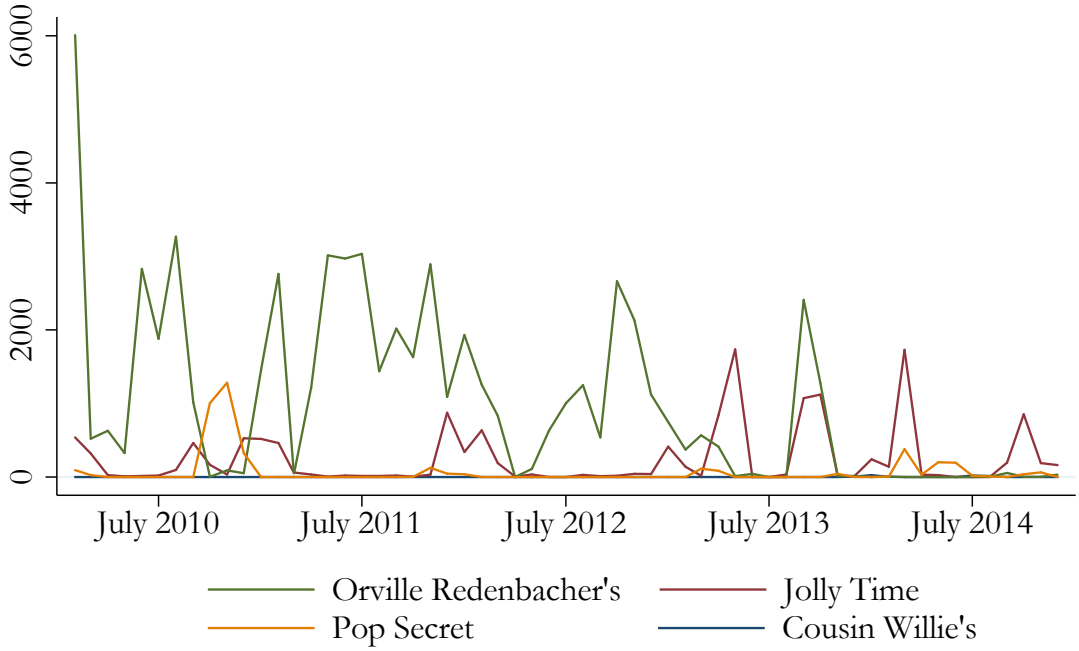
Table 2.3 Summary Statistics of Nutrition Ingredients

Variable	Unit	n	Mean	S.D.	Min	25th	Mdn	75th	Max
Calories		77	464.4	71.2	152.2	424.2	472.2	514.3	642.9
Total fat	g	77	27.7	10.0	3.0	21.1	30.0	35.7	42.9
Saturated fat	g	77	9.0	4.6	0.0	6.3	8.3	11.8	20.6
Trans fat	g	77	2.0	4.3	0.0	0.0	0.0	0.0	15.2
Sodium	mg	77	803.1	347.0	0.0	531.3	852.9	1000.0	1896.6
Total carbohydrate	g	77	53.2	10.3	11.4	46.9	52.8	60.0	70.3
Dietary fiber	g	77	9.6	3.7	0.0	8.1	8.8	10.0	18.2
Sugars	g	77	1.7	6.0	0.0	5.9	6.7	9.7	37.8
Protein	g	77	7.3	2.4	0.0	0.0	0.0	0.0	12.1

*Serving size normalized to 100 g.

As significant changes in market-share distribution occurred across the observed period, we would prefer to see whether any brand adjusted its advertising strategy, which could explain the observed changes. Figure 2.2 provides monthly advertising expenditures for the top brands.

Figure 2.2 Monthly Advertising Expenditures by Brand (in $1,000) 2010–2014



Orville Redenbacher's and Jolly Time spent the most on advertising on average, with Pop Secret maintaining relatively low expenditures most of the observed period. This advertising snapshot suggests that advertising changes do not seem to be behind the observed changes in market shares across the top brands in our sample. We only have access to advertising expenditures data starting in 2010, which limits our ability to consistently control for the effects of advertising in our main model estimation. Given that advertising does not seem to drive observed market share changes, we omit this factor from our main analysis.

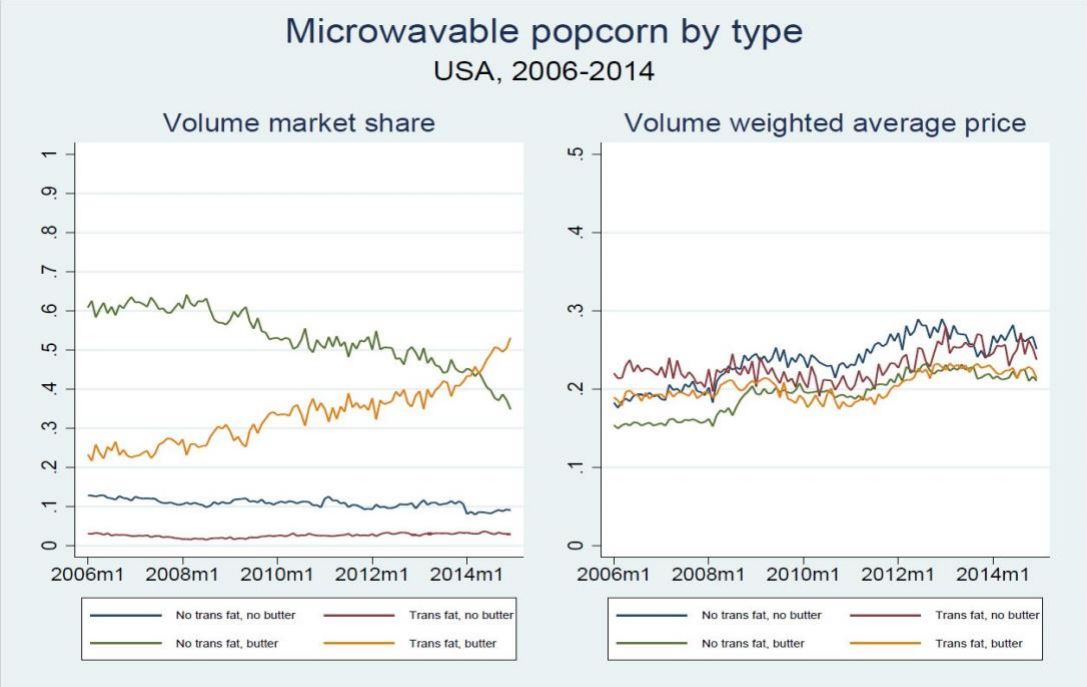
2.4 Descriptive Results

Nutrition information—including serving size, calories, total fat, saturated fat, trans fat, cholesterol, sodium, dietary fiber, sugars, and protein—was collected manually from the top 5 brands' websites for 77 of 104 popcorn products. These 77 products accounted for 91.3% of market share in volume of sales across 49 U.S. states and over a 9-year period (2006–2014).

Figure 2.3 categorizes all 77 products by trans fat content and butter flavor. We present the monthly volume market shares and monthly volume weighted average prices for each of the four types of microwavable popcorn over our sample period using all retail store sales from the Nielsen scanner data. In January 2006, over 60% of microwavable popcorn sold in markets was butter flavored and trans fat free. A little more than 20% of products were butter flavored and had trans fat. However, butter-flavored, trans fat–free products gradually lost market share to butter-flavored products with trans fat. By the end of 2014, the market share for butter-flavored microwavable popcorn with trans fat was larger than that of butter-flavored products without trans fat by nearly 20%. Non-butter microwavable popcorn products experienced a modest decrease in volume market share for products without trans fat from 2006 to 2014. Over time, monthly volume market shares for non-butter products with trans fat stayed relatively unchanged. Interestingly, butter-flavored products (both with and without trans fat) were priced lower than their non-butter counterparts for the entirety of our sample period. The average price of non-butter products with trans fat was higher until around late 2008, and mostly lower afterward, than that of non-butter products without trans fat. For butter-flavored products, having trans fat would initially increase prices by approximately $0.4/g, but since late 2009, prices for both butter-flavored products with and without trans fat remained similar. This implies that consumers were price sensitive and less likely to purchase butter-flavored products with trans fat when they were priced higher than their non–trans fat counterparts. Nevertheless, when given the same price, they would actually prefer butter-flavored products with trans fat to butter-flavored products without trans fat, even though there were only 7 butter-flavored products with trans fat compared to 28 without across the sample period. Non-butter products without trans fat sold better than those with trans fat at all times, which might result from the fact that there were only

8 non-butter products with trans fat, compared to 34 without. Another potential explanation could be that consumers think products with trans fat taste better when they choose butter-flavored microwavable popcorn, which are already "bad" in the sense that they contain high levels of saturated fat. However, non-butter microwavable popcorn is considered to be a relatively healthier choice, so less trans fat would be preferred.

Figure 2.3 Microwavable Popcorn Volume Market Shares and Volume Weighted



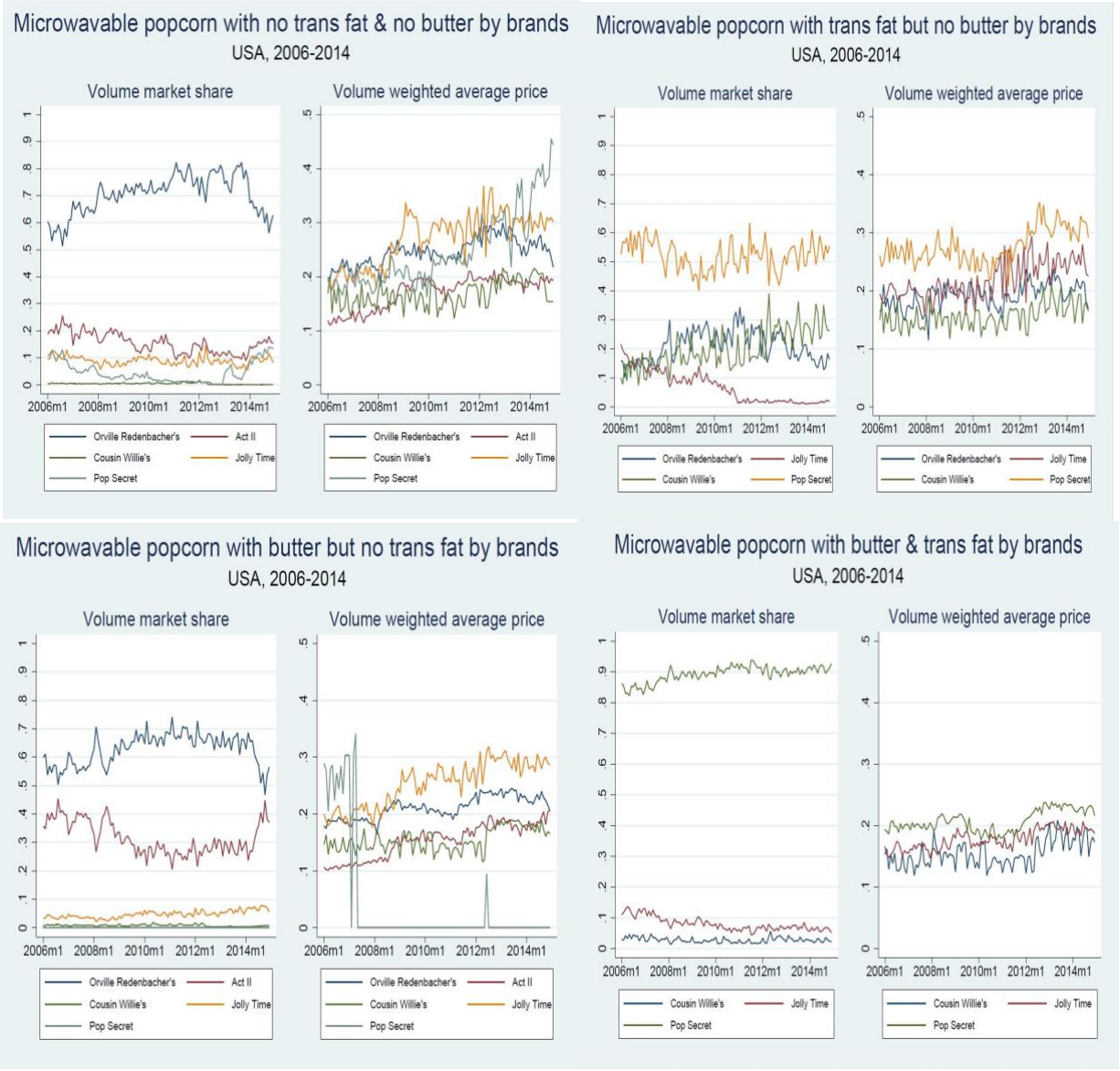
2.4.1 Summary Statistics by Category

We then examine the four microwavable popcorn markets by comparing monthly volume market shares and volume weighted average monthly prices of the top five brands. Figure 2.4 (will be reformatted later) shows that Orville Redenbacher's dominated the markets for both butter and non-butter products without trans fat, while Pop Secret was the top brand in markets for both butter and non-butter products with trans fat. Note that Act II did not have any products

with trans fat and only Orville Redenbacher's non-butter products had trans fat.[6] Counterintuitively, the dominant brand (Pop Secret) in the trans fat microwavable popcorn market, both with butter and without butter, was sold at the highest price at all times. Jolly Time's market share for butter microwavable popcorn with trans fat decreased slightly, while its market share for butter microwavable popcorn without trans fat had a compensating slight increase. Jolly Time's market share in the market of non-butter microwavable popcorn with trans fat dropped dramatically from more than 2% to nearly 0, but its market share for non-butter microwavable popcorn without trans fat stayed relatively similar over time. This seems to imply that Jolly Time made efforts to promote its products without trans fat and had some success in increasing sales of butter microwavable popcorn without trans fat but did not make any breakthrough in the market for non-butter products without trans fat. We expect that the 2015 trans fat ban will greatly affect Cousin Willie's and Pop Secret, both of which had a much larger market share in the trans fat products markets than in the non–trans fat markets.

[6] Market shares of Orville Redenbacher's and Act II in both non–trans fat microwavable popcorn markets mirrored one another nearly perfectly. Since the same manufacturer owns both brands, it is possible that the firm strategically promotes one brand at a time.

Figure 2.4 Monthly Volume Market Shares and Volume Weighted Average Monthly Prices by Brand



2.4.2 Summary Statistics by State

In Figure 2.5, we further decompose and explore consumer preference for trans fat by region, as defined by United States Census Bureau.[7]

[7] Figure cited from https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf

Figure 2.5 Census Regions and Divisions of the United States

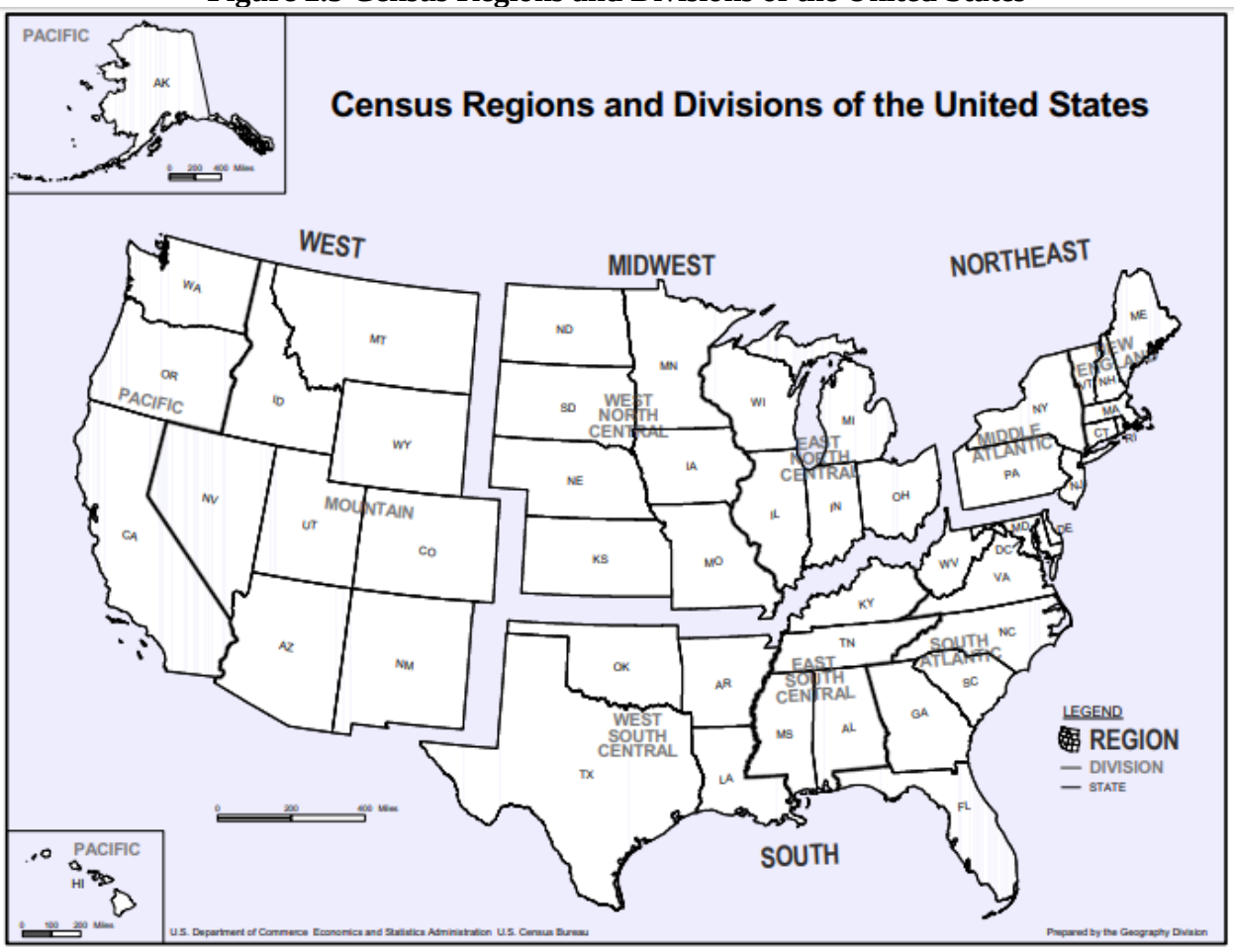


Table 2.4 summarizes the average number of microwavable popcorn products available annually in four regional areas.[8] For example, on average, 6 out of 30 microwavable popcorn products offered in one northeastern state contained trans fats in 2008. Between 2006 and 2014, the Northeast and West had fewer products available with trans fat than did the Midwest or the South; this is also true for products with trans fat as a percentage of all products. This implies that consumers in the Northeast and West were generally exposed to fewer microwavable popcorn products with trans fat.

[8] We assume that there was no change in the nutritional contents of the products. Unfortunately, no available database allows us to observe the nutrition panels for all 77 products over time. Product reformulations were possible after the 2006 trans fat labeling rule, but we were able to confirm limited, if any, changes in the nutrition panel information for all 77 products using their historical websites.

While the number of total products available regardless of region, experienced a slight decrease in 2009 and 2010, the number of products with trans fats remained roughly the same for all four regions. Due to the global 2008 financial crisis (when people were tight on budget and less willing to spend money on snacks), it is possible that manufacturers temporarily cut down the availability of some of their products, only a few of which had trans fat, suggesting that firms consider products with trans fat to be potentially more profitable than other products. Consumers did not show a strong preference for avoiding products with trans fat, even after the 2006 mandatory trans fat labeling rule.

Table 2.4 Average Number of Microwavable Popcorn Products with Trans Fat

Year	Northeast			Midwest			West			South		
	# All	# TF	% TF	# All	# TF	% TF	# All	# TF	% TF	# All	# TF	% TF
2006	34	7	20.6	38	9	23.7	37	8	21.6	40	10	25.0
2007	34	6	17.6	39	9	23.1	37	8	21.6	39	10	25.6
2008	30	6	20.0	38	9	23.7	36	8	22.2	36	10	27.8
2009	27	5	18.5	35	9	25.7	31	8	25.8	32	9	28.1
2010	26	6	23.1	34	9	26.5	30	8	26.7	30	8	26.7
2011	30	6	20.0	35	9	25.7	33	7	21.2	35	9	25.7
2012	29	6	20.7	33	10	30.3	31	7	22.6	35	10	28.6
2013	31	6	19.4	37	10	27.0	36	8	22.2	38	11	28.9
2014	29	5	17.2	36	9	25.0	36	8	22.2	37	10	27.0

Table 2.5 shows the annual average number of microwavable popcorn products with trans fat available in 49 states across all sample years. We observe variation in the number of Products with trans fat in the Midwest and the South than in the Northeast and West. While the Northeast states averaged 6 products with trans fat and Western states averaged almost 7 products with trans fat, the average number of products with trans fat in the Midwest and Southern states varied between 6 and 12. Again, we notice that, on average, fewer microwavable popcorn products and fewer products with trans fat were available in stores in the Northeast and West than in the Midwest and the South. Similarly, the number of products with trans fat as a

percentage of all available products was also lower in the Northeast and West than in the Midwest and the South. Annual average percentages of products with trans fat all differed in four

Table 2.5 Average Number of Microwavable Popcorn with Trans Fat by State

Region	State	# All	# TF	% TF	Region	State	# All	# TF	% TF
Northeast	CT	29	6	20.7	Midwest	IA	35	8	22.9
	MA	29	6	20.7		IL	44	12	27.3
	ME	27	5	18.5		IN	41	12	29.3
	NH	28	5	17.9		KS	31	8	25.8
	NJ	33	6	18.2		MI	37	12	32.4
	NY	33	6	18.2		MN	35	7	20.0
	PA	36	7	19.4		MO	40	12	30.0
	RI	27	6	22.2		ND	34	7	20.6
	VT	26	5	19.2		NE	35	8	22.9
	Average	30	6	20.0		OH	40	12	30.0
						SD	32	7	21.9
South	AL	34	10	29.4		WI	31	7	22.6
	AR	40	12	30.0		Average	36	9	25.0
	DC	28	6	21.4					
	DE	32	6	18.8	West	AZ	32	7	21.9
	FL	29	6	20.7		CA	37	7	18.9
	GA	41	12	29.3		CO	34	7	20.6
	KY	38	12	31.6		ID	35	8	22.9
	LA	34	9	26.5		MT	32	8	25.0
	MD	34	6	17.6		NM	32	8	25.0
	MS	38	12	31.6		NV	36	8	22.2
	NC	38	10	26.3		OR	34	7	20.6
	OK	28	7	25.0		UT	35	8	22.9
	SC	36	10	27.8		WA	34	7	20.6
	TN	41	12	29.3		WY	34	8	23.5
	TX	40	11	27.5		Average	34	7	20.6
	VA	42	12	28.6					
	WV	38	11	28.9					
	Average	36	10	27.8					

regions, depending on the total number of products. Michigan had the highest annual average percentage (32.4%) of microwavable popcorn with trans fat, and Maryland had the lowest (17.6%). Mississippi, Kentucky, and Arkansas in South and Ohio and Missouri in the Midwest all had high annual average percentages (≥30%) of products with trans fat. In comparison, many Northeastern states—including New York, New Jersey, and New Hampshire—and one Western

state—California—had low annual average percentages (<20%) of products with trans fat on the market.

We also decompose monthly sales by volume of each type of microwavable popcorn by state.[9] Table 2.6 shows that butter-flavored microwavable popcorn products without trans fat had the highest average monthly sales, followed by butter-flavored products with trans fat, which together made up over 80% of average sales by volume each month in all states. Similarly, non-butter microwavable popcorn without trans fat had larger average monthly sales than non-butter products with trans fat in all 49 states (by as little as 7.1% in Kentucky and as high as 965.1% in Maine). More specifically, Western states had the highest average sales of butter-flavored products with trans fat (2,374,200 oz.) and the highest average sales of non-butter products with trans fat (345,500 oz.), whereas Midwestern states had the lowest average sales of butter-flavored products with trans fat (3,536,600 oz.) and Northeastern states had the lowest average sales of non-butter products with trans fat (110,500 oz.). Generally, we observe considerable variation in average monthly sales within each region as well as across regions due to demographics such as population For instance, given similar product offerings, Connecticut had smaller average monthly sales of all four types of microwavable popcorn than neighboring Massachusetts, as Massachusetts has twice as many residents. Among all states, average monthly sales by volume of butter-flavored products with trans fat was the largest in California (more than 18 million oz.) sales by volume and smallest in Oklahoma (167,100 oz.). California also had the largest average monthly sales by volume of non-butter products with trans fat (1,719,400 oz.)

[9] While we decompose the volume-weighted average prices by product types and states, we see very limited variation in volume-weighted average monthly unit prices both within regions and across regions. With very few exceptions, we find butter-flavored products both with and without trans fat, on average, were priced lower than their non-butter counterparts. In general, though some states had higher average monthly prices for products with trans fat, and vice versa, the average monthly prices for butter-flavored products with and without trans fat were very similar; the same was true for the average monthly prices for non-butter products with and without trans fat.

and Oklahoma the smallest sales by volume (9,600 oz.). Consequently, we control for time and state differences in our regression analysis.

Table 2.6 Average Monthly Microwavable Popcorn Sales by Volume (1,000 Oz.) by Category and State

region	State	No trans fat & no butter	Trans fat but no butter	Butter but no trans fat	Trans fat & butter
Northeast	CT	313.5	74.6	2,411.9	1,435.9
	MA	1,060.7	81.9	7,632.1	3,569.4
	ME	374.9	35.2	2,099.0	1,224.3
	NH	518.2	38.9	3,161.5	1,743.0
	NJ	669.1	179.9	5,731.5	3,465.5
	NY	1,469.3	252.3	11,968.9	6,185.2
	PA	1,611.8	301.7	9,048.9	8,080.9
	RI	83.1	12.4	780.3	306.3
	VT	136.4	17.4	641.0	445.0
	Average	693.0	110.5	4,830.6	2,939.5
Midwest	IA	713.7	238.8	3,770.8	1,977.8
	IL	2,059.2	397.5	11,524.8	5,409.9
	IN	822.8	478.0	4,570.0	2,223.7
	KS	473.9	71.9	2,287.2	987.8
	MI	913.2	255.9	5,399.8	2,281.0
	MN	1,394.8	120.2	5,984.4	3,188.1
	MO	504.5	124.5	2,450.2	1,008.3
	ND	108.9	14.2	506.6	255.8
	NE	351.9	76.3	1,676.0	825.9
	OH	1,946.5	827.7	10,272.5	7,194.7
	SD	142.4	35.3	669.6	397.4
	WI	894.1	74.8	4,208.3	2,739.7
	Average	860.5	226.3	4,443.3	2,374.2
West	AZ	1,424.8	389.6	6,715.9	4,366.8
	CA	8,138.2	1,719.4	30,566.8	18,810.0
	CO	1,399.5	446.8	6,616.3	3,670.9
	ID	233.9	80.2	933.2	691.3
	MT	175.3	58.8	819.3	576.9
	NM	163.4	41.4	1,009.7	502.2
	NV	485.8	130.8	2,572.2	1,505.1
	OR	1,104.8	259.2	3,909.2	2,465.8
	UT	370.0	142.5	1,569.8	1,035.5
	WA	1,894.4	487.2	7,746.7	4,898.0
	WY	113.0	44.9	581.9	379.6
	Average	1,409.4	345.5	5,731.0	3,536.6
South	AL	329.4	43.1	1,610.3	1,051.1
	AR	279.4	125.5	1,405.9	588.6
	DC	118.8	30.2	391.5	341.6
	DE	165.7	44.2	1,385.4	948.2
	FL	1,754.9	151.9	10,472.8	5,686.4

GA	1,478.1	348.2	7,658.8	4,205.0
KY	723.7	675.8	3,928.1	2,479.0
LA	476.8	95.2	2,478.7	1,099.7
MD	1,363.6	321.0	6,607.4	5,092.1
MS	243.4	102.1	1,214.5	500.1
NC	3,057.9	444.1	14,405.0	10,591.6
OK	114.5	9.6	564.1	167.1
SC	1,018.8	119.8	4,861.2	3,449.3
TN	1,349.5	677.9	6,967.8	3,403.5
TX	2,831.0	586.5	13,402.0	6,174.3
VA	2,515.9	499.1	11,749.7	7,958.9
WV	289.6	67.4	1,502.6	740.8
Average	1,065.3	255.4	5,329.7	3,204.5

2.5 Regression Model

To identify consumers' preferences for trans fat, we assume that we observe *N* markets, defined by the unique combination of week and state. In each market, *n*, there are *J* alternative microwavable popcorn products and one aggregated outside option, *j=0*. The level of utility from each choice in each market is denoted as U_{nj}. We do not directly observe this utility, but we know amount of trans fat (in grams) contained in each product, TF_j, and some other product attributes, x_j, including brand, flavor, and nutrient content. Additionally, $year_i$ and $region_k$ are indicator variables for year and region fixed effects, respectively. The coefficients of interest are δ_0, the coefficient on the level of trans fat in Southern states in 2006; δ_i, the coefficients on the interaction between TF_j and a year dummy (i = 2007, …, 2014); δ_k, the coefficients on the interaction between TF_j and a region dummy (k = Northeast, Midwest, and West); and $\delta_{i,k}$, the coefficients on the interaction between TF_j, a year dummy, and a region dummy. These coefficients plot the progression of demand for products with trans fat over time and by region relative to products without trans fat. The utility is assumed to be a linear function of these observed factors and the unobserved idiosyncratic shock ϵ_{nj}:

$$U_{nj}$$

$$= \alpha p_{nj} + \delta_0 TF_j + \sum_i \delta_i year_i * TF_j + \sum_k \delta_k region_k * TF_j$$

$$+ \sum_{i,k} \delta_{i,k} year_i * region_k * TF_j + \beta x_j + \gamma d_{nj} + \epsilon_{nj}$$

$$V_{nj}$$

$$= \alpha p_{nj} + \delta_0 TF_j + \sum_i \delta_i year_i * TF_j + \sum_k \delta_k region_k * TF_j$$

$$+ \sum_{i,k} \delta_{i,k} year_i * region_k * TF_j + \beta x_j + \gamma d_{nj}$$

where p_{nj} is the average price of product j paid in market n, α is the price coefficient, β is a vector of coefficients for all other product characteristics, and γ is a vector of coefficients for all controlling fixed effects, including region, state, year, month, and brand dummies. The error term, ε_{nj}, is distributed according to *i.i.d.* Type 1 Extreme Value. Therefore, the closed form of the purchase probability or market share for each product in each market S_{nj} is

$$S_{nj} = \frac{\exp(V_{nj})}{\sum_j \exp(V_{nj})} \quad , \qquad j = 1 \dots J$$

$$S_{n0} = \frac{1}{\sum_j \exp(V_{nj})}$$

We nominate the outside option (i.e., all choices except the top 77 brands) as the baseline and calculate the log odds for each of the top 77 popcorn brands relative to the baseline, so that the difference of the log of each brand's observed market share and the log of the share of the outside good is a linear function of the predictors:

$$V_{nj} = \log(S_{nj}) - \log(S_{n0})$$

We first use the simplest ordinary least squares approach to estimate our multinomial logit model, shown in Model I. For Models II–IV, we then use two-stage least squares estimation

to deal with price endogeneity. More specifically, Model II uses the first set of Hausman instruments (Hausman 1996, Nevo 2001), that is, average prices of popcorn products in other markets that are intended as proxies for common cost shocks. Model III uses the second set of BLP instruments (Nevo 2001) the rival product characteristic proxies that help reveal substitution patterns. Model IV includes both sets of instruments. All models control for region, state, year, month, and brand fixed effects.

2.6 Regression Results

Table 2.7 offers evidence that consumers have positive demand for trans fat products relative to products without trans fat. After the 2006 labeling legislation, demand for trans fat products continued to increase significantly, with heterogeneous regional preferences. This result is stable across all model estimation results.

Table 2.7 Multinomial Logit Regression Results

Variables	Model I OLS	Model II IV	Model III IV	Model IV IV
Price	-3.079***	-2.645***	-10.87***	-2.649***
	(0.0298)	(0.0321)	(0.988)	(0.0321)
Trans fat (g)	0.0959***	0.0949***	0.109***	0.0949***
	(0.00467)	(0.00467)	(0.00580)	(0.00467)
2007*Trans fat	0.00513	0.00541	0.00108	0.00541
	(0.00633)	(0.00633)	(0.00757)	(0.00633)
2008*Trans fat	0.0285***	0.0298***	0.00727	0.0298***
	(0.00652)	(0.00652)	(0.00824)	(0.00652)
2009*Trans fat	0.0572***	0.0591***	0.0262***	0.0590***
	(0.00657)	(0.00657)	(0.00877)	(0.00657)
2010*Trans fat	0.0818***	0.0843***	0.0391***	0.0843***
	(0.00661)	(0.00661)	(0.00956)	(0.00661)
2011*Trans fat	0.0637***	0.0675***	-0.00402	0.0674***
	(0.00656)	(0.00656)	(0.0116)	(0.00656)
2012*Trans fat	0.0747***	0.0785***	0.00610	0.0785***
	(0.00648)	(0.00648)	(0.0116)	(0.00648)
2013*Trans fat	0.0852***	0.0891***	0.0174	0.0890***
	(0.00641)	(0.00642)	(0.0115)	(0.00641)
2014*Trans fat	0.122***	0.127***	0.0413***	0.127***

	(0.00642)	(0.00642)	(0.0128)	(0.00642)
Northeast*Trans fat	0.0487***	0.0496***	0.0339***	0.0496***
	(0.00799)	(0.00799)	(0.00972)	(0.00799)
Midwest*Trans fat	0.0184***	0.0186***	0.0146*	0.0186***
	(0.00676)	(0.00676)	(0.00808)	(0.00676)
West*Trans fat	0.0361***	0.0359***	0.0390***	0.0359***
	(0.00724)	(0.00724)	(0.00865)	(0.00724)
2007*Northeast*Trans fat	-0.0115	-0.0117	-0.00786	-0.0117
	(0.0112)	(0.0112)	(0.0133)	(0.0112)
2008*Northeast*Trans fat	-0.0141	-0.0147	-0.00360	-0.0147
	(0.0114)	(0.0114)	(0.0136)	(0.0114)
2009*Northeast*Trans fat	-0.00791	-0.00818	-0.00312	-0.00817
	(0.0115)	(0.0115)	(0.0137)	(0.0115)
2010*Northeast*Trans fat	-0.0128	-0.0133	-0.00418	-0.0133
	(0.0115)	(0.0115)	(0.0138)	(0.0115)
2011*Northeast*Trans fat	-0.00293	-0.00341	0.00509	-0.00341
	(0.0115)	(0.0115)	(0.0137)	(0.0115)
2012*Northeast*Trans fat	-0.0201*	-0.0207*	-0.00906	-0.0207*
	(0.0114)	(0.0114)	(0.0136)	(0.0114)
2013*Northeast*Trans fat	-0.00208	-0.00261	0.00701	-0.00260
	(0.0114)	(0.0114)	(0.0136)	(0.0114)
2014*Northeast*Trans fat	-0.00371	-0.00439	0.00826	-0.00438
	(0.0114)	(0.0114)	(0.0137)	(0.0114)
2007*Midwest*Trans fat	0.0210**	0.0211**	0.0203*	0.0211**
	(0.00940)	(0.00940)	(0.0112)	(0.00940)
2008*Midwest*Trans fat	0.00710	0.00678	0.0124	0.00678
	(0.00955)	(0.00955)	(0.0114)	(0.00955)
2009*Midwest*Trans fat	-0.0274***	-0.0279***	-0.0180	-0.0279***
	(0.00957)	(0.00957)	(0.0115)	(0.00957)
2010*Midwest*Trans fat	-0.0367***	-0.0374***	-0.0240**	-0.0374***
	(0.00960)	(0.00960)	(0.0116)	(0.00960)
2011*Midwest*Trans fat	-0.0159*	-0.0164*	-0.00823	-0.0164*
	(0.00962)	(0.00962)	(0.0115)	(0.00962)
2012*Midwest*Trans fat	-0.0295***	-0.0299***	-0.0222*	-0.0299***
	(0.00952)	(0.00952)	(0.0114)	(0.00952)
2013*Midwest*Trans fat	-0.0285***	-0.0292***	-0.0162	-0.0292***
	(0.00946)	(0.00946)	(0.0114)	(0.00946)
2014*Midwest*Trans fat	-0.0213**	-0.0219**	-0.0117	-0.0219**
	(0.00949)	(0.00949)	(0.0114)	(0.00949)
2007*West*Trans fat	0.00916	0.00917	0.00880	0.00917
	(0.0101)	(0.0101)	(0.0120)	(0.0101)
2008*West*Trans fat	0.00318	0.00309	0.00420	0.00310
	(0.0102)	(0.0102)	(0.0122)	(0.0102)
2009*West*Trans fat	-0.0155	-0.0154	-0.0189	-0.0154
	(0.0102)	(0.0102)	(0.0121)	(0.0102)
2010*West*Trans fat	-0.0276***	-0.0280***	-0.0227*	-0.0280***

	(0.0102)	(0.0102)	(0.0122)	(0.0102)
2011*West*Trans fat	-0.0165	-0.0169	-0.00977	-0.0169
	(0.0104)	(0.0104)	(0.0124)	(0.0104)
2012*West*Trans fat	-0.0234**	-0.0239**	-0.0135	-0.0239**
	(0.0103)	(0.0103)	(0.0124)	(0.0103)
2013*West*Trans fat	-0.0242**	-0.0247**	-0.0147	-0.0247**
	(0.0103)	(0.0103)	(0.0123)	(0.0103)
2014*West*Trans fat	-0.0498***	-0.0504***	-0.0387***	-0.0504***
	(0.0102)	(0.0102)	(0.0123)	(0.0102)
Butter	1.394***	1.421***	0.908***	1.421***
	(0.0128)	(0.0128)	(0.0634)	(0.0128)
Total fat (g)	-0.143***	-0.142***	-0.171***	-0.142***
	(0.00386)	(0.00387)	(0.00583)	(0.00387)
Saturated fat (g)	0.246***	0.242***	0.320***	0.242***
	(0.00229)	(0.00229)	(0.00978)	(0.00229)
Calories	0.0130***	0.0129***	0.0158***	0.0129***
	(0.000435)	(0.000436)	(0.000631)	(0.000436)
Sodium (mg)	-0.00202***	-0.00201***	-0.00231***	-0.00201***
	(2.22e-05)	(2.22e-05)	(4.52e-05)	(2.22e-05)
Total carbohydrate (g)	0.0606***	0.0600***	0.0621***	0.0600***
	(0.00214)	(0.00214)	(0.00256)	(0.00214)
Dietary fiber (g)	0.0105**	0.0157***	-0.0598***	0.0156***
	(0.00414)	(0.00414)	(0.0102)	(0.00414)
Protein (g)	-0.128***	-0.134***	-0.0220	-0.134***
	(0.00460)	(0.00461)	(0.0145)	(0.00461)
Sugars (g)	-0.103***	-0.101***	-0.128***	-0.101***
	(0.00168)	(0.00168)	(0.00380)	(0.00168)
Constant	-15.47***	-15.07***	-15.24***	-15.08***
	(0.0884)	(0.0883)	(0.107)	(0.0883)
Observations	161,230	161,220	161,230	161,220
R-squared	0.421	0.420	0.174	0.420
Price Instruments	No	Yes	No	Yes
Product Instruments	No	No	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Brand FE	Yes	Yes	Yes	Yes
Saragan p-val		0	0	0

Standard errors in parentheses

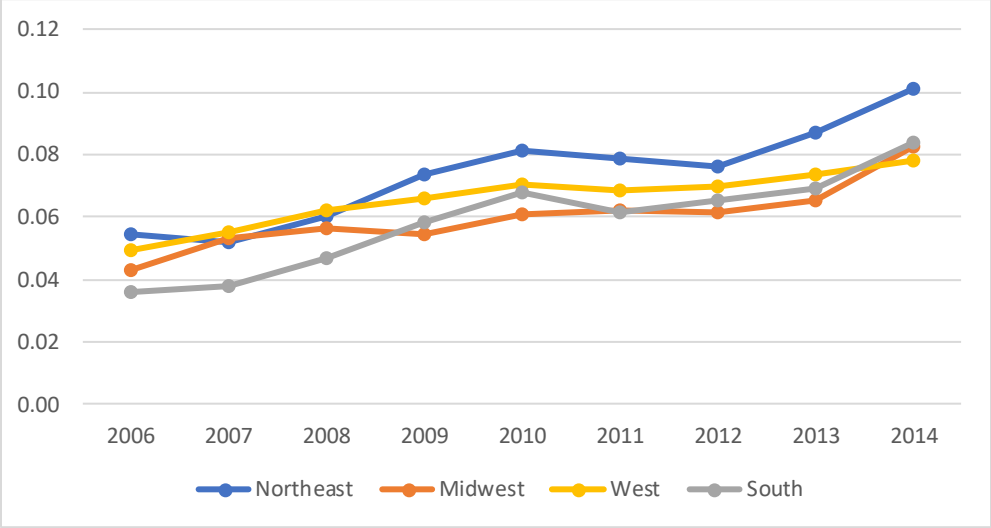
*** p<0.01, ** p<0.05, * p<0.1

All other flavor and nutrient coefficients are statistically significant and of the expected sign. It is interesting to note that popcorn marketed as “butter” noticeably increases demand;

taste parameters for saturated fat also have a positive effect. However, consumers value total fat in a negative way, with a smaller magnitude than saturated fat. Moreover, the marginal valuations of calorie, total carbohydrates, and dietary fiber are positive, while the marginal valuations of sodium, sugar, and protein are negative. In other words, a consumer with average demographic characteristics prefers popcorn products with higher calories, total carbohydrates, and dietary fiber but tends to avoid popcorn products with higher sodium, sugar, and protein.

In addition, we plot changes in WTP for trans fat, $\frac{\delta}{\alpha}$, over time in different regions. More specifically, average WTP for trans fat in 2006 is \$0.055 per g of product in the Northeast, \$0.043 per g in the Midwest, \$0.049 per g in the West, and \$0.036 per g in the South. These positive coefficients imply that individuals would be willing to pay around \$0.04, on average, to consume popcorn with 1 more gram of trans fat given the same utility obtained.

Figure 2.6 Willingness to Pay for Trans Fat by Region and Year



Over time, we observed an increasing trend in WTP for trans fat in all states. The average WTP for trans fat increased by 85%, to \$0.101 in 2014 in the Northeast. Similarly, the average WTP for trans fat increased by 93% in the Midwest (to \$0.083 in 2014), by 134% in the South (to \$0.084), and by 59% in the West (to \$0.078). In general, people in Northeast are willing to

pay more for trans fat taste than those in other regions.

2.7 Conclusions

In this paper, we explore consumers' willingness to pay for trans fat using scanner data on purchases of microwavable popcorn from 2006 to 2014, after the introduction of mandatory trans fat labeling. We estimate how a change in trans fat content affects consumer demand for popcorn products with and without trans fat.

Our product-level multinomial logit model results suggest that, on average, trans fat content increases consumer demand, with significant regional preference heterogeneity. Consumers in the Northeast have a higher preference for trans fat popcorn than those in the other regions. In addition, we found evidence that this positive preference for trans fat has become increasingly stronger over time, even after the 2006 mandatory labeling rule. This implies that consumers actually value the taste of trans fat over the health concerns caused by trans fats.

CHAPTER 3

SPILLOVER MECHANISMS OF WIC INFANT FORMULA REBATE PROGRAM

3.1 Introduction

After food stamps and school lunches, the Special Supplemental Nutrition Program for Women, Infants and Children (WIC), established in 1972, is the third-largest food assistance program in the United States. WIC provides vouchers to low-income pregnant women, mothers, and their children up to age 5 for a variety of foods. Infant formula represents the largest cost to WIC: 57%–68% of all infant formula sold in the United States is purchased through the program (Oliveira et al. 2010). To reduce costs, state WIC programs began an infant formula rebate system in 1987. This competitive bidding system awards a single-source contract to the firm that offers the lowest net price (i.e., wholesale price minus the rebate bid). The rebates are typically about 85% of the wholesale price, which reduces WIC food costs by about $1.7 billion a year.

As WIC contracts assure a large amount of program-specific formula sales, previous literature suggests that winning manufacturers enjoy spillover on their non–WIC formula market shares. That is, they benefit from indirect sale increases in the non–WIC market (Oliveira, Frazão, and Smallwood 2011; Huang and Perloff 2014). Spillover effects can also exist through price strategies (Chernew et al. 2010). To maximize profit, manufacturers that win the WIC bid may decrease prices in the more price-sensitive toddler formula market while increasing prices in the infant formula market, where WIC sales are guaranteed. However, price premiums may still exist for losing companies even after contract changes.

The purpose of this paper is to explain why manufacturers compete aggressively on their rebates to win WIC contracts. As spillovers are one of the forces that shape the market over time, we pay particular attention in this paper to correctly identifying and estimating distinct spillover

mechanisms and to understanding the features of consumer purchasing behavior that drive spillover patterns.

3.2 Literature Review

In general, literature suggests that the WIC infant formula rebate program has a significant spillover effect on sales by volume. The manufacturer that wins a WIC contract experiences increased sales in the non–WIC formula market (an indirect effect). That is, the benefits of being the exclusive formula provider for WIC participants extend to increasing the winning manufacturer's share of non–WIC sales. Davis (2011) finds a 50%–60% increase in a brand's market share of non–WIC sales after that formula becomes the WIC–contract brand.

The spillover effect may work through several mechanisms. First, since WIC subsidizes nearly half of infants born in the United States, it is in retailers' best interest to secure guaranteed WIC sales by making the WIC brand most easily visible to WIC participants. The WIC–contract brand may therefore gain greater shelf space and better product placement in retail stores, which may also drive its sales to non–WIC consumers. In an interview conducted by the U.S. Government Accountability Office (2006), three bidding infant formula manufacturers noted the importance of shelf space and product placement to their marketing strategies. Further, many studies have found that better shelf allocation was associated with greater purchase percentage (Frank and Massy 1970; Drèze Hoch, and Purk 1994; Sigurdsson, Saevarsson, and Foxall 2009).

Second, sales may also rise from hospital and physician recommendations of WIC–brand formula, since they are more likely to recommend the WIC brand to non–WIC consumers (GAO 1998; Oliveira et al. 2010, 2011). Knowing that most WIC participants are required to use the WIC–brand infant formula, physicians may recommend that brand to all patients. Hospitals may also provide free samples of WIC–brand formula to all new mothers without differentiating

between WIC and non–WIC consumers (GAO 2006).

Third, WIC logos on shelf labels may be viewed as the government's tacit endorsement of the product, increasing the product' credibility among non–WIC consumers Huang and Perloff (2014) report that winning manufacturers sometimes use the trademarked WIC logo in their promotional materials because of the positive labeling effect.

Fourth, WIC participants are more likely to buy WIC–brand formula out of pocket when they use up WIC formula vouchers and after they exit WIC. Once the WIC infants are doing well on the contract-brand formula, their mothers may be reluctant to feed them a different brand, since new formulas may cause stomach upset and gas.

Fifth, spillover may come from WIC recipients' recommendations to non–WIC friends and relatives. Lastly, mothers may be more likely to buy the WIC brand of toddler formula after their infants reach 1 year of age (Oliveira, Frazão, and Smallwood 2011).

Chernew, Baicker, and Martin (2010) review the literature examining the impact of public-sector (i.e., Medicare or Medicaid) fee reductions on prices charged to private payers. They find that dynamic cost shifting could account for price spillover effect (Sloan and Becker 1984; Lynk 1995; CBO 1993; ProPAC 1995a,b; Sheils 2009). Dynamic cost shifting—in which payers in one sector pay more because those in another sector pay less—is different from static cost shifting or price discrimination—in which different customers are charged different prices for the same service or product. But both dynamic and static cost shifting are pricing strategies that allow providers with market power to charge a higher price for payers with less elastic demand. Similarly, dynamic cost shifting could occur in the WIC formula bid system. To maximize profit, contract-winning manufacturers would decrease wholesale prices for toddler formula because they can increase wholesale prices for infant formula. The toddler formula

market is not subsidized by any government programs and is therefore a more competitive market, with all customers sensitive to price changes. However, a large fraction of infant formula purchasers are WIC participants, who use food vouchers and do not pay for formula out of pocket. With these price-insensitive consumers in the infant formula market, it is in the best interest of the winning manufacturer to exercise its market power to capture large markups from non–WIC infant formula consumers. Empirical studies on infant formula wholesale prices show mixed results. While Davis (2011) argue that WIC does not affect wholesale prices, while Prell et al. (2004) find that WIC distorts them.

Considerable research has been conducted on retail prices. Using a sample from 1994 to 2000, Oliveira et al. (2004) conclude that WIC–contract brands are associated with modestly higher retail prices in supermarkets. Oliveira et al. (2001) find the prices for the WIC–contract brand milk-based powder formula exceed those for non-contract brands in 23 of 55 of market areas (42%). No consistent relationship exists between a formula's being the WIC–contract brand and having the highest average retail price within market areas. Oliveira, Frazão and Smallwood (2011) report that the percentage price change for the winning WIC brand is greater than for the losing brand in 12 of 23 states between the year prior to and the year after the contract change, while the reverse is true for the remaining 11 states. On average, the relative retail price of the winning WIC brand to the losing brand increased by less than 2%, suggesting that the shift in market share from losing manufacturer to winning manufacturer was not due to a decrease in the relative retail prices but rather to the change in contract-brand status.

3.3 Data Description

To study WIC spillover effects, we use large-scale Nielsen retail scanner datasets from the Kilts Center for Marketing, which were prepared by the Booth School of Business from

University of Chicago. The Nielsen market-panel database contains weekly purchase and pricing data from more than 90 participating grocery stores, including Stop & Shop and Big Y. This particular study focuses on milk-based powder formula; about 80% of all infant formula sold is milk-based, and approximately 85% of those sales are in powder form.

Further, we aggregate store-level data by state for the three types of milk-based powder formula: Top WIC–contract brand infant formula, non–WIC infant formula, and toddler formula. Top WIC infant formula is defined as the WIC–contract brand with the largest sales by volume in the market. All other infant formulas except the top WIC infant formula are categorized as non–WIC formula. Missing data points for manufacturers' name and formula sizes were fixed by incorporating information from the New Product Launch database and checking product websites. Each formula product line was identified through the official WIC formula list provided by the U.S. Department of Agriculture (USDA)[10] and further confirmed by double-checking the dataset, where the introduction of a new generation of the same formula product line coincides with the discontinuation of the old one. For example, Similac Advance was previously called Similac Advance Early Shield, so these two brands are considered to be the same product line.

Other complementary databases used in this study include the WIC rebate database collected by Davis (2016), which has information on 11 contracts in 24 states where one firm replaced another as the WIC supplier between 2007 and 2013. For each state, the data span 1 year before and 2 years after each contract change. State-level summary statistics from the 2007–2011 American Community Survey are also incorporated to control for demographic differences. To capture state-specific demand trends, we also include the annual number of live births from the Centers for Disease Control.

[10] The list was obtained from the USDA WICWorks website. https://wicworks.fns.usda.gov/databases

Table 3.1 shows the details of the 11 WIC contracts. For example, California experienced a contract change on August 1, 2007, when Mead Johnson Nutrition Co. replaced Abbott Lab as the contract winner. Some states—such as Texas, Iowa and Minnesota—form alliances and make joint WIC bids. During the sample period, Pennsylvania had two contract changes, in 2008 and in 2013.

Table 3.1 Milk-Based Powder Infant Formula WIC Contract Changes

State	Contract begin date	Previous winner	Current winner
California	8/1/2007	A	MJ
Arizona, Delaware, Idaho, Kansas, Maryland, Montana, Nevada, Oregon, Utah, Washington, West Virginia	10/1/2007	MJ	A
Louisiana	10/1/2007	A	MJ
Texas, Iowa, Minnesota	10/1/2007	MJ	A
Colorado	1/1/2008	A	MJ
Illinois	2/1/2008	A	MJ
Pennsylvania	10/1/2008	A	N
Arkansas, New Mexico, North Carolina	10/1/2012	MJ	N
New Jersey	10/1/2012	A	MJ
North Dakota	7/1/2013	N	MJ
Pennsylvania	10/1/2013	N	A

Note: A denotes Abbott Lab; MJ denotes Mead Johnson Nutrition Co; N denotes Nestle Sa.

Table 3.2 summarizes the control variables used in the regression analysis. Generally, the sample statistics match national averages. For instance, the mean of average household size across 24 states is 2.6, while the 2010 national average household size was 2.58. The sample mean of median household income is $52,900, while the 2013 national median household income was around $52,000. On average, 9.88% of families have incomes below the poverty level; 86.77% of the population have a high school diploma and 27.64% of the population have a bachelors degree; 60.56% of mothers are in the labor force. The population is 78.84% white,

9.13% black, 3.5% Asian, and 14.17% Hispanic. The mean of median age is around 37, and an average of 6.79% of the population under 5 years of age.

The birth growth rate, which changes annually, is calculated as the ratio of the number of live births in the current year to that in the previous year. As shown in Table 3.2, the average birth growth rate is 1 across all states and years, with a range of 0.93–1.08. This implies the number of births in the sample is relatively stable, so we expect decreasing demand for formula due to recent increases in the rate of breastfeeding,[11] The mean WIC ratio is 46.4%, meaning that on average approximately 46 out of 100 newborn babies are subsidized by WIC. We observe some variation in the size of the WIC ratio, with a range of 25.7%–64.6%.

Table 3.2 Summary Statistics of Variables Included in Regression Analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
Average household size	24	2.58	0.17	2.30	3.06
Median household income	24	52.92	8.43	39.55	72.42
Poverty (%)	24	9.88	2.46	6.06	14.37
College (%)	24	27.64	4.77	17.62	36.29
High school (%)	24	86.77	3.52	80.43	91.59
Mother in labor force (%)	24	60.56	6.42	49.10	73.73
Hispanic (%)	24	14.17	12.37	1.19	45.86
White (%)	24	78.84	10.27	59.22	94.05
Black (%)	24	9.13	9.10	0.45	31.88
Asian (%)	24	3.50	2.92	0.61	13.05
Median age	24	36.79	2.39	29.10	41.10
Children under 5 (%)	24	6.79	0.78	5.64	9.53
Number of births	99	1.00	0.03	0.93	1.08
WIC ratio (%)	99	46.40	0.09	25.70	64.60

One limitation of this study is that the demographic variables do not change over time, as they came from the 5-year ACS and have only 1 observation per state. We use a 5-year demographic survey rather than a 1-year survey because the 5-year survey data is more

[11] https://www.cdc.gov/media/releases/2013/p0731-breastfeeding-rates.html

comprehensive, covers a much larger population, and provides more reliable estimates than the 1-year short-term survey. Since demographic changes are very slow, a static demographic variable may work as well as a dynamic one.

3.4 Models

3.4.1 Multinomial Logit for Market Share

Our multinomial logit model contains $s = 1, \cdots, S$ states that experienced a WIC infant formula contract change between 2007 and 2013. In each state, we observe market share for each of the $j = 1, \cdots, J$ manufacturers in $t = 1, \cdots, T$ weeks from 1 year before to 2 years after each contract change. We denote manufacturer j's market share in state s and week t (McFadden 1974) as

$$S_{jst} = \frac{exp\alpha_j + X_{st}^{'}\gamma_j + Z_s^{'}\delta_j}{\sum_{j=1}^{J} exp\alpha_j + X_{st}^{'}\gamma_j + Z_s^{'}\delta_j},$$

where predictors X_{st} include time dummy variables that reflect WIC infant formula contract changes, annual birth growth rate, and the ratio of WIC infants to total live births; Z_s denote state demographics; α_j is a constant; and γ_j and δ_j are vectors of WIC-relevant and demographic-regression coefficients, respectively, for $j = 1, \cdots, J$. We know that $\sum_{j=1}^{J} S_{jst} = 1$ for each unique combination of state s and week t (i.e., the total market shares add up to 1 in a given state for a particular week). Therefore, once we know the market shares of the winning and losing manufacturers, we automatically know the market share of all other manufacturers by subtraction. We transform our multinomial logit model into its log-linear equivalent. We further assume the log odds of the winning and losing manufacturers relative to the baseline, all other manufacturers, to be a linear function of all explanatory variables:

$$\eta_{jst} = log\frac{S_{jst}}{S_{Jst}} = \alpha_j - \alpha_J + X_{st}^{'}\gamma_j - \gamma_J + Z_s^{'}\delta_j - \delta_J + \epsilon_{jst}$$

$$= \alpha_j^* + X_{st}' \gamma_j^* + Z_s' \delta_j^* + \epsilon_{jst}$$

$$\epsilon_{jst} \sim i.i.d\ N(0, \sigma^2)$$

We also include brand dummy variables that indicate whether Abbott Lab or Mead Johnson Nutrition Co. held the WIC contract in a given week and in a specific state, while Nestlé and all other small manufacturers constitute the residual category. We fit our model using OLS regression and separately model each of the three types of formula: the top WIC brand, non–WIC infant formula, and toddler formula. We do not separately identify all coefficients for $j = 1, \cdots, J$, but we can get estimates for the differences between corresponding coefficients (i.e., α_j^*, γ_j^*, δ_j^* for $j = 1, \cdots, J-1$) that allow us to back up the market shares for all manufacturers.

3.4.2 OLS for Price

Spillover could also exist through price channel. To maximize profit, contract–winning manufacturers may decrease prices in the more price-sensitive toddler formula market and increase prices in the less price-sensitive infant formula market, where WIC sales are guaranteed. To determine whether there price spillover occurs, we model simple average prices as a linear function of predictors X_{st} that include time dummy variables reflecting WIC infant formula contract changes and the ratio of WIC infants to total live births and state demographics Z_s:

$$P_{st} = \beta + X_{st}' \theta + Z_s' \eta + \mu_{st}$$

$$\mu_{st} \sim i.i.d\ N(0, \sigma^2)$$

where β is a constant, and θ and η are vectors of WIC relevant and demographic regression coefficients, respectively, for $j = 1, \cdots, J$. Again, we model the three types of formula separately.

3.4.3 Estimated Manufacturing Profit

Total revenues can be calculated as retail prices multiplied by total volume sold:

$$\frac{R_{jt}^{post}}{R_{jt}^{pre}} = \frac{P_{jt}^{post}}{P_{jt}^{pre}} * \frac{TV_{jt}^{post} * S_{jt}^{post}}{TV_{jt}^{pre} * S_{jt}^{pre}}$$

where *R* denotes revenue, *P* denotes price, *TV* denotes total volume sold, *S* denotes market share, and t denotes time period for 0–24, 3–6, 6–12, 12–18, and 18–24 months. Thus, revenues after the contract change can be estimated based on predicted retail price $\widehat{P_{jt}}$ and predicted market share $\widehat{S_{jt}}$, adjusted by the actual total volume of sales in the market before and after the contract change across 24 states:

$$\frac{\widehat{R_{jt}}^{post}}{R_{jt}^{pre}} = \frac{\widehat{P_{jt}}^{post}}{P_{jt}^{pre}} * \frac{TV_{jt}^{post} * \widehat{S_{jt}}^{post}}{TV_{jt}^{pre} * S_{jt}^{pre}}$$

$$= \frac{\widehat{P_{jt}}^{post}}{P^{pre}} * \frac{\widehat{S_{jt}}^{post}}{S^{pre}}$$

Lastly, manufacturer profit was separated from predicted revenue in hopes of quantifying the spillover effects.

$$\widehat{Manufacturer\ Profit}$$

$$= \begin{cases} (\widehat{R} - \widehat{Retail\ Markup}) * (1 - \widehat{Rebate\ Rate}) - \widehat{Cost} & WIC \\ \hat{R} - \widehat{Retail\ Markup} - \widehat{Cost} & Non-WIC, \quad Toddler \end{cases}$$

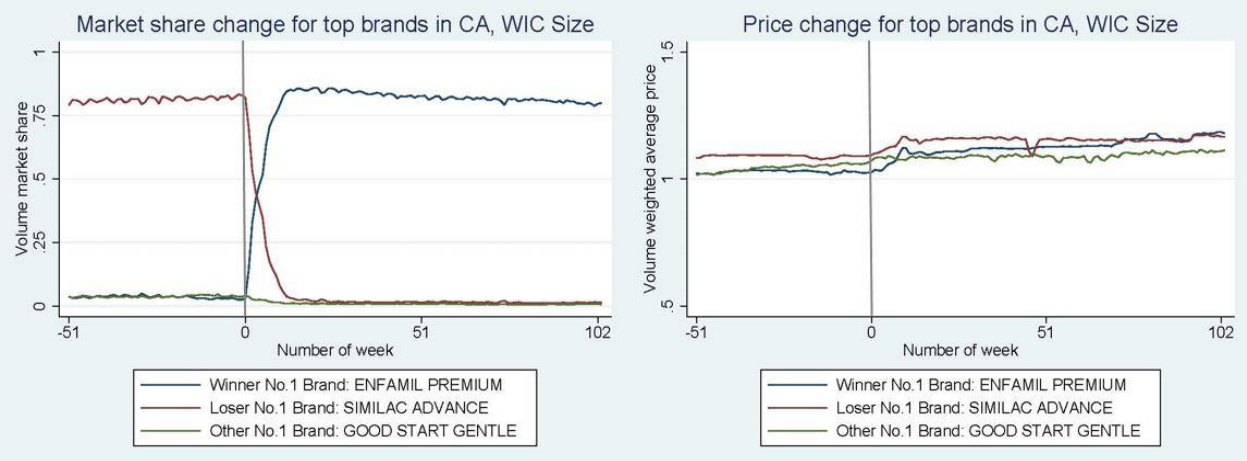
We made several assumptions based on previous literature: Manufacturing cost was assumed to be 20% of total revenue sales, as retail prices were estimated to be five times the cost of manufacture in 1994 (Richter 2001). Retail markup was estimated to be around 13% of retail price in 2004 (Oliveira and Davis 2006). Rebates are set at 85% of the 2008 wholesale price (Oliveira et al. 2010):

$$\widehat{Manufacturer\ Profit} = \begin{cases} (\widehat{R} - 0.13\widehat{R}) * 0.15 - 0.2\hat{R} & WIC \\ \hat{R} - 0.13\hat{R} - 0.2\hat{R} & Non-WIC, \quad Toddler \end{cases}$$

3.5 Descriptive Results

One big challenge is to correctly identify the top WIC brand, since there is no comprehensive dataset that distinguishes WIC–brand and non–WIC infant formulas in each state. However, two important features help identify WIC infant formula: 1) WIC brands only come in sizes between 12 oz. and 13 oz. and 2) the top WIC brand in each state shows a unique pattern in the data different from that of all other brands. For example, in California, the winning manufacturer stole a chunk of sales from the losing manufacturer immediately after the WIC contract change (Figure 3.1). All 24 states in our sample showed similar patterns after a contract change. This is likely due to greater shelf space, better product placement, and the advantages of carrying WIC labels. The top WIC brand was assumed to be the only WIC brand as (on average) it accounts for 76.1% of all WIC-size infant formula sales across 24 states. Interestingly, both winning and losing manufacturers significantly increased their prices shortly after the contract change and remained at that level.

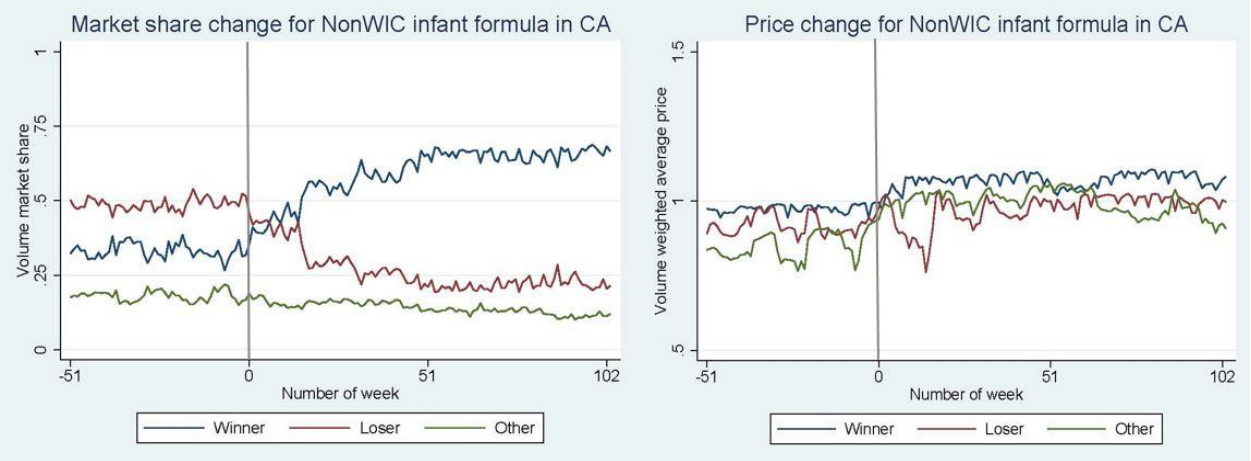
Figure 3.1 Market Share and Price Change for Top No. 1 WIC Brand in California



The non–WIC infant formula market is defined as all infant formula except the top WIC brand. Figure 3.2 shows that the winning manufacturer took over the lead around 10 weeks after

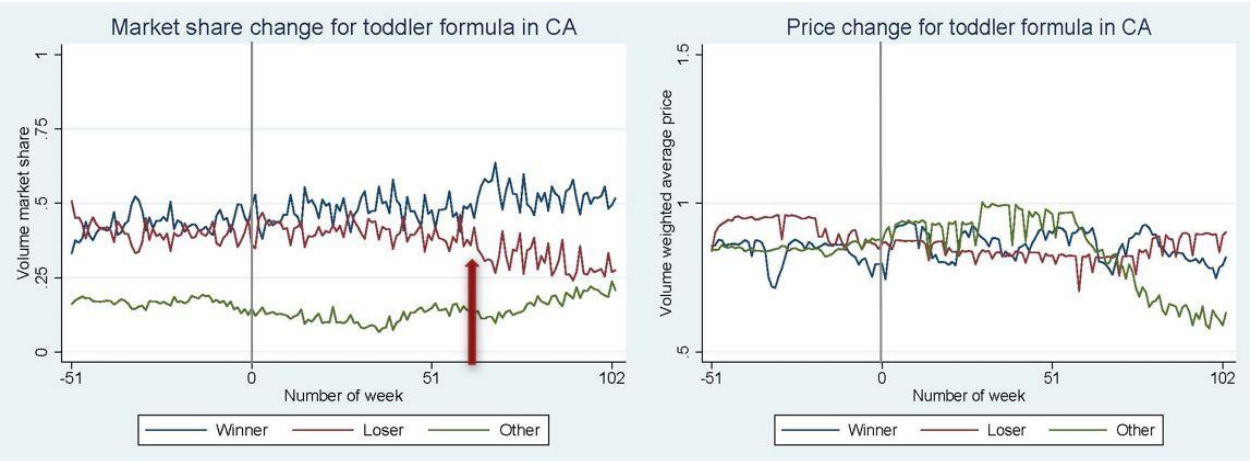
the contract change, but its average price of non–WIC infant formula increased significantly just after the contract change.

Figure 3.2 Market Share and Price Change for Non-WIC Infant Formula in California



A similar pattern was not observed in the toddler formula market. It took more than 1 year for that shift to happen. The average price of toddler formula for the winning manufacturer decreased occasionally after the contract change, suggesting that consumers may have become loyal purchasers of the brand, so the losing manufacturer was still able to enjoy a spillover effect.

Figure 3.3 Market Share and Price Change for Toddler Formula in California



3.6 Regression Results

Table 3.3 shows multinomial logit regression results of market share for the top WIC brand, non–WIC infant formula, and toddler formula. As shown in Table 3.3, most coefficients of interest—a contract change dummy to capture overall WIC effect and four time dummies to distinguish potential short-run and long-run impacts—are statistically significant and have the expected signs.

Table 3.3 Multinomial Regression without Price by Formulas Type

Variable	top WIC Brand		Non-WIC Infant		Toddler	
	Winner	Loser	Winner	Loser	Winner	Loser
Constant	7.469	-2.176	-9.543	-40.199**	21.884	-29.107
	23.348	13.889	19.422	14.454	23.799	25.783
Contract change	3.674***	-1.411***	0.742***	-0.236***	0.638***	0.379***
	0.160	0.093	0.159	0.070	0.164	0.090
3m<t<6m	0.298***	-0.719***	0.212***	-0.203***	0.242***	-0.005
	0.091	0.098	0.073	0.057	0.086	0.118
6m<t<12m	0.304***	-1.175***	0.394***	-0.294***	0.214**	-0.247*
	0.105	0.111	0.085	0.065	0.100	0.134
12m<t<18m	0.447***	-1.130***	0.531***	-0.330***	0.338**	-0.319
	0.118	0.141	0.098	0.089	0.129	0.199
18m<t<24m	0.228	-1.607***	0.606***	-0.429***	0.288*	-0.529*
	0.158	0.172	0.125	0.118	0.156	0.264
Average household size	-5.458*	-5.665***	-4.656**	-4.864**	-4.228	-5.528
	2.679	1.874	2.023	2.037	2.523	3.751
Median household income	-0.136	-0.109*	0.072	0.040	0.032	0.011
	0.084	0.061	0.086	0.058	0.083	0.091
Poverty (%)	-0.458**	-0.537***	0.097	-0.045	0.146	-0.104
	0.218	0.132	0.272	0.135	0.300	0.185
College (%)	0.192**	0.190***	-0.025	0.013	0.075	0.046
	0.082	0.056	0.081	0.040	0.051	0.057
High school (%)	-0.276*	-0.349***	0.028	0.007	-0.148	-0.038
	0.146	0.088	0.156	0.111	0.148	0.186
Mother in labor force (%)	-0.093**	-0.085***	-0.055	-0.078***	-0.016	-0.055
	0.039	0.026	0.036	0.023	0.041	0.040
Hispanic (%)	0.026	0.001	0.006	0.012	-0.072**	-0.059
	0.027	0.016	0.028	0.025	0.034	0.044
White (%)	0.146**	0.055	0.054	0.020	-0.052	-0.105
	0.065	0.042	0.050	0.036	0.058	0.070
Black (%)	0.190***	0.090**	0.058	0.042	-0.052	-0.089
	0.064	0.042	0.054	0.046	0.067	0.091
Asian (%)	0.360***	0.181*	0.150	0.143*	0.134	0.107
	0.122	0.090	0.089	0.069	0.124	0.151
Median age	0.428	0.855***	0.079	0.793***	-0.046	0.826***
	0.302	0.212	0.258	0.185	0.257	0.276
Children under 5 (%)	2.240**	3.662***	0.870	3.081***	0.607	3.650**

	1.015	0.693	1.025	0.840	1.078	1.324
Number of births	-4.108	-2.213	2.796	1.488	1.180	2.014
	4.934	3.020	3.947	2.526	3.823	4.919
WIC brand is Mead Johnson	0.421	1.046***	0.395	0.541***	0.804**	0.140
	0.289	0.221	0.352	0.150	0.328	0.194
WIC brand is Abbott lab	0.643**	0.927***	0.706**	0.430**	0.816**	0.013
	0.264	0.257	0.310	0.181	0.320	0.244
WIC ratio (%)	0.902	1.664	2.549	3.772***	-3.432	5.332**
	2.053	1.261	1.992	1.291	2.678	2.157
Number of observations	7750		7750		7750	
LR Ratio	15750.88		8159.38		4616.57	
Prob LR	0		0		0	
pseudo R2	0.875		0.651		0.473	
adj. pseudo R2	0.874		0.649		0.470	
Degrees of freedom	42		42		42	

Table 3.4 exhibits simple OLS regression results for retail price using the same set of predictors used in the market share regressions. Holding all other variables constant, the winning manufacturer significantly increased prices of infant formula by more than $0.05/oz. and decreased prices of toddler formula by $0.07/oz. just after WIC contract change. The losing manufacturer seemed to follow the winner's strategy. Results are robust among different setups when different control variables are included.

Table 3.4 OLS Regression for Prices by Formula Type

Variable	WIC Infant		Non-WIC Infant		Toddler	
	Winner	Loser	Winner	Loser	Winner	Loser
Constant	3.082	2.82	4.225**	0.322	-1.78	0.605
	2.811	2.786	1.78	1.6	1.287	1.513
Contract change	0.055***	0.046***	0.069***	0.040***	-0.007	-0.020**
	0.009	0.011	0.006	0.009	0.008	0.007
3m<t<6m	0.017***	0.007	0.018***	0	-0.001	0.034***
	0.004	0.007	0.004	0.003	0.007	0.007
6m<t<12m	0.022***	0.018**	0.022***	0.005	-0.005	0.042***
	0.005	0.008	0.005	0.004	0.009	0.007
12m<t<18m	0.033***	0.029**	0.029***	0.011*	-0.005	0.044***
	0.007	0.013	0.007	0.006	0.009	0.009
18m<t<24m	0.052***	0.037**	0.033***	-0.003	0.018	0.034***
	0.011	0.016	0.011	0.01	0.012	0.011
Average household size	-0.059	0.037	0	-0.236	0.434**	-0.019
	0.276	0.288	0.189	0.155	0.17	0.096
Median household income	0.012	0.006	0.007	0.005	0.004	0.011**
	0.009	0.01	0.006	0.006	0.007	0.004
Poverty (%)	0.036	0.038	0.033	0.012	0.016	0.034*
	0.035	0.034	0.021	0.021	0.019	0.019
College (%)	-0.002	0.003	0.002	0.003	-0.017**	-0.001
	0.006	0.008	0.004	0.005	0.006	0.003
High school (%)	-0.02	-0.018	-0.018	-0.013	0.042***	-0.005
	0.019	0.019	0.012	0.012	0.013	0.007
Mother in labor force (%)	0.007*	0.007*	0.006**	0.001	-0.001	0.003
	0.004	0.004	0.002	0.002	0.002	0.002
Hispanic (%)	-0.008*	-0.008*	-0.006*	-0.004	0.007***	-0.002
	0.005	0.004	0.003	0.002	0.002	0.002
White (%)	-0.014*	-0.013*	-0.008	-0.007	0.008*	0.001
	0.008	0.007	0.006	0.004	0.004	0.004
Black (%)	-0.018*	-0.015*	-0.01	-0.008	0.008*	-0.002
	0.009	0.008	0.006	0.005	0.004	0.004
Asian (%)	-0.021	-0.013	-0.012	-0.006	-0.001	0
	0.015	0.014	0.01	0.007	0.007	0.008
Median age	0.008	0.008	-0.025	0.044**	-0.049**	-0.008
	0.03	0.033	0.018	0.02	0.022	0.014
Children under 5 (%)	0.017	0.012	-0.081	0.163**	-0.251**	-0.039
	0.119	0.122	0.078	0.076	0.093	0.046
Number of births	-0.168	-0.27	-0.281*	0.006	0.652**	0.409**
	0.293	0.338	0.162	0.18	0.237	0.17
WIC brand is Mead Johnson	-0.081*	-0.079**	-0.044	-0.059***	0.033*	-0.038**
	0.04	0.035	0.032	0.02	0.017	0.014
WIC brand is Abbott lab	-0.083*	-0.078*	-0.038	-0.058**	0.011	-0.015
	0.046	0.042	0.036	0.025	0.013	0.011
WIC ratio (%)	-0.539*	-0.570*	-0.514**	-0.076	0.234*	-0.394**
	0.309	0.303	0.189	0.171	0.136	0.167
Number of observations	3,875	3,875	3,875	3,875	3,875	3,875
F statistic	247.02	124.18	363.67	81.74	38.36	40.35
Prob > F	0	0	0	0	0	0
R2	0.559	0.545	0.672	0.511	0.379	0.431

Table 3.5 shows the predicted changes in market share by formula type. We find that, the winner experiences a significant increase in market share for all three types of formula immediately after WIC contract change. While the losing manufacturer experiences a sharp decrease in market share for all infant products, its market share in the toddler formula market only begins to decrease significantly around 6 months after a WIC contract changes. Over time, the winner's share in non–WIC infant formula sales increases, while the losing manufacturer experiences the opposite; this pattern suggests the presence of an important long-run spillover effect.

Table 3.5 Estimated Market Share over Time by Formula Type

	Top WIC Brand		Non-WIC Infant		Toddler	
	Winner	**Loser**	**Winner**	**Loser**	**Winner**	**Loser**
Pre change	0.03	0.94	0.20	0.65	0.22	0.57
Post change	0.82	0.16	0.39	0.47	0.28	0.57
3m<t<6m	0.92	0.06	0.48	0.38	0.34	0.53
6m<t<12m	0.94	0.04	0.54	0.33	0.37	0.47
12m<t<18m	0.95	0.04	0.58	0.30	0.42	0.43
18m<t<24m	0.95	0.03	0.62	0.26	0.44	0.39

Table 3.6 Estimated Price over Time by Formula Type

Time Period	Top WIC Brand		Non-WIC Infant		Toddler	
	Winner	**Loser**	**Winner**	**Loser**	**Winner**	**Loser**
Pre change	1.06	1.07	0.99	1.03	0.86	0.85
Post change	1.12	1.11	1.05	1.07	0.85	0.84
3m<t<6m	1.13	1.12	1.07	1.07	0.85	0.87
6m<t<12m	1.14	1.13	1.08	1.08	0.85	0.88
12m<t<18m	1.15	1.14	1.08	1.08	0.85	0.88
18m<t<24m	1.17	1.15	1.09	1.07	0.87	0.87

Predicted prices suggest that the top WIC infant formula is the highest-priced formula among the three types, with toddler formula being the least expensive. Winning manufacturers

increased the price of all infant formulas. At the same time, toddler formula prices decreased by about $0.01/oz. over the first 18 months after winning the contract.

An important finding in Table 3.7 is that, immediately after contract change, both winning and losing manufacturers made around $20 million more than they had prior to the change. The winning manufacturer continued to make more money, while the losing manufacturer's profit decreased over time for all three types of formula. The evidence seems to justify the substantial discounts manufacturers give WIC. Last, the spillover effect was estimated to be larger in the non–WIC infant formula market than in the toddler market, as the non–WIC infant formula enjoyed a much larger market.

Table 3.7 Estimated Annual Manufacturer Profit over Time by Formula Type in $Million

Time Period	Top WIC Brand		Non-WIC Infant		Toddler		Total	
	Winner	Loser	Winner	Loser	Winner	Loser	Winner	Loser
Pre change	6.48	-19.08	43.21	109.96	7.09	10.06	56.78	100.94
Post change	-19.41	32.62	85.93	79.82	10.95	11.82	77.47	124.26
3m<t<6m	-22.86	13.77	109.10	65.77	12.84	11.27	99.08	90.81
6m<t<12m	-22.93	8.75	121.90	56.04	13.92	10.00	112.88	74.79
12m<t<18m	-23.00	7.97	131.47	50.71	16.34	9.68	124.81	68.36
18m<t<24m	-22.34	5.92	138.89	44.31	17.47	8.49	134.02	58.73

3.7 Conclusion

We use large-scale Nielsen retail scanner data to study WIC's impact on the market for milk-based powder formula from 2007 to 2013. While controlling for demographic differences and state-specific demand trends, we identify spillover patterns by observing market share and pricing changes before and after each contract change for three types of infant formulas and for both WIC contract winners and losers.

This paper contributes to previous studies by, first, identifying the top WIC brands that make up almost all WIC formula sales in each state. Second, using multinomial logit models

based on Huang and Perloff (2014), we find different spillover patterns by comparing three types of formula. In particular, immediately after the contract change, the winning manufacturer experiences a significant increase in market share for all three types of formula due to greater shelf space, better product placement, the advantages of carrying WIC labels.

While the loser's market share for the top WIC infant formula and all other infant formula promptly decrease, the loser's market share in the toddler formula market continues to increase and only begins to decrease around 18 months after WIC contract changes. This suggests that losing manufacturers still enjoy a spillover effect because of consumers' brand loyal purchases. Over time, the spillover effect increases the winner's share and decreases the loser's share for all other infant formula, which may reflect the combined impact of recommendations from physicians and WIC participants. Lastly, we observe that winning manufacturers increase prices for top WIC and all other infant formulas and decrease toddler formula prices over time. A spillover effect helps the losing manufacturer to continue increasing its prices for all three types of formula for at least 2 years after contract changes.

In conclusion, this study finds evidence that significant spillover effects through multiple channels drive manufacturers to win WIC infant rebate contracts. Winning manufacturers can make considerably more money in the non–WIC market to compensate for the loss in the WIC market, mainly because manufacturing costs are so small, leaving room for large profit margins.

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