How Consumers Respond to Food Safety Crisis

A Study of Peanut Butter and Egg Recalls on Consumer Behavior

by

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Abstract: In 2009, salmonellosis was found in peanut products processed by the Peanut Corporation of America, resulting in 714 cases of severe food poisoning from ingesting contaminated peanut butter. In 2010, over 1900 people were hospitalized due to salmonella outbreak from eggs produced on two Iowa farms. Using a modified regression discontinuity design, this paper examines how consumers responded to these two recent and acute national food safety crises, and whether consumers' responses correlate with their socioeconomic statuses. The regression results show a statistically significant decrease of 13.7% in peanut butter sales in the second week after the recall announcement, the egg sales were not significantly affected. The socioeconomic statuses of consumers did not play a determining factor in their purchasing behaviors in either case. This finding implies that national food recalls have mixed effect on preventing consumers from purchasing potentially contaminated products regardless of socioeconomic classes.

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Disclaimer

Results from the paper are calculated based on data from The Nielsen Company (US), LLC and marketing databases provided by the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. The conclusions drawn from the Nielsen data are those of the researchers and do not reflect the views of Nielsen. Nielsen is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.

I. Introduction

Food consumption choices are complex and multifaceted -- determined by both traditional economic factors such as prices and consumer income, and more idiosyncratic determinants like emerging food related information; changing product characteristics; new product developments or offerings; and shifts in consumer demographics and lifestyles (Tonsor, Mintert, & Schroeder, 2010). Under the broad topical umbrella of food demand, consumer response to food safety scandals and product recalls are of particular research interest to food producers and policymakers – it allows us to evaluate the effectiveness of food safety recalls in protecting public health and to estimate the risks facing food companies if consumers alter their behavior following food safety scandals. Understanding the magnitude and economic impact of these demand shocks is also pertinent in the United States because around 47.8 million Americans contract food borne illness every year.[2]

Research in this field has employed both experimental studies and empirical analyses to quantify the impact of food safety crises on consumers' purchasing behavior. The main question of interest consists of how consumption changes when consumers learn about the contaminated products. Past literature has explored this central question from several angles, including the economic impact of food safety scandals on producers; whether consumers substitute or completely avoid the product that is declared unsafe; whether consumer response varies according to their geographic location, socioeconomic status and education level; and whether the intensity of media coverage has impact on consumer demand (Arnade, Calvin, & Kuchler, 2009; Burton & Young, 1996; Müller & Gaus, 2015; Schlenker & Villas-Boas, 2009; Yadavalli & Jones, 2014). Findings have been mixed. The magnitude and duration of demand shocks vary from crisis to crisis. The mad cow disease outbreak in the U.S. led to a swift, economically significant, and long lasting withdrawal of demand for beef (Schlenker & Villas-Boas, 2009) whereas more recent food safety crises such as the E.coli outbreak in spinach only led to a temporary shift in consumer demand for leafy greens (Arnade, Calvin, and Kuchler 2009).

Conclusions on how income and education level influence consumer response also vary. A study on the 2011 German Dioxin scandal that affected chicken and pork products shows that

[2] Estimates of Foodborne Illness in the United States. (2016, July 15). Retrieved April 03, 2018, from https://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html

highly educated households with small children significantly reduced their purchases of chicken filet meat (Rieger, Kuhlgatz, & Anders, 2016). A research on Canadians' response to the mad cow disease grouped households by their risk perception towards beef consumption through a household survey and revealed statistically significant differences in risk attitudes related to meat-purchasing across different demographic groups. Single member households and low income households showed higher risk aversion to beef consumption and higher elasticity of demand for beef. (Yang & Goddard, 2011).

This paper contributes to the existing literature by examining how consumers responded to the reporting of two recent and acute national food safety crises, and whether consumers' responses correlate with their socioeconomic statuses. I place a particular focus on evaluating how income level impacts consumers' purchasing behavior to determine whether there exist equity implications following food recalls caused by differences in financial resources available to avoid the affected product.

The paper distinguishes itself from past research by studying two crises with a high temporal resolution to determine whether there are consistent factors that lead to greater changes in consumption behaviors. Specifically, I use detailed weekly scanner data from Nielsen to analyze two major recent crises: the salmonellosis outbreak in 2009 from peanut butter and the massive egg recall in 2010 due to salmonella.

In 2009, as a result of Salmonella contamination in peanut butter manufactured by Peanut Corporation of America, nine people died and at least 714 people fell ill, with 166 hospitalized.[3] It triggered an extensive recall of products that contained ingredients manufactured by PCA, spanning 46 states. In 2010, 550 million eggs were recalled after dangerous levels of Salmonella were detected in the eggs of two Iowa producers. There were more than 1,900 reported illnesses and an estimated 60,000 unreported illnesses linked to this outbreak.[4] By using these two events, occurring in consecutive years, I hope to evaluate the magnitude of consumers' response for each

[3] Salmonella. (2009, May 11). Retrieved April 03, 2018, from https://www.cdc.gov/salmonella/2009/peanut-butter-2008-2009.html

[4] "Disgraced egg industry titan charged over 2010 salmonella outbreak." (2014, May 21). Retrieved April 03, 2018, from https://www.cbsnews.com/news/disgraced-egg-industry-titan-charged-over-2010-salmonella-outbreak/

crisis and consider how factors such as geographic and socioeconomic characteristics of households affect their responses.

These two crises are chosen based on three criteria: the number of illnesses with which the disease was associated, the number of hospitalizations, and the number of deaths. According to the CDC, the two selected crises caused one of the highest incidences of illnesses, hospitalizations and deaths due to food pathogen outbreaks since 2008.[5] The Nielsen dataset contains grocery stores' scanner data starting from 2006. To adequately control for seasonal variations and store heterogeneity, only food crises after 2008 are considered to allow for inclusion of data on consumption from two years before the food-borne illness outbreak. Furthermore, since I am examining grocery purchase data, only crises involving products that can be prepared at home are considered.[6] Purchasing behaviors for peanut butter and eggs are also likely to be divided among income classes. While peanut butter[7] is often perceived to be more heavily purchased by lower income households and thus an inferior good, eggs are thought to be normal good whose consumption increases with income. These distinctive properties of the two products thus allow a detailed examination on how consumers' responses to food crises differ by product and by income class.

This paper is organized as follows. Section II summarizes the timeline of the peanut butter recall and the egg recall in 2008 and 2009 respectively. Section III reviews past literature that examines the effect of food scandals on consumers' purchasing habits. Section IV presents this paper's regression model that is used in later sections to determine whether food safety scandals lead to a decreased consumption of affected products and whether consumers' socio-economic backgrounds influence their behavior. Section V provides an overview of the data, including sources and summary statistics. Section VI details this study's empirical results and Section VII discusses the implications of the key findings.

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[5] National Outbreak Reporting System (NORS). (2017, November 27). Retrieved April 03, 2018, from https://wwwn.cdc.gov/foodborneoutbreaks/

[6] Outbreaks associated with food consumed in restaurants, fairs, and catered events, are not considered in this study.

[7] Here, the peanut butter solely refers to the jars of pure peanut butter sold at supermarkets and not gourmet products made from nut butter

II. Recall Crises Timeline

2009 Peanut Butter Recall

The Salmonella outbreak linked to Peanut Corporation of America products caused at least 714 food-borne illnesses in 47 states, of which nine cases were fatal. As early as June 17, 2008, in a seven-day inspection of the Blakely Plant of the Peanut Corporation of America in Georgia, the state Department of Agriculture documented unsanitary conditions that were corrected during the inspection. On November 10, 2008, the CDC began monitoring incidences of salmonella in 12 states. On Jan. 9, 2009, the FDA initiated an inspection of the Blakely Plant after contamination was found for King Nut peanut butter, one of the distributors of Blakely manufactured products. On Jan 10th, King Nut issued its first recall related to the outbreak and on Jan 14th, PCA announced a nationwide recall. The recall by PCA was expanded a total of three times, with the third announcement on Jan 28, 2009 and all peanut product made in the last two years were recalled.[8]

2010 Egg Recall

From May 1 to November 30, 2010, a total of 1939 reported illnesses were estimated to be associated with the Salmonella outbreak from consuming contaminated eggs.[9] Investigations by public health officials since April traced the sources of infection to two farms in Iowa. Further on-site investigations by the FDA identified Wright County Egg and Hillandale Farms of Iowa as two major egg suppliers that were the common sources of contaminated shell eggs contributing to this outbreak. On August 13, 2010, Wright County Egg conducted a nationwide voluntary recall of shell eggs and expanded its recall to 380 million eggs on Aug 18, 2010. Two days later, Hillandale Farms of Iowa conducted a nationwide voluntary recall of 170 million shell eggs in 14 states.[10]

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[8] Peanut Corporation of America from Inception to Indictment: A Timeline. (2013, February 22). Retrieved April 03, 2018, from http://www.foodsafetynews.com/2013/02/peanut-corporation-of-america-from-inception-to-indictment-a-timeline/#.WphLckxFzZs

[9] Salmonella. (2010, December 02). Retrieved April 03, 2018, from https://www.cdc.gov/salmonella/2010/shell-eggs-12-2-10.html

[10] Landau, E., Hagan, C., Willingham, V., & Morgenstein, M. (2010, August 20). Half a billion eggs have been recalled. Retrieved April 03, 2018, from http://www.cnn.com/2010/HEALTH/08/20/eggs.recall.salmonella/index.html

III. Literature Review

Literature addressing consumers' responses to food safety crises is mostly driven by an effort to understand how consumers react to information on the quality, safety, or composition (presence of allergens, etc.) of their food, as such knowledge then informs policy makers on the effectiveness of food information and recalls in preventing consumers from ingesting unsafe products. Researchers have used a variety of measures to determine changes in demand, as well as diverse methodologies and data sources. Findings on the effect and magnitude of food safety crises' impacts on consumption are mixed and seem to be highly dependent on the specific crisis examined.

A common data source used for empirical analysis is aggregate demand data at the product level. Researchers often construct a variant of the Almost Ideal Demand System (Deaton & Muellbauer, 1980) to investigate consumer behavior. The AIDS model, by specifying the dependent variable as the expenditure share of a product among its reasonable substitutes, has the advantage of accounting for cross-commodity responses. For example, Burton & Young (1996) used AIDS to determine the extent to which that a shift in beef demand observed in UK since 1990 can be attributed to the publicity surrounding mad cow disease. Using a similar model, Arnade, Calvin, and Kuchler (2009) researched into consumers' response to the 2006 FDA announcement about E.coli contamination in spinach. They found that consumers temporarily substituted other vegetables for leafy greens. In the long run, however, total leafy greens consumption stayed constant – there was a shifting among leafy green vegetables toward less spinach and more substitutes such as lettuce. Yadavalli and Jones (2014) studied the increased media attention to lean finely textured beef (LFTB) in 2012 using a variation on the AIDS model and found that media coverage did not lead to immediate changes in consumer demand across meats or within the beef category, but purchases were affected two weeks or more after news reports surfaced. Yang & Goddard (2011) used a demand system to quantify the impact of mad cow disease on Canadian household beef purchasing behavior. They grouped households according to their risk perceptions toward beef and found that households with lower willingness to accept the risks of eating beef have more elastic beef demand relative to the household clusters with higher willingness to accept the risks of eating beef.

Aside from using demand systems to analyze changes in consumer behavior, a few papers use standard regression models to determine the decrease in purchased quantity in the wake of food safety concerns. Schlenker and Villas-Boas (2009) study the impact of the first discovery of mad cow disease in the U.S. in December 2003 using aggregate retail data and derived the difference between pre-event and post-event purchases. They find that following the discovery, there was a statistically significant and robust drop in beef demand. Other studies use household-level purchase data to control for household specific characteristics including income level, number of children, and level of education. Taylor, Klaiber, & Kuchler (2016) find that there was a persistent structural shift in consumer demand for beef following the discovery of mad cow disease in the U.S. – an average reduction of 0.26 lb per person in retail purchases of ground beef. Income and education levels were nevertheless insignificant predictors of quantity of beef purchased. Rieger, Kuhlgatz, & Anders (2016) study the 2011 German Dioxin scandal that affected chicken and pork products. They find that highly educated households with small children, as well as households with older consumers, significantly reduced their purchases of chicken filet meat, implying that households with vulnerable members who are at higher health risks are more sensitive to food safety news.

One common factor among the quantitative research on this topic is the inclusion of a metric to account for the intensity of media coverage. Piggott & Marsh (2004) measure media coverage to determine the effect of food safety information on meat demand by searching the top fifty English language newspaper using keywords related to food safety issues. Yadavalli & Jones (2014) construct a weighted news media index by summing the number of news articles across each news source per week and weighting based on percent of consumer readership per news source and the total number of news articles per week. Similarly, to account for the issue that not all media outlets have the same potential impact, Rieger et al. (2016) compute a Food Scandal Index by weighting different media according to their actual reach using print distribution levels, website visit frequencies, and TV viewing rates. They find strong empirical evidence supporting the hypothesis that responses to negative media exposure in terms of changes in consumption patterns were short lasting.

As we can see, there have been mixed findings in existing literature on whether negative information on food safety issues has a statistically significant impact on consumers' demand for the affected product. My paper contributes to this field by simultaneously studying two events involving peanut butter and eggs to seek pattern in the characteristics of a crisis that likely determine the magnitude and length of consumer response. I control for time variant and store-specific factors to isolate and quantify the impact of food recall crises. I also group counties by their median household income levels to examine whether socioeconomic statuses influence consumers' purchase decisions of affected product post food safety crises. My main hypotheses are as follow:

Hypothesis 1): Food recall announcements will lead to a significant decrease in the amount of affected product purchased.

Hypothesis 2): High-income consumers will decrease their demand more for the affected product than low-income consumers.

By studying the first hypothesis, I examine the impact of food safety related information on product demand and whether the sale volume of affected products is negatively impacted by food recall announcements. The hypothesis tests if food recall announcements generate a sudden heightened level of concern about the safety of products and stimulate a rapid and significant reductions in demand.

The second hypothesis explores the question of whether various socio-economic groups show heterogeneous responses to the same food safety event. Two key components driving food consumption decisions post food safety alert consist of consumers' risk attitude and risk perception (Wansink, 2004). If wealthy individuals show more elasticity in demand following food safety alerts, it can be deduced that they either have more capital to dispense in purchasing substitutes to avoid the risk of ingesting unsafe products and/or that they perceive higher risks from the food recalls that they are more willing to avoid the products.

IV. Quantitative Specifications

Food safety crises represent sudden demand shocks that jolt market demand out of its regular seasonal fluctuations. In this paper, we assume that aggregate consumption behavior follows a predictable seasonal pattern that is only interrupted by unexpected events such as announcements of food contamination. We use a model similar to regression discontinuity in time design to quantify how much consumers responded to food safety crises in terms of their purchasing behavior.

Regression discontinuity with time series is gaining traction in the environmental economics literature. Environmental research often faces identification challenges such as that 1) there is no cross-sectional variation in treatment, and 2) there are many cofounders that change at the threshold (Hausman & Rapson, 2017). The same set of challenges is applicable in this current study because 1) the food recalls are nationwide, eliminating the possibility for cross-sectional comparison across states, and 2) purchase decisions for peanut butter and egg are influenced by a plethora of factors that goes well beyond the effect of food recall announcements.

In a regression discontinuity set up, time is the running variable and the date *c* of the treatment is known. It is thus assumed that for all $t>c$, the unit is treated, and for all $t<c$, the unit is not. In our scenario, food recall announcements by the U.S. Food and Drug Administration are exogenous factors that mark the moment of discontinuity in consumers' purchasing behavior. I aggregate sales data from major retail stores around the country encompassing two years (104 weeks) before and five months following the announcement (20 weeks). Ideally, the data examined before and after the crisis would be more balanced; however, the amount of data used in this study is constrained by the limited storage capacity on the secured network. Therefore, after carefully reviewing past literature, I decided to use a longer timeline leading up to the crises to establish the consumption trends, as several previous studies have also done. The purchase level and trend before the crises serve as controls for the immediate time segment after the crises.

In this model, instead of using a running time variable, I include monthly and yearly dummy variables to represent the passage of time. This is because a running time variable imposes a linear relationship between time and quantity sold, but there exist big fluctuations in sale volumes from month to month, which renders a linear relationship an unrealistic assumption. Figures 1 and 2 show the weekly movement of average units of peanut butter and eggs sold per thousand people, grouped by income quantiles and aggregated across the nation. I also modify the traditional regression discontinuity model that has a single cut-off point and include twenty dummy variables that capture ten weeks before and ten weeks after the recall announcements to identify consumers' reactions to the food recalls on a higher time resolution. By allowing each week in the immediate timeframe before and after the recall to take on its own value, this specification is granting the regression model maximum flexibility to fit observations and indicate the movement in quantity of affected products sold.

The base model for my regression design can be expressed in the following equation:

$$Q_{w,y,c} = \beta_0 + \beta_1 before\_and\_after\_crisis_{w,y,c} + \beta_2 income_c + \beta_3 demographics_c + \beta_4 month_y + \beta_5 year + \beta_6 holiday_y + \beta_7 before\_and\_after\_crisis_{w,y,c} * income_c + \varepsilon_{w,y,c}$$

where *Q* represents the purchased quantity of affected product per thousand people in county *c* during week *w* in year *y*. The quantity sold is an aggregate number of all brands of the affected product in all stores across each county, divided by the population (in thousands) of the county. *Before_and_after_crisis* represents the twenty time dummy variables for ten weeks before and ten weeks after the crisis to estimate the week-to-week change in quantity purchased. The decrease in sales after the announcement will be indicated by the coefficients on the week dummy variables immediately following the recall. The coefficients on each dummy variable allow us to estimate the magnitude and length of consumers' reaction to the food recall announcement. *Income* is represented as county *c*'s median income in thousands of dollars in one model and as its median income quartile group on the national level in another model. *Demographics* is a list of variables accounting for each county's demographic characteristics that likely influence the amount of affected product purchased. *Month* is a categorical variable that is used to control for seasonal effect of consumption. *Holiday* represents the week of holidays for Thanksgiving and Christmas, when significant drops or spikes in peanut butter or egg sales can be observed. *Easter* represents the week of Easter for egg regression. Finally, the interaction variable between the time dummy variables and the income groups represent how various socio-economic groups respond differently following the recall announcements.

V. Data

This analysis uses the Retail Scanner Data provided by the Kilts Center for Marketing at Chicago Booth and the Nielsen Company, and the American Community Survey data.

The Nielsen dataset is used under a restrictive access agreement. It consists of weekly purchase and pricing data generated from participating retail stores across the U.S. market, as well as the geographic information on all stores. UPC codes associated with all peanut butter products under the "jams/jellies/spread" group and all fresh eggs products under the "dairy" group were extracted. The UPC codes were then merged with stores' weekly sales data and geographic data. Prices were adjusted to reflect products' per unit price as calculated by dividing product price by the corresponding UPC's product size. The weekly sales volume is finally summed by county. To adequately control for seasonal sales pattern and the long-term sales trend, this analysis includes two years of data prior to the food recall announcement and five months after the announcement.

To get an overview of the sales trend of peanut butter and eggs over the two years before the recall announcements, I plot the average units of peanut butter and egg sold per thousand people against time, grouped by counties' income percentile group. From inspecting the graphs (Figures 1 and 2), I notice that holidays including Thanksgiving, Christmas, and New Year, are associated with a significant drop in peanut butter sold. In contrast, the same holidays, with the addition of Easter, are associated with notable spikes in the quantity of eggs sold. Thus, holiday dummy variables are created to control for the short-term drastic consumption changes observed.

The black vertical lines in both graphs represent the day when food recall announcements were made by the FDA. In both cases, there were noticeable drops in the quantity sold, but the magnitude of the drop is comparable to the week to week fluctuations. In the summary statistics table (Table 1), I present the average sale volume of both products three weeks leading up to the announcement and three weeks following the announcement, grouped by county income quantiles. From the raw data, it appears that there is a steady decline in peanut butter sales over the course of three weeks following the announcement. The consumption for eggs, in comparison, dropped more significantly immediately following the announcement but rebounded quickly.

Table 1 Summary Statistics on Units Sold Before and After the Crisis

	Income Quantile							
VARIABLES	25th		50th		75th		100th	
	Median	S.D	Median	S.D	Median	S.D	Median	S.D
Peanut Butter (Units in 16oz jars)								
3 weeks before announcement	5.916	7.817	7.065	8.55	8.27	9.21	11.17	10.51
2 weeks before announcement	4.28	5.98	5.86	6.45	7.04	7.14	9.77	9.31
1 week before announcement	6.574	8.73	8.74	9.64	10.69	10.36	14.86	11.93
1 week after announcement	6.69	7.93	8.40	8.59	9.92	9.91	13.49	11.28
2 weeks after announcement	5.09	6.02	6.68	6.89	7.94	8.09	11.14	9.30
3 weeks after announcement	4.41	8.98	6.3	16.85	8.29	18.12	11.18	11.8
Egg (Units in one dozen egg)								
3 weeks before announcement	28.14	30.64	30.96	31.00	38.35	37.29	47.35	46.61
2 weeks before announcement	31.86	33.47	32.63	33.38	38.88	40.16	52.31	50.48
1 week before announcement	31.07	35.35	35.96	33.67	41.80	39.89	52.33	48.10
1 week after announcement	29.81	34.89	31.06	33.82	37.42	36.11	48.15	45.73
2 weeks after announcement	26.56	31.27	27.71	28.10	36.77	34.18	44.86	42.29
3 weeks after announcement	28.39	30.17	29.62	30.72	38.16	34.12	48.89	41.10

Figure 1 Average weekly sales of peanut butter per thousand people, grouped by county income level.

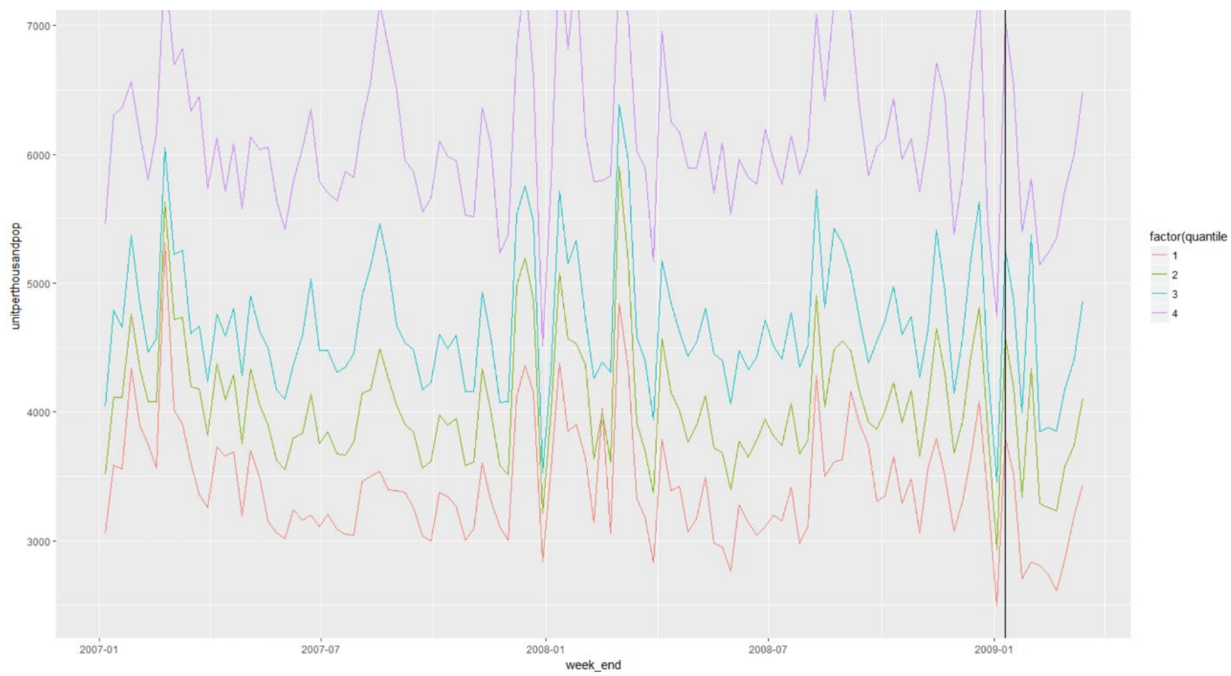
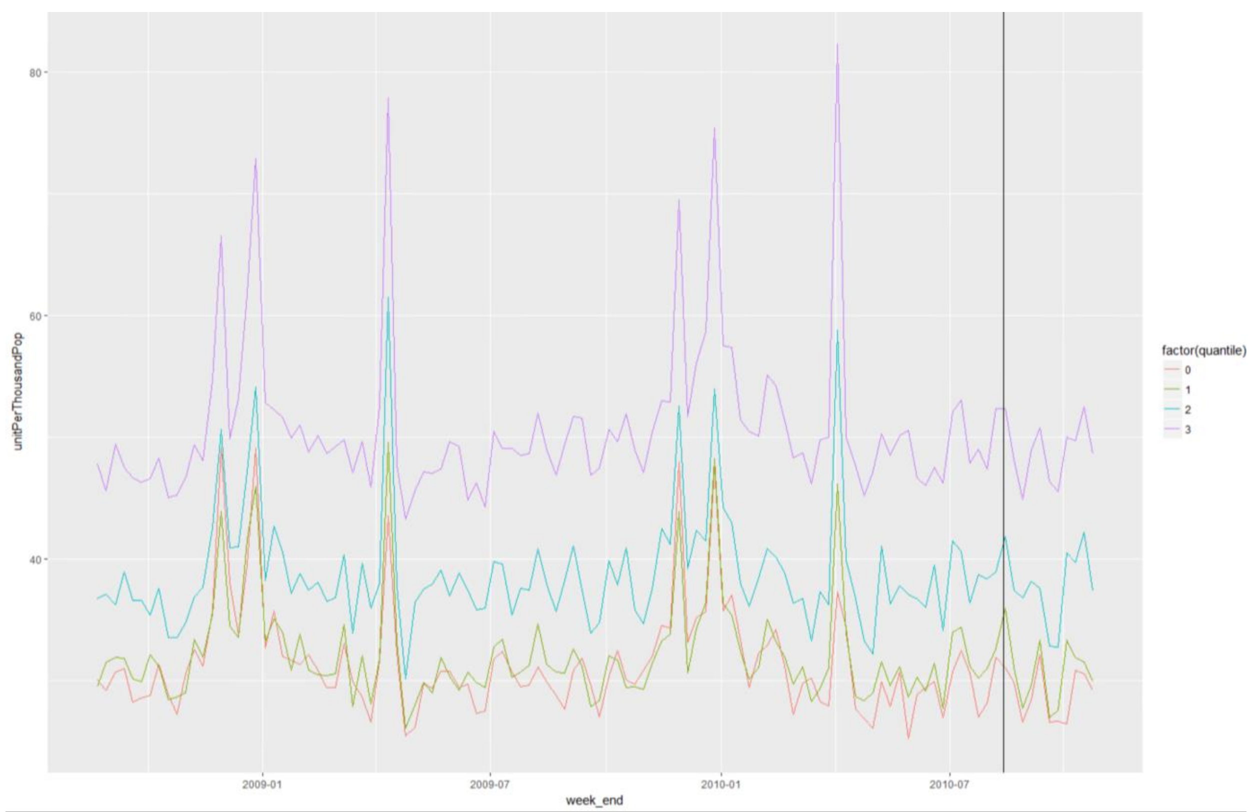


Figure 2 Average weekly sales of eggs per thousand people, grouped by county income level.



In addition to the Nielsen Marketing data, the American Community Survey data is used to inform the socioeconomic and demographic details of counties to control for geographic idiosyncrasies. I used 3-Year Estimates data (07-09 for peanut butter analysis and 08-10 for egg analysis) because of the availability of county level demographic data. Variables included in the analysis are median household income, population, racial composition, and education level. Median household income is transformed into two variables; one is continuous and expresses the income in thousands of dollars while the other is discrete and takes on four values based on quartiles of the national income distribution. County racial composition is expressed in percentages of White, African American, Asian, and Native American populations in the county. Education level is indicated as the percentage of population with high school, college, master, and doctorate degrees and the population without high school degrees serves as the base level for comparison.

The county level demographic data is merged with Nielsen marketing data based on county FIPS code. County population data adjusts counties' weekly purchase volume to a per capita basis for meaningful comparison between counties' purchase levels. Due to discrepancy between the counties included in Nielsen marketing data and those included in ACS (3-year ACS data does not include demographic data on all counties), observations with no demographic data are omitted in the final analysis. There are total of 1760 counties included in both analysis. 177,517 observations are in the final peanut butter analysis and 173,362 observations in the egg analysis.

Table 2 Demographic information summary statistics

VARIABLES (Value in %)	(2) mean	(3) sd	(4) min	(5) max
White	83.06	14.04	17.23	98.46
African American	9.323	12.40	0	67.15
Native	1.203	4.207	0	77.10
Asian	1.638	2.494	0	31.22
High School	16.05	6.694	2.570	50.98
Some College	28.63	4.885	9.510	45.15
Bachelor	13.59	5.567	2.950	36.42
Master	5.369	2.701	1.040	24.01
Professional School	1.311	0.841	0	8.390
Doctorate	0.847	0.905	0	9.130

VI. Model Estimation Results

<u>Peanut Butter</u>

The regression is performed on all observations and five model specifications are presented. Each observation consists of units of product sold across all stores within each county. County demographic information is included to control for unobserved heterogeneity in individual counties.

Results from the regression models are presented in Table 3. The demographic and monthly control variables are not shown and coefficients on the weekly dummy variables are abridged to focus on more statistically significant and interesting results. In models 1-3, the dependent variables are units of peanut butter sold per thousand people. Coefficients on the weekly dummy variables for the weeks before and after the crisis represent the deviation in sales volumes from average weekly sales, after controlling for seasonal and holiday sales trends. Coefficients on the interaction variables indicate the differences in quantity purchased among the four income groups post recall announcements. Column 1 accounts for county level income by the quartile groups to which they belong; Column 2 represents income as a continuous variable comprised of each county's median income in thousands of dollars; Column 3 also uses a continuous income variable, but it accounts for seasonality through season dummy variables, which are created by combining months into groups of three. All three models include interaction terms between the income quartile groups and the weekly dummy variables to demonstrate whether reaction to food safety recalls varies among income classes.

The results of the different specifications affirm the hypothesis that consumers decrease their level of consumption following a food recall announcement but refutes the hypothesis that richer communities respond more than poorer communities. The three models included demonstrate different responses from consumers. The first column shows a significant decrease in consumption only starting from the second week following the announcement– a 2.5-units drop in peanut butter purchased per one thousand people, but the effect lasts eight weeks into the initial announcement. The second and third specifications show a significant drop right after the announcement – around two units of decrease in peanut butter consumed per one thousand people. However, the effect becomes insignificant after second week of the announcement. The coefficients on interaction terms between income and weekly time variables in all three models closely resemble each other, and thus the interaction terms in model 1 between income quantiles and weekly time variables are omitted in Table 3. No significant difference in reaction to the peanut butter recall among consumers in different income groups can be parsed out from the regression. In Models 2 and 3 where income is included as a continuous variable, we see that consumers in higher income counties purchased more peanut butter immediately following the crisis than those in low income counties, an observation that directly contradicts the second hypothesis. This effect, however, is only weakly significant and disappears in week two after the announcement.

In models 4-5, the dependent variables are the natural log of total units sold in a county. A natural log on county population is included as independent variables to control for population size. In contrast to models 1-3, the coefficients on the independent variables in these two models represent the percentage change in sales volume relative to the baseline purchase levels within the same county. While model 4 includes the interaction terms between income and week dummy variables, model 5 excludes all interaction terms because of their non-statistically significant values demonstrated in previous models. Coefficients in model 4 are mostly insignificant but those in model 5 demonstrate similar findings to the ones shown in models 1-3. Statistically significant declines in sales are observed from the second week after the announcement of the recall. Sales volume is shown to be 13.7%, 16.9%, and 21.2% lower in the second, third, and fourth week respectively than the expected sales volume without the recall. It can be thus concluded that the insignificant findings in column 4) are likely the result of multicollinearity from the interaction variables between income and weekly time dummies.

Figure 3 shows predicted units of peanut butter purchased by each income group ten weeks before and after the peanut butter recall announcement, based on the regression model in Column 1. It offers a visual representation of the regression results shown in Table 3.

From both the regression table and Figure 3, we see that peanut butter, contrary to my original assumption, is a normal good whose consumption increases in wealthier neighborhoods. Counties in the 75^{th} – 100^{th} percentile income group on average purchases 1.1 more units of peanut butter per thousand people than the bottom income group. We see a spike in peanut butter sales four weeks before the recall was issued – this increase can likely be explained by the beginning of Spring Semester after Christmas and New Year holidays (the week of Jan. 5^{th}) and the subsequent increased demand for peanut butter for packed school lunches. From the graph, it seems that all four income groups dropped their consumption level of peanut butter directly following the crisis but the decline in peanut butter sales ends three weeks after the announcement.

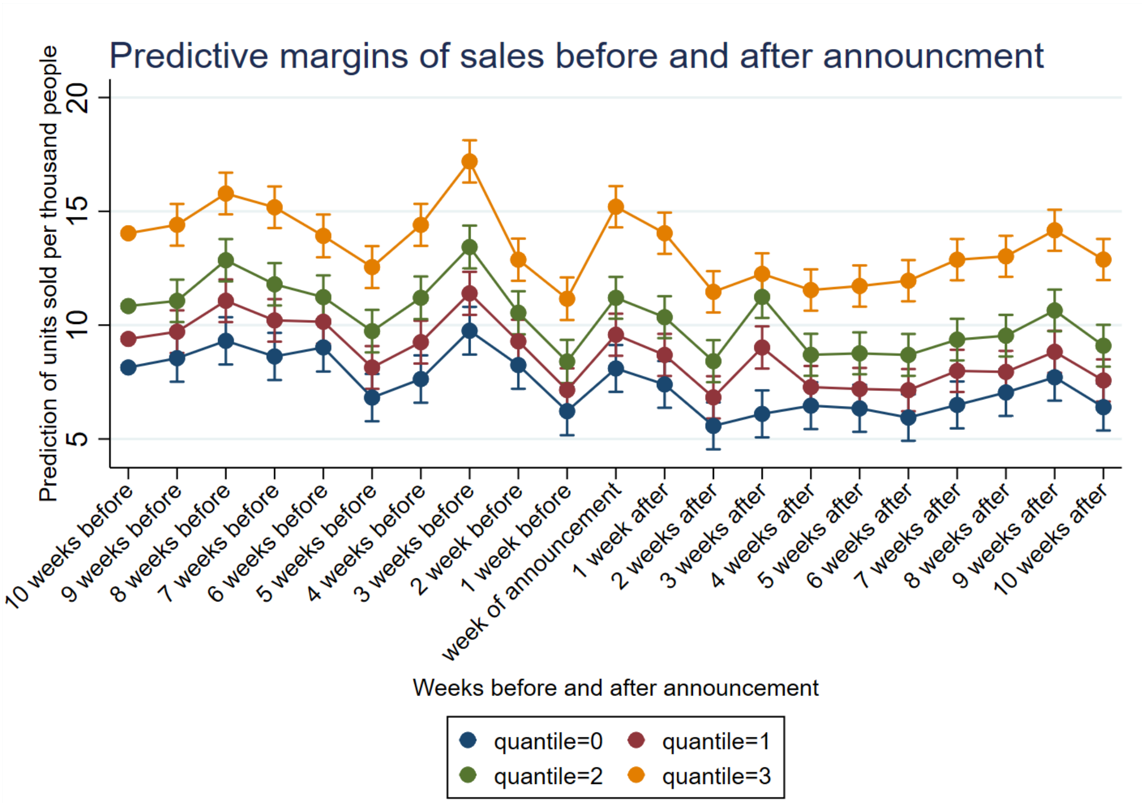
Table 3 Regression output for peanut butter sales.

	(1)	(2)	(3)	(4)	(5)
	Units sold per thousand ppl	Units sold per thousand ppl	Units sold per thousand ppl	In(units sold)	In(units sold)
50th Quantile	0.158*				
75th Quantile	0.438***				
100th Quantile	1.101***				
Income in thousands		0.0512***	0.0512***	0.00684***	0.00686***
ln(population)				1.237***	1.237***
Holiday	-1.317***	-1.317***	-1.161***	-0.182***	-0.182***
5 weeks before	0.0524	-1.311	-1.108	-0.0170	0.0152
4 weeks before	2.389***	0.110	0.157	0.406**	0.374***
3 weeks before	-0.396	1.469	1.516	0.0789	-0.00428
2 weeks before	-2.398***	-0.926	-0.794	-0.212	-0.164***
1 week before	0.449	-1.780	-1.492	0.196	0.164***
1 week after	**-0.465**	**-2.574****	**-2.286***	**-0.0214**	**0.0497**
2 weeks after	**-2.530*****	**-2.343***	**-2.055***	**-0.164**	**-0.137*****
3 weeks after	**-0.901*****	**0.0330**	**0.321**	**-0.285**	**-0.169*****
4 weeks after	**-2.132*****	**-0.981**	**-1.336**	**-0.259**	**-0.212*****
5 weeks after	**-2.115*****	**-1.435**	**-1.791**	**-0.120**	**-0.135****
6 weeks after	-2.167***	-2.517**	-2.872**	-0.233	-0.136***
7 weeks after	-1.407***	-2.227*	-2.582**	-0.136	-0.0714
8 weeks after	-1.219***	-1.795	-1.254	-0.173	-0.115**
9 weeks after	-0.250	-1.709	-1.168	0.127	0.0866*
10 weeks after	-1.604***	-3.093**	-2.552**	-0.372*	-0.169***
1 week after * income in thousands		0.0444*	0.0444*	0.00149	
2 weeks after * income in thousands		-0.00391	-0.00391	0.000564	
3 weeks after * income in thousands		-0.0196	-0.0196	0.00243	
4 weeks after * income in		-0.0242	-0.0242	0.000989	

thousands					
5 weeks after * income in thousands		-0.0143	-0.0143	-0.000317	
summer			-0.245***		
fall			-0.352***		
winter			0.551***		
_cons	5.932***	4.247***	3.408***	-9.286***	-9.287***
N	177401	177401	177401	177401	177401
adj. R^2	0.116	0.117	0.116	0.511	0.511

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 3 Predicted units of peanut butter consumption before and after the crisis



Eggs

The regression models used in the eggs analysis are set up in a similar way to those used in the peanut butter analysis and the results are presented in Table 4. Models 1-2 specify the dependent variables as units of eggs sold per thousand people in one county. The first column analyzes household median income as quartile groups while the second column treats income as a continuous variable. Both regressions include interaction terms between income and weekly time variables but the coefficients on interaction for model 1 are again omitted due to insignificance and similar values to the ones presented in column 2. From the regression results, we see that consumers' responses to egg recall are only statistically significant in the second week following the announcement in the first model – consumers decreased their consumption level by 3 units per thousand in population. None of the coefficients on weekly time variables in the second model are significant, nor are the interaction variables, indicating that there exist no discernable differences in how consumers from different income groups respond to food recalls.

Models 3-5 use the natural log of total units of eggs sold in a county, with log of county population included as an independent variable to control for county population size. Models 3 and 4 test the regression model with and without the income interaction terms due to concerns about multicollinearity since the interaction terms are found to be insignificant. Interestingly, no significant percentage change in consumers' egg consumption is noted after the recall announcement in either regression model though the coefficients are all negative.

Given that there is little effect found on sales volume following the egg recall when the data is examined on a national level, Column 5 expands on the previous regression models to test whether the recall had a more localized effect in Iowa, the state where all contaminated eggs originated from. The regression identifies all stores in Iowa with a dummy variable and includes interaction terms between the Iowa dummy and the weekly time variables. The negative coefficient value on the interaction term between Iowa and the first week after recall suggests that egg consumption withdrawal might be more pronounced in Iowa. However, the coefficients are not statistically significant at the 10% level.

All of the above findings suggest that consumers' reactions to the egg recall announcement was much weaker than their responses to the peanut butter recall that happened one year prior. Income again is not a factor in explaining the heterogeneity of consumer response to food crises. Figure 4 presents the finding by plotting predicted egg sale volume per thousand people according to the 1st regression model against weeks before and after the recall announcement. From the graph, we can see that sales dropped immediately after the announcement and lasted for two weeks before ascending again.

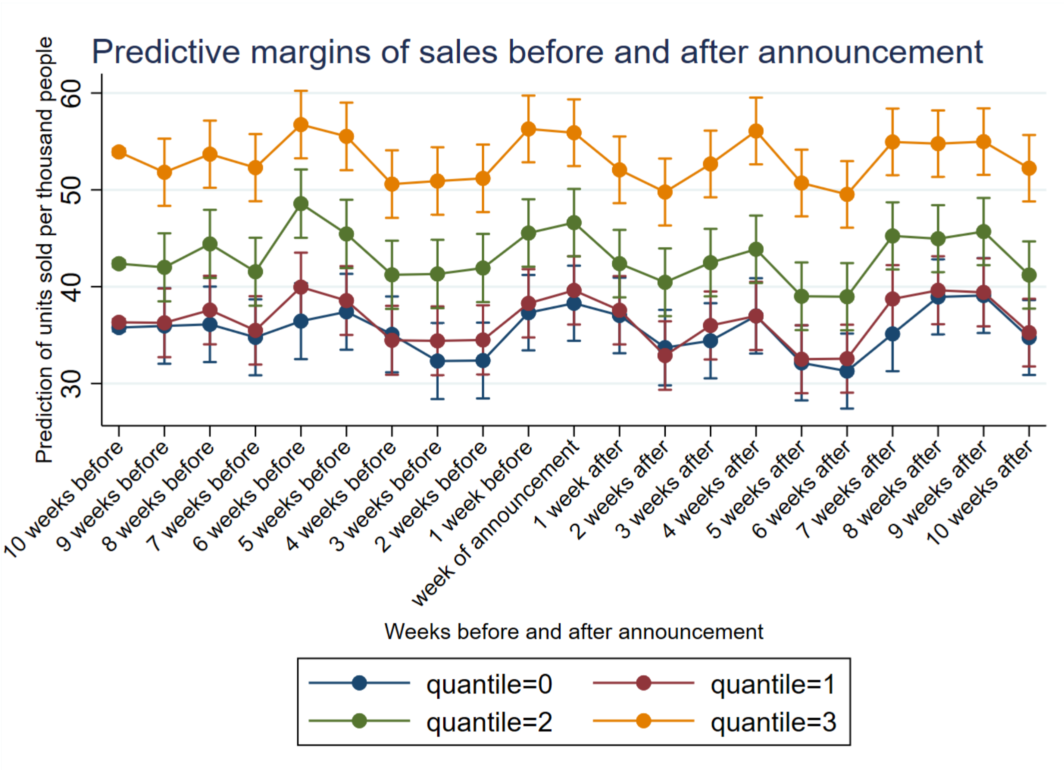
Table 4 Regression results for egg consumption

	(1)	(2)	(3)	(4)	(5)
	Units sold per thousand ppl	Units sold per thousand ppl	ln(units sold)	ln(units sold)	ln(units sold)
Income in thousands		0.319***	0.0101***	0.0102***	0.0107***
50th Quantile	-0.701**				
75th Quantile	2.014***				
100th Quantile	5.215***				
Iowa					0.999***
In(population)			1.310***	1.310***	1.322***
Holiday	10.72***	10.72***	0.188***	0.188***	0.188***
Easter	25.32***	25.33***			
5 weeks before	-1.819	2.937	-0.0283	-0.0332	-0.0336
4 weeks before	-2.306*	-0.193	-0.106	-0.0474	-0.0446
3 weeks before	-2.035*	-0.0203	-0.00537	-0.00277	-0.00146
2 weeks before	2.302*	2.865	0.101	0.0612	0.0567
1 week before	3.027**	5.882	0.0229	0.0380	0.0413
1 week after	**0.0854**	**5.368**	**-0.00278**	**-0.0342**	**-0.0319**
2 weeks after	**-2.938****	**1.727**	**-0.117**	**-0.0845**	**-0.0863**
3 weeks after	**-0.675**	**1.250**	**-0.00964**	**0.0188**	**0.0143**
4 weeks after	**1.398**	**0.562**	**-0.0799**	**0.0232**	**0.0209**
5 weeks after	**-3.497*****	**-3.887**	**-0.272**	**-0.0892**	**-0.0880**
6 weeks after	-3.988***	-2.250	-0.177	-0.103*	-0.103*
7 weeks after	1.518	2.054	-0.0168	0.0419	0.0443
8 weeks after	2.427**	7.383*	0.0294	-0.00227	-0.00105
9 weeks after	2.653**	7.294*	0.0335	0.0268	0.0223
10 weeks after	-1.250	0.733	-0.134	-0.0636	-0.0614
1 week after * income in thousands		-0.111	-0.000660		
2 weeks after * income in thousands		-0.0978	0.000677		
3 weeks after * income in thousands		-0.0404	0.000597		
4 weeks after * income in thousands		0.0176	0.00217		
5 weeks after * income in thousands		0.00827	0.00383		
1 week after * Iowa					-0.153
2 weeks after * Iowa					0.114
3 weeks after * Iowa					0.277

4 weeks after * Iowa					0.142
2 weeks after * Iowa					-0.0934
_cons	14.47***	3.659***	-9.247***	-9.252***	-9.342***
N	173248	173248	173248	173248	173248
adj. R^2	0.105	0.107	0.444	0.445	0.447

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 4 Predicted units of eggs sold before and after the food recall announcement based on regression model 1



VII. Discussion

This paper focuses on two food safety crises in 2009 and 2010 involving peanut butter and egg recalls to examine consumers' behavioral change in response to food contamination alerts. The two crises are chosen based on a number of shared characteristics. Both products are household staple items that are available for purchase in almost all retail stores. The outbreaks are associated with high rates of hospitalization and numerous cases of death, resulting in nationwide large-scale food recalls and generated high-levels of media attention. These two products are also chosen because of their potential to offer insights into how different socioeconomic groups respond to a perceived inferior good (peanut butter) versus a normal good (egg). The paper places a special emphasis on analyzing whether the socioeconomic standings of counties have direct impact on the magnitude of consumers' responses to food recalls as related findings would have social equity implications.

The regression results shown above demonstrate that consumers had a stronger response to the peanut butter recall than the egg recall, although neither crisis elicits different responses from different income groups that are statistically significant. There are a number of factors that likely contributed to the more marked responses from consumers on peanut butter recall. First, the peanut butter recall was given considerably higher media attention – even President Barack Obama commented on the crisis as extremely alarming due to the high consumption of peanut butter in the U.S.[11] The outbreak was also followed immediately by the declaration of bankruptcy by the Peanut Corporation of America (PCA) in February 2009, and the beginning of legal trials involving the Executive Director of PCA over criminal charges on knowingly marketing contaminated peanut products. Compared to the sustained, strong media attention given to the peanut butter crisis, the egg recall was large and swift – about 550 million eggs were recalled in the span of two weeks, but the story quickly faded away as the rest of the eggs were declared to be safe to consume.[12]

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[11] 2009 Peanut Butter Outbreak: Three Years On, Still No Resolution for Some. (2013, February 22). Retrieved April 03, 2018, from http://www.foodsafetynews.com/2012/04/2009-peanut-butter-outbreak-three-years-on-still-no-resolution-for-some/#.WpmmRExFzZs

[12]Lemon, D., Endo, S., & Smith, M. (2010, August 24). No further egg recalls expected, feds say. Retrieved April 03, 2018, from http://edition.cnn.com/2010/HEALTH/08/23/eggs.salmonella/index.html

Second, the peanut butter crisis likely generated more public fear because PCA, the company responsible for all contaminated peanut butter, sits at the top of peanut product distribution chain and thus caused a rippling effect throughout the food industry. Its peanut processing facilities distribute solely to large institutions, food service providers, food manufacturers and distributers rather than direct retail stores.[13] Thus, the contamination had far reaching consequences into peanut butter related consumer products across the nation. Major food brands such as Kellogg and retail stores like Kroger issued their own voluntary recall of products containing peanut butter because PCA is a major peanut butter supplier to these companies. The contaminated eggs, in comparison, were distributed directly to retail stores and were easy to track down as they were all produced by two farms in Iowa.

Third, it is also likely that peanut butter faces a higher elasticity of demand because of its substitutability. It can be replaced by jam or other nut butter options as a spread and may not be as essential in diet as eggs are. One potential support for this hypothesis is the observation that while the quantity of peanut butter consumed decreases during holiday seasons (Christmas and Thanksgiving), the quantity of eggs consumed significantly increases. This phenomenon can likely be explained by the fact that peanut butter is used as an ingredient in convenient meals like sandwiches that are easily replaced by more substantial meals served during holidays, meals in which eggs also constitute a key ingredient.

This paper, however, solely quantifies the amount of change in quantity purchased following a food safety scandal. It does not include mechanism for attributing the potential drop in consumption to specific causes such as media coverage intensity or product substitutability. Future endeavors can study the effect of media by examining different media coverage intensity in different states and compare the responses in states with relatively weak media coverage to those with strong coverage. However, this is beyond the scope of this paper. The findings of this paper confirm observations from previous literature that consumers' responses to recent food safety warnings are small and transient. In addition, it shows that different income groups have no significant differences in their responses to food safety scandals. This understanding of how consumers respond to food recall announcements is important as it helps FDA to better evaluate

[13] Salmonella. (2009, May 11). Retrieved April 03, 2018, from https://www.cdc.gov/salmonella/2009/peanut-butter-2008-2009.html

the cost and benefit of such announcements to consumer health and the affected food industry. It also raises the question of the effectiveness of food safety recalls in preventing public health crises and whether there are more effective options of protecting consumer health such as the implementation of tighter food safety regulations.

VIII. References

Arnade, C., Calvin, L., & Kuchler, F. (2009). Consumer Response to a Food Safety Shock: The 2006 Food-Borne Illness Outbreak of E. coli O157: H7 Linked to Spinach. *Applied Economic Perspectives and Policy*, *31*(4), 734–750. https://doi.org/10.1111/j.1467-9353.2009.01464.x

Burton, M., & Young, T. (1996). The impact of BSE on the demand for beef and other meats in Great Britain. *Applied Economics*, *28*(6), 687–693. https://doi.org/10.1080/000368496328434

Deaton, A., & Muellbauer, J. (1980). An Almost Ideal Demand System. *The American Economic Review*, *70*(3), 312–326.

Hausman, C., & Rapson, D. (2017, July). Regression Discontinuity in Time: Considerations for Empirical Applications. The National Bureau of Economic Research.

Müller, C. E., & Gaus, H. (2015). Consumer Response to Negative Media Information About Certified Organic Food Products. *Journal of Consumer Policy*, *38*(4), 387–409. https://doi.org/10.1007/s10603-015-9299-z

Piggott, N. E., & Marsh, T. L. (2004). Does Food Safety Information Impact U.S. Meat Demand? *American Journal of Agricultural Economics*, *86*(1), 154–174.

Rieger, J., Kuhlgatz, C., & Anders, S. (2016). Food scandals, media attention and habit persistence among desensitised meat consumers. *Food Policy*, *64*(Supplement C), 82–92. https://doi.org/10.1016/j.foodpol.2016.09.005

Schlenker, W., & Villas-Boas, S. B. (2009). Consumer and Market Responses to Mad Cow Disease. *American Journal of Agricultural Economics*, *91*(4), 1140–1152.

Taylor, M., Klaiber, H. A., & Kuchler, F. (2016). Changes in U.S. consumer response to food safety recalls in the shadow of a BSE scare. *Food Policy*, *62*(Supplement C), 56–64. https://doi.org/10.1016/j.foodpol.2016.04.005

Tonsor, G. T., Mintert, J. R., & Schroeder, T. C. (2010). U.S. Meat Demand: Household Dynamics and Media Information Impacts. *Journal of Agricultural and Resource Economics*, *35*(1), 1–17.

Wansink, B. (2004). Consumer Reactions to Food Safety Crises. *Advances in Food and Nutrition Research*, *48*, 103–150.

Yadavalli, A., & Jones, K. (2014). Does media influence consumer demand? The case of lean finely textured beef in the United States. *Food Policy*, *49*(Part 1), 219–227. https://doi.org/10.1016/j.foodpol.2014.08.002

Yang, J., & Goddard, E. (2011). Canadian Consumer Responses to BSE with Heterogeneous Risk Perceptions and Risk Attitudes. *Canadian Journal of Agricultural Economics/Revue Canadienne d'agroeconomie*, *59*(4), 493–518. https://doi.org/10.1111/j.1744-7976.2011.01225.x