THREE ESSAYS ON THE EFFECTS OF INFORMATION ON CONSUMER CHOICE OF GENETICALLY MODIFIED FOODS

A Dissertation

by

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ABSTRACT

The dissertation applies three different methods to reveal consumers' attitude toward Genetically Modified Organisms (GMOs). I incorporate experimental economics methods, surveys and causal inference methods, by using market data thoroughly to analyze consumers' reaction to GMO related information and explain the reason behind it.

My first essay investigates whether the available information on the health and safety of GMOs can affect consumers' acceptance of GMO products. Grocery shoppers were provided with information from the 2016 National Academy of Science, Engineering, and Medicine report on GMO products, and asked to participate in second price auctions for different products. We found that health concerns were the key reasons as to why consumers prefer non-GMO products to GMO products. People who believe that GMOs have negative effects on their health pay more for non-GMO products. We conclude that information about the health and safety of GMOs can change consumers' perception on GMO products, but its effectiveness varied across different news media for different consumers.

In the second essay, I used factor analysis focusing on the latent variables. More specifically, I applied Confirmatory Factor Analysis (CFA) based on Theory of Planned Behavior trying to figure out the effect of interaction of perceived risk, perceived benefits and knowledge level on the acceptance of GMO. The results confirmed the

effect of knowledge. Moreover, subjective knowledge level and objective knowledge level will cause different levels of acceptance of GMO.

In my third essay I used the national level data to study how GMO labeling information influences consumers' purchase decision. Vermont has become the first state that requires mandatory GMO labeling starting July 1st, 2016. The expectation of enforcement of mandatory GMO labeling law forced companies to label their products that include GMO ingredients as GMO, not only in Vermont but also around the U.S. I apply causal inference method to analyze the demand change after Vermont's GMO labeling law took into effect. By comparing the sales of GMO and Non-GMO cereal products before and after the mandatory labeling, I found the mandatory labeling caused a decrease in the sales of GMO products.

DEDICATION

To my mother, Jing.

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NOMENCLATURE

CFA	Confirmatory Factor Analysis
DID	Difference-in-difference
FDA	Food and Drug Administration
GE	Genetically Engineering
GMO	Genetically Modified Organism
NASEM	National Academy of Science, Engineering, and Medicine
NBFDS	National Bioengineered Food Disclosure Standard
RTE	Ready to eat
SPAs	Second price auctions
WTP	Willingness to Pay

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1. INTRODUCTION

In 1943, an American psychologist Abraham Maslow created a theory called "Maslow's Hierarchy of Needs". The theory summarizes how humans intrinsically partake in behavioral motivation. Basically, after the basic needs such as physiological needs, safety, and love/belonging being satisfied, human beings will move "up" to pursue "high level" needs such as self-esteem and self-actualization. This trend can be found along with the rising concern for animal wellbeing, environmentally friendly production, fair trade etc. (Ubilava, et al., 2010).

For millions of years, our ancestors have been trying so hard to fight for food or a safe place to live. For a recent couple of centuries, most of us no longer worry about whether we have enough potatoes for the next meal, and instead start to care about the quality of life. We began to "have a dream" and started pursuing higher level of needs, such as the quality of life. We fight for freedom, for human rights and for our self-esteem.

Indeed, the development of technology saved us from tons of repeated work, made life convenient, and fulfilled our leisure time. At the same time, as the technology is getting more complicated and is gaining more power that's beyond lay people's knowledge, panic has started to spread because people are feeling that it has started to get out of control. Genetically Modified Organisms (GMOs) is an example.

Humans' interference with species' genes can be traced back to very ancient time. In fact, almost everything we eat has been genetically modified in some manner.

Besides, there is no evidence to show that GMOs pose negative effect on human health or environment. Even so, consumers still show a general concern about GMOs. In 2014, Vermont become the first state in the U.S. to pass mandatory GMO labeling law. On July 29, 2016, President Obama signed the federal law to regulate GMO food labeling. The National Bioengineered Food Disclosure Standard (NBFDS) came into effect on February 19, 2019 and set the mandatory compliance date as January 1, 2022. This event will be a milestone in the U.S. GMO labeling history. It is a victory for consumers and NGOs who resist GMO. However, it will also cause a large amount of implementation and compliance costs for food industry, and enforcement cost for the government, a portion of which will also be passed on to tax payers. Thus, understanding consumers' attitude toward the GMO will help companies make wise decisions on the upcoming GMO labeling and at the same time provide the government with understanding about consumers' needs and further regulation.

Auction method has been widely used to elicit consumers' willingness to pay (WTP). My first essay is applying auction method comparing consumers' WTP for GMO labeled products, and products without GMO labeling. More specifically, we focus on the effect of information treatment on the WTP. We use National Academy of Science, Engineering, and Medicine (NASEM) report as information treatment to evaluate consumers' reaction to positive GMO information. If scientific report could alter consumers' reaction to GMO information, then food companies could choose to support those scientific analyses, and use that to save the potential loss of market share.

The second essay is trying to dig deeper into consumers' attitude toward GMO. From the first study, we found that consumers' attitude toward GMO is a comprehensive result of interactions of many factors. It can be influenced by some media information (i.e. the information treatment we provided in the first study). It can also be dominated by some latent variables like perceived risks, perceived benefits and the knowledge level. The interaction of perceived risks and benefits has been revealed by many scholars (Frewer et al., 2013; Prati et al., 2012; Traill et al., 2006). Recent studies also found the impact of subjective and objective knowledge, and how those two kinds of knowledge cause opposite impact (Fembach et al., 2019). My second essay is an attempt to incorporate the analysis of knowledge, and perceived benefits and risks, into a single system. I use factor analysis to analyze those latent variables and find the relation between them, and how those variables affect consumers' attitude toward GMOs.

The third essay is a continuation of my study on GMOs, where instead of applying lab experiment on a small group of people or online surveys, I use the state-level market data from Nielsen consumer panel. The data provides us with a large sample of consumers' purchase information from 2004 to 2017.

In 2016, before Vermont's mandatory labeling law went into effect, giant food companies (General Mills, Mars and Kellogg) started to take actions. Some of them have changed ingredients (Hershey), and some of them have stopped supplying less popular products to Vermont. A large number of them have started labeling their products as GMO, nation-wide. That provides us with a treatment to use market data for testing consumers' reaction to GMO labeling.

With the development of technology and accumulation of people's wealth, we pay less attention to our basic needs and more toward the life quality. Therefore, for food products, people not only care about price or taste but have also started to pay attention to credence attributes such as Organic, GMO, environmental-friendly, fair trade and COO. However, less is known about how consumers evaluate those attributes. The GMO study is just a start. GMO is a relatively new credence attribute and has attracted so much attention in the past decades. My study is trying to contribute to understanding people's attitude toward those credence attributes, and more studies are needed in the future for a better understanding of consumer behavior behind the evaluating of credence attributes.

2. UNDERSTANDING CONSUMER RESPONSE TO GMO INFORMATION*

2.1. Introduction

Since the first genetically modified organism (GMO) food, Flavr-Savr tomatoes commercially released in 1994, genetic engineering (GE) technology has been widely applied to many species of crops planted in 28 countries. According to the National Academy of Science, Engineering, and Medicine (NASEM) report, genetically engineered crops have been planted on 12% of the world's cropland and 40% of all GE crops are planted in the U.S. (NASEM, 2016). The most recent data of United States Department of Agricultural (USDA) reports that more than 90 percent of the corn and cotton grown in the U.S. is genetically modified.

The development of GE technology has brought substantial economic benefits to farmers and environmental benefits to the society (Chen and Lin, 2013), especially benefitted developing countries (Napier et al., 2004). GE seeds are favored by farmers. It reduces the expenditure on insecticides (Qaim and Janvry, 2003), which has been found to cause more than 40% of all potential food production (Paoletti and Pimentel, 2000), increased yields, and reduced production costs (Huang et al., 2002; Shankar and Thirtle, 2005; Subramanian and Qaim, 2009; Ali and Abdulai, 2009). The benefits can vary for different countries. Huang et al. (2002) found that the GE cotton significantly reduced the use of pesticides, and benefits the environment for China, because China was most

* Reprinted with permission from "Understanding Consumer response to GMO Information" by Xiaotong Yuan, Yu Yvette Zhang, Marco A. Palma, & Luis A. Ribera, 2018, 2018 Annual Meeting, February 2-6, 2018, Jacksonville, Florida 266720, Southern Agricultural Economics Association.

likely to over-use pesticides before. Shankar and Thirtle (2005) investigated the crop yield of GE cotton in South Africa and found that the GE technology is more likely to increase crop yield by recovering the lost productivity from pests, because South African farmers tends to under-use pesticides. Subramanian and Qaim (2009) found GE technology saved labor in cotton production in India.

Foreseeing the potential market of the GE seeds, many companies started to spend a lot on the R&D of GE seeds. The number of permits issued by USDA's Animal and Plant Health Inspection Service (APHIS) has grown from 4 in 1985 to 1194 in 2002, and after that is about 800 each year until 2013 (Fernandez-Cornejo, et al., 2014).

Contrary to the wide acceptance of GE technology on the producer side, consumers showed a general concern to GMO even after its boom for more than 20 years. A large amount of research has been developed to address and explain consumers' concern to GMO. Social psychologists usually reveal consumers' attitude by using Likert scale questionnaires, the answer categorized according to the agree level, ranging from "definitely agree" to "definitely disagree" (Gaskell et al., 2004). Economists are more comfortable with the valuation methods like willingness to pay (WTP). Many studies have suggested that consumers are willing to pay more for non-GMO products compared to GMO products (e.g. Frewer et al., 2013; Costa-Font et al., 2008; Lusk, Roosen and Fox, 2003; Chern and Rickertsen, 2001). Lusk et al. (2005) applied meta-analysis and summarized 25 studies on the valuation of GMO and reported that on average, consumers would like to pay 29% more for Non-GMO foods (excluding outliers).

Demographic information and consumer heterogeneity have been used to explain consumers' attitude toward GMO. Loureiro and Hine (2002) stated that people with higher income and those who cared more about fresh food and nutrition would pay more for non-GMO products. Consumers from different countries hold different attitude toward GMO. Marques et al. (2014) used a national sample of more than 8000 observations over 10 years, and showed that Australians were not comfortable with GMO products, and compared to GMO animals, the acceptance to GMO plants was higher. It also found the acceptance of GMO changes over time. Consumers in North America and Asia are more friendly to GMO compared to Europeans (Frewer et al., 2013). Some other demographic characteristics such as education (Onyango et al., 2004), religious beliefs (Hossain and Onyango, 2004), and gender (Siegrist 2000; Gaskell et al., 2004) have also been shown to affect consumers' attitudes toward GMO products.

With the approval of national GMO mandatory labeling law in 2016, the GMO producers are facing two choices - either remove their GMO ingredients or label their products as GMO. The heterogeneity of consumers' perception to GMO made it very difficult for the producers to make decisions. Despite the consumer heterogeneity, the GMO industry may care more about how to alleviate consumers' concern. In fact, many food companies have tried to deliver positive information of GMO to consumers. For example, consumers can find GMO information on Kellogg's website. Government also encourages the delivery of GMO information because it reduces the information asymmetry (Lusk et al., 2004).

For new technologies, consumers' knowledge level is usually relatively low. Therefore, information always plays an important role on manipulating consumers' attitude. Chen et al. (2013) found that consumers attitude toward new food technology, vacuum packaging, is highly affected by the positive and potential negative information regarding the vacuum packaging. The study of information effect on attitude toward GMO started from last century. Savadori et al. (2004) suggested that providing information about benefits could lower the perceived risk and increase the acceptance of GMO. However, the question of what kind of information is more persuasive, remains undetermined. Rousu et al. (2002) found that information from third-party groups (including scientists, professionals and academics) had a slight effect on consumers' attitude towards GMO products. Lusk et al. (2004) isolated the benefits obtained from GMOs for the environment, health, and to the third world, from the general positive information and found that the effects vary across different geographical areas. Environment related information could change consumers' reaction more compared to other kinds of information, in Texas. Tenege et al. (2003) investigated how consumers would react to information from different sources and found that information from interested parties and third-party sources had stronger effect. From those previous studies, we found that consumers' beliefs regarding information vary across different kinds of information. Consumers may choose to believe the information they trust most, and less trustworthy information will not make any difference.

Among all the information sources, news media outlets can play an important role in disseminating information useful for the consumers. It is quite easily accessible

by most people through different modes such as television channels, online portals and apps, print media, and radio. When Napier et al. (2004) investigated consumers' attitude toward GMO, they found that the media information could affect the perception of risks and benefits. In fact, the role of educated information from media has also been widely discussed. Frewer et al. (2002) discovered that peoples risk perception of GMO changes along with media exposure of GMO risks. Marques et al. (2015) found that the support for GMO is negative correlated to the media coverage about GMO. They stated that high media coverage would affect consumers' trust on scientists and regulators and in result influence their attitude toward GMO.

The relation of media information and consumers' attitude is hard to determine. Mostly because it is difficult to examine changes in attitude contemporaneous with the exposure of media information (Frewer, et al., 2002). The objective of our study is to contribute to this area. We applied a field experiment using news video directly sourced from FOX news and NBC channel to test consumers' reaction.

Fox and NBC are popular examples of news media outlets in the US. A very interesting thing to note is that people's political ideology and the news sources they trust are related. According to a new Pew Research Center study, Americans are divided along partisan lines with respect to the media outlets they trust (Jurkowitz et. al., 2020). They surveyed 12,043 U.S. adults in October and November of 2019, regarding 30 media outlets. They found that Republicans trust one news source- Fox News, far more than any other source. Around 65% of them trusted Fox news. On the contrary, the

Democrats trust multiple sources- CNN (67%), NBC (61%), ABC (60%). They also found that Democrats distrust Fox News (Jurkowitz et. al., 2020).

We investigated consumers' perceptions for GMO products using second price auctions (SPAs), which is a popular incentive-compatible method to elicit consumer willingness to pay (WTP) (Vickery, 1962; Coppinger, et al. 1980). In particular, we provided health and safety information about GMO products, from different news sources to the consumers, and examined the effect of the educational information on consumer WTPs. The rest of the paper is organized as follows. The second section presents the experimental procedures, and develops a model to analyze consumers' attitudes towards GMOs, and how consumers respond to the information. The third section shows the key results and regression analysis. The last final part includes policy implications conclusions.

2.2. Methodology

2.2.1. Experiment procedure

Lusk et al. (2005) has shown that consumers' attitude varies across different products. To find the general pattern of consumers' attitude and reveal the effect of product heterogeneity, we included six products in our research, which are beef, canola oil, cotton ball, milk, plain yogurt and zucchini squash.

We recruited 173 primary grocery shoppers aged from 18 to 83 in the Bryan and College Station area in Texas. Demographic characteristics are summarized in Table 2.1.

Table 2.1 Description of demographic variables and regression variables

Statistic	*Definition*	*Mean*	*Frequency*
Gender	1 = female	0.595	59.5%
	0 = male		40.5%
Age	Age in years	37.08	
Marital Status	1 = married before	0.451	45.1%
	0 = Otherwise		54.9%
Child	1 = children in household	0.185	18.5%
	0 = no child in household		81.5%
Education	1 = bachelor or higher degree	0.867	86.7%
	0 = otherwise		13.3%
Income	1 = income >$50000 per year	0.439	43.93%
	0 = otherwise		56.07%
CRRA risk attitude		0.694	
Health Concern	1 = have health concern in GMO products	0.283	28.32%
	0 = otherwise		71.78%
Knowledge	question score = 0	0.884	26.59%
	question score = 1		58.38%
	question score = 2		15.03%
Political Ideology	1 = lean conservative		33.53%
	2 = moderate		35.84%
	3 = lean liberal		19.08%
	4 = undecided		11.56%
Trust	1 = trust information provided	0.474	47.4%
	0 = do not very trust		52.6%

Subjects were presented with these products with "non-GMO" labels and similar products without "non-GMO" labels. As of 2017, the GMO labelling law is not in effect in the US except in the state of Vermont. However, we know more than 90% of corn, soy, and cotton planted in the U.S. are genetically modified[1]. Zucchini squash is one of the available GMO vegetables in the market, and over 24,000 acres of zucchini and yellow squash planted in the U.S. are GMOs[2]. As corn and soy are the main feed for livestock, milk and beef have always been suspected to be influenced by GE technology. Therefore, it is highly likely that the above products without GMO labeling are GMO products.

There were two stages in this study, Before-Information-Treatment stage and After-Information-Treatment stage. Subjects were randomly assigned into 24 groups with 6 to 9 bidders in each group, to participate in SPAs. Upon arrival, subjects were given a pre-experiment survey, which collected their demographic information and basic understanding about GMO. In the first stage of the experiment, participants were asked to bid for each product. After the completion of the first stage, participants watched a 2-minute news about NASEM's report, stating that GMOs pose no health risks and are safe for the environment. Twelve groups watched the news on FOX news, and the other 12 groups watched the news on NBC channel. Then the participants bid again after watching the news. Once every subject submitted their bid for second stage, participants

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1 Seth J. Wechsler, Recent Trends in GE Adoption, https://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us/recent-trends-in-ge-adoption.aspx.
2 Caldwell, M. (2013, Aug 5) http://www.motherjones.com/environment/2013/08/what-are-gmos-and-why-should-i-care/

were asked to rank their level of trust about the news from 1 to 5, 1 meaning "do not trust at all" and 5 meaning "trust completely".

We followed Holt and Laury (2002) to elicit subjects' risk preference. Participants were presented with a table of lottery choices (see Appendix A). For each pair of choices, they chose between lottery A and lottery B. Assuming subjects exhibit CRRA utility function $U(x) = \frac{x^{1-r}}{1-r}$. Rational risk averse subjects would choose lottery A for the first 6 choices and switch to B at some point. By equating the expected utility from A and B at the switching point and before the switching point, the range of coefficient of risk aversion can be determined. We used the average of those two points as the coefficient r. Before making the choices, subjects were informed that they have the chance to play the lottery and win real money.

At the end of experiment, we randomly chose one bidding product as the binding round for payment; the winner of the binding round paid for the product with real money. We also randomly chose one subject who played the lottery, and paid all the subjects with the reward accordingly.

2.2.2. Analytical model

First, we define the utility function $U = U\ (y, Z, K, q, m,)$, where y is a dummy denoting whether the product is GMO or non-GMO (Loureiro and Umberger, 2003), 1 for non-GMO and 0 for GMO. The vector Z is a vector of personal characteristics that may affect consumers' preference for GMO, K is their prior knowledge, and q is a function of information. For simplicity, we assume q is a product of information efficiency and the information they received, $q\ (t, I)\ = tI$, where t captures the

efficiency. In our experiment, I is a dummy where $I = 1$ means "after watching positive information about GMO". m denotes the income. Then we can get the expenditure function $e\ (y, Z, K, q, m, U)$, it increases with y and decreases with I.

In the first part of the study, we only observe consumers perception of GMO without giving any information. It is reflected by the difference of WTP between products labeled “non-GMO” and products without “non-GMO” labeling,

$$\Delta WTP = e(1, Z, K, q^0, m, U)\ - e(0, Z, K, q^0, m, U)$$

Since we assume $U = U\ (0, Z, K, q^0, m,)$,

$$\Delta WTP = e(1, Z, K, q^0, m, U)\ - m$$

Thus, ΔWTP is a function of personal characteristics Z and knowledge K. At the first period, information I is 0, so does q^0.

$$\Delta WTP = f(Z, K, q^0, m, U)$$

Any characteristics with positive effect on consumers’ preference on non-GMO products will increase ΔWTP. Prior knowledge has been proven to affect consumers' perception on GMO (House, et al., 2004). The effects were captured by regressing ΔWTP on those characteristics Z, and knowledge K.

The second part of the study was designed to explore the effect from information. It is reflected by the equation below,

$$\Delta WTP^1 - \Delta WTP^0 = f(Z, K, q^1, m, U)\text{-}f\ (Z, K, q^0, m, U)$$

where q^1 denotes the stage where subjects receive the information treatment. The only factor changed here is the information function q. Since q is a function of

information I and efficiency of information t, and every consumer receive information $I = 1$. To what extent the information affects the difference of WTP, depends on t.

Siegrist (2000) used a model to prove that trust in institutions affected consumers' perception of GMO. Yee et al. (2005) found that increasing the trustworthiness of GMO have positive influence on consumers' purchasing. Therefore, higher the trust level (t) is, the more they trust the positive information and change their attitude significantly.

2.3. Results and analysis

2.3.1. Summary statistics

Our study shows that subjects on average bid more for non-GMO labeled products compared to products without GMO labeling. However, after information treatment, the WTP for both products changed as shown in Figure 2.1 and Figure 2.2.

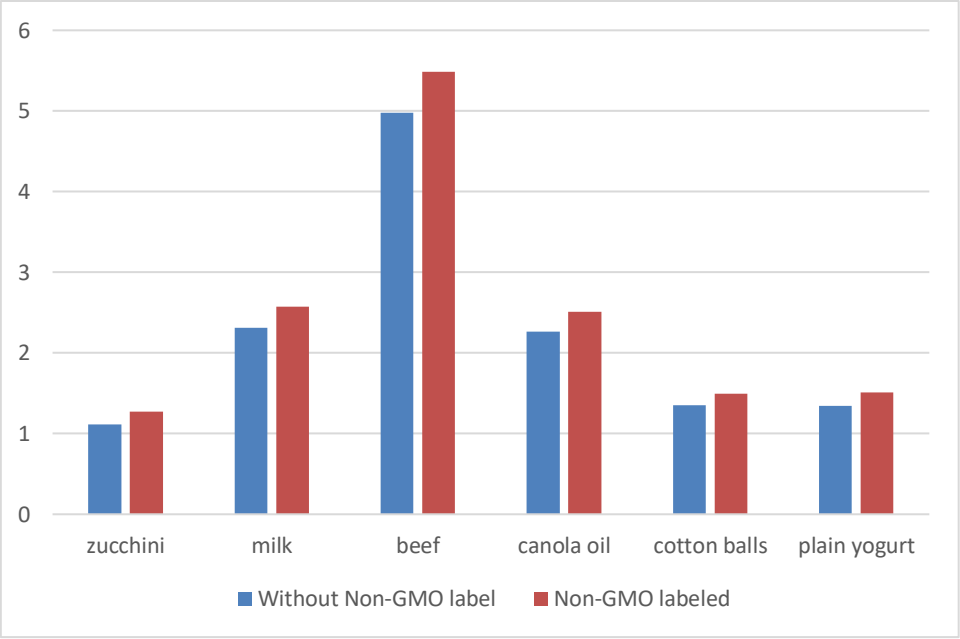

Figure 2.1 WTPs before information treatment

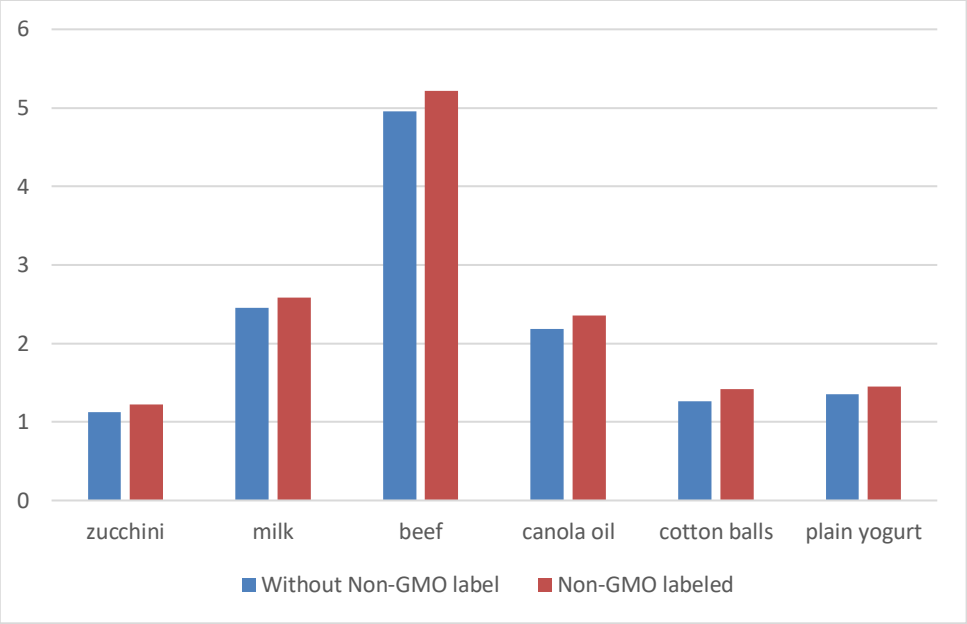

Figure 2.2 WTPs after information treatment

Histograms revealing the change of the difference of WTPs between non-GMO products and products without non-GMO labeling are presented in Figure 2.3. The y-axis represents the price premium for non-GMO products. Before news information, subjects would like to pay more than 10% for non-GMO products compared to the ones without GMO labeling. After being provided with the information about health and safety, the consumers' premium of WTP on non-GMO products decreased, which implies consumers' perception for GMO products has been affected by our information treatment.

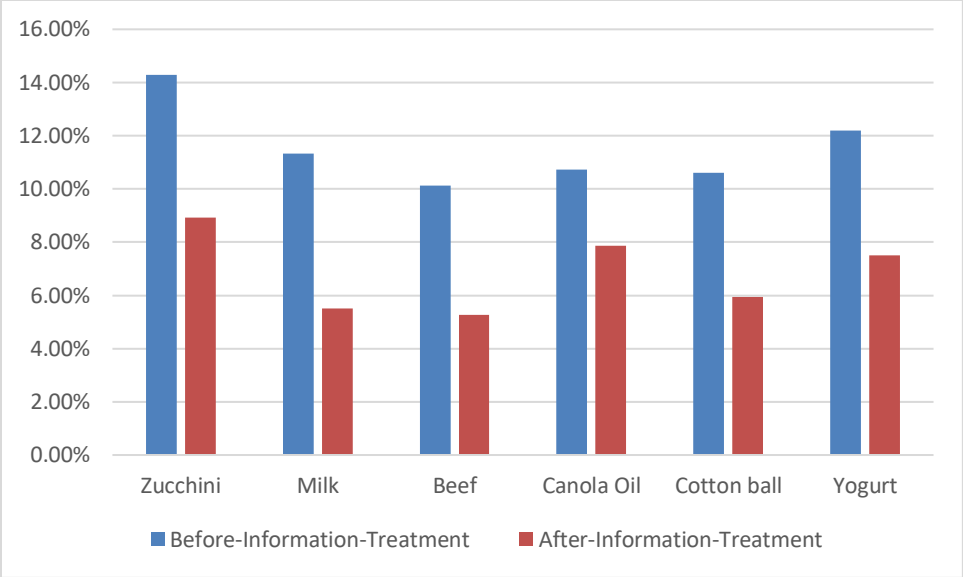

Figure 2.3 Price premium on non-GMO labeled products

As stated before, we divided subjects into two groups, one group watched the information from FOX news and the other group watched it on NBC channel. The change of price premium from those two groups are presented in Figure 2.4. It is obvious that FOX news changes consumers' attitude more compared to NBC news.

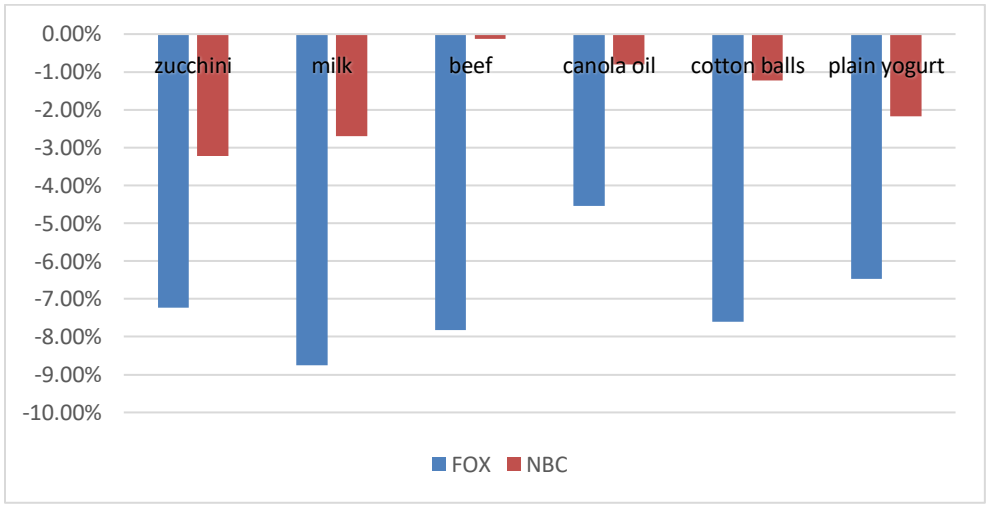

Figure 2.4 Change of price premium on non-GMO labeled products

Fernbach et al. (2019) and House et al. (2004) mentioned knowledge has mixed effect on consumers' attitude toward GMO. Extreme consumers tend to have high subjective knowledge and low objective knowledge. To understand consumers' current knowledge level and reveal the effect on their attitude toward GMO, we collected objective and subjective knowledge level from the subjects. Two questions about GMO labeling were used to reveal consumers' objective knowledge. Subjects got an extra dollar for each correct answer for the question. Therefore, they had financial incentive to reveal their true knowledge about GMO. Subjective knowledge was directly observed by asking them how familiar they are with the term GMO. Most of them believed they had some level of knowledge about GMO (Figure 2.5). Table 2.2 reported the relation between their subjective knowledge and objective knowledge. For most subjects who indicated they have been very familiar with GMO, their objective knowledge is not very high.

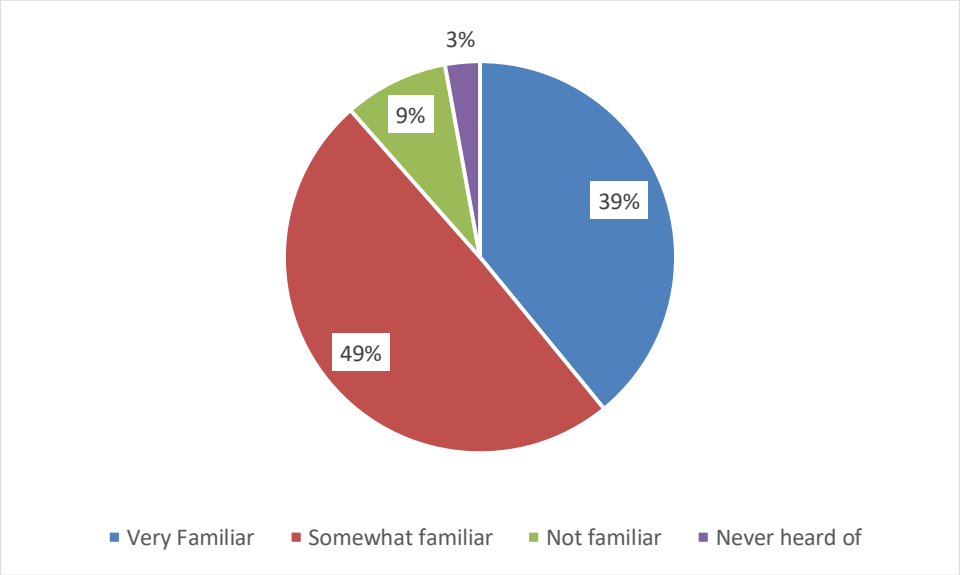

Figure 2.5 Consumers subjective knowledge about GMO

Table 2.2 Subjective and objective knowledge of GMO

		Objective knowledge		
		Low	Medium	High
Subjective knowledge	Very familiar	0	45	23
	Somewhat familiar	8	41	37
	Not familiar	5	6	4
	Never heard of	1	2	2

If we categorize "somewhat familiar" and "Not familiar" as medium level of subjective knowledge, "very familiar" as high level and "Never heard of" as low level of subjective knowledge, the premium that subjects put on non-GMO labeled products shows a pattern as seen in Figure 2.6. Consumers with high objective knowledge tends to put lower premium on non-GMO labeled products, whereas consumers with high subjective knowledge put high premium on non-GMO labeled products.

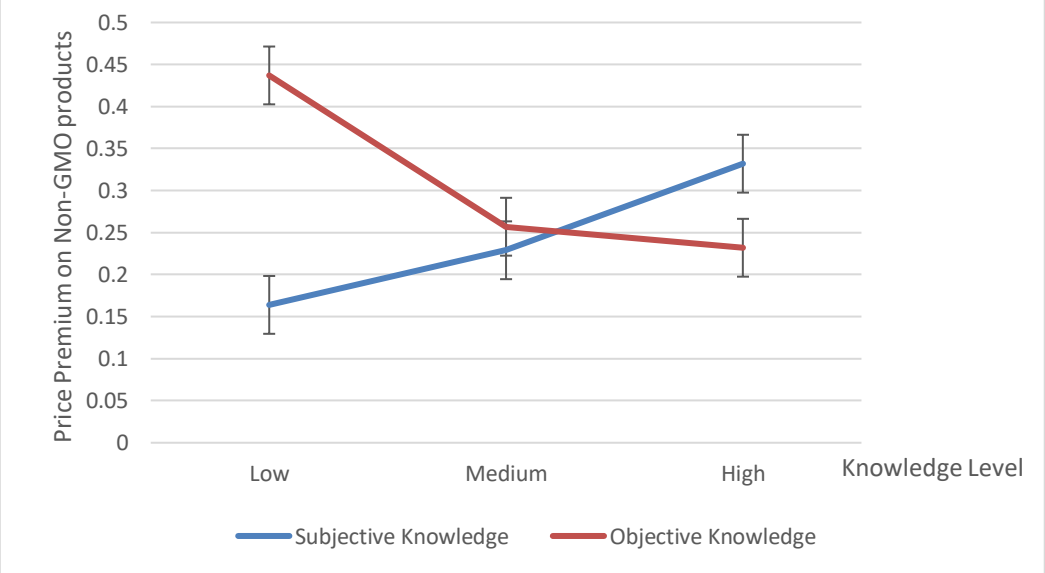

Figure 2.6 Price premium vs knowledge level

2.3.2. Regression analysis

We applied mixed effect model (Lusk et al., 2004) to understand what affects consumers' attitude toward GMO products, including information treatment.

$$\Delta WTP_{it} = \alpha + \beta Z_i + \gamma_1 FOX_{it} + \gamma_2 NBC_{it} + c_i + \epsilon_{it}$$

In this regression, at $t = 0$, $FOX_{it} = 0\ and\ NBC_{it} = 0$. After information treatment, which means at $t = 1$, $FOX_{it} = 1\ and\ NBC_{it} = 0$. At $t = 2$, $FOX_{it} = 0\ and\ NBC_{it} = 1$. Z_i contains all variables affecting consumers' preference on GMO, and c_i is a time invariant individual effect. The information treatment effect from FOX news and NBC news are captured by γ_1 and γ_2. The regression results are presented in table 2.3.

Results indicate that consumers in general would like to pay more for non-GMO products. After watching FOX news, the price premium consumers put on non-GMO labeled products decreased significantly. For participants who watched NBC news, the result is not significant. We also regress separately on products without non-GMO labeling and non-GMO labeled products. Table 2.4 and table 2.5 present the mixed effect model for GMO and non-GMO products separately.

$$WTP_{it} = \alpha + \beta Z_i + \gamma_1 FOX_{it} + \gamma_2 NBC_{it} + c_i + \epsilon_{it}$$

The results show that consumers' WTP for both products decreased for subjects who watched NBC news. However, the WTP for most products without non-GMO labeling increased after watching FOX news, and the WTP for non-GMO labeled products decreased significantly for the same group of subjects.

Table 2.3 Mixed effect model for price premium on non-GMO labeled products

	Dependent Variable: WTP for non-GMO labeled products- WTP for products without non-GMO labeling					
	Zucchini	Milk	Beef	Canola Oil	Cotton Balls	Yogurt
Female	-0.039	0.004	0.136	-0.034	0.003	-0.008
	(0.040)	(0.067)	(0.125)	(0.061)	(0.028)	(0.048)
Age	-0.003*	-0.002	-0.009*	-0.001	-0.001	-0.002
	(0.002)	(0.003)	(0.005)	(0.003)	(0.001)	(0.002)
Education	0.051	0.104	0.248	0.074	0.025	0.040
	(0.056)	(0.095)	(0.178)	(0.089)	(0.038)	(0.068)
Marital Status	0.096	0.027	0.262	0.005	0.052	0.055
	(0.072)	(0.122)	(0.229)	(0.111)	(0.051)	(0.088)
Have Child	-0.041	-0.085	-0.077	-0.021	-0.045	-0.078
	(0.056)	(0.095)	(0.176)	(0.086)	(0.038)	(0.067)
Income	0.043	-0.054	-0.017	-0.005	0.009	-0.018
	(0.044)	(0.074)	(0.139)	(0.068)	(0.030)	(0.053)
Risk Averse	-0.001	-0.015	-0.004	-0.015	0.001	-0.014
	(0.009)	(0.016)	(0.029)	(0.014)	(0.007)	(0.011)
Health Concern	0.194***	0.324***	0.614***	0.328***	0.126***	0.218***
	(0.043)	(0.073)	(0.135)	(0.066)	(0.029)	(0.052)
FOX News	-0.069***	-0.215***	-0.422***	-0.157***	-0.090***	-0.104***
	(0.023)	(0.039)	(0.088)	(0.037)	(0.027)	(0.029)
NBC News	-0.028	-0.035	-0.057	-0.009	-0.021	-0.023
	(0.023)	(0.040)	(0.090)	(0.038)	(0.028)	(0.030)
(Intercept)	0.133*	0.181	0.276	0.111	0.031	0.163*
	(0.075)	(0.126)	(0.238)	(0.116)	(0.051)	(0.091)
Observations	342	346	348	342	322	344
Log Likelihood	-16.648	-192.863	-442.971	-169.557	13.705	-90.387
σ_i	0.222	0.374	0.655	0.338	0.094	0.265
σ_u	0.158	0.268	0.623	0.258	0.193	0.203
ICC	0.664	0.661	0.525	0.632	0.192	0.630

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2.4 Mixed effect model for products without non-GMO labeling

	Dependent Variable: WTP for products without non-GMO labeling					
	Zucchini	Milk	Beef	Canola Oil	Cotton Balls	Yogurt
Female	0.01	0.13	-0.12	-0.07	0.08	-0.02
	(0.10)	(0.17)	(0.43)	(0.18)	(0.11)	(0.15)
Age	-0.01**	-0.003	0.01	-0.01	-0.004	-0.02***
	(0.004)	(0.01)	(0.02)	(0.01)	(0.005)	(0.01)
Education	-0.07	-0.14	-0.64	0.20	-0.15	-0.32
	(0.14)	(0.24)	(0.62)	(0.26)	(0.15)	(0.22)
Marital Status	0.31*	0.36	0.72	0.80**	0.23	0.52*
	(0.17)	(0.31)	(0.79)	(0.32)	(0.20)	(0.28)
Have Child	-0.08	0.26	-0.24	0.13	-0.001	-0.21
	(0.13)	(0.24)	(0.61)	(0.25)	(0.15)	(0.21)
Income	-0.11	0.11	0.37	-0.47**	-0.15	-0.06
	(0.11)	(0.19)	(0.48)	(0.20)	(0.12)	(0.17)
Risk Attitude	-0.02	0.04	-0.12	-0.04	-0.01	-0.04
	(0.02)	(0.04)	(0.10)	(0.04)	(0.03)	(0.04)
Health Concern	-0.10	-0.09	-0.03	-0.26	-0.25**	0.29*
	(0.10)	(0.18)	(0.47)	(0.19)	(0.12)	(0.16)
FOX news	0.05	0.09*	0.16	0.01	-0.08**	0.04
	(0.03)	(0.05)	(0.11)	(0.06)	(0.04)	(0.05)
NBC news	-0.03	0.08	-0.22**	-0.12**	-0.10***	-0.04
	(0.04)	(0.05)	(0.11)	(0.06)	(0.04)	(0.05)
(Intercept)	1.48***	2.21***	5.04***	2.17***	1.55***	2.21***
	(0.18)	(0.32)	(0.81)	(0.33)	(0.20)	(0.28)
Observations	342	346	348	344	342	348
Log Likelihood	-223.64	-380.06	-672.60	-416.02	-251.01	-375.56
σ_i	0.573	1.037	2.677	1.075	0.654	0.918
σ_u	0.233	0.329	0.721	0.395	0.243	0.352
ICC	0.858	0.909	0.932	0.881	0.879	0.872

Note: *p<0.1; **p<0.05; ***p<0.01

We observed that the information from NBC news and FOX news caused different effects on consumers' attitude toward GMO. One possible reason could be that our sample is not perfectly randomly assigned so that one group of subjects has different attitude toward GMO even before the information treatment. To eliminate this

possibility, we run OLS only on the ΔWTP before information treatment. The results are presented in Table 2.6.

Table 2.5 Mixed effect model for non-GMO labeled products

	Dependent Variable: WTP for non-GMO labeled products					
	Zucchini	Milk	Beef	Canola Oil	Cotton Balls	Yogurt
Female	-0.03	0.13	0.02	-0.12	0.22**	-0.03
	(0.11)	(0.19)	(0.46)	(0.19)	(0.09)	(0.16)
Age	-0.01***	-0.005	-0.003	-0.01	-0.004	-0.02***
	(0.005)	(0.01)	(0.02)	(0.01)	(0.004)	(0.01)
Education	-0.02	-0.04	-0.40	0.26	-0.21	-0.33
	(0.16)	(0.26)	(0.66)	(0.27)	(0.13)	(0.22)
Marital Status	0.41**	0.39	0.98	0.82**	0.29*	0.65**
	(0.20)	(0.34)	(0.84)	(0.34)	(0.17)	(0.28)
Have Child	-0.12	0.17	-0.32	0.10	-0.002	-0.28
	(0.15)	(0.26)	(0.65)	(0.27)	(0.13)	(0.22)
Income	-0.06	0.06	0.35	-0.46**	-0.19*	-0.04
	(0.12)	(0.21)	(0.51)	(0.21)	(0.10)	(0.17)
Risk Attitude	-0.02	0.02	-0.12	-0.06	-0.02	-0.04
	(0.03)	(0.05)	(0.11)	(0.04)	(0.02)	(0.04)
Health Concern	0.09	0.23	0.58	0.09	-0.05	0.48***
	(0.12)	(0.20)	(0.50)	(0.20)	(0.10)	(0.17)
FOX news	-0.02	-0.12**	-0.24**	-0.15**	-0.16***	-0.07
	(0.04)	(0.05)	(0.12)	(0.07)	(0.04)	(0.05)
NBC news	-0.07*	0.04	-0.29**	-0.13*	-0.14***	-0.06
	(0.04)	(0.05)	(0.12)	(0.07)	(0.04)	(0.05)
(Intercept)	1.61***	2.39***	5.32***	2.28***	1.48***	2.35***
	(0.21)	(0.35)	(0.87)	(0.35)	(0.17)	(0.29)
Observations	342	346	348	342	322	344
Log Likelihood	-255.06	-408.91	-702.81	-445.24	-221.03	-370.19
σ_i	0.667	1.142	2.855	1.137	0.535	0.949
σ_u	0.244	0.355	0.806	0.449	0.260	0.340
ICC	0.882	0.912	0.926	0.865	0.809	0.886

Note: *p<0.1; **p<0.05; ***p<0.01

The coefficient of the FOX news is not significant for any product. We also did a robustness check by doing logistic regression of the news on gender, self-reported

preference, age and education. There is no evidence to show that those two groups have any difference.

Table 2.6 Regression of price premium before information treatment

	Dependent Variable: WTP for non-GMO labeled products - WTP for products without non-GMO labeling before information treatment					
	Zucchini	Milk	Beef	Canola Oil	Cotton Ball	Yogurt
Female	-0.02	0.05	0.27*	-0.02	-0.03	0.01
	(0.05)	(0.07)	(0.14)	(0.08)	(0.05)	(0.06)
Age	-0.003	-0.005	-0.01	-0.002	-0.003	-0.002
	(0.002)	(0.003)	(0.01)	(0.003)	(0.002)	(0.002)
Income	0.10*	-0.05	-0.06	0.002	0.05	-0.003
	(0.05)	(0.08)	(0.15)	(0.08)	(0.05)	(0.06)
Education	0.09	0.10	0.30	0.10	0.11*	0.02
	(0.07)	(0.10)	(0.20)	(0.11)	(0.07)	(0.08)
Marital Status	0.04	0.09	0.33	0.07	0.10	0.01
	(0.09)	(0.13)	(0.25)	(0.14)	(0.08)	(0.10)
Have Child	-0.07	0.02	0.07	-0.04	-0.14**	-0.11
	(0.07)	(0.10)	(0.19)	(0.11)	(0.07)	(0.08)
Risk Attitude	-0.003	0.01	-0.01	-0.01	0.01	-0.01
	(0.01)	(0.02)	(0.03)	(0.02)	(0.01)	(0.01)
Health Concern	0.17***	0.28***	0.63***	0.35***	0.18***	0.21***
	(0.05)	(0.08)	(0.15)	(0.08)	(0.05)	(0.06)
Familiarity	-0.02	0.06	0.30**	0.07	-0.06	0.06
	(0.05)	(0.07)	(0.14)	(0.08)	(0.05)	(0.06)
FOX news	-0.05	-0.02	-0.06	0.01	-0.04	-0.01
	(0.05)	(0.07)	(0.13)	(0.07)	(0.04)	(0.06)
(Intercept)	0.14	0.19	0.01	0.07	0.08	0.16
	(0.10)	(0.14)	(0.28)	(0.15)	(0.09)	(0.12)

Note: *p<0.1; **p<0.05;***p<0.01

As we already found the information effect on ΔWTP, in the following regression, we are going to investigate what affects the efficiency of the information.

The information effect on the difference of WTPs between non-GMO products and products without non-GMO labeling is explained by the regression below,

$$\Delta WTP_{ik}^{after} - \Delta WTP_{ik}^{before} = \alpha + \theta_k S_{ik} + \beta Z_i + \gamma_1 K_i + \gamma_2 FOX_i + \gamma_3 t_i + u_{ik},$$

where ΔWTP is the price premium for non-GMO products. We impose FOX_i as a dummy to identify the news media, where $FOX_i = 1$ means subjects were presented with FOX news and $FOX_i = 0$ means subjects were presented with NBC news. The dependent variable reflects the change of the price premium on non-GMO products. Results is presented in Table 2.7.

The regression results are consistent with the results of mixed effect model. FOX news generally caused a more significant effect compared to NBC news. In addition, there is strong inconsistency effect among those six products. Consumers' attitude toward beef is easily affected by personal characteristics and news. Attitude toward GMO beef changed for subjects who have children. However, for those who are more risk averse, the information actually amplified parents' worries about GMO.

In the before-information-treatment survey, we asked subjects a question about their current attitude about GMO. The question stated that "if a product label indicates it is GMO, how likely are you going to purchase it". The answer ranges from "Never" to "100%". In addition, about 30% subjects stated they are "Unsure" about it. Therefore, we separate subjects into 4 groups and carried out a regression for each group (Table 2.8 to Table 2.11).

Table 2.7 Change of price premium on non-GMO labeled products

	Δ WTP after information treatment - Δ WTP before information treatment					
	Zucchini	Milk	Beef	Canola Oil	Cotton Balls	Yogurt
Female	-0.07**	-0.08	-0.25*	-0.02	0.02	-0.03
	(0.04)	(0.06)	(0.14)	(0.06)	(0.05)	(0.05)
Age	-0.0004	0.004	0.002	0.004	0.002	-0.0005
	(0.002)	(0.003)	(0.01)	(0.003)	(0.002)	(0.002)
Income	-0.12***	0.01	0.04	-0.02	-0.08	-0.03
	(0.04)	(0.07)	(0.15)	(0.07)	(0.05)	(0.05)
Education	-0.05	0.02	-0.08	-0.06	-0.12*	0.02
	(0.05)	(0.08)	(0.19)	(0.09)	(0.06)	(0.06)
Marital Status	0.08	-0.07	-0.16	-0.11	-0.04	0.10
	(0.06)	(0.11)	(0.25)	(0.11)	(0.08)	(0.08)
Have Child	0.06	-0.08	-0.35*	0.07	0.16**	0.12*
	(0.05)	(0.09)	(0.20)	(0.09)	(0.06)	(0.07)
Risk Averse	0.01	-0.03*	-0.05	-0.02	-0.01	0.01
	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)	(0.01)
Health Concern	0.02	0.10	-0.13	-0.08	-0.07	-0.02
	(0.04)	(0.07)	(0.15)	(0.07)	(0.05)	(0.05)
Familiarity	-0.001	0.11*	-0.12	0.01	0.06	0.01
	(0.04)	(0.06)	(0.14)	(0.06)	(0.05)	(0.05)
FOX news	-0.02	-0.17***	-0.30**	-0.15**	-0.05	-0.08*
	(0.03)	(0.06)	(0.13)	(0.06)	(0.04)	(0.04)
Trust	0.01	-0.07	0.07	0.05	0.01	-0.06
	(0.04)	(0.06)	(0.14)	(0.06)	(0.05)	(0.05)
Have Child * Risk Averse	-0.03	0.02	0.36***	0.002	0.01	-0.08***
	(0.02)	(0.07)	(0.09)	(0.04)	(0.03)	(0.03)
(Intercept)	0.06	-0.15	0.25	-0.04	-0.003	-0.02
	(0.08)	(0.13)	(0.29)	(0.13)	(0.09)	(0.10)
Observations	171	173	174	171	161	172
R^2	0.11	0.15	0.15	0.09	0.11	0.10
Adjusted R^2	0.04	0.09	0.08	0.02	0.04	0.04
RSE	0.22	0.37	0.86	0.37	0.27	0.28
F Statistic	1.58	2.38***	2.31***	1.27	1.53	1.55

Note: *p<0.1; **p<0.05; ***p<0.01

Table 2.8 Subjects who would buy GMO products with probability less than 25%

	Δ WTP after information treatment - Δ WTP before information treatment					
	Zucchini	Milk	Beef	Canola Oil	Cotton Balls	Yogurt
Female	-0.13	-0.11	-0.22	0.17	-0.05	0.11
	(0.10)	(0.17)	(0.28)	(0.18)	(0.14)	(0.18)
Age	0.004	0.003	0.01	0.01	0.001	-0.01
	(0.004)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Income	-0.26**	-0.26	-0.01	0.04	-0.04	0.15
	(0.12)	(0.22)	(0.35)	(0.22)	(0.17)	(0.22)
Education	0.03	0.35*	-0.12	0.02	0.37**	0.15
	(0.10)	(0.18)	(0.29)	(0.18)	(0.13)	(0.18)
Marital Status	-0.06	0.18	-0.35	0.45	-0.16	0.15
	(0.18)	(0.31)	(0.50)	(0.36)	(0.22)	(0.31)
Have Child	0.02	-0.05	-0.63	-0.35	-0.21	0.43
	(0.17)	(0.30)	(0.49)	(0.30)	(0.26)	(0.30)
Risk Averse	0.18	0.08	-0.30	-0.05	0.21	-0.21
	(0.20)	(0.33)	(0.52)	(0.35)	(0.24)	(0.33)
Health Concern	0.05	-0.19	0.19	0.07	-0.02	0.03
	(0.06)	(0.12)	(0.19)	(0.15)	(0.08)	(0.12)
Familiarity	0.15	0.04	0.28	0.04	-0.13	-0.10
	(0.14)	(0.24)	(0.39)	(0.26)	(0.18)	(0.25)
FOX news	0.05	0.13	-0.45	0.03	0.07	0.06
	(0.10)	(0.17)	(0.28)	(0.19)	(0.13)	(0.18)
Trust	0.24*	-0.11	0.22	0.10	-0.01	-0.10
	(0.14)	(0.25)	(0.40)	(0.27)	(0.19)	(0.25)
Trust*Health Concern	-0.38	-0.07	-0.76	-0.23	0.15	0.09
	(0.24)	(0.43)	(0.69)	(0.45)	(0.31)	(0.44)
Have Child*Risk Averse	0.54	1.63	-3.71	-0.65	-0.15	-0.59
	(1.08)	(1.79)	(2.89)	(1.87)	(1.25)	(1.82)
(Intercept)	-0.12	-0.19	0.23	-0.89	0.02	-0.18
	(0.29)	(0.52)	(0.84)	(0.58)	(0.40)	(0.53)
Observations	38	39	39	36	34	38
R^2	0.38	0.32	0.34	0.14	0.36	0.17
Adjusted R^2	0.04	-0.04	-0.01	-0.36	-0.06	-0.28
Residual Std. Error	0.25	0.46	0.74	0.45	0.32	0.46
F Statistic	1.13	0.90	0.98	0.28	0.86	0.38
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 2.9 Subjects who would buy GMO products with probability between 25% to 75%

	Δ WTP after information treatment - Δ WTP before information treatment					
	Zucchini	Milk	Beef	Canola Oil	Cotton Balls	Yogurt
Female	-0.09	-0.17	-0.68*	-0.09	0.07	-0.05
	(0.08)	(0.14)	(0.38)	(0.15)	(0.07)	(0.08)
Age	0.001	0.01*	0.01	0.003	0.004	0.01**
	(0.004)	(0.01)	(0.02)	(0.01)	(0.003)	(0.004)
Income	-0.15	0.18	0.46	0.09	-0.04	-0.12
	(0.10)	(0.18)	(0.48)	(0.19)	(0.08)	(0.10)
Education	-0.14	-0.24	-0.13	-0.15	-0.09	0.05
	(0.12)	(0.22)	(0.58)	(0.23)	(0.12)	(0.11)
Marital Status	-0.03	-0.53**	-0.31	-0.15	-0.19	-0.17
	(0.13)	(0.23)	(0.62)	(0.24)	(0.12)	(0.12)
Have Child	0.23*	-0.07	-0.29	0.07	0.22*	0.15
	(0.12)	(0.22)	(0.55)	(0.22)	(0.11)	(0.11)
Risk Averse	0.01	-0.07**	-0.003	-0.01	-0.01	0.03
	(0.02)	(0.03)	(0.09)	(0.04)	(0.02)	(0.02)
Health Concern	0.03	0.27	-0.32	0.12	0.05	-0.09
	(0.10)	(0.18)	(0.48)	(0.19)	(0.09)	(0.09)
Familiarity	0.13	0.08	-0.27	-0.05	0.11	-0.07
	(0.08)	(0.14)	(0.38)	(0.15)	(0.07)	(0.08)
FOX news	-0.04	-0.31**	-0.16	-0.33**	-0.07	-0.15*
	(0.08)	(0.14)	(0.39)	(0.15)	(0.07)	(0.08)
Trust	-0.15	0.15	-0.12	0.05	0.11	-0.24**
	(0.11)	(0.18)	(0.50)	(0.20)	(0.09)	(0.10)
Trust*Health Concern	0.24	-0.13	1.14	-0.02	-0.06	0.48***
	(0.17)	(0.29)	(0.80)	(0.32)	(0.15)	(0.16)
Have Child*Risk Averse	-0.08**	-0.02	0.24	0.02	-0.01	-0.06*
	(0.04)	(0.31)	(0.17)	(0.07)	(0.04)	(0.03)
(Intercept)	0.07	-0.22	-0.25	0.02	-0.20	-0.17
	(0.14)	(0.25)	(0.67)	(0.27)	(0.15)	(0.13)
Observations	46	46	47	47	86	46
R^2	0.40	0.45	0.26	0.23	0.15	0.52
Adjusted R^2	0.16	0.23	-0.03	-0.07	-0.01	0.32
Residual Std. Error	0.24	0.41	1.12	0.44	0.30	0.22
F Statistic	1.64	2.04*	0.88	0.78	0.97	2.62**
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 2.10 Subjects who would buy GMO products with probability higher than 75%

	Δ WTP after information treatment - Δ WTP before information treatment					
	Zucchini	Milk	Beef	Canola Oil	Cotton Balls	Yogurt
Female	0.01	-0.23*	-0.06	0.01	0.07	-0.02
	(0.06)	(0.13)	(0.23)	(0.14)	(0.05)	(0.07)
Age	-0.002	-0.003	-0.01	-0.001	0.002	-0.0004
	(0.002)	(0.01)	(0.01)	(0.01)	(0.002)	(0.003)
Income	-0.15**	-0.01	0.05	0.07	-0.02	-0.07
	(0.06)	(0.14)	(0.25)	(0.15)	(0.06)	(0.07)
Education	0.05	0.23	-0.35	0.01	0.003	0.27**
	(0.10)	(0.23)	(0.41)	(0.24)	(0.08)	(0.12)
Marital Status	0.09	0.14	0.07	-0.09	-0.10	0.08
	(0.09)	(0.21)	(0.38)	(0.23)	(0.09)	(0.11)
Have Child	-0.03	-0.10	-0.40	-0.05	0.14*	0.03
	(0.08)	(0.19)	(0.34)	(0.20)	(0.07)	(0.10)
Risk Averse	0.003	0.01	0.004	-0.03	-0.01	0.002
	(0.01)	(0.02)	(0.04)	(0.03)	(0.01)	(0.01)
Health Concern	-0.11	-0.31	-0.72	-0.43	0.002	0.05
	(0.16)	(0.37)	(0.66)	(0.39)	(0.07)	(0.19)
Familiarity	-0.13*	-0.05	-0.26	-0.07	0.09*	-0.06
	(0.06)	(0.15)	(0.26)	(0.15)	(0.05)	(0.08)
FOX news	-0.07	-0.20	-0.31	-0.13	-0.04	-0.06
	(0.06)	(0.13)	(0.23)	(0.13)	(0.05)	(0.07)
Trust	0.06	-0.10	0.14	0.12	0.08	-0.02
	(0.07)	(0.17)	(0.30)	(0.18)	(0.06)	(0.09)
Trust*Health Concern	-0.49**	0.13	-0.02	-0.61	-0.08	-1.00***
	(0.23)	(0.53)	(0.95)	(0.56)	(0.12)	(0.28)
Have Child*Risk Averse	-0.004	-0.11	0.70***	-0.17	0.01	-0.14**
	(0.05)	(0.11)	(0.20)	(0.12)	(0.03)	(0.06)
(Intercept)	0.08	0.03	0.77	0.03	-0.24**	-0.21
	(0.16)	(0.35)	(0.64)	(0.37)	(0.11)	(0.18)
Observations	39	39	39	39	125	39
R^2	0.53	0.27	0.72	0.40	0.10	0.71
Adjusted R^2	0.29	-0.12	0.58	0.09	0.0001	0.56
Residual Std. Error	0.14	0.32	0.58	0.34	0.27	0.17
F Statistic	2.19**	0.70	5.05***	1.28	1.00	4.65***
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 2.11 Subjects who are unsure about whether they would buy GMO products

	Δ WTP after information treatment - Δ WTP before information treatment					
	Zucchini	Milk	Beef	Canola Oil	Cotton Balls	Yogurt
Female	-0.11	-0.05	-0.37	-0.09	-0.28**	-0.14*
	(0.08)	(0.09)	(0.31)	(0.10)	(0.14)	(0.07)
Age	-0.001	-0.003	0.01	0.001	-0.003	-0.01**
	(0.003)	(0.003)	(0.01)	(0.004)	(0.004)	(0.003)
Income	-0.001	0.11	0.02	-0.20**	-0.08	-0.16**
	(0.07)	(0.08)	(0.28)	(0.09)	(0.11)	(0.06)
Education	-0.01	-0.03	-0.16	-0.11	-0.34**	-0.10
	(0.08)	(0.09)	(0.32)	(0.10)	(0.13)	(0.07)
Marital Status	0.16	0.15	-0.68	0.15	0.35	0.34**
	(0.14)	(0.16)	(0.55)	(0.18)	(0.22)	(0.13)
Have Child	0.12	-0.25*	0.78	-0.24	0.15	0.16
	(0.12)	(0.14)	(0.48)	(0.15)	(0.19)	(0.11)
Risk Averse	0.02	0.01	-0.14**	-0.01	0.003	-0.01
	(0.02)	(0.02)	(0.06)	(0.02)	(0.03)	(0.01)
Health Concern	0.04	-0.04	0.50	-0.17	-0.18	-0.17
	(0.21)	(0.24)	(0.82)	(0.26)	(0.32)	(0.19)
Familiarity	-0.16*	0.01	0.04	0.10	-0.04	-0.03
	(0.09)	(0.10)	(0.36)	(0.11)	(0.15)	(0.08)
FOX news	0.03	-0.17**	0.14	-0.14*	-0.29**	-0.11*
	(0.06)	(0.07)	(0.25)	(0.08)	(0.11)	(0.06)
Trust	0.03	-0.11	-0.36	0.09	-0.16	-0.10
	(0.07)	(0.08)	(0.28)	(0.09)	(0.12)	(0.06)
Trust*Health Concern	0.04	0.24	-0.82	0.04	0.20	0.16
	(0.25)	(0.28)	(0.98)	(0.31)	(0.39)	(0.22)
Have Child*Risk Averse	-0.07	0.17	-0.85	0.51**	0.003	0.03
	(0.19)	(0.22)	(0.76)	(0.24)	(0.30)	(0.17)
(Intercept)	-0.01	0.13	0.38	0.17	0.63**	0.36**
	(0.16)	(0.18)	(0.60)	(0.19)	(0.25)	(0.14)
Observations	48	49	49	49	46	49
Adjusted R^2	-0.06	0.01	0.05	0.15	0.18	0.23
Residual Std. Error	0.20	0.22	0.77	0.24	0.30	0.17
F Statistic	0.80	1.04	1.18	1.63	1.76*	2.13**
Note:						*p<0.1; **p<0.05; ***p<0.01

The regression results show that information can hardly affect consumers who have strong positive or negative attitude toward GMO. It would more likely change consumers' attitude for those who are neutral about GMO or unsure about their attitude toward GMO.

Table 2.12 Multinomial logistic regression

	Baseline: Trust level =3	
	Do not trust Trust level<3	Trust Trust level>3
Health concern	1.076**	-0.290
	(0.507)	(0.450)
FOX News	-0.530	-0.434
	(0.472)	(0.358)
Risk Averse	-0.152	0.047
	(0.155)	(0.081)
Female	0.240	-0.608*
	(0.499)	(0.366)
Age	-0.002	-0.012
	(0.012)	(0.009)
Have Childe	0.231	0.336
	(0.612)	(0.468)
Prefer to buy Non-GMO	0.483**	-0.208
	(0.231)	(0.159)
(Intercept)	0.487	0.716
	(1.004)	(0.749)
Note:		*p<0.1; **p<0.05; ***p<0.01

In our hypothesis, subjects who trust the information would be more likely to change their attitude toward GMO after watching the news. However, we did not observe that effect from the regression results. As we found in Table 2.8 to Table 2.11, information has different impact on consumers with different attitude toward GMO.

Previous literature showed that trust level was highly influenced by subjects' attitude toward GMO (Frewer et al., 2003). Therefore, we did a multinomial logistic regression to study how trust level is affected by subjects' attitude toward GMO (Table 2.12).

The result is consistent with Frewer et al., 2003. The correlation between trust and consumers' initial preference on GMO might be the reason as to why trust does not affect the effectiveness of information.

2.4. Concluding results

In this study, we explored consumers' acceptance towards GMO products including beef, canola oil, cotton balls, milk, yogurt, and zucchini. Most consumers reported that they had some level of understanding about GMO. However, their objective knowledge is relatively low compared to their subjective knowledge. Moreover, those who have high subjective knowledge would like to pay more for non-GMO labeled products. On the contrary, the ones with high objective knowledge put less premium on non-GMO labeled products. In conclusion, consumers who really know about GMO are less averse to GMO products.

Consistent with many previous studies, we found that consumers are willing to pay a price premium for non-GMO products. In our study, health concern was found to be the key reason that consumers prefer non-GMO products to GMO products. People who believe that GMOs have negative effect on health would like to pay more for non-GMO products.

The third part of our analysis is focusing on the information effect. From our study, we confirmed that information about the health and safety of GMOs can change

consumers' perception on GMO, but the effectiveness of the information may vary among different news media for different persons. Consumers who have strong initial preference on GMO are less likely to be affected by the information.

3. CONSUMER KNOWLEDGE AND ATTITUDES ABOUT GENETICALLY MODIFIED FOODS

3.1. Introduction

With the development of new technology and self-awareness, consumers now care more about food qualities, especially in high income countries like the U.S. Consumers usually evaluate food products based on many food attributes. Those food attributes can be evaluated by observing or consuming the products, such as the appearance of a fruit, smell of a bread or the taste of a prime steak. However, there are some attributes that cannot be evaluated even after the consumption of the product, those we call as credence attributes. Even though the quality of credence attribute cannot be evaluated during either purchasing or consuming period, consumers do put a price premium on it. Many researches have shown that consumers would like to pay more for non-GMO and organic products (Loureiro and Hine, 2000; Costa-Font et al., 2008; Yuan et al., 2018).

The reason behind the aversion to GMO can be complicated. It could be a combination of perceived risks and benefits (Bredahl, 2001; Frewer et al., 2003; Gaskell et al., 2004; Prati et al., 2012). Since 1950s, the public has started to be concerned about the risks accompanying the emerging technology (Frewer, 1999). Technology does make our life way much easier. Many people probably cannot even survive a day without a smartphone (Smith, 2015); however, it has also brought many unimaginable disasters, such as Chernobyl nuclear accident in 1986, poison gas release in India in 1984, etc. A thought has been growing in our mind that the technology might be “out of control”

(Frewer, 1999). The potential risk and the limited knowledge level of the high-tech can easily cause a strong reservation to those emerging techniques; the aversion to GMO is an example.

Besides consumers' perception of the potential risk come with GMO, the misperception and the absence of perceived benefits also contributes to consumers' aversion to GMO (Gaskell et al., 2004; Prati et al., 2012). Even though we see GE technology benefits the production procedure for farmers, it does not necessarily bring observable benefits for consumers. Gaskell et al. (2004) addressed the issue that compared to the misperception of the scientific risks, the perceived absence of benefit could be the key reason of the aversion to GMO.

So far, the role of the interaction of perceived risks and benefits has been well addressed by many scholars. Bredahl (2001) showed that consumers' attitude toward GMOs is based on their perceived risks and benefits. The perceived benefits cause a positive effect on consumers' attitudes toward GMOs, while the perceived risks result in a negative effect. Traill et al. (2006) showed similar results except that they measured risks and benefits separately and found that benefits and risks were not perfectly correlated, and instead benefits had stronger effects than risks. Prati et al. (2012) applied the theory of planned behavior and systematically applied the mechanism behind consumers' intention to buy, and emphasized the role of perceived risks and benefits.

Demographic information also partially explains the reasons behind consumers' aversion to GMO. Loureiro and Hine (2002) stated that people with higher income and those who cared more about fresh food and nutrition would pay more for non-GMO

products. Some other demographic characteristics such as education (Onyango et al., 2004), religious beliefs (Hossain and Onyango, 2004), and gender (Siegrist 2000; Gaskell et al., 2004) have also been shown to affect consumers' attitudes toward GMO products.

During the demographic study, one interesting finding is that scientists tend not to worry too much about the safety of GMO compared to lay-people. (Funk & Rainie, 2015). This finding is consistent with the positive correlation between education level and GMO aversion (Heiman et al., 2000). That provides us with an idea that the knowledge level might be a latent variable behind the perceived risks and perceived benefits, and it manipulates consumers attitude towards GMO through the impact of perceived risks and benefits. In fact, this bottom-up formation is a famous model on consumer behavior research (Fishbein, 1963) and has been applied in the study of GMO by Grunert et al. (2003).

Previous researchers have found that consumers do not have sufficient knowledge of GMO (Grunert et al., 2003; Vecchione et al., 2014). Our recent study found even though consumers knowledge level has increased, it is still not sufficient (Yuan et al., 2018). Many scholars have shown the relationship between knowledge and attitude towards GMO. The results are heterogeneous. Ganiere et al. (2006) found the positive correlation between knowledge and consumers attitude in a subgroup of the subjects. Only a couple of years earlier, Scholderer and Frewer (2003) found knowledge is not related the consumer attitude towards GMO.

In addition to that, previous studies have found that sometimes objective knowledge and subjective knowledge would cause different effects. In marketing, people have noticed the difference long time ago. Park and Lessig (1981) have already tried to distinguish “a person thinks she knows” from “a person knows”. House et al. (2004) first reviewed the studies of objective knowledge and subjective knowledge, and concluded that the two kinds of knowledge caused different influence on the acceptance of GMO. Objective knowledge may not cause any influence whereas subjective knowledge significantly determined consumer acceptance. A very recent study by Fernbach et al. (2019) found that “extreme opponents know the least, but think they know the most”. This divergence of subjective knowledge from objective knowledge, made it hard for the scientists to efficiently deliver objective information to consumers.

Our study is trying to understand the difference of objective knowledge and subjective knowledge. Moreover, we are going to apply factor analysis to try to understand how those knowledges affects consumers attitude toward GMO

Factor analysis is a statistical method to use some unobserved latent variables to explain observed variables or indicators. There are two common types of factor analysis methods, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). EFA is used when you trying to reveal an underlying structure, whereas CFA is used to test an existing structure. Factor analysis can be traced back in to 1904 when Charles Spearman first presented it. It innovatively imposes the study of latent variable in social science (Cudeck and MacCallum, 2007). After over 100 years of application, it has become one of the most favorable tools for the study of latent variable.

Theory of planned behavior (Ajzen, 1985) is a psychological model trying to explain one's behavior by three factors: Attitude, Subjective Norms and Perceived Behavioral Control. It has been widely used in explaining many social behaviors and been found more powerful in health-related fields. Previous studies have applied it on leisure (Ajzen and Driver, 1992), diet (Conner et al., 2003), smoking (van der Pligt and de Vries, 1998), exercise (Nguyen et al., 1997). It has been used on online shopping (Hansen et al., 2004). Prati et al. (2012) has already applied theory of planned behavior on consumers' attitude on GMO. However, they did not include knowledge in their structure.

Our study is going to follow Prati et al. (2012) in applying theory of planned behavior to understand the mechanism of how knowledge affects consumers' attitude toward GMO.

3.2. Data

We recruited 511 subjects in total from Amazon's Mechanical Turk (MTurk) service, where researchers can post "Human Intelligence Tasks" (HITs) for paid workers to complete different tasks. Results of previous research (Casler et al., 2013) have shown that MTurk provides more socioeconomically diverse subject pools and gives similar results compared to face to face tasks.

The subjects were self-selected into our project. At the beginning of the survey, participants were presented with the consent form. Only by accepting the consent form were they able to participate in our study. They had the option to quit any time during the survey. On average, the participants spent 15 minutes finishing the whole survey.

We included 2 questions for attention check. After eliminating the subjects who did not pass the attention check, it left us with 468 valid subjects. The demographic information is summarized in Table 3.1.

Table 3.1 Demographic summary

Statistic	***Definition***	***Mean***	***Min***	***Max***	***Frequency***
Gender	1 = Male				53.21%
	2 = Female				46.37%
	3 = Other				0.43%
Age	Age in years	35.79	18	73	
Marital Status	1 = Single				45.1%
	2 = Married				54.9%
	3 = Separated				
	4 = Divorced				
	5 = Widowed				
Children	1 = children in household	0.530			52.99%
	0 = no child in household				47.01%
Education	1 = High school or lower				10.04%
	2 = Lower than Bachelor's degree				28.85%
	3 = Bachelor's degree				46.15%
	4 = Master's degree or higher				14.96%
Income	Income value	35416.67	5000	350000	
Race	1 = White				72.01%
	0 = Other				27.99%

3.3. Results

3.3.1. Descriptive statistics

We used the questions from Prati et al. (2012) to measure attitude, intention to buy, perceived risks, and perceived benefits. For subjective knowledge, we just used a standard question asking "How much do you know about bioengineered/genetically modified foods?". We used 7 questions from Connor and Siegrist (2010) combined with two True or False questions used in our previous experiments to measure the objective knowledge. The two added questions are- "The use of genetic engineering, or genetically modified organisms (GMOs) is prohibited in all USDA certified organic products? (True/False/Not Sure)" and "All products that are certified as being GMO-free (non-GMO) are also organic products. (True/False/Not Sure)".

In line with Prati et al. (2012), we used the confirmatory factor analysis (CFA) instead of exploratory factor analysis (EFA) because we are trying to understand the effect of knowledge under the current structure.

Table 3.2. presents the mean, standard deviation, skewness and kurtosis. The score of skewness is close to zero and the value of kurtosis is not greater than 3, which means our data does not significantly deviate from normal distribution. The mean of subjective knowledge is 2.89 and median is 3, which means most consumers thought they have some but not very high level of understanding regarding GMO. The mean of objective knowledge is 5.86 and median is 6, which is higher than I expected. One possible reason is that subjects used web search engines to search for the answer. We have restricted the time for each knowledge question to 15 seconds to try to avoid this

kind of behavior. However, because those questions are money-incentivized, the timer is not guaranteed to stop the subjects.

Table 3.2 Descriptive statistics of factors

		mean	sd	median	min	max	skewness	kurtosis
Attitude	at_1	5.8	2.82	6	1	10	-0.26	-1.09
	at_2	5.83	2.79	6	1	10	-0.23	-1.03
Intention to consume	ic_1	3.49	1.31	4	1	5	-0.56	-0.77
	ic_2	8.98	4.9	11	1	15	-0.3	-1.43
	ic_3	3.57	1.35	4	1	5	-0.66	-0.77
Perceived Risk	pr_1	3.03	1.37	3	1	5	-0.07	-1.26
	pr_2	3.11	1.33	3	1	5	-0.16	-1.13
	pr_3	3.14	1.41	3	1	5	-0.17	-1.29
Perceived benefit	pb_1	3.39	1.29	4	1	5	-0.47	-0.86
	pb_2	3.8	1.21	4	1	5	-0.85	-0.15
	pb_3	3.18	1.32	3	1	5	-0.23	-1.09
Subjective Knowledge	sbj_k	2.89	0.96	3	1	5	-0.21	-0.42
Objective knowledge	Obj_k	5.86	1.72	6	0	9	-0.68	0.33

3.3.2. Correlations

Table 3.3 displays the correlation matrix of all the variables. For the correlation between all indicators please see Appendix B. The highest correlations were found between perceived benefits & attitude, and attitude & intention to consume. The correlation between objective knowledge & perceived risks is negative, between objective knowledge & perceived benefits is positive. However, both the correlation of subjective knowledge and perceived benefits & risks are negative.

Table 3.3 Correlation between variables

Variable	PB	PR	AT	IC	OBJ_K	SBJ_K
PB	1					
PR	-0.6889	1				
AT	0.9639	-0.7168	1			
IC	0.9023	-0.6711	0.9362	1		
OBJ_K	0.0622	-0.2778	0.0836	0.0783	1	
SBJ_K	-0.1306	-0.1033	-0.1064	-0.0996	0.1204	1

3.3.3. Factor analysis results

The whole procedure was performed using STATA's structural equation modeling tools. Figure 3.1 presents the path diagram. The factor loadings are presented in Table 3.4.

Table 3.4 Factor loadings

	PERCEIVED BENEFITS	PERCEIVED RISKS	ATTITUDE	INTENTION TO CONSUME
Objective knowledge	0.0483*	-0.1492***	NA	NA
Subjective knowledge	-0.1542***	-0.2116***	NA	NA
Perceived benefits	NA	-0.7955***	2.1713***	NA
Perceived risks	NA	NA	-0.214**	NA
Attitude	NA	NA	NA	0.402***

Note: *p<0.1; **p<0.05; ***p<0.01

From the factor loadings we can find that perceived benefits and risks all have strong effect on consumers' attitude toward GMO, and therefore affect consumers' intention to consume. Both objective knowledge and subjective knowledge reduced

consumers' perceived risks. However, the high subjective knowledge caused a negative impact on perceived benefits. It tells us that when consumers think they know enough about GMO, it is hard to deliver information regarding their benefits to those consumers. As a result of that, it might be hard for them to be persuaded by the educational information on GMO.

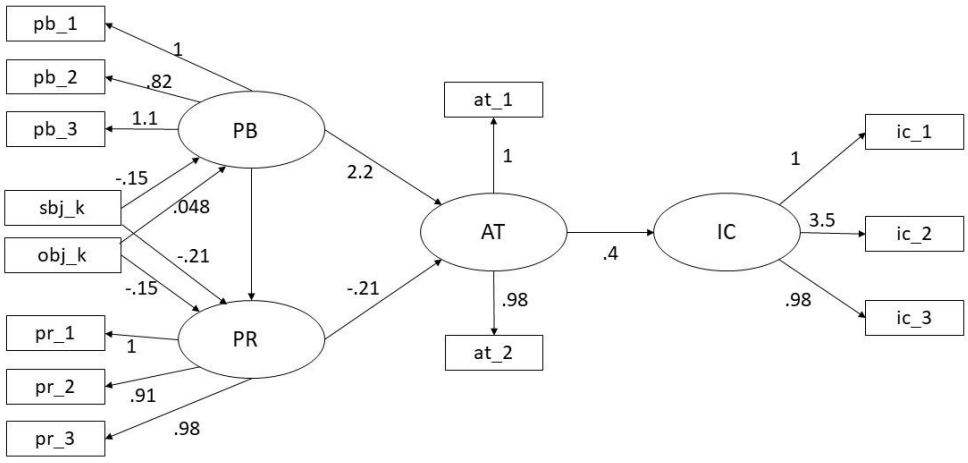

Figure 3.1 Path diagram results

The standardized loadings on each indicator are summarized in Table 3.5. The indicators are all balanced except for the intention to consume. The test statistics of the whole model are presented in column 4 of Table 3.5. The overall fitting is good. Comparative fit index (CFI) is 0.973, which is greater than 0.95. Tucker-Lewis index (TLI) is 0.964, which is greater than 0.95. The root mean squared error of approximation (RMSEA) is 0.064, which is slightly greater than 0.05 but is still acceptable.

Table 3.5 Standardized loadings of indicators

Construct	Indicators	Standardized loadings	Measurement model
subjective knowledge	sbj_k	1	
objective knowledge	obj_k	1	χ^2
Perceived benefits	pb_1	1	df=58
	pb_2	0.82	p=0.000
	pb_3	1.13	CFI = 0.973
Perceived risks	pr_1	1	TLI = 0.964
	pr_2	0.91	RMSEA=0.064
	pr_3	0.98	
Attitude	at_1	1	
	at_2	0.98	
Intention to consume	ic_1	1	
	ic_2	3.53	
	ic_3	0.98	

3.4. Discussion and concluding remarks

Researchers found the difference between objective knowledge and subjective knowledge more than 20 years ago. In real life, almost everyone has encountered someone who thinks they know a lot and are so stubborn that no one can persuade them. That is a problem when delivering positive information of GMO. GMO has been proven as a product that pose no negative effect on human health and environment. The consumers' aversion to GMO has incurred a lot of cost to the taxpayers, especially after the mandatory GMO labeling law. The government has already invested a fair amount of money on ascertaining benefits and risks from GMO. It will be useless if consumers will not accept any of the information.

In our previous research we have shown that some consumers are easily affected by positive GMO information and some are not. It depends on their previous attitude

toward GMO. However, there are some other factors, which have not been explored. Knowledge is one of them. This study has shown that the subjective knowledge level affects consumers' perceived benefits of GMO. Since perceived benefits significantly impact consumers' attitude toward GMO, the positive information regarding GMO will be less effective for consumers with high subjective knowledge level.

When a new technology comes out, it always raises a lot of attention. Human beings are naturally risk averse. However, we should be alert when most information from the social media are negative. The overloading of negative information perceived by consumers will make them feel like they know a lot (high subjective knowledge) but actually it may not be enough. At that time, any other information will not be able to cancel out the previous negative information efficiently. This might be what is happening with GMO.

4. FIRMS' STRATEGIES AND CONSUMERS' REACTIONS TO MANDATORY GMO LABELING

4.1. Introduction and background

On Dec 20, 2018, the U.S. Secretary of Agriculture, Sonny Perdue, announced the National Bioengineered Food Disclosure Standard (NBFDS) and set the mandatory compliance date to Jan 1, 2022, which means, by the end of 2021, all products with detectable GMO ingredients will be forced to be labeled as GMO. In the following paragraphs, we will provide an overview of the GM labeling rules and history. We will now provide an overview of the GM labeling rules and history.

In 1992, the Food and Drug Administration (FDA) issued a policy in response to the general concern of Genetically Engineering (GE) or Genetically Modified Organisms (GMOs). The policy specified FDA's regulation on GMO and determined no labeling requirements for GMO products. Recently, the discussion of mandatory GMO labeling has come back to the foreground. Figure 4.1 shows the Google Trends of the word "GMO Labeling".

Google Trends is created by Google to reflect the search volume of any keywords. It was launched as "Google Insights for Search" in 2008 and became Google Trends in 2012. Google Trends has already been widely used in economic research (Choi and Varian, 2012). The Google Trends of "GMO Labeling" reflects consumers' attention to GMO labeling since Jan 1, 2004. Figure 4.2 reflects the concentration by state.

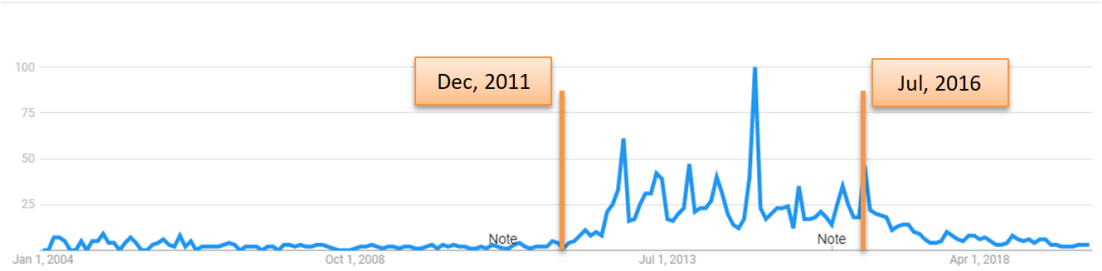

Figure 4.1 Google trends of "GMO labeling"
1

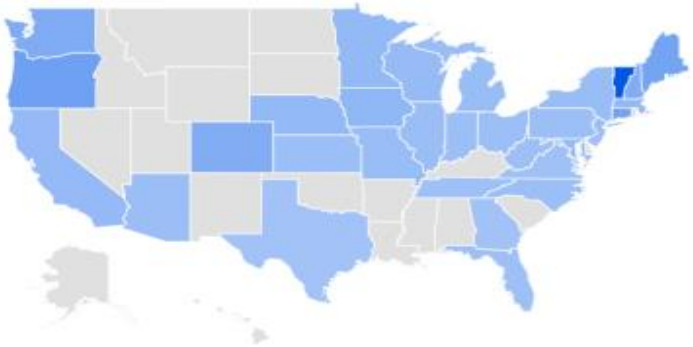

Figure 4.2 Google trends of "GMO Labeling"- interest by state

Under the pressure of consumers' demand for GMO labeling, from 2011 to 2016, 26 states have proposed formal political proposals on GMO labeling legislation. Connecticut was the first state that passed the GMO labeling law in 2013, followed by Maine. However, both states' GMO labeling rules have a "trigger" provision, which means that the law won't go into effect until the adjacent states passed similar laws. In 2014, Vermont has become the first state that passed the GMO labeling law without any

[1] Data source for Table 4.1 and Table 4.2: Google Trends (https://www.google.com/trends)

additional provisions. The law went into effect on July 1, 2016. Figure 4.3 shows the timeline of GMO Labeling legislation.

The state-level mandatory labeling is costly for all the producers. "We can't label our products for only one state without significantly driving up costs for our consumers and we simply will not do that," explains Harmening, COO of General Mills (Harmening, 2016).

Under the pressure of both consumers and producers, a federal labeling legislation has been signed into a law by President Obama on July 27, 2016. The federal law preempted state level GMO labeling law, which as a result terminated the implementation of Vermont's, and all other states' pending GMO labeling laws.

On Dec 20, 2018, the U.S. Secretary of Agriculture, Sonny Perdue, announced the NBFDS to regulate all products with detectable GMO ingredients. However, compared to Vermont's GMO labeling law, the national GMO labeling requirement is less restricted. Instead of clearly stating "partially produced with genetic engineering," "may be produced with genetic engineering," or "produced with genetic engineering" under Vermont's labeling law, the national standard accepts electrical or digital links. It gives producers alternative ways to label their product as GMO.

Even though Vermont GMO labeling law has been nullified by the federal law, it still deeply affected the food industry. Facing the Vermont mandatory labeling law, the economies of scale leave companies with two choices: 1. Label all products with GE ingredients nationwide, or 2. Use only Non-GE ingredients.

Many food companies started to take actions in early 2016. Hershey has switched from using sugar beets to cane sugar because cane sugar is 100% GMO-free (Carter and Schaefer, 2018). Coke announced that they will only keep their most popular products and the less popular flavors will be unavailable in Vermont right away (Strom, 2016). For companies which did not plan to withdraw the GE ingredients or GE products from Vermont, started to label products with GE ingredients as GMO or GE not only in Vermont, but also all over the United States. After all, it would be more costly for companies to create a new packaging line just for Vermont.

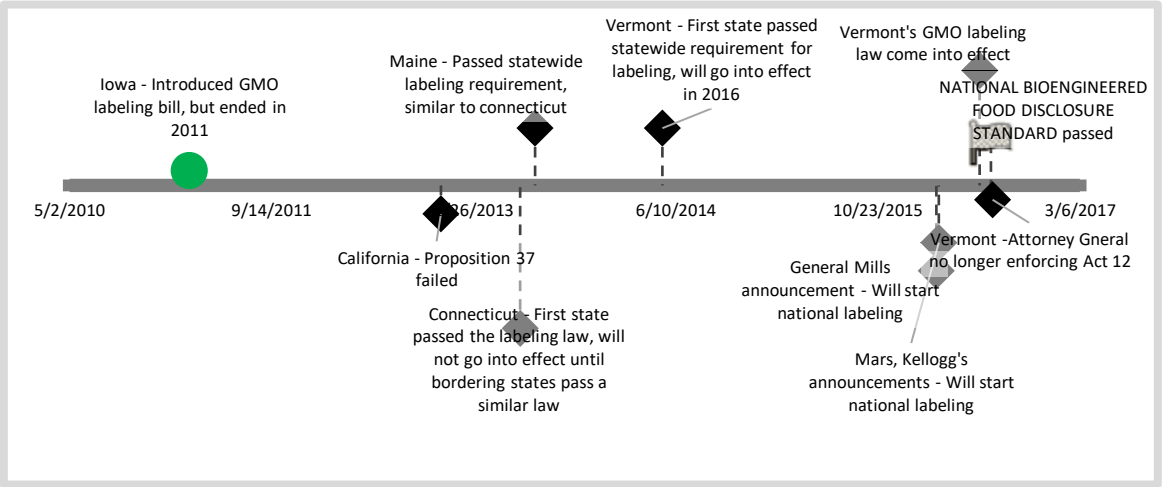

Figure 4.3 GMO labeling timeline

An organization advocating GMO labeling collected the package pictures of GMO food in 2016. From their tweets, I found that many companies like General Mills, Pepsi, Mars, Kellogg etc. have labeled their products "partially produced with genetic engineering" in many states including but not limited to Vermont, Florida, California, Texas and Washington, which is consistent with the companies' claims. However, in April 2017, Kellogg was found to change the labeling into a less obvious website link.

In October, 2019, I investigated the GMO labeling including many products like ready to eat (RTE) cereals, cooking oil, soda drinks in both Vermont and Texas. I found that the labeling in Vermont is the same as in Texas. Combined with the companies' claims and the consumers' reports all over the United States, we can conclude that the labeling is consistent across the nation. Therefore, even though Vermont mandatory GMO labeling was a state law, it caused a nationwide change of labeling. This provided us with a chance to study consumers' reaction to mandatory GMO labeling and predict the possible consequence of the upcoming federal GMO labeling law.

Many foods in the market contain GE ingredients. In this study, I am going to focus on the RTE cereals. The selection of RTE Cereals as the target product was based on a number of considerations.

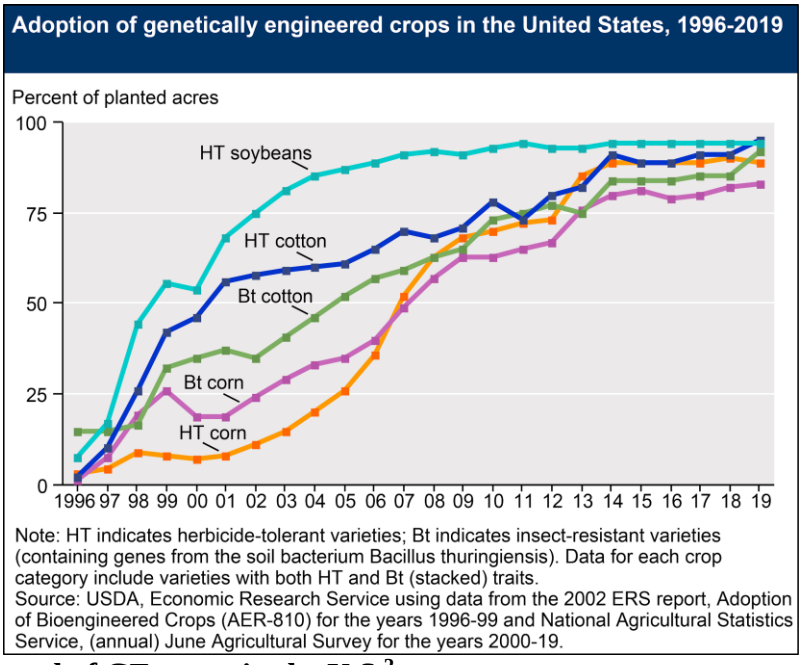

Figure 4.4 Trend of GE crops in the U.S.[2]

[2] USDA, Recent trend in GE Adoption, 2019

First, most RTE Cereals contain GE ingredients. As more than 90% of corn and soybean grown in the United States are genetically engineered (Figure 4.4), the cereals which contains soy and corn are highly potential to be regulated under Vermont's GMO labeling law. I have checked almost all popular cereals (top 20 brands) and found almost all cereals (except for Cheerios) from General Mills and Kellogg's reveal that their products contain genetically engineered ingredients. Besides, cereal is normally treated as healthy food (Drayer, 2017) and GMO has been found to raise health concerns in consumers (Yuan et al., 2018). Compared to other food products, the GE contents in cereals may easily raise concerns in consumers (Kling, 2014).

Another reason that made me choose RTE Cereals is because the market information of cereal is relatively sufficient compared to other products. The RTE Cereal industry is pretty concentrated (Nevo, 2000). The two major companies- General Mills and Kellogg take up more than 50% of the market share. The GMO labeling strategy of both companies are very clear, which provide us good treatment and control. By the end of 2013, General Mills removed the GE ingredients from their original Cheerios and made Cheerios GMO-free. In June, 2016, many RTE cereals of General Mills were found to be labeled as "Partially Produced with Genetic Engineering". Similar labeling was also found on the packages of Kellogg's Cereals.

4.2. Literature review

United States was always the leading country in adopting GMOs (Bovay and Alston, 2018). However, after passing the federal mandatory labeling law, it will join the world in becoming the 65th country with GMO labeling (Huffman and McCluskey,

2015). Before the federal mandatory GMO labeling law goes into effect, it would be useful for both government and producers to know potential outcomes of mandatory labeling, especially the potential reaction of consumers.

Controversy of GMO labeling has been on main stage for decades. The consumers and Non-Governmental Organizations (NGOs) demanding GMO mandatory labeling stood on the point of "right to know" (Marchant et al., 2010). Scientists and many companies have been against GMO labeling because GMO pose no negative effect on human health and environment (NASEM, 2016). They were also worried that after the mandatory labeling, the GE ingredients would be removed from the supply chain as well as the retailer stores (Marchant, et al., 2010; Carter and Schaefer, 2018), which will reduce the variety of choices for consumers (Bovay and Alston, 2016).

Many researches have discussed the potential outcome of GMO labeling and the results are always ambiguous. Fulton and Giannakas (2004) proposed a model to analyze the welfare of GMO labeling. It shows that the welfare of GMO labeling is highly affected by consumers' aversion to GMO, and consumers' aversion may lead to a decision in favor of mandatory GMO policy. Hu et al. (2006) also showed that the welfare implications varies across different consumer preference.

The advocators of GMO labeling argue that labeling GMO will increase market efficiency. GMO products are usually treated as credence food (Fulton and Ginnakas, 2004). Credence attributes created asymmetric information, which reduced consumer welfare. Imposing labeling would reduce the asymmetric information and in result benefit consumers (Akerlof, 1970). In addition, Costa-Font and Mossialos (2006) argued

that consumers' aversion to GMO can be attributed to the absence of information. Thus, GMO labeling might improve consumers' sense of control and trust and therefore increase consumer demand (Kolodinsky and Lusk, 2018). Kolodinsky and Lusk (2018) also supported this view by imposing a survey method using DID to compare consumers' perception on GMO before and after Vermont's GMO labeling. They found the labeling policy reduced the aversion to GMO by 19%.

Previous research has shown that GMO labeling will reduce the demand for GMO products. Fallon et al. (2007) applied Theory of Planned Behavior (Ajzen, 1985) and conducted surveys across 15 European countries; they conclude that consumers are less likely to consume products with GMO labeling, but for those who would like to consume GMO labeled product, they believed GMO labeling is unnecessary. McFadden and Lusk (2017) collect 1132 responses from online survey shows that GMO labeling reduced consumers' willingness to pay (WTP) and the text labeling reduced WTP more than the scannable QR code (Quick Response code).

Nevertheless, more concern on mandatory GMO labeling came from the "signaling effect" (Costanigro and Lusk, 2014). Research indicated that the mandatory GMO labeling will send signals to the consumers that the product might pose potential risks to human health (Marchant et al., 2010), like the label on cigarettes, even though GMO is harmless. Huffman et al. (2003) shows that consumers would be opt out of the market under the present of GMO labeling. Lusk and Rozan (2008) used mail surveys and revealed that mandatory GMO labeling policy would convey information suggesting

GMO products were unsafe, to consumers. However, Costanigro and Lusk (2014) conducted economic experiments and detected very little signal effects.

Most previous researches are either theoretical or hypothetical (Fulton and Giannakas, 2004; Costanigro and Lusk, 2014, Kolodinsky et al., 2019). Kolodinsky and Lusk (2018) applied difference-in-difference model on survey data. So far, I only found one empirical research using market level data to test the effect of GMO labeling. Carter and Schaefer (2018) use sugar market data and found that after the mandatory labeling policy, the price of sugar beets (GMO) significantly decreased with a slight increase in the price of cane sugar (Non-GMO). However, because sugar is the key ingredients in many food products, Carter and Schaefer (2018)'s finding is derived from the producer side and not the consumer side. Our research is going to contribute to this area by using Nielsen consumer panel data to study the consumers' reaction to GMO labeling.

4.3. Data

The data I use is from Nielsen consumer panel dataset[3]. It contains 40,000 to 60,000 panelists each year and covers about 400,000 products. It covers household level purchase information including products purchased for each trip, quantity purchased, date purchased, location of the purchase, price paid, coupon value and whether there are any deals presented. Moreover, it also contains the household characteristics.

[3] Researcher(s) own analyses calculated (or derived) based in part on data from The Nielsen Company (US), LLC and marketing databases provided through the Nielsen Datasets at 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 researcher(s) 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.

For this study, we only restrict our analysis to RTE cereal. From Nielsen consumer panel data, the market share of the top 5 RTE Cereal companies from 2014 to 2017 is summarized as below.

Table 4.1 Summary of RTE cereal industry

Company	Share by number of households	Share by OZ	Share by Quantity
General Mills	32.40%	29.65%	32.94%
Kellogg Company	27.79%	28.88%	28.23%
Post Holdings	15.16%	18.30%	14.75%
Quaker Oats	6.21%	6.37%	6.48%
Kashi	2.09%	1.87%	2.09%

Table 4.2 Market share from Nielsen consumer panel data 2017

Company	Share by number of households	Share by OZ	Share by Quantity	Market share from Statista 2019[4]
General Mills	34.05%	31.39%	34.37%	29.85%
Kellogg Company	28.61%	29.58%	29.02%	30.10%
Post Holdings	15.36%	18.71%	14.93%	18.92%
Quaker Oats	6.69%	6.68%	6.95%	6.45%
Kashi	1.82%	1.53%	1.77%	NA

[4] Data source: Conway, 2018, Statista https://www.statista.com/statistics/858562/cereal-company-market-share-us/

I also compared the market share calculated from Nielsen data with the actual market level data. I can only obtain the market level data of year 2017. The comparison results are presented in Table 4.2, which shows that the market share from Nielsen data is consistent with the actual market level data.

As we can tell from both Table 4.1 and Table 4.2, the total market share from the four largest companies accounts for more than 85% of the market. Because of limited market information, our research only focuses on the two largest companies, General Mills and Kellogg, which account for more than 50% of the market share.

I summarized the data into state-month-product level. For each state-month, I calculated the sales of each product by ounce. The price is also recalculated to ounce level.

4.4. Conceptual framework

In this study we use Cheerios and KASHI GO LEAN as control, and other brands produced by General Mills and Kellogg Company as treatment.

In 2014, General Mills made their original Cheerios non-GMO (Bain and Dandachi, 2014). Therefore, original Cheerios won't be affected by the mandatory labeling of General Mills in 2016. By the end of 2014, a cereal line of Kashi, KASHI GO LEAN has been verified as Non-GMO, so it will not be affected by the mandatory labeling of Kellogg. On the contrary, all other popular cereal products of Kellogg and General Mills have been labeled "partially produced with genetic engineering".

Another event in the labeling history is from Kellogg. After the federal law preempted the ongoing Vermont GMO labeling law, Kellogg has switched from a text

label to QR code in April, 2017. That event was supposed to serve us a treatment to test the effect of different labeling format.

I am using DID framework to estimate the average treatment effects. The control products should serve as a counterfactual of product sales in the absence of labeling. Following Angrist and Pischke (2008), I also included control variables such as price, deals, seasonal dummy variables and state fixed effects. The average treatment effect (ATE) is captured by the equation below,

$$Q_{\text{its}} = \beta_0 + \beta_1 GMO_{is} + \beta_2 Label_{ts} + \beta_3 GMO_{is} * Label_{ts} + \theta X_{its} + \varepsilon$$

where Q_{its} is the sales by oz of each cereal product in each state of each month. GMO_{is} is a binary variable, which equals to 1 when it contains GE ingredients (all General Mills' cereals except for Cheerio and Kellogg's cereals). $Label_{ts}$ is another binary variable equal to 1 when it is after June 2016 when the Vermont GMO labeling law come into effect. Therefore, β_3 captures the ATE. X_{its} captures all control variables including price, deals, seasonal dummies to control for seasonality and state fixed effects. I include state level data because price and demand vary a lot, across states. The estimation will be more efficient if controlled for state fixed effects.

The analysis consists of three parts. First, we compare the change of sales between original Cheerios and two other Cheerios, Honey Nut Cheerios and Multi-grain Cheerios. In this analysis, Honey Nut Cheerios and Multi-Grain Cheerios serve as treatment products because those two are the most popular Cheerios besides the original Cheerios. They have similar taste and ingredients compared to original Cheerios and can be treated as close substitutes for original Cheerios. The sales of Cheerios would serve as

counterfactual of Honey Nut Cheerios' sales in the absence of labeling. The second part of analysis is comparing KASHI GO LEAN and Kellogg's cereals, where KASHI GO LEAN is treated as control and Kellogg's cereals form the treatment group. The third part is combining General Mills and Kellogg, but this time, I only include the 10 most popular brands in the analysis to reduce the size of treatment group.

There are two questions I am trying to answer with this analysis- 1. Is there a divergence in the demand of GMO and Non-GMO cereals? 2. If there is a divergence, can it be attributed to the Vermont labeling law.

4.5. Summary statistics

4.5.1. GMO Cheerios (Honey Nut and Multi-Grain) vs. non-GMO Cheerios (original Cheerios)

The first set of products I am comparing is original Cheerios (non-GMO Cheerios) and other two Cheerios (GMO Cheerios). Original Cheerios has been Non-GMO since January, 2014. However, all other Cheerios have remained as GMO.

The total sales of non-GMO Cheerios and GMO Cheerios for each month is summarized in Figure 4.5. It is hard to tell the changes in sales before and after July 2016. One of the reasons is that the price of Cheerios and Honey Nut Cheerios changed after July 2016. Therefore, I summarized the average price for each oz. of Cheerios and Honey Nut Cheerios in Figure 4.6.

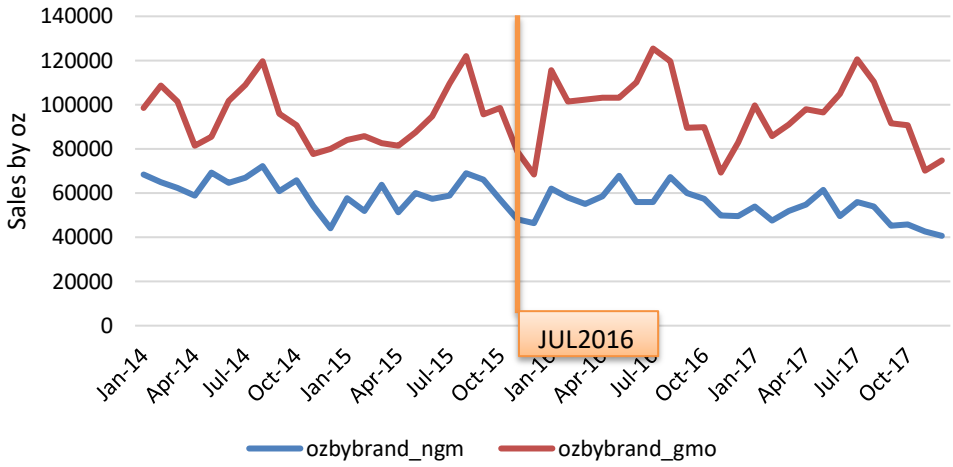

Figure 4.5 Sales of GMO and non-GMO Cheerios

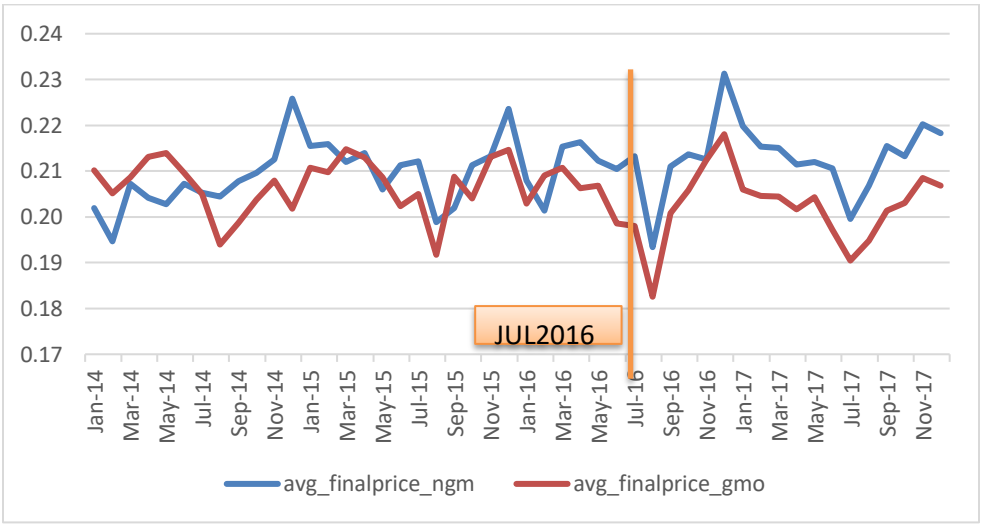

Figure 4.6 Price of GMO and non-GMO Cheerios

Table 4.3 compares the sales and price before and after the application of Vermont's GMO labeling law. It shows us that the price of non-GMO Cheerios increased after July 2016, with a decrease in the price of GMO Cheerios. Therefore, the difference in sales might be caused by the change in price.

Table 4.3 Sales and price before and after July, 2016

	Price before Jul2016	Price after Jul2016	difference	%diff of Price	Sales before Jul2016 (oz)	Sales after Jul2016 (oz)	differen ce	%diff of sales
Non-GMO Cheerios	0.2094	0.2129	0.0035	1.68%	59928.1	52412.32	-7,515.8	-12.54%
GMO Cheerios	0.2067	0.2023	-0.0045	-2.17%	95,798.7	95,044.4	-754.3	-0.79%
Difference in difference			-0.0080				6,761.4	

4.5.2. Kellogg vs. KASHI

I have checked Kellogg's website and found that all popular brands of Kellogg are GMO. However, Kellogg company also provides non-GMO alternative by its subsidiary company KASHI. KASHI GO LEAN has been verified to be non-GMO since the end of 2014.

Before the analysis, I first summarized the trend of the price and sales of KASHI GO LEAN and Kellogg in Figure 4.7 and Figure 4.8. Similar to the comparison of non-GMO Cheerios and GMO Cheerios, the comparison of KASHI GO LEAN and Kellogg cereals shows the same pattern. The price of non-GMO Cereal increased after Vermont's GMO labeling law. The sales of GMO Cereal (Kellogg Cereal) decreased after GMO labeling law. (More details in Table 4.4)

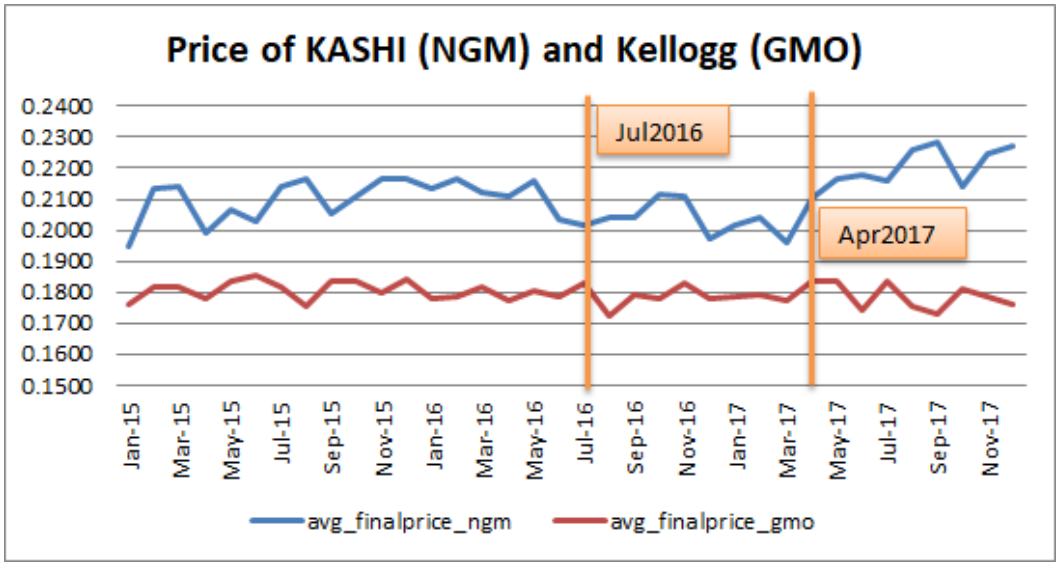

Figure 4.7 Price of KASHI (non-GMO) and Kellogg (GMO)

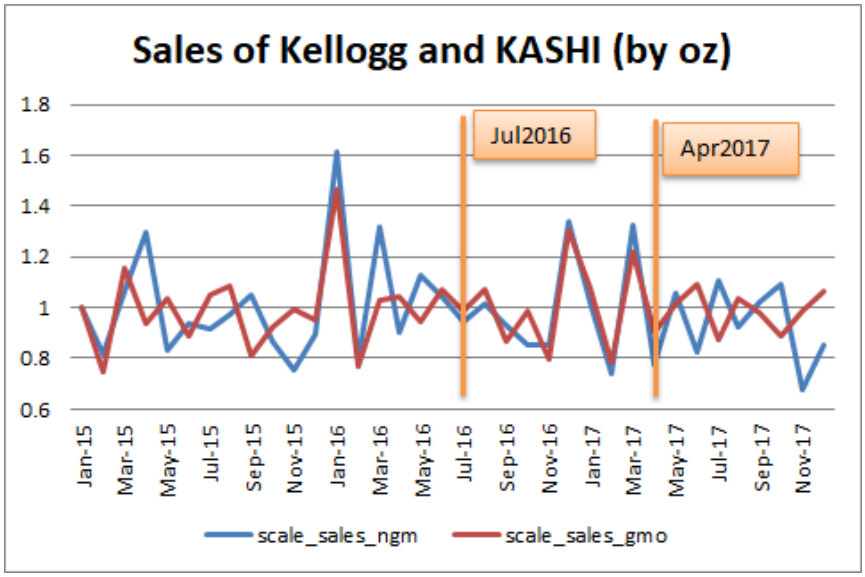

Figure 4.8 Sales (oz) of Kellogg and KASHI

The plot starts from Jan 2015 because the control group KASHI GO LEAN started to be completely Non-GMO by the end of 2014. A little bit different from General Mills, Kellogg changed their labeling scheme to a website link since April 2017,

so in the plot below I also marked April 2017 to show how the change of labeling would affect the demand of cereals.

Table 4.4 Sales and price change of KASHI GO LEAN and Kellogg

	Price before Jul2016	Price after Jul2016	diff in Price	%diff of Price	Sales before Jul2016	Sales after Jul2016	diff in sales	% diff of Sales
KASHI	0.2102	0.2118	0.0016	0.77%	12859.6	9818.3	-3041.3	-23.65%
Kellogg	0.1805	0.1787	-0.0019	-1.03%	404870.6	348655.9	-56214.7	-13.88%
Difference in difference			-0.0035				-53173.3	

Table 4.5 Scaled sales and price of KASHI GO LEAN and Kellogg

	Price before Jul2016	Price after Jul2016	diff in Price	Sales before Jul2016	Sales after Jul2016	diff in sales
KASHI	0.2102	0.2213	0.0112	1.0104	0.9434	-0.0670
Kellogg	0.1805	0.1787	-0.0019	0.9950	0.9914	-0.0035
Difference in difference			-0.0130			0.0634

The sales volume of KASHI GO LEAN and Kellogg's RTE Cereals are extremely different (Table 4.4). To make it comparable, I recalculated the scaled sales

and summarized it in Table 4.5 and Table 4.6. The scaled sales are calculated by the sales of the month divided by the sales of the first period (Q_t/Q_1).

From Table 4.4 and 4.5, we can conclude that the price of non-GMO cereals (KASHI GO LEAN) increased after July 2016 and the sales decrease a lot with the increase in price. For GMO cereals (Kellogg's cereals), the company discounted the price by about 1%. However, even after decreasing the price, it still lost about 14% the customers. Since the decrease in sales of non-GMO cereals is more severe than the decrease in sales of GMO cereals, we can conclude consumers may be more sensitive to the change of price compared to the GMO labeling. In the next section, I am going to use regression to control for the change in price and deals.

Table 4.6 Scaled sales and price of KASHI GO LEAN and Kellogg before and after change of labeling

	Jul2016 to Mar2017	after Mar2017	diff in Price	Jul2016 to Mar2017	after Mar2017	diff in sales
KASHI	0.2035	0.2201	0.0166	1.0027	0.9250	-0.0777
Kellogg	0.1787	0.1786	0.0000	1.0096	0.9813	-0.0284
Difference in difference			-0.0166			0.0494

4.5.3. Combine General Mills and Kellogg

In the last part of the analysis, I am going to combine General Mills and Kellogg. Without the loss of generality, I only chose the top 10 brands of General Mills and

Kellogg, the reason I did that is because if using Cheerios and KASHI GO LEAN as control, the market share of the Non-GMO Cereal is too small compared to the market share of GMO. The products I chose are listed in Table 4.7. The total market share of the selected products is about 36%.

Table 4.7 List of brands

GMO Cereals (30.75% market share)		Non-GMO Cereals (5.19% market share)	
General Mills	**Kellogg's**	**General Mills**	**Kellogg's**
Honey Nut Cheerios	Frosted Mini-Wheats®	Cheerios	KASHI GO LEAN CRUNCH!
Cinnamon Toast Crunch	Frosted Flakes cereal		KASHI GO LEAN CRISP!
Original Lucky Charms	Raisin Bran		KASHI GO LEAN
	Raisin Bran Crunch cereal		
	Froot Loops cereal		
	Rice Krispies cereal		
	Special K Red Berries Cereal		

Figure 4.9 summarizes the change of average price of non-GMO RTE cereals and GMO RTE cereals from January 2015 to December 2017. Figure 4.10 presents the change of average sales. Since the volumes of sales of non-GMO RTE cereals and GMO

RTE cereals are different, I scale the volume by using the sales of each period divided by the first period, January 2015.

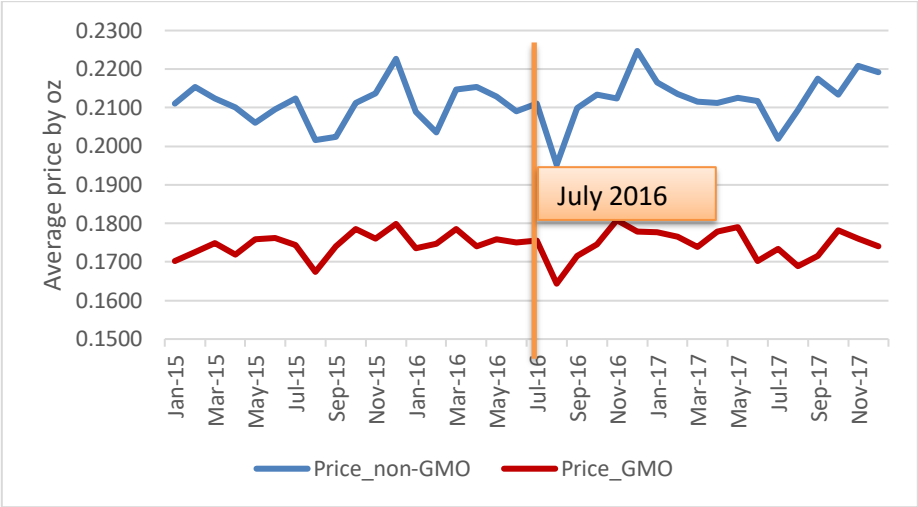

Figure 4.9 Price of GMO and non-GMO RTE Cereals

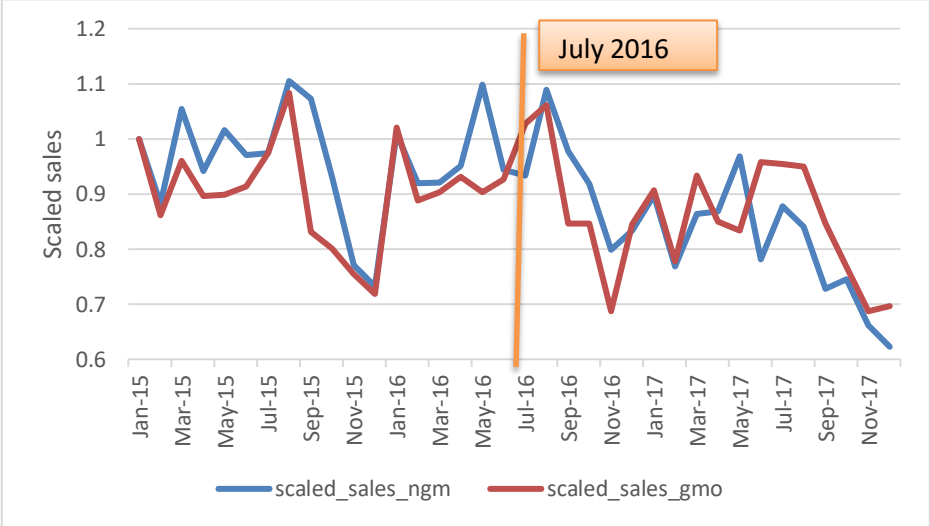

Figure 4.10 Scaled sales of GMO and non-GMO RTE Cereals

Table 4.8 summarized the change of average sales and price after July 2016. Again, we can tell the seller decreased the price for GMO RTE cereals and increased the

price for non-GMO RTE cereals. However, the sales of GMO RTE cereals did not increase after the price drop. On the contrary, the sales of GMO RTE cereals decreased by 4.83%.

Table 4.8 Summary of change of sales and price before and after July 2016

	non-GMO Cereals	GMO Cereals	Difference in difference
Price before Jul2016	0.210729	0.174653	
Price after Jul2016	0.212529	0.174551	
diff in Price	0.0018	-0.0001	-0.0019
Percentage difference in Price	0.85%	-0.06%	
Sales before Jul2016	70925.52	423381.4	
Sales after Jul2016	62230.59	402917	
diff in sales	-8694.93	-20464.4	-11769.5
Percentage difference in Sales	-12.26%	-4.83%	

4.6. Regression results

From section 4.5, we found that after Vermont's labeling law, the cereal companies (General Mills and Kellogg) decreased the price for GMO RTE cereals and increased the price for non-GMO RTE cereals.

The change of firm's pricing strategy caused a decrease in sales of non-GMO RTE cereals. The mandatory labeling may results in an increase in sales of non-GMO RTE cereals compared to a decrease in sales of GMO RTE cereals, so the overall effect on the sales of GMO Cereal is hard to determine. Only by plotting the sales and

comparing the average sales change is not clear, because the sales of GMO cereals could increase because of the price change or decrease because of the presence of GMO label. To control for the price and promotion effect, I ran a regression analysis using both state level sales data.

$$Q_{its} = \beta_0 + \beta_1 GE\ Cereal_i + \beta_2 Treatment\ Period_t + \beta_3 GE\ Cereal_i * Treatment\ Period_t + \theta X_{its} + \varepsilon$$

$GE\ Cereal_i$ equals to 1 when the product is GMO RTE cereals (Table 4.7). $Treatment\ Period_t$ equals to 1 when it's after July 2016. X_{its} controls for all other characteristics including price, deals and state fixed effects. Since the sales of RTE cereals are affected by seasonality (Figure 4.5 to Figure 4.10), I also included 3 seasonal dummies. Again, I did three separate regression for 3 groups of treatment and control.

4.6.1. Original Cheerios vs. Honey Nut Cheerios and Multi-Grain Cheerios

The regression used the state level sales of three cheerios from January 2014 to December 2017. In the first regression (column 1 of Table 4.9), I only controlled for price and we did not observe any treatment effect. After controlling for all other variables including deals, seasonal dummy variables and state fixed effects, we found the labeling caused a significant negative effect on treatment group, GMO cereals (Column 2-4 of Table 4.9).

Since regression of quantity on price normally faces endogeneity problem, I also used instrument variable to control for that. Following Nevo (2000), I use the average price of other states as IV for the price of the current state. First, I did the Hausman test. The p-value is less than 0.0001, so we reject the null hypothesis and there is endogeneity

Table 4.9 Regression of sales of GMO Cheerios and non-GMO Cheerios

	Dependent variable: Sales by Oz			
	OLS			2SLS
	(1)	(2)	(3)	(4)
(Intercept)	3,005.97***	292.00***	440.16***	1,755.03***
	(80.60)	(28.91)	(37.73)	(65.06)
Price	-8,428.99***	-1,246.17***	-1,417.97***	-7,370.26***
	(351.86)	(115.30)	(109.21)	(249.18)
Deals		44.87***	42.87***	37.22***
		(0.18)	(0.26)	(0.37)
GE Cereal	-105.63***	106.01***	92.96***	141.28***
	(38.64)	(12.23)	(10.53)	(12.70)
Treatment Period	-138.79***	129.13***	117.60***	102.97***
	(50.90)	(16.30)	(14.00)	(16.74)
Quarter 2		-0.75	-0.77	4.38
		(12.77)	(10.93)	(13.07)
Quarter 3		-121.60***	-113.38***	-143.68***
		(13.06)	(11.20)	(13.44)
Quarter 4		14.03	6.19	-15.87
		(13.02)	(11.17)	(13.38)
State Fixed effect	NO	NO	YES	YES
	NO	NO	YES	YES
GE Cereal*Treatment Period	90.61	-70.927***	-62.846***	-77.298***
	(62.54)	(19.76)	(16.93)	(20.25)
Observations	6,975	6,975	6,975	6,975
R^2	0.081	0.908	0.933	0.905
Adjusted R^2	0.081	0.908	0.933	0.904
RSE	1,194.16	377.124	322.754	385.876

problem. We also tested whether the IV is a weak IV or not and the p-value is less than 0.0001 so the IV is not a weak IV. The result from the two stage least squares (2SLS) is presented in column 4.

4.6.2. Kellogg vs. KASHI

In this part of the regression, we included sales from all RTE cereals from Kellogg in our treatment group and KASHI GO LEAN as control. The data ranged from January 2015 to December 2017. All variables are kept the same as in section 4.6.1.

The Hausman test results and weak instrument test results are presented in Table 4.10.

Table 4.10 Hausman test and weak instrument test

	Statistic	p-value
Weak instruments	51035	<2e-16 ***
Wu-Hausman	5000	<2e-16 ***

The regression results are shown in Table 4.11. Consistent with the previous section, we can find that the labeling caused negative effect on sales

4.6.3. Combine General Mills and Kellogg

This time I controlled for the fixed brand effect in column (2), (3) and (4). Consistent with the previous two regressions, the sales of GMO RTE cereals in the treatment period decrease after controlling price and deals.

Table 4.11 Regression of sales of Kellogg (GMO) and KASHI GO LEAN (non-GMO)

	Dependent variable: Sales by Oz			
	OLS			2SLS
	(1)	(2)	(3)	(4)
(Intercept)	583.084***	60.499***	107.450***	240.220***
	(13.09)	(6.22)	(8.72)	(9.57)
Price	-2,205.323***	-447.181***	-434.727***	-1,039.335***
	(32.59)	(15.29)	(15.12)	(22.58)
GE Cereal	168.639***	41.369***	41.103***	49.022***
	(11.51)	(5.23)	(5.07)	(5.15)
Treatment Period	-13.225	17.490**	18.085**	18.058**
	(16.03)	(7.31)	(7.08)	(7.18)
Deals		54.819***	55.232***	53.748***
		(0.12)	(0.13)	(0.13)
Quarter 2		16.693***	17.161***	17.604***
		(2.71)	(2.62)	(2.66)
Quarter 3		24.114***	24.494***	25.949***
		(2.82)	(2.73)	(2.77)
Quarter 4		38.539***	39.058***	38.383***
		(2.86)	(2.77)	(2.81)
State Fixed effect	NO	NO	YES	YES
GE Cereal * Treatment Period	6.042	-22.242***	-22.847***	-26.600***
	(16.64)	(7.56)	(7.32)	(7.42)
Observations	54,501	54,501	54,501	54,385
R-square	0.084	0.811	0.823	0.819
Adjusted $\boldsymbol{R^2}$	0.084	0.811	0.823	0.818
RSE	500.755	227.335	220.084	223.099

Table 4.12 Regression of sales of cereals from General Mills and Kellogg

	Dependent variable: Sales by Oz			
	OLS			2SLS
	(1)	(2)	(3)	(4)
(Intercept)	1,237.753***	-8.598	221.125***	-51.964
	(38.209)	(19.406)	(21.170)	(86.479)
GE Cereal	333.521***			
	(20.911)			
Price	-3,759.553***	-84.114	-54.183	1,183.119***
	(159.331)	(75.346)	(64.315)	(385.195)
G M CINNAMON TOAST CRUNCH		137.198***	91.732***	131.364***
		(13.183)	(10.924)	(16.406)
G M HONEY NUT CHEERIOS		203.222***	245.222***	261.391***
		(12.990)	(10.738)	(11.907)
G M LUCKY CHARMS		-22.002*	-84.223***	-74.360***
		(13.033)	(10.807)	(11.306)
KASHI GO LEAN		21.868	-199.999***	-211.434***
		(13.643)	(11.868)	(12.468)
KASHI GO LEAN CRISP		-10.259	-212.352***	-201.883***
		(13.114)	(11.373)	(11.907)
KASHI GO LEAN CRUNCH		21.798*	-162.140***	-149.106***
		(12.734)	(10.984)	(11.772)
KEL FROOT LOOPS		18.299	-88.977***	-76.681***
		(13.150)	(11.013)	(11.726)
KEL FROSTED FLAKES		280.146***	230.100***	290.572***
		(13.471)	(11.189)	(21.716)
KEL FROSTED MINI-WHEATS		569.271***	518.387***	597.262***
		(13.814)	(11.496)	(26.836)
KEL RAISIN BRAN		367.362***	281.253***	372.077***
		(14.145)	(11.862)	(30.329)
KEL RAISIN BRAN CRUNCH		245.000***	103.037***	177.653***
		(14.042)	(11.923)	(25.861)

Table 4.12 Continued

	Dependent variable: Sales by Oz			
	OLS			2SLS
	(1)	(2)	(3)	(4)
KEL RICE KRISPIES		66.582***	-55.301***	-53.632***
		(13.181)	(11.079)	(11.180)
KEL SPECIAL K RED BERRY		46.501***	-81.367***	-94.888***
		(13.284)	(11.174)	(12.004)
Deals		48.144***	41.094***	41.396***
		(0.141)	(0.171)	(0.195)
Treatment Period	-23.848	44.215***	26.631***	24.353***
	(25.307)	(9.435)	(7.790)	(7.884)
Quarter 2		-5.261	-5.534	-7.408
		(6.493)	(5.355)	(5.428)
Quarter 3		-21.706***	-13.218**	-12.075**
		(6.717)	(5.541)	(5.597)
Quarter 4		30.619***	4.698	1.95
		(6.763)	(5.594)	(5.702)
State Fixed effect	NO	NO	YES	YES
GE Cereal*Treatment Period	-20.474	-38.633***	-26.367***	-21.625**
	(29.172)	(10.700)	(8.831)	(9.020)
Observations	22,940	22,940	22,940	22,940
R-square	0.06	0.874	0.914	0.913
Adjusted $\boldsymbol{R^2}$	0.06	0.874	0.914	0.913
RSE	952.622	349.187	287.956	290.277

4.7. Conclusion and future discussion

When we talk about monetary policy, we always consider the expectation effect, which means without implementation of the policy, only the expectation of the upcoming policy will affect the economy. It is also true for some market policies like mandatory GMO labeling. “Food companies can dramatically respond to mandatory

labels in light of potential consumer reactions" (Costanigro and Lusk, 2014). The Vermont GMO labeling law made companies change their labeling and price policy not only in Vermont, but also in all other states in the U.S. The change of labeling provided us an opportunity to analyze consumers' reaction to mandatory labeling.

From our analysis, the labeling of GMO products resulted in a decrease in the sales, after controlling for price. The labeling does reduce the demand of the product. Our study is the first study trying to use market data to reveal consumers' attitudes to GMO labeling. The results consist with most of previous studies and shows consumers' general aversion to GMO labeled products. However, the magnitude of aversion is small. Since it has only been 2 years since many food companies have started to label their products GMO (The data is only available until 2017), more studies can be devoted to the market analysis when future market data is available.

The Nielsen home-scan panel data provides more detailed information about household characteristics; future study could apply more complicated demand models to incorporate the consumer characteristics and reveal consumer heterogeneity on the reaction to GMO labeling.

5. CONCLUSIONS

Nowadays, consumers are putting more weights on credence attributes during purchasing decision. The study of consumers' attitude toward those credence attributes not only helps with policy implementation but also enriches the literature on consumer decision-making.

This dissertation is a focus on one of the popular credence attributes- GMO. This food attribute produced by new technology provides many benefits for the human society but has received critical judgement from the consumer side. We applied three methods including field experiment, online survey, and secondary data analysis, in trying to understand consumers' attitude toward GMO, and how consumers will react to GMO information.

In the first essay, we found consumers in general would like to pay more for non-GMO products. Consumers' health concern is the key reason that they avoid GMO. Positive information would help alleviate consumers' concern on GMO. However, the effect varies across different kind of consumers and different social media.

The second essay is an application of factor analysis. It is trying to understand the effect of those latent variables including perceived benefits and perceived risks, and more importantly the effect of subjective and objective knowledge, on consumers' acceptance of GMO. Consistent with Prati et al. (2012), we found the perceived benefits caused significant positive effect whereas the perceived risks caused negative effect on consumers' acceptance of GMO. Moreover, we found the effect from subjective knowledge and objective knowledge are different. The subjective knowledge level is

negatively correlated with the perceived benefits so it is difficult for the stubborn consumers to be persuaded by positive information of GMO, which partially explains the heterogeneity from the first essay.

The third essay is using market level data trying to understand consumers' reaction to GMO labeling. With the GMO mandatory labeling signed into a law in 2016, it is important to understand how consumers would react to the labeling information. Our study is contributing to this field by using market level data from Nielsen consumer panel dataset. This study is the first one to show consumers' aversion to GMO using market level purchasing data.

Besides the GMO attributes, many credence attributes need to be studied. With the increase in the attention to food quality, consumers are not only considering the observable food attributes but have also started to focus on the unobservable ones. The widely discussed GMO is an example. The general concern on GMO caused even more costs for the government to implement the mandatory labeling. In the future, there might be more credence attributes that come to light. Further research is required on this.

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APPENDIX A

ELICITATION OF RISK PREFERENCE

	Lottery A				Lottery B			
	Probability	Pay	Probability	Pay	Probability	Pay	Probability	Pay
1	1%	$10	99%	$8	1%	$19	99%	$1
2	5%	$10	95%	$8	5%	$19	95%	$1
3	10%	$10	90%	$8	10%	$19	90%	$1
4	20%	$10	80%	$8	20%	$19	80%	$1
5	30%	$10	70%	$8	30%	$19	70%	$1
6	40%	$10	60%	$8	40%	$19	60%	$1
7	50%	$10	50%	$8	50%	$19	50%	$1
8	60%	$10	40%	$8	60%	$19	40%	$1
9	70%	$10	30%	$8	70%	$19	30%	$1
10	80%	$10	20%	$8	80%	$19	20%	$1
11	90%	$10	10%	$8	90%	$19	10%	$1
12	100%	$10	0%	$8	100%	$19	0%	$1

APPENDIX B

CORRELATION OF INDICATORS

	PB_1	**PB_2**	**PB_3**	**PR_1**	**PR_2**	**PR_3**	**AT_1**	**AT_2**	**IC_1**	**IC_2**	**IC_3**	**OBJ_K**	**SBJ_K**
PB_1	1												
PB_2	0.5837	1											
PB_3	0.7345	0.6460	1										
PR_1	-0.4921	-0.4328	-0.5446	1									
PR_2	-0.4611	-0.4055	-0.5103	0.7203	1								
PR_3	-0.4704	-0.4137	-0.5206	0.7349	0.6886	1							
AT_1	0.7102	0.6247	0.7861	-0.5685	-0.5327	-0.5435	1						
AT_2	0.7034	0.6186	0.7785	-0.5630	-0.5276	-0.5382	0.8102	1					
IC_1	0.6159	0.5417	0.6817	-0.4930	-0.4620	-0.4713	0.7095	0.7027	1				
IC_2	0.5809	0.5109	0.6430	-0.4650	-0.4357	-0.4445	0.6692	0.6627	0.6622	1			
IC_3	0.5858	0.5152	0.6484	-0.4689	-0.4394	-0.4482	0.6748	0.6683	0.6677	0.6298	1		
OBJ_K	0.0507	0.0446	0.0561	-0.2436	-0.2282	-0.2329	0.0756	0.0749	0.0656	0.0619	0.0624	1	
SUB_K	-0.1064	-0.0935	-0.1177	-0.0906	-0.0849	-0.0866	-0.0963	-0.0953	-0.0835	-0.0787	-0.0794	0.1204	1

APPENDIX C

LOGISTIC REGRESSION ON NEWS MEDIA

	NBC news
(Intercept)	-0.238
Female	0.038
Age	0.007
Education	-0.188
Marital Status	0.126
Have Child	0.199
Income	-0.336
Health Concern	0.270
Risk Averse	0.068