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Understanding Consumer response to GMO Information

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Abstract

Many studies have found that consumers are willing to pay a price premium for non-genetically modified organism (non-GMO) products compared to GMO products, even though scientific analysis showed that GMOs are safe for both human health and environment. In this study, we investigated whether the information on health and safety of GMOs can affect or change consumer's acceptance towards GMO products. Grocery shoppers were provided with the news of the 2016 National Academy of Sciences Report on GMO products and participated in the second price auctions for different products including beef, canola oil, cotton ball, milk, yogurt, and zucchini. We found that health concern was 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. Moreover, 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 consumers.
Keywords: GMOs, consumer WTP, Experimental auction, information effect
JEL Classification: D12, Q13

1. Introduction

Since the first genetically modified organism (GMO) product, the Flavr-Savr tomatoes commercially released in 1994, genetic engineering (GE) has been widely applied to many species of crops. According to the National Academy of Science (NAS) 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. (NAS, 2016).

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). Bredahl (2001) showed that consumers' attitude to GMO is a result of the interaction of their perceived risk and benefit. The perceived

benefits cause a positive effect on consumers' attitude to GMO and the perceived risk results in a negative effect. Traill et al. (2006) gave similar results except that they measured risks and benefits separately. They found benefits and risks were not perfectly correlated and benefits had stronger effect than risks. Demographic characteristics have also been imposed to explain consumers' favor on non-GMO products. 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 belief (Hossain and Onyango, 2004), and gender (Siegrist 2000) have also been shown to have effects on consumers' attitude to GMO products.

Since perceived benefits is one of the main factors which determined consumers' attitude to GMO products. Any factors which have effects on the perceived benefits would improve consumers' acceptance of GMO. Savadori et al. (2004) suggested that providing information about benefits could lower the perceived risk and in results increase the acceptance of GMO. However, information itself could be complicated. It is diverse in the resource horizon and contend horizon. Rousu et al. (2002) first imposed verifiable information from third-party group (including scientists, professionals and academics) and found that information had slight effect on consumers' attitude to GMO products. On the content horizon, Lusk et al. (2004) explored what component of the positive information about GMO mostly like to change consumers' attitude toward GMO. They differentiated environment benefit, health benefit and benefit to the third world from the general positive information and found that the effects vary among different areas. Environment information could change consumers' reaction more compared to other kinds of information in Texas. Different from Lusk et al. (2004) who explored the content of information, Tenege et al. (2003) investigated how consumers would react to information from different sources and found information from interested parties and third-party sources had stronger effect. As previous studies have shown that consumers reacted differently to various information, one question remains unknown is what factors related to the effectiveness of information.

In this study, we investigat 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 provide health and safety information about GMO products from different news sources to the consumers and examine the

effect of GMO information on consumer WTPs. The rest of paper is organized as follows. The second section presents the experimental procedures and develops a model to analyze consumers' attitudes to GMO and how consumers response to the information. The third section shows the results and regressions. The last part is the conclusion.

2. Methodology

2.1 Experiment procedure

We recruited 174 primary grocery shoppers aged from 18 to 83 in the Bryan and College Station area, Texas. Demographic characteristics are summarized in table 1.

[Table 1 is about here.]

The products studied include beef, canola oil, cotton ball, milk, plain yogurt and zucchini squash. The 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 is one of the available GMO vegetable in the market, and over 24000 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 are always been suspect influenced by GE technology. Therefore, it is highly likely that those 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 before 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 news about NAS's report, which

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/

stating that GMOs pose no health risks and 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 the bid for second stage, participants were asked to rank their level of trust about the news from 1 to 5, 1 means "do not trust at all" and 5 means "trust completely".

We followed Holt and Laury (2002) to elicit subjects' risk preference. Participants were presented 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 equal the expected utility from A and from B, the range of coefficient of risk aversion can be determined. We used the middle point as the coefficient r. Before making the choices, subjects were acknowledged 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 and played the lottery and pay them with the according reward.

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 on GMO and 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, $q\ (t, I)\ = tI,\ t$ 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,

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

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.

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

Any characteristics with positive effect on consumers' preference on non-GMO products will increase ΔWTP. Prior knowledge has been proven affects 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 extend the information affects the difference of WTP depends on t.

We assume the efficiency t is influenced by consumers self-reported trust and objective trust, where $t = t(t_{subjective}, t_{objective})$. Both $t_{subjective}$ and $t_{objective}$ reflect the level of trust. They all have positive effect 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, the higher trust level (t) is, the more they trust about the positive information and change their attitude significantly. However, Frewer et al., 2003 argued that the subjective trust was highly influenced by subjects' attitude to GMO. Consumers who thought GMO was more acceptable would be more trusting of positive news about GMO. Even though Frewer et al. (2003) denied the direct influence from subjective trust, we suspect objective trust could still have impact on the acceptance of information. In our experiment, two groups randomly receive FOX news and

NBC news. FOX news was recognized as lean conservative and NBC news as lean liberal.[3] The interaction term of subjects' political ideology and the news media could be used as a potential indicator for objective trust level. For example, consumers lean liberal should trust more about NBC news. Since effect from $q(I)$ affected by t, a large $t_{objective}$ would cause a large decrease of ΔWTP.

3. Results and analysis

3.1 Summary Statistics

Our study shows that subjects on average bid more for Non-GMO products compared to products without GMO labeling. However, after information treatment, the difference decreased as shown in figure 1 and figure 2.

[Figure 1 is about here.]

[Figure 2 is about here.]

Histograms revealing the difference of WTPs between non-GMO products and products without non-GMO labeling are presented in figure 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 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 3 is about here.]

[3]Blake, A.(2014, October 21). Ranking the media from liberal to conservative, based on their audiences. The Washington Post. Retrieved from https://www.washingtonpost.com/news/the-fix/wp/2014/10/21/lets-rank-the-media-from-liberal-to-conservative-based-on-their-audiences/?utm_term=.2ba11e4433d3

Understanding consumers' current knowledge level is important for studying their perception on GMO. We collected objective and subjective knowledge level from subjects. Two questions about GMO labeling were used to revealing consumers' objective knowledge. Subjective knowledge was directly observed by asking them how familiar they are with the term GMO. Most of them believe they have some level of knowledge about GMO (figure 4). However, only a small portion of them got the right answer for both of the questions. Figure 5 reported the relation between their subjective knowledge and objective knowledge. Overall, people are overconfident about their knowledge of GMO.

[Figure 4 is about here.]

[Figure 5 is about here.]

3.2 Regression Analysis

We applied random effect model (Lusk et al., 2004) to understand what affects the difference of WTP for Non-GMO and GMO products. Regress the price premium of non-GMO products on the factors which might affects consumers' attitude towards GMO.

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

In this regression, at $t = 0$, $FOX_{it} = 0 \; and \; NBC_{it} = 0$. After information treatment, 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 affect 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.

[Table 2 is about here.]

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 products significantly decreased. For participants who watched NBC news, the result is not significant.

Following Huffman et al. (2003), fixed effect model was used to explore what affects consumers' perception on GMO. Consider the following regression,

$$\Delta WTP_{ik} = \alpha + \theta_k S_{ik} + \beta Z_i + \gamma_1 K_i + \gamma_2 H_i + u_{ik}$$

where i index for individuals and k index for each products, $i = 1, \ldots, N, k = 2, \ldots, 6$. Cotton ball were used as the baseline. S_{ik} is a vector of dummy variables of dimension 5, which indicates for each product other than cotton balls. Dependent variable is the price premium for non-GMO products before information treatment. Z_i contains all the variables that may have effects on consumers' perception, K_i denotes the knowledge level, H_i is the health concern and u_{ik} is the error term with zero mean. The regression results are presented in table 3.

[Table 3 is about here.]

It is easy to find consumers' education level, health concern, knowledge about GMO and political ideology affect their perception on GMO. Higher education, higher knowledge, and relatively more health concern on GMO would cause consumers pay more for non-GMO products. Within the risk averse people, those who have child pay more for non-GMO. Mothers would like to consume more on non-GMO comparing to fathers. Among married people, risk-averse subjects pay more for non-GMO products.

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

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

where ΔWTP is the price premium for non-GMO products. We impose NBC_i as a dummy to identify the news media, where $NBC_i = 0$ means subjects were presented with FOX news and $NBC_i = 1$ means subjects were presented with NBC news. As we mentioned in section 2, since the self-reported trust have the confounding problem, we used the objective trust t_i to capture the effect from trust. One possible objective measurement of trust could be the interaction term $NBC * political\ ideology$. The dependent variable reflects the change of the preference for non-GMO products. Results is presented in table 4.

[Table 4 is about here.]

Compared to FOX news, consumers who receive NBC news actually amplified their preference for Non-GMO. However, among those who receive NBC news, the price premium for non-GMO products decreased for subjects who lean liberal, which reflects a relatively strong effect from information. If we refer the term NBC*political ideology as the objective trust, the effect could be explained as that higher objective trust in information caused a relative large effect from news information.

Concluding Remarks

In this study, we explored consumers' acceptance towards GMO products including beef, canola oil, cotton balls, milk, yogurt, and zucchini. Though most consumers reported that they had some level of understanding about GMO. The survey reflected that consumers are overconfident about their knowledge level.

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. We also found that people with higher education level would like to pay more for non-GMO products, which is consistent with Onyango et al. (2004).

Moreover, 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. Furthermore, the effectiveness of the information is affected by consumers' objective trust measured by the correlation between a person's political ideology and the news channel, instead of self-reported trust.

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Table 1

Description of Demographic Variables and Regression Variables.

Statistic	*Definition*	*Mean*	*Frequency*
Gender	1 = female	0.577	57.7%
	0 = male		42.3%
Age	Age in years	37.213	
Marital Status	1 = married before	0.454	45.4%
	0 = Otherwise		54.6%
Child	1 = children in household	0.184	18.4%
	0 = no child in household		81.6%
Education	1 = bachelor or higher degree	0.873	87.3%
	0 = otherwise		12.7%
Income	1 = income >$50000 per year	0.437	43.68%
	0 = otherwise		56.32%
Risk Attitude	0 = risk loving	0.856	14.37%
	1 = risk averse		85.63%
Health Concern	1 = have health concern in GMO products	0.282	28.16%
	0 = otherwise		71.84%
Knowledge	question score = 0	0.879	27.01%
	question score = 1		58.05%
	question score = 2		14.94%
Political Ideology	1 = lean liberal	0.190	19.0%
	0 = otherwise		81.0%
Trust	1 = trust information provided	0.477	47.7%
	0 = do not very trust		52.3%

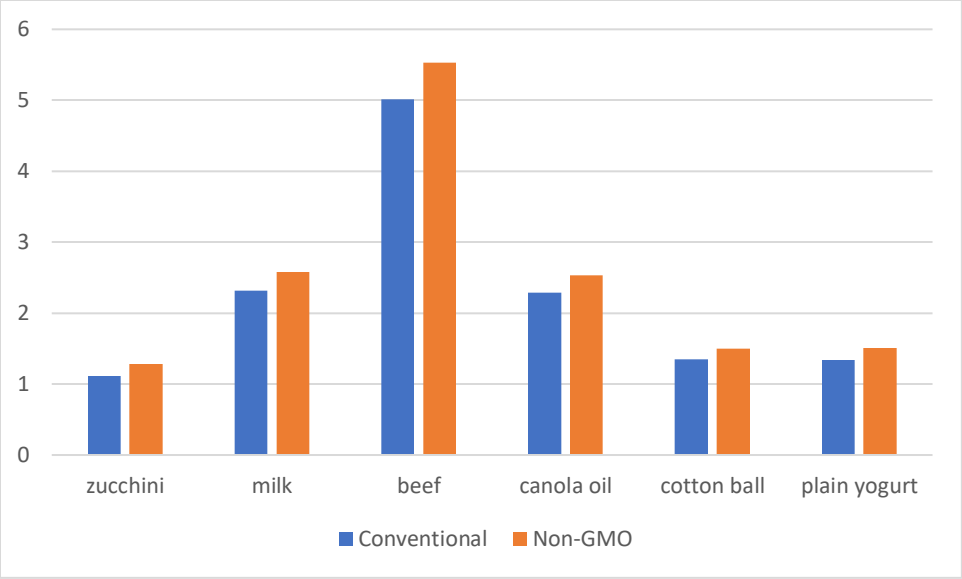

Fig. 1 WTPs before information treatment

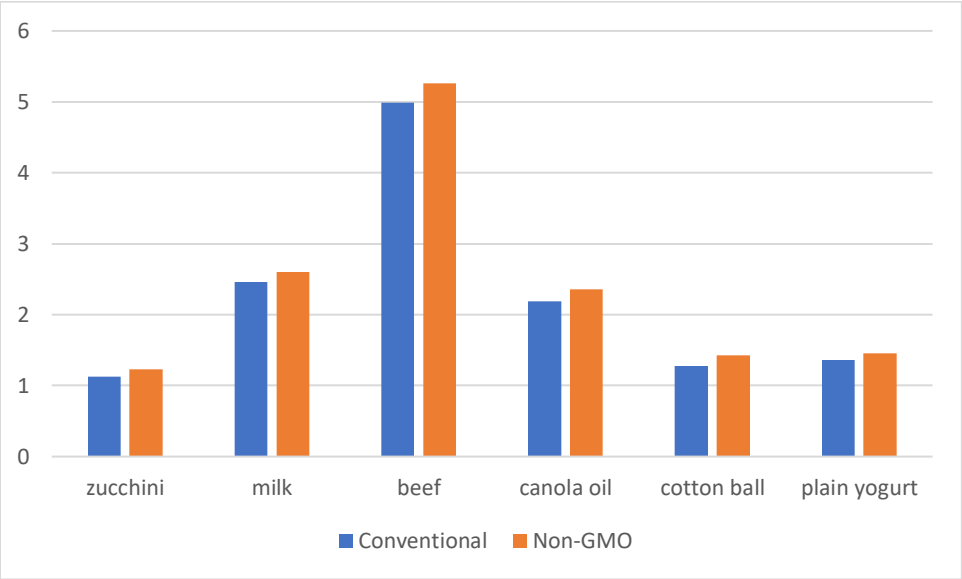

Fig. 2 WTPs after information treatment

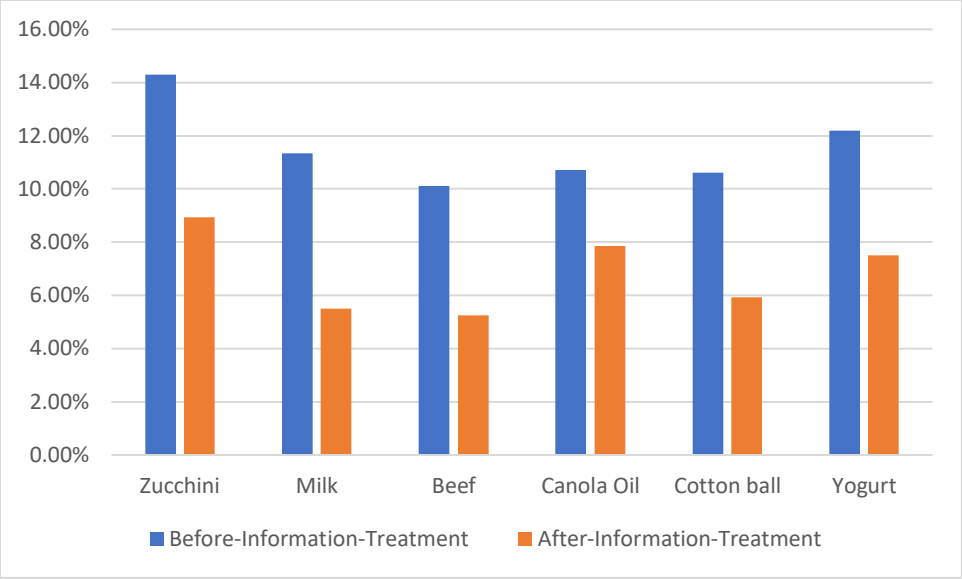

Fig. 3 Price premium of non-GMO products (before and after information treatment)

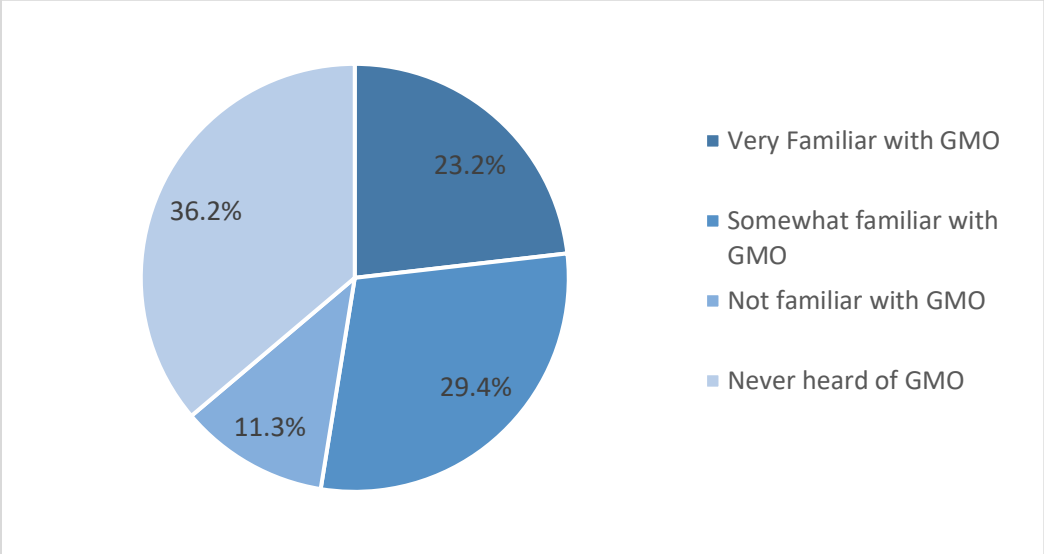

Fig. 4 Consumers' subjective knowledge about GMO

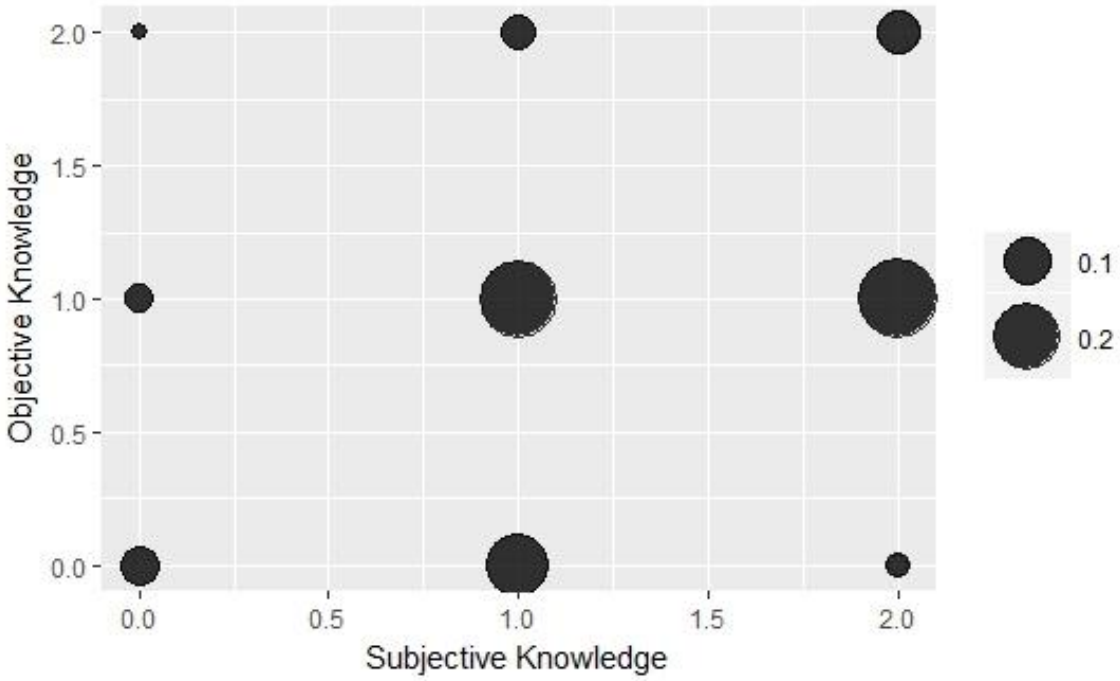

Fig. 5 Comparison of subjective knowledge and objective knowledge

Table 2

Mixed effect model

	Dependent variable:					
	WTP of non-GMO labeling products -WTP of products without non-GMO labeling					
	Zucchini	Milk	Beef	Canola Oil	Cotton balls	Yogurt
Intercept	0.318***	0.507***	0.806***	0.365*	0.348**	0.411***
Female	-0.041	0.016	0.150	0.050	-0.076	0.015
Age	-0.003	-0.002	-0.008	-0.001	0.000	-0.002
Education	0.071	0.111	0.260	0.160	0.075	0.066
Marital Status	0.086	0.000	0.232	-0.069	-0.011	-0.001
Child	-0.06	-0.096	-0.167	-0.008	-0.050	-0.100
Income	0.037	-0.037	0.027	-0.014	-0.031	0.010
Risk attitude	0.011	-0.032	0.046	0.080	-0.032	-0.023
Health concern	0.185***	0.340***	0.586***	0.336***	0.26***	0.267***
FOX news	-0.101***	-0.212***	-0.421***	-0.123**	-0.118***	-0.107***
NBC news	-0.025	-0.020	-0.01	-0.015	-0.013	-0.015

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

Table 3
Fixed effect model (before information treatment only)

	Dependent variable: WTP for Non-GMO labeled products-WTP for products without GMO labeling						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
(Intercept)	0.142**	0.172***	-0.020	-0.003	0.003	0.049	0.038
Health concern	0.304***	0.307***	0.311***	0.297***	0.289***	0.277***	0.279***
Knowledge	-0.063***	-0.080	0.053*	0.043	0.040	0.041	0.054*
Political ideology	0.139***	-0.091	-0.037	-0.073	-0.068	-0.046	-0.012
Knowledge*Political ideology		0.151**	0.188**	0.208***	0.207***	0.201***	0.179**
Risk attitude			0.003	0.002	-0.008	-0.024*	-0.025*
Female				0.042	0.036	0.023	-0.016
Age				-0.004**	-0.004**	-0.004**	-0.003**
Education				0.106**	0.112**	0.099*	0.112**
Child				-0.050	-0.076	-0.061	-0.182**
Marital status				0.099	0.090	-0.001	-0.001
Income				-0.019	-0.021	-0.095*	-0.084
Risk attitude*Child					0.067***	0.056**	0.043*
Marital status*Income						0.150*	0.127
Risk attitude*Marital status						0.032*	0.035**
Female*Child							0.225**
Zucchini	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Milk	0.118**	0.118**	0.118**	0.118**	0.118**	0.118**	0.118**
Beef	0.361***	0.361***	0.361***	0.361***	0.361***	0.361***	0.361***
Canola oil	0.099*	0.099*	0.099*	0.099*	0.099*	0.099*	0.099*
Yogurt	0.020	0.020	0.020	0.020	0.020	0.020	0.020

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

Table 4
Fixed effect model

	Dependent variable: price premium for non-GMO products after information- price premium for non-GMO products before information						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
(Intercept)	-0.068	-0.017	-0.005	-0.037	-0.020	0.025	0.020
NBC news	0.154***	0.157***	0.150***	0.193***	0.165***	0.160***	0.146***
Trust		-0.012	-0.008	-0.002	-0.006	-0.012	-0.010
Health concern		-0.035	-0.035	-0.045	-0.043	-0.046	-0.037
Knowledge		0.003	-0.030	-0.037	-0.038	-0.046	-0.042
Political Ideology		-0.003	-0.187*	-0.138	-0.149	-0.143	-0.130
Knowledge*Political ideology			0.196**	0.264***	0.275***	0.280***	0.269***
NBC * Political ideology				-0.242**	-0.243**	-0.245**	-0.234**
NBC*Risk attitude					0.033*	0.047**	0.048**
Risk attitude					-0.005	0.026	0.023
Female						-0.033	-0.037
Age							0.001
Education							-0.041
Child							-0.017
Marital Status							-0.020
Income							-0.064
Risk attitude*Female						-0.044*	-0.043
Zucchini	-0.067	-0.067	-0.067	-0.067	-0.067	-0.067	-0.067
Milk	-0.135**	-0.135**	-0.135**	-0.135*	-0.135**	-0.135**	-0.135**
Beef	-0.251***	-0.251***	-0.251***	-0.251***	-0.251***	-0.251***	-0.251***
Canola oil	-0.079	-0.079	-0.079	-0.079	-0.079	-0.079	-0.079
Yogurt	-0.071	-0.071	-0.071	-0.071	-0.071	-0.071	-0.071

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

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