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Consumer Knowledge, Perception and Acceptance of GMOs

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In the United States, only a few states have voted to label foods containing genetically modified organisms (GMO): Connecticut, Maine and Vermont. Only Vermont has implemented their mandate, with the other states waiting for participation by larger agriculture producing states. This summer, however, President Obama signed into law a federal mandate requiring all GM foods to be labeled. Importantly, companies can choose to use a text label, a toll-free phone number or a digital label such as a QR code. As a result, within 2 years all foods will be required to identify if they contain GMOs.

While food producers have been largely against the provision of GMO labels, citing the potential for misleading consumers and additional costs, moving forward with the federal mandate it is important for them to understand more about consumer preferences for GMO labels. Noussair et al (2002) found that consumers in France were not aware of GMO labels on products they observed in an experimental auction. When they were made aware of the labels, however, their willingness to pay declined by 30%. In a meta-analysis, Lusk et al (2004) found that consumer had a higher valuation for non-GM foods. At the same time, a large share of the variation of the estimated willingness to pay for GM foods, they found, is explained by consumer characteristics, the characteristics of the food being valued and methodology used. The primary objective of this paper is to further analyze what types of consumers are in favor of GMO labels and how might these characteristics be relevant to food producers.

To this end, we collect data of 1200 consumers in the state of Connecticut, where GMO labeling has already been approved. We then examine what types of consumers are more likely to be in favor, against or indifferent to GMO labels. To add to this analysis, we examine differences across 3 product categories food, plants and turfgrass. Importantly, we expect different preferences for products that are consumed directly versus those that are used for other purposes (Bovay and Alston 2016). We also assess consumer trust in different sources of information regarding GMOs, their perception and knowledge of GMOs as well as a variety of demographic differences.

Our results indicate that a large majority of respondents want GMO labeling, but there is a sizeable segment that is indifferent to labeling. Concerns for health issues related to GMOs and interest in technological advancement significantly influence consumer preferences. In addition, trust in sources of information on GMOs play an important role in consumer preferences for GMO labels. It may be important for industry marketing to invest in informational efforts regarding GMOs and health safety as well as technological advancement. As the federal mandate allows for providing more information than just a simple logo, there could be some potential advantages to providing consumers with more information regarding GMO products.

Data and Methods

During the summer and fall of 2016 we implemented an online survey to better understand consumer preferences for GMO labeling. Utilizing a sample from Global

Market Insite, Inc. (GMI), panelists within the GMI sample were randomly invited to participate in the survey. They were then asked whether they thought 3 different product categories (food, plants, turfgrass) should be labeled as GMO. Labeling of food is important given consumer concerns for GMOs and their health. Plants provide food (e.g. garden vegetables) or are used to decorate (e.g. ornamentals) and are indirectly consumed. Turfgrass provides a different type of household utility than food or plants. Further, there is the expectation of GMO turfgrass introduction into the market in the near future.

Panelists were then asked to rank their perceived GMO knowledge level on a 0-100 point scale (0="not at all knowledgeable" and 100="extremely knowledgeable"). After rating their own knowledge, respondents were asked to rate the knowledge level of other entities, including scientists and the federal government. Respondents were then asked to rate their trust in environmental information provided by various sources on a 0-100 point scale (0="not accurate at all" and 100="extremely accurate"). Finally, respondents were asked to rate on a 0-100 point scale (0="strongly disagree" and 100="strongly agree") whether they agreed/disagreed that a listed statement (e.g., contains DNA from another organism, increased chance of long term health issues, step forward for agricultural technology) was characteristics of a GMO in general. We collected demographic data of the respondents as well.

For a variety of reasons only respondents from the state of Connecticut (CT) were included in the sample. Notably, the sample was limited to CT based on funding agency requirements. However, CT offers an interesting market to examine GMO labeling given CT was the first state to pass a GMO labeling law (CT General

Assembly, 2013). Even though the law has since been nullified by a federal labeling requirement passed in 2016 (Radelat, 2016), CT is still at the forefront of GMO labeling.

Optimally, we would compare our sample to census estimates at the state level to statistically assess representativeness, but standard errors are not provided for the census estimates. Simply looking at the sample data provide some insight into the representativeness of our sample (Table 1). The median household income in CT is \$70,000 (U.S. Census Bureau, 2011), which is comparable to our sample median income of \$73,129. With respect to age, the CT population median age is 40 years (U.S. Census Bureau, 2015), which is slightly younger than our sample's median age of 45. Eighty-one percent of our sample was Caucasian which is similar to the CT population make-up of 80.8% (U.S. Census Bureau, 2011). Our sample oversamples women relative to CT. However, women are shown to be the majority shopping group (Zepeda, 2009; Flagg et al., 2013; Wolfe, 2013) thus providing us more detail on household purchasing habits.

We analyzed our survey response data using a multinomial logit (MNL) model to identify the drivers that potentially lead to a respondent supporting/not supporting GMO labeling. Following Greene (2003, p. 721), the MNL model probability is specified as:

$$Prob(S_i = j) = \frac{e^{\beta'_j X_i}}{\sum_{k=1}^3 e^{\beta'_j X_i}} \quad \text{where } j = 1, 2, 3 \tag{1}$$

where $Prob(S_i=j)$ represents participant i's probability of being in category j, k_i are demographic, knowledge, informational trust, and perceived characteristic variables, and β_i is a vector of model parameters. We evaluated correlation between the

explanatory variables but found it was not statistically important. We calculated marginal effects from the estimated model parameters. Marginal effects of continuous variables are interpreted as the percent change in category membership given a one-unit change from the mean variable of interest. The marginal effects for categorical variables are interpreted as the percent change category membership given a move from the base category.

Results and Discussion

When respondents were asked how knowledgeable they were about GMOs, on average they viewed themselves as moderately knowledgeable (Table 2). However, respondents viewed the federal government significantly more knowledgeable and scientists the most knowledgeable.

With respect to trusting sources of environmental information, a university was considered the most accurate followed by non-profits and environmental activists (Table 2). The federal government was perceived as being moderately accurate in providing information, whereas, industry associations and mass merchandisers were perceived as the least accurate. Of interest, environmental activists were viewed as providing more accurate environmental information than industry associations.

Respondents were split on whether GMOs are a step forward for agricultural technology (Table 3). On average, respondents neither agreed nor disagreed that GMOs were an agricultural technological advancement (rating 49.6). Delving more into this variable provided some interesting results. First, the median rating was 51

implying a major split between respondents' views. Furthermore, approximately 25% of respondents were below 30 (disagree spectrum of scale) while 25% were above 67 (agree spectrum of scale). Based on these results there is quite a degree of heterogeneity within consumers. As for long term health issues, respondents leaned more toward believing GMOs would increase long term health issues (average rating 61.7). The median for health issues was 60. Finally, respondents by and large agreed (average rating of 65.1) with the statement that GMOs contain DNA from another organism. The median rating was 64.

In general, we find that respondents have varied knowledge of GMOs, perceive information sources differently, and perceive GMOs differently. However, when it comes to labeling, respondents were overwhelmingly in favor of GMO labeling regardless of product type. Specifically, 82%, 80%, and 76% of respondents were in favor of GMO labeling for food, plants, and turfgrass, respectively (Table 4). Only a small percentage were not in favor with 10-20% indifferent.

Multinomial Logit Marginal Effects: Food

Based on our analysis we find that demographics play a role in driving the labeling decision (Table 5). Older consumers were more likely to want GMO labeling for food, although this effect was small: a10 year increase in the mean age (45 to 55) would result in a 1% increase in the likelihood a respondent would want GMO labeling. Respondents identifying themselves as republicans and independent were 8.4% and 5.2% less likely than democrats to want GMO food labeled.

For each rating point above the mean perception that GMOs are a step forward for agricultural technology, the respondent was 0.2% less likely to want GMO food labeled. However, as respondents' increasingly perceived GMOs as increasing long term health risks they were more likely to want GMO labeling. Furthermore, as respondents perceived the federal government as providing accurate environmental information they were less likely to want GMO food labeling.

In contrast, an increasing belief that the federal government provides accurate information resulted in an increased likelihood that a respondent would want no GMO food labeling (Table 5). For every one-unit increase in the mean rating for accuracy of information provided by the federal government, a respondent was 0.1% more likely to want no GMO food labeling. Furthermore, an increased perception that GMOs cause increased long-term health issues resulted in a respondent being less likely to be in the no label group.

As noted in Table 4, almost 14% of respondents were indifferent to GMO food labeling. Respondents that considered themselves politically independent were 5% more likely to be indifferent on GMO food labeling (Table 5). Increasing health issues resulted in a respondent being less likely to be indifferent, while perceiving GMO as a step forward for agricultural technology increased a respondents' likelihood of being indifferent. Finally, perceiving the federal government as being accurate was a positive indicator of being indifferent to GMO food labeling.

Results from the MNL GMO food labeling model provided some interesting results. Notably, respondents that viewed the federal government as providing accurate information were more likely to be indifferent or prefer no labeling.

Further, whether the respondent perceived GMOs as a health issue in the long term (negative) or a scientific break-through for agriculture (positive) played a role in whether labeling was preferred or not.

Multinomial Logit Marginal Effects: Plants

Compared to the food model above, the MNL plants model had more significant demographics and a similar number of environmental source and GMO perception variables being significant. Similar to the food model, older consumers were more likely to want GMO plant labeling. However, Caucasians and males were less likely to prefer labeling. Caucasians and males were 5.1% and 5.1% less likely to want GMO plant labeling. Republicans and other political affiliations compared to democrats with republicans being 6.7% less likely to want GMO plant labeling. Furthermore, as household income increases, respondents would be less likely to want labeling.

In contrast to the foods model, the more a respondent viewed the federal government as having knowledge about GMOs, the more likely they were to want GMO plants labeled. However, as trust in information provided by the federal government increased, a respondent was likely to want plants labeled as GMO. Furthermore, respondents viewing GMOs as a potential health risk were apt to want plant GMO labeling, while respondents viewing it as a technological advancement were less likely.

With respect to respondents not wanting GMO plant labeling, younger consumers were more likely to not want labels. Respondents viewing GMOs as a

technological advancement were less likely to want labeling, while increased trust in industry associations and the federal government are predisposed to not want labeling.

Younger respondents, males, and Caucasians were more likely to be indifferent to GMO plant labeling. As a respondent's perception of the federal government's knowledge about GMOs increases, they were less likely to be indifferent on labeling. In contrast, as trust in environmental information by the federal government increases, they were more likely to be indifferent about labeling. For every unit increase in rating that GMOs cause long term health issues a respondent was 0.2% less likely to be indifferent. Yet a rating increase of one unit for technological advancement would result in a 0.2% increase in being indifferent.

Multinomial Logit Marginal Effects: Turfgrass

Similar to the foods model, demographics seemed to play only a small role in a respondent wanting GMO turfgrass labeling. Republicans were 10% less likely to want GMO turfgrass labeling compared to democrats. However, as household income increased, respondents were less likely to want labeling. The income result is different from the food model (no significance) but similar to that of the plants model. The most likely reason for income to be significant for the non-food models is that plants and turfgrass are luxury goods and higher incomes might see GMO labeling as meaning higher prices or increased burden to find non-GMO products.

In contrast to the other models, we find that GMO knowledge by the federal government variable is insignificant. However, respondents perceiving GMOs as

containing DNA from another organism (accurate definition) are more likely to want labeling as are respondents that perceive long term health issues. However, respondents perceiving GMOs as a technological advancement would be less likely. Increased trust in environmental information provided by the federal government would decrease the likelihood that a respondent would want GMO turfgrass labeling.

As with the food and plant models, long term health perceptions (negative) and trust in information provided by the federal government (positive) are significant indicators of not wanting GMO turfgrass labeling. However, trust in university information is significant as well. As trust in environmental information by universities increases, a respondent is less likely to be in the "no" GMO turfgrass labeling category.

With respect to indifference to labeling, our results match the food and plant models. Perceived health risk provides a negative impact on being indifferent, while perceiving GMO as a technological advancement and being more trusting of environmental information provided by the federal government are positive indicators of being indifferent to GMO turfgrass labeling.

Conclusions

The goal of this paper was to examine attitudes and drivers of GMO labeling for food and non-food (plants and turfgrass) products. Overall, we find that a large majority (75-82%) of respondents want GMO labeling. However, there is a sizeable segment that is indifferent to labeling. We also find that long-term health issues is a concern for many respondents, thereby, most likely driving up the number of

respondents wanting GMO labeling. As for knowledge, scientists are considered the most knowledgeable, followed by the federal government, and then the respondent themselves.

Perhaps the biggest contribution of this paper is that perceptions and trust in information source are seem to be larger drivers in the labeling decision with demographics only playing a small role. The federal government is seemingly a key indicator to whether a respondent wanted labeling or not. Even though scientists rated higher in terms of knowledge about GMOs and universities were the most trusted provider of environmental information, the trust in environmental information provided by the federal government was a key indicator in the labeling decision. Notably, increased trust in federal government environmental information resulted in a respondent being less likely to want GMO labeling for food and nonfood products. This is an interesting insight as the federal government seems to have no true GMO stance other than the recent labeling law that was passed. The federal government stance on environmental issues is complex.

The findings of this study suggest that consumers want GMO labeling. Since mandatory labeling is impending, opponents of GMO labeling could make gains by focusing on the informational efforts that no evidence of health issues has been found. Further, messaging should focus on GMOs being a technological advancement. Other messaging should look to increase trust in environmental information provided by the federal government. Proponents of GMO labeling should focus on the health issue and by encouraging more research to examine the health aspects of GMOs. Proponents should also look to shape the federal

government's message on environmental issues as this perception is a key driver for respondents not wanting or being indifferent to labeling.

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Tables

sample.		
		Std.
	Mean	Dev.
Age (median)	45.0	
Ethnicity: Caucasian	81.1%	39.1%
Gender: Male	26.6%	44.2%
Political party		
Democrat	29.8%	45.7%
Republican	21.8%	41.3%
Independent	38.1%	48.6%
Other Political (not		
Democrat)	10.3%	30.4%
Urbanicity		
Rural	23.5%	42.4%
Suburban	63.8%	48.1%
Urban	12.7%	33.3%
# household adults	2.3	1.1
# household children	0.5	0.9
Household income		
(median)	\$73,129	
Education		
High school diploma or		
less	20.4%	40.3%
Some college/2 year	34.7%	47.6%
Bachelor's degree	26.8%	44.3%
Graduate degree	18.1%	38.6%

Table 1. Demographics of the surveysample.

Perceived knowledge of GMO		
	Mean	Significance
Respondent	46.5	С
Scientists	74.6	А
Federal Government	53.9	В
Trust of environmental information source	Maan	Significance
TT • •.	Mean	Significance
University	68.2	A
Industry associations	44.5	D
Federal government	46.2	С
Non-profit	61.9	В
Mass merchandiser	43.0	D
Environmental activist group	63.1	В

Table 2. Respondent perceived knowledge and information source trust.

Note: categories with the same letter are not significantly different at the 0.1 level.

Note: responses were on a 0-100 point line scale. For knowledge 0 = not at all knowledgeable and 100 = extremely knowledgeable. For information source, 0 = not accurate at all and 100 = extremely accurate.

Table 3. Perceptions of GMO.

	Mean	Std. Dev.
Contains DNA from another organism	65.1	25.5
Increased chance of long term health issues	61.7	30.2
Step forward for agricultural technology	49.6	27.3

Note: scale used was a 0-100 point line scale where 0 = strongly disagree and 100 = strongly agree.

	Food	Plants	Turfgrass
Yes	82.2%	80.3%	75.9%
No	4.1%	4.4%	6.0%
Indifferent	13.7%	15.3%	18.1%
Observations	1,243	1,240	1,244

Table 4. Should GMO products be labeled?

	Yes		No		Indifferent			
				p-		p-		
	Coeff.	p-value	Coeff.	value	Coeff.	value		
Age	0.001	0.062	-0.000	0.280	-0.001	0.113		
Ethnicity: Caucasian	0.024	0.459	-0.030	0.106	0.006	0.800		
Gender: Male	-0.009	0.661	0.006	0.418	0.003	0.880		
Political party								
Republican	-0.084	0.036	0.036	0.107	0.049	0.155		
Independent	-0.052	0.065	0.002	0.833	0.050	0.056		
Other Political (not								
Democrat)	-0.049	0.343	0.007	0.644	0.042	0.395		
Urbanicity								
Suburban	-0.029	0.215	0.003	0.758	0.026	0.221		
Urban	0.002	0.962	-0.002	0.890	-0.000	0.997		
# household adults	0.006	0.567	0.006	0.080	-0.012	0.247		
# household children	0.013	0.276	-0.001	0.824	-0.012	0.275		
Household income	-0.000	0.355	-0.000	0.710	0.000	0.265		
Education								
Some college/2 year	0.026	0.317	-0.011	0.195	-0.014	0.544		
Bachelor's degree	0.038	0.122	-0.002	0.839	-0.037	0.104		
Graduate degree	0.028	0.302	0.000	0.990	-0.028	0.240		
GMO knowledge perception								
Respondent	0.000	0.694	0.000	0.141	-0.000	0.304		
Scientists	0.000	0.408	-0.000	0.872	-0.000	0.398		
Federal Government	0.001	0.205	-0.000	0.337	-0.000	0.320		
GMO perception								
Contains DNA from								
another organism	0.001	0.092	-0.000	0.314	-0.000	0.161		
Increased chance of long								
term health issues	0.003	0.000	-0.001	0.000	-0.002	0.000		
Step forward for								
agricultural technology	-0.002	0.000	0.000	0.598	0.002	0.000		
Environmental information pro	ovider tru	st						
University	0.001	0.156	-0.000	0.110	-0.000	0.363		
Industry associations	-0.001	0.146	0.000	0.110	0.000	0.367		
Federal government	-0.001	0.003	0.001	0.029	0.001	0.013		
Non-profit	-0.000	0.593	0.000	0.340	0.000	0.892		
Mass merchandiser	0.000	0.268	-0.000	0.246	-0.000	0.469		
Environmental activist								
group	0.001	0.127	-0.000	0.872	-0.000	0.110		
Log pseudolikelihood			-378.	23				
Prob>Chi2	0.000							
Pseudo R2	19.99%							

Table 5. Marginal effects for GMO food labeling model.

	Ye	es	N	No		Indifferent	
	р-		p-				
	Coeff.	value	Coeff.	value	Coeff.	p-value	
Age	0.002	0.008	-0.001	0.073	-0.001	0.024	
Ethnicity: Caucasian	-0.051	0.037	-0.000	0.946	0.051	0.025	
Gender: Male	-0.051	0.053	0.007	0.290	0.043	0.079	
Political party							
Republican	-0.067	0.085	0.020	0.156	0.048	0.186	
Independent	-0.047	0.107	0.002	0.754	0.045	0.108	
Other Political (not Democrat)	-0.135	0.038	0.034	0.236	0.101	0.090	
Urbanicity							
Suburban	-0.040	0.106	0.016	0.023	0.024	0.306	
Urban	0.015	0.659	-0.002	0.858	-0.014	0.682	
# household adults	0.009	0.385	0.002	0.434	-0.011	0.286	
# household children	0.011	0.315	-0.003	0.422	-0.009	0.410	
Household income	-0.001	0.012	0.000	0.846	0.001	0.011	
Education							
Some college/2 year	0.031	0.245	-0.005	0.534	-0.026	0.291	
Bachelor's degree	0.040	0.141	0.011	0.341	-0.051	0.033	
Graduate degree	0.021	0.483	0.005	0.674	-0.027	0.326	
GMO knowledge perception							
Respondent	0.000	0.801	0.000	0.116	-0.000	0.450	
Scientists	0.001	0.185	-0.000	0.346	-0.000	0.259	
Federal Government	0.001	0.039	-0.000	0.387	-0.001	0.056	
GMO perception							
Contains DNA from another							
organism	0.001	0.048	-0.000	0.223	-0.001	0.081	
Increased chance of long term							
health issues	0.002	0.000	-0.001	0.000	-0.002	0.000	
Step forward for agricultural							
technology	-0.002	0.000	0.000	0.666	0.002	0.000	
Environmental information prov	vider trust						
University	0.000	0.298	-0.000	0.120	-0.000	0.537	
Industry associations	-0.000	0.757	0.001	0.067	-0.000	0.740	
Federal government	-0.002	0.000	0.001	0.004	0.001	0.001	
Non-profit	0.000	0.768	0.000	0.808	-0.000	0.695	
Mass merchandiser	0.001	0.124	-0.000	0.679	-0.001	0.127	
Environmental activist group	0.000	0.775	-0.000	0.872	-0.000	0.799	
Log pseudolikelihood			-39	6.73			
Prob>Chi2			0.	000			
Pseudo R2			21.	11%			

Table 6. Marginal effects for GMO plants labeling model.

<u> </u>	Yes		No		Indifferent		
	p-		р-			p-	
	Coeff.	value	Coeff.	value	Coeff.	value	
Age	0.001	0.122	-0.000	0.312	-0.001	0.199	
Ethnicity: Caucasian	-0.033	0.359	-0.006	0.689	0.039	0.229	
Gender: Male	-0.046	0.141	0.006	0.606	0.040	0.166	
Political party							
Republican	-0.100	0.034	0.038	0.092	0.062	0.145	
Independent	-0.058	0.104	0.003	0.831	0.055	0.098	
Other Political (not Democrat)	-0.071	0.265	0.008	0.729	0.063	0.295	
Urbanicity							
Suburban	-0.028	0.400	0.018	0.142	0.009	0.759	
Urban	0.001	0.988	0.032	0.311	-0.032	0.402	
# household adults	0.003	0.821	0.007	0.137	-0.010	0.440	
# household children	0.014	0.331	-0.004	0.543	-0.011	0.422	
Household income	-0.001	0.080	0.000	0.136	0.000	0.192	
Education							
Some college/2 year	0.006	0.880	-0.017	0.161	0.011	0.752	
Bachelor's degree	0.040	0.288	-0.010	0.398	-0.031	0.392	
Graduate degree	0.029	0.494	-0.014	0.232	-0.016	0.700	
GMO knowledge perception							
Respondent	0.000	0.438	0.000	0.198	-0.001	0.160	
Scientists	0.000	0.483	0.000	0.910	-0.000	0.408	
Federal Government	0.001	0.248	-0.000	0.836	-0.001	0.240	
GMO perception							
Contains DNA from another							
organism	0.001	0.044	-0.000	0.114	-0.001	0.128	
Increased chance of long term							
health issues	0.003	0.000	-0.001	0.000	-0.002	0.000	
Step forward for agricultural							
technology	-0.002	0.000	0.000	0.437	0.002	0.000	
Environmental information provider	r trust						
University	0.000	0.455	-0.001	0.071	-0.000	0.910	
Industry associations	-0.000	0.751	0.000	0.108	-0.000	0.673	
Federal government	-0.002	0.000	0.001	0.017	0.001	0.003	
Non-profit	0.000	0.623	0.000	0.957	-0.000	0.581	
Mass merchandiser	0.001	0.298	0.000	0.795	-0.001	0.211	
Environmental activist group	0.000	0.569	-0.000	0.381	-0.000	0.780	
Log pseudolikelihood	-492.18						
Prob>Chi2	0.000						
Pseudo R2	15.37%						