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A randomized group approach to identifying label effects

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ABSTRACT

Motivated by the National Bioengineered Food Disclosure Standard (NBFDS), which requires companies to label bioengineered food products, this paper examines the choice effects of using a symbol approved by the standard relative to using text to disclose that a food product has bioengineered contents. Choice effects were determined using a randomized group design that assigned respondents to one-of-two labeled choice experiment groups. One group selected products that used the symbol disclosure and the other group selected products using text disclosure. Besides a label, the price was the only attribute displayed to respondents during the choice experiment and varied at three levels. The same price levels were used for all labels, and prices were balanced within a label, and balanced and orthogonal across labels. This randomized design using a discrete choice experiment allows for the identification of group effects, which in this paper are the choice effects associated with the form of bioengineering disclosure.

1. Introduction

Hypothetical discrete choice experiments (DCEs) in food research often measure consumer preferences for products or attributes, or consumer reaction to a policy intervention like a labeling program (Lizin et al., 2022; Caputo and Scarpa, 2022). Hypothetical choice studies can provide preliminary evidence about products or attributes before revealed preference data are available; for example, consumer acceptance of emerging food technologies (McFadden et al., 2021) or demand for potential sustainable food packaging (Boccia and Sarnacchiaro, 2020). Typically, the data from these studies are used to estimate market shares, willingness to pay (WTP), or changes in consumer welfare.

Critiques of DCEs typically stem from possible biases and heuristics associated with respondents making simulated purchasing decisions (Lizin et al., 2022; Caputo and Scarpa, 2022). For example, respondents may rely on alternative decision rules to reduce cognitive effort or are context dependent resulting in choices made in a DCE that do not reflect behavior outside the simulated setting (Chorus, 2014). Non-binding DCEs increase the likelihood of biased behavior, like hypothetical bias (List and Gallet, 2001) and social desirability bias (Larson, 2019), because there is no consequentiality for the choices made by respondents. While there are methods to reduce or control for the effects associated with biases and heuristics in DCEs (Lizin et al., 2022; Caputo and Scarpa, 2022), it is

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essentially impossible to identify the influence of all the potential alternative decision rules that may cause divergence in choices made in a simulated setting and actual market behavior (Chorus, 2014).

It is argued that randomized control trials (RCTs) are the most rigorous approach to identifying causal effects (Sibbald and Roland, 1998; Hariton and Locascio, 2018), and the use of RCTs, or at least group randomization, has become increasingly popular in economics (Banerjee et al., 2016) and social sciences in general (Cunningham, 2021). A powerful contribution of group randomization in identifying an average effect is the theoretical removal of unobservable effects like biases and heuristics (Gangl, 2010). Randomized DCEs have also been used in previous food preference research; for example, to evaluate the impacts of text versus labels on food packaging (DeLong et al., 2021) and to identify the updates to the Nutrition Facts Label on the selection of sugar-sweetened beverages (Neuhofer et al., 2020). Group randomization has also been used with best-worst scaling to identify the effects of text versus images on consumer preference for tomatoes (Bir et al., 2022).

The objective of the DCEs using group randomization in this study was to examine the effects of disclosure methods (i.e., symbol vs text) allowed by the National Bioengineered Food Disclosure Standard (NBFDS) on the selection of food products. Respondents were randomized to a group that either made choices for products displaying a symbol disclosure or test disclosure. The DCEs used a fractional factorial orthogonal design so that the product labels and prices were uncorrelated and balanced. Together, this design provides a randomized approach to conducting DCEs so that group effects for selected choice options can be identified while theoretically controlling for the unobserved component of utility. Discerning how choice varies by disclosure methods, via group effects, is important for government agencies, food companies, and those interested in mandatory labeling of food where bioengineering material may be detected.

2. Background on the National Bioengineered Food Disclosure Standard (NBFDS)

The NBFDS, a rule by the Agricultural Marketing Service, ordered that some foods containing certain ingredients from bioengineered (BE) crops be labeled in the U.S. by January 1, 2022 (AMS, 2018). There is a clear divergence between the public and experts in formed risk perceptions of BE food (Sjöberg, 2008). Bioengineering techniques are complex and consumers without expertise may default to what is perceived as familiar or information that is cognitively available when forming risk perceptions (Wang et al., 2011; Slovic et al., 1980).

While the NBFDS seeks to "provide a mandatory uniform national standard for disclosure" (AMS, 2018), the standard allows foods defined as BE to be disclosed by several methods including an approved symbol or text. There may be heterogeneity in consumer response to the disclosure option used by food companies. Some proponents of mandatory labeling are concerned that the approved symbol causes a halo effect compared to other forms of disclosure. The halo effect (Thorndike, 1920) is used in psychology to describe individuals' tendency to allow positive perceptions about an attribute to subconsciously influence perceptions about other attributes (Nisbett and Wilson, 1977; Forgas and Laham, 2016). The Organic Trade Association stated, "The stylized GMO symbol with a four-pointed starburst does not reflect a neutral symbol as Congress intended and is misleading. It could convey that GM foods are safer than non-GM foods, which is prohibited by the statute." (OTA, 2018). Thus, the concern is that the approved symbol causes positive perceptions about BE products leading consumers to make purchasing decisions that would not have been made if another form of disclosure, like text, was used.

Another contention around NBFDS is how BE food was defined because the Agricultural Marketing Service did not define a scope of genetic engineering techniques that would trigger mandatory labeling (e.g., genetic modification, gene editing, etc.). With the advent of gene editing, gene-edited (GnEd) traits may be 'stacked' with genetically modified (GM) traits. Stacking of traits already occurs with multiple GM traits. Currently, it is unclear whether various competing claims of BE, GM, and GnEd might be viewed as substitutes or complements by consumers. A product labeled "BE and GM" might seem redundant as the former label implies the latter. However, Wilson and Lusk (2020) studied consumer demand for redundant food claims on non-GMO sea salt and gluten-free orange juice; they found that many consumers were willing to pay premiums for redundantly labeled products.

3. Methodology

This study was approved by the [*masked for review*] and data were collected from an online panel of respondents maintained by Qualtrics. The online survey was fielded to 1 331 respondents in February of 2021 using quota-based sampling to match the U.S. population across age, education, gender, and income. The panel provider restricted mobile responses due to the number of choice options in the DCEs; a more detailed description of the DCE is provided below.

3.1. Survey questions and design

The survey questions asked to respondents can be separated into three categories: consumer interaction with the labeling of genetically engineered food, choice experiments, and socio-demographics. More details about these questions are provided in the subsections below.

3.1.1. Choice experiment and randomized group design

Respondents completed labeled choice experiments for two products, one for avocado and one for a 48-ounce bottle of vegetable oil because previous research has indicated that discounts applied to GM products vary by level of processing. Typically, discounts are lower for processed foods compared to whole foods (Lusk et al., 2015; Kalaitzandonakes et al., 2018); thus, we decided to use vegetable oil as the processed food and avocado as the whole food. Additionally, soybean oil with improved fatty acid composition has been developed using gene editing and is currently on the market (Calxyt, 2019). Some GnEd and GM applications target traits like reducing browning of produce and extending shelf-life (Shipman et al., 2021). An 'Always Green Avocado' has been used as a hypothetical product in a previous consumer study examining perceptions about GM food (Burger, 2019).

Choice options within a choice set varied by label and price. Labels represented the descriptions of genetic techniques and the possible combinations of descriptions (i.e., BE, GnEd, GM, BE/GnEd, BE/GnEd/GM, BE/GM, GnEd/GM), and respondents were also provided a choice option without a label (no-label). Thus, there were nine choice options with an accompanied price in each choice set. An option not to choose any of the products shown was also provided (would not purchase). Product prices were chosen to be representative of market prices, at the time of study design, and to provide meaningful variation across choice options. Avocado prices varied from $1, $2, and $3, and vegetable oil prices varied from $2, $4, and $6.

Due to the research question resulting in nine choice options and the decision to use three price levels, a total of 27 choice sets were required to achieve a fractional factorial design that was both balanced and orthogonal. That is price levels were balanced within a choice option and across all choice options, and prices were not correlated across the choice options. Labeled choice experiments can cause attribute levels to be correlated with choice options, which violates the independent and identically distributed (IID) assumption (Hensher et al. 2015). This is not a concern in this study because of the balanced orthogonal design used for the price attribute, the only attribute. To reduce respondent fatigue, the 27 choice sets were evenly split into three blocks so that each respondent was randomized to a block of nine choice sets. The orthogonal coding used to assign prices across choice sets and the three blocks of choice sets used are shown in Appendix Table 1.

Before partaking in a choice experiment, respondents were randomly assigned to either the Symbol Group or Text Group. Respondents remained in the same group for both products. The Symbol Group was shown the approved 'Bioengineered' symbol for avocado and the approved 'Derived from Bioengineering' symbol for vegetable oil (AMS, *n.d.*) when making choices, while the Text Group was shown the text 'Bioengineered' and 'Derived from Bioengineering' when making choices. The labels used for the groups and definitions for the labels are presented in Table 1. To illustrate what respondents in the groups viewed when making choices, an example of an avocado choice set shown to both groups is presented in Fig. 1. An example for vegetable oil can be found in Appendix Fig. 1.

To minimize possible order effects, the avocado and vegetable oil choice experiments were randomized across respondents. As were the ordering of the nine choice sets and eight choice options within a choice set (the 'would not purchase' option was always presented on the far right). Also, the blocks of choice sets were randomized for each product so that while respondents remained in a group the price levels across choice options could vary. The number of respondents randomized to the three question blocks is shown by group in Appendix Table 2.

3.1.2. Moderating variables

While previous research has used choice experiments to determine preferences for GM food (presence label) and food explicitly labeled as non-GM (absence label) (McFadden and Lusk, 2018; Huffman et al., 2007), it is unclear how consumers perceive a food option with no label relative to a choice option disclosing the presence of genetically engineered material. It is plausible that some consumers assume food products without a presence disclosure contain genetically engineered material. It is also unclear whether the relatively new term, BE, used by the NBFDS is closely associated with GM. Respondents were asked several label behavior questions to provide insight into interpretations of BE and no-label products and about the likelihood of looking for a GM disclosure on food products.

Table 1
Definitions of labels used in the choice experiments.

Label	Definition
(Symbol Group for Avocados)	Bioengineered foods contain detectable genetic material that has been modified through *in vitro* recombinant deoxyribonucleic acid (rDNA) techniques and for which the modification could not otherwise be obtained through conventional breeding or found in nature.[a]
(Symbol Group for Vegetable Oil)	
Bioengineered (Text Group)	
Gene Editing (Symbol Group and Text Group)	A process that enables scientists to make changes to DNA by cutting the DNA at a specific spot. Then scientists can remove, add, or replace the DNA where it was cut.[b]
Genetically Modified (Symbol Group and Text Group)	A process that uses laboratory-based technologies to alter the DNA makeup of an organism. Genetic modification may involve adding a gene from one species to an organism from a different species to produce a desired trait.[c]

[a] Paraphrased from the U.S. Department of Agriculture, available at: https://www.ams.usda.gov/rules-regulations/be/faq/general.
[b] Paraphrased from the National Institutes of Health, available at: https://www.genome.gov/about-genomics/policy-issues/what-is-Genome-Editing.
[c] Paraphrased from the National Institutes of Health, available at: https://www.genome.gov/genetics-glossary/Genetic-Engineering.

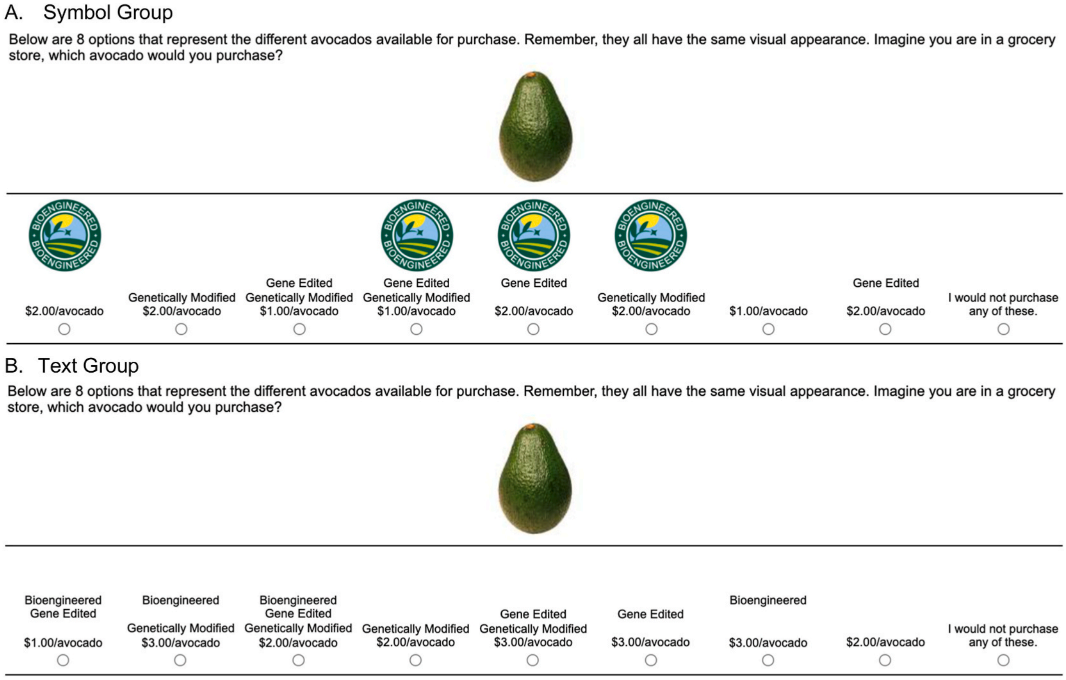

Fig. 1. Example choice sets for the symbol (Panel A) and text (Panel B) groups completed by respondents in the avocado choice experiment.

Table 2
Proportion of labels chosen by group.

Variables	Avocado Choice Frequency			Vegetable Oil Choice Frequency		
	Symbol Group	*Text Group*	*Group Diff (Symbol - Text)*	*Symbol Group*	*Text Group*	*Group Diff (Symbol - Text)*
BE	10.22%	7.66%	2.56%	9.54%	8.50%	1.04%
BE/GnEd	7.40%	5.86%	1.53%	8.22%	7.21%	1.00%
BE/GnEd/GM	7.53%	6.38%	1.15%	8.13%	6.11%	2.02%
BE/GM	7.55%	6.70%	0.85%	8.75%	5.81%	2.94%
GnEd	4.00%	5.40%	−1.40%	4.48%	5.85%	−1.36%
GnEd/GM	3.85%	4.68%	−0.83%	4.10%	4.86%	−0.76%
GM	4.97%	5.66%	−0.69%	5.72%	6.53%	−0.81%
No-label	29.95%	32.13%	−2.18%	25.28%	28.70%	−3.42%
Would not purchase	24.53%	25.52%	−0.99%	25.77%	26.42%	−0.65%
BECombined	32.70%	26.60%	6.09%	34.64%	27.64%	7.00%
GnEdCombined	22.77%	22.32%	0.45%	24.93%	24.04%	0.90%
GMCombined	23.90%	23.42%	0.47%	26.71%	23.32%	3.39%
n	6 003	5 976		6 003	5 976	
# of respondents	667	664		667	664	

Before the choice experiments, we asked questions to assess perceptions of the BE symbol and the association between BE and genetic techniques. Respondents were asked if they believed there were differences between a product with the BE symbol and a no-label product, and if there were differences between products with the BE symbol and a GM label. Changes in default options can affect preferences; for example, a mandatory label about the presence of GMOs may generate a higher value associated with avoiding GMOs compared to voluntary labels communicating the absence of GMOs (Costanigro and Lusk 2014). Response options provided were: 1) there is a difference between the two options, and the difference is: (text box), 2) there is a difference between the two options, but I am unsure of what the difference is, and 3) there is not a difference. This allows us to understand if food labeled with the BE symbol or GM is perceived to be equivalent.

After the choice experiments, respondents were asked how they interpreted the no-label choice option in the avocado and vegetable oil DCEs. This question essentially measures whether some consumers assume all food is bioengineered, and it can be a reasonable

Table 3
Symbol effects across the *BECombined* models (reduced results).

Variable	Avocado Models						Vegetable Oil Models					
	BECombined$_1$		*BECombined*$_2$		*BECombined*$_3$		*BECombined*$_1$		*BECombined*$_2$		*BECombined*$_3$	
	Odds Ratio	Std. Error	Odds Ratio	Std. Error	Odds Ratio	Std. Error	Odds Ratio	Std. Error	Odds Ratio	Std. Error	Odds Ratio	Std. Error
Symbol Effect (β_{1-3})	1.238***	0.074	1.271***	0.071	1.286***	0.070	1.264***	0.072	1.285	0.069	1.292	0.067
Log pseudo likelihood	−15,593		−15,331		−15,151		−16,185		−15,960		−15,574	

Note: Estimates are from logistic regression models with 107,811 observations and standard errors were adjusted for 1 331 clusters. All estimation results for *BECombined*$_2$ and *BECombined*$_3$ are shown in Appendix Table 4.

assumption given that data were collected before the mandatory compliance date set by NBFDS. Research on improving DCEs has given focus to the importance of providing an opt-out option (Kontoleon and Yabe, 2003), but little attention has been given to how consumers perceive a default option. Response options were: 1) the product contained genetically engineered material but was not labeled, 2) the product did not contain genetically engineered material, 3) other: (text box), and 4) I don't know. Asking how respondents perceived the no-label option may provide insight into differences in preferences, as the no-label choice option is typically considered a default choice option that is mutually exclusive from the other choice options.

Respondents were then asked several questions to measure the potential salience of disclosure information. Specifically, respondents were asked how often they search for disclosure information or scan a QR code on food products, and how likely they were to look for labels indicating a food is GM on the front or back of a product or scan a QR code. Nutrition labeling literature has concluded that front-of-packaging labels typically attract more attention than the back of a package (Dumoitier et al., 2019), and labeling research has shown that consumers are unlikely to scan a QR code (Li and Messer 2019; McFadden and Lusk 2018).

Socio-demographic data collected include age, gender, income, education, employment status, residency region and density, race and ethnicity, political affiliation, religion, past agricultural work experience, and subjective agricultural knowledge. Mean responses for the label behavior and socio-demographic variables are shown in Appendix Table 3. These summary statistics are displayed separately for the Symbol Group and Text Group, and there was not an overall difference between the groups across the label behavior and socio-demographic variables (Wilks Lambda test statistic = 0.98, *p-value* > 0.63).

3.2. Hypotheses and tests

The primary question of interest in this study is if the BE symbol affects choice. Thus, discrete choice models were estimated to determine the effects of using the approved symbol to disclose a food is BE. The Symbol Group effects in choice experiment data were examined by estimating two sets of models. The first set of estimated models combined all choice options that had a BE disclosure (i.e., BE; BE/GnEd; BE/GM; BE/GnEd/GM) to examine if there was an overall difference in the selection of BE options between groups. This analysis can be thought of as a more powerful test for a symbol effect before examining the symbol effect for combinations of the BE symbol and genetic techniques.

An indicator variable, equal to one if a respondent chose a BE product, was created so that binary logistic regression models could be estimated to determine if respondents in the BE Group were more likely to choose a BE choice option. Three models were estimated for each product to examine the stability of the symbol effect, and the three estimated models can be specified by:

$$BECombined_1 = \alpha_1 + \beta_1 SG_i, \quad (1)$$

$$BECombined_2 = \alpha_2 + \beta_2 SG_i + \boldsymbol{LabelBehavior_i}\gamma_1, \quad (2)$$

$$BECombined_3 = \alpha_3 + \beta_3 SG_i + \boldsymbol{LabelBehavior_i}\gamma_2 + \boldsymbol{Socio\_demographics_i}\delta, \quad (3)$$

where SG_i is an indicator variable equal to one if respondent i was randomized to the Symbol Group, $\boldsymbol{LabelBehavior_i}$ and $\boldsymbol{Socio\_demographics_i}$ are matrices of responses from the label behavior and socio-demographic questions, respectively, and $\alpha_{\cdot}$, $\beta_{\cdot}$, $\gamma_{\cdot}$, δ represent coefficients to be estimated by the models. The main coefficients of interest are $\beta_{\cdot}$, which estimates if respondents in the Symbol Group were more likely, on average, to choose a BE choice option. This allows us to test the null hypothesis of a halo effect (i.e., H_0: $\beta_{\cdot} > 0$). Simultaneous Chi-square tests statics with Bonferroni-adjusted *p*-values were estimated to determine if the added variables in Eqs. (2) and (3) improved model fit (Sribney 2005; Korn and Graubard 1990). Price was included in the choice experiments to simulate a purchasing environment; however, prices were not included in Eqs. (1)–(3) because prices were balanced across choice options and constant across groups and unnecessary to include when estimating a group effect.

The second set of models examined the group effect on indirect utility to determine whether a halo effect was associated with the symbol approved by NBFDS. From the random utility framework McFadden (1973), utility for respondent i can be represented by $U_{ij} = V_{ij} + \varepsilon_{ij}$; where V_{ij} is the observable portion of utility derived from choice option j and ε_{ij} is the unobserved portion of utility associated with individual variation in taste or possible biases and heuristics associated with making simulated purchasing decisions. Similar to the causal analysis for a group effect discussed in Gangl (2010), the difference in the observable proportion of utility between the Symbol Group and Text Group can be described by

$$\Delta U_{ij} = \left(V_{ij} + \varepsilon_{ij} \middle| SG_i = 1\right) - \left(V_{ij} + \varepsilon_{ij} \middle| SG_i = 0\right), \quad (4)$$

where SG_i equals one for respondents randomized to the Symbol Group.

To examine the stability of the symbol effect on indirect utility, two mixed logistic regression model specifications were estimated using 500 Halton draws for each product (Train, 2009), and can be specified by:

$$V_1 = ASC_{1j} + \zeta_{1j} P_j, \quad (5)$$

$$V_2 = ASC_{2j} + \eta_j \left(SG_i * ASC_{2j}\right) + \zeta_2 P_j, \quad (6)$$

where ASC are alternative specific constants for the jth choice option to be estimated, P_j is the price of the jth choice option, and ζ are random coefficients distributed lognormal to relax the independence of irrelevant alternatives property possible in multinomial logistic regression models (Hensher et al. 2015). The main coefficient of interest is η in the second specification, which estimates the Symbol Group effect on each choice option. This allows us to test the null hypothesis that indirect utility is similar whether BE is disclosed using a symbol or text (i.e., H_0: $\eta_j \neq 0$). Standard errors were clustered to account for the panel nature of repeated choice decisions made by respondents.

Lastly, we examine the incremental label effects in the choice experiment data. This allows us to determine how the inclusion of the BE label alters consumer valuations of competing labels related to GM and GnEd. The overall alternative specific constants were replaced by including label dummies and their interactions (e.g., BE and BE*GnEd and BE*GnEd*GM) in a multinomial logit model that accounted for the panel nature of repeated choice decisions made by respondents. This approach is observationally equivalent to the approach with the alternative specific constants, but the first approach gives the "total" effect whereas this second approach shows the marginal effect of adding a label on top of another. Two model specifications (i.e., V_3 and V_4) were estimated for each product, one model pooled groups and the other model included interaction terms with the Symbol Group variable (SG_i).

4. Results

Table 2 shows the frequency distributions of choice options selected by respondents in each group for both products. Given that both groups were presented with the same choice sets, with only the presentation of BE varying across the groups, the empirical distributions of labels chosen and the differences in choice are informative and provide an analytical approach to understanding results estimated by Eqs. (1)–(3) and (5) and (6). The BE option was chosen more than the other options displaying a disclosure, and respondents in the Symbol Group chose the BE options more often than the Text Group (1%–3%). Together, the no-label and no-choice options were chosen for more than half of the choice sets for both products and groups. BECombined, the sum of proportions for BE labels, was 6% (avocados) to 7% (vegetable oil) higher for the Symbol Group.

Results for the label behavior questions are presented in Fig. 2 and Appendix Figs. 2–3. As shown in Appendix Fig. 2, 32% of respondents stated searching for GM labels often or always (panel A), and 68% had not scanned a QR code in the last year (panel B). The likelihood of looking for a GM disclosure is illustrated in Appendix Fig. 3. Around 60% of respondents were somewhat or very likely to look for disclosures on the front or back of packages, compared to 30% for scanning a QR code. Thus, disclosure information is likely less salient if provided via a QR code.

Perceived differences between products with a BE symbol and no-label or GM products are shown in panel A of Fig. 2. Only 30% of respondents perceived a product displaying a BE symbol equivalent to a GM product. A large proportion of the sample perceived a product with the BE symbol to be different from a no-label (84%) or GM product (70%). While interpreting a difference for a product with no label is correct, many consumers may not interpret a BE symbol to indicate that a food is GM. Panel B of Fig. 2 illustrates the results for perceptions about the presence of genetically engineered material in the no-label avocado or vegetable oil presented in the DCEs. More than a third of respondents did not interpret that a no-label product implicitly indicated the absence of genetically engineered material.

The first set of models was estimated to examine the stability of the symbol effect on choosing a BE choice set by piecewise controlling for respondent label behavior and socio-demographics (i.e., Eqs. (1)–(3)). Results for the binary logistic regression models using *BECombined* as the dependent variable are shown in Table 3. Odds ratios are reported and used to test the null hypothesis of a halo effect (i.e., H_0: $\beta_n > 0$). Odds ratios are similar and significant within the avocado models and within the vegetable oil models. Thus, heterogeneity across interaction with labeling and socio-demographics had little impact on the estimated symbol effect.

The odds ratios for all variables included in *BECombined*$_2$ and *BECombined*$_3$ are shown in Appendix Table 4. Including the moderating variables measuring respondent interaction with labeling of genetically engineered food variables in *BECombined*$_2$ improved model fit (avocados: X^2 statistic = 209, p-value<0.01; vegetable oil: X^2 statistic = 174, p-value<0.01), as did adding the socio-demographics in *BECombined*$_3$ (avocados: X^2 statistic = 149, p-value<0.01; vegetable oil: X^2 statistic = 164, p-value<0.01). Several of the variables are significant across products and some, if not all, specifications. Respondents who were more likely to look at the front or back of a product for a disclosure indicating genetically engineered contents, were older, or stated having knowledge about agriculture were less likely to choose *BECombined*. While those who recently scanned a QR code, stated being likely to scan a QR for

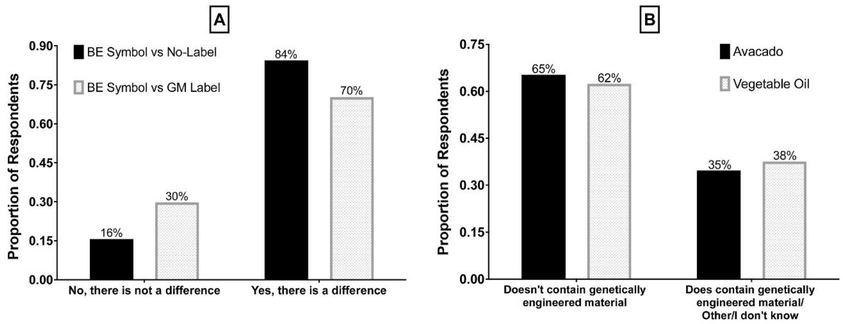

Fig. 2. Panel A: perceived differences between a product with the Bioengineered symbol and a no-label product or product labeled genetically modified. Panel B: perceptions of what the 'no label' option in choice experiments indicated.

Table 4
Symbol effects in the choice experiments.

ASC Symbol Effect (η_j)	Avocado Models				Vegetable Oil Models			
	V_1		V_2		V_1		V_2	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
BE	2.376***	0.133	2.031***	0.176	2.729***	0.140	2.481***	0.185
Symbol			0.684***	0.257			0.526*	0.273
BE/GnEd	2.030***	0.130	1.726***	0.173	2.533***	0.137	2.283***	0.181
Symbol			0.607**	0.252			0.527**	0.267
BE/GnEd/GM	2.104***	0.133	1.830***	0.178	2.476***	0.140	2.127***	0.186
Symbol			0.556**	0.258			0.710***	0.275
BE/GM	2.114***	0.132	1.870***	0.175	2.479***	0.138	2.057***	0.184
Symbol			0.500*	0.256			0.837***	0.270
GnEd	1.708***	0.132	1.668***	0.177	2.154***	0.140	2.097***	0.185
Symbol			0.070	0.257			0.127	0.274
GnEd/GM	1.594***	0.130	1.508***	0.173	1.991***	0.139	1.890***	0.182
Symbol			0.175	0.253			0.226	0.272
GM	1.796***	0.133	1.688***	0.177	2.283***	0.139	2.174***	0.184
Symbol			0.221	0.259			0.242	0.271
No-label	3.729***	0.125	3.575***	0.164	3.939***	0.128	3.819***	0.168
Symbol			0.319	0.240			0.268	0.247
Ln(Price)	−0.292***	0.078	−0.292***	0.078	−0.786***	0.074	−0.784***	0.074
Sd(Price)	2.007***	0.083	2.010***	0.083	1.987***	0.081	1.989***	0.081
Log likelihood	−18,406		−18,367		−18,425		−18,371	

Note: Estimates are from mixed logit models with 107,811 observations and standard errors were adjusted for 1 331 respondents. The 'would not purchase' option was used as the base alternative. ***, **, and * indicate a *p*-value less than 0.01, 0.05, and 0.10, respectively.

disclosure, recently purchased the products considered, or were relatively more educated were more likely to choose *BECombined*. Respondents who had experience in agriculture were more likely to choose *BECombined* in the vegetable oil model, and those who correctly identified that the no-label (default) choice option was supposed to be interpreted as not bioengineered were less likely to choose a vegetable oil with a BE disclosure.

Table 4 shows the results for the mixed logistic regression model specifications estimated to examine symbol effects in the choice experiments (i.e., Eqs. (5) and (6)). The alternative specific constants in the first specification (V_1) are the average label effects across both groups, and the second specification (V_2) includes an indicator variable equal to one if a respondent was randomized to the Symbol Group. Including the Symbol Effect improved the fit for both avocado (X^2 statistic = 41, p-value<0.01) and vegetable oil (X^2

Table 5
Incremental label effects in the choice experiments.

Variables	Avocado Models				Vegetable Oil Models			
	V_3		V_4		V_3		V_4	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
BE	0.017	0.044	−0.159***	0.059	0.090**	0.043	0.019	0.057
BE*GnEd	0.326***	0.071	0.238**	0.098	0.311***	0.068	0.189**	0.092
BE*GnEd*GM	0.894***	0.097	0.797***	0.127	0.535***	0.094	0.271**	0.123
BE*GM	0.281***	0.069	0.330***	0.095	0.087	0.067	−0.136	0.094
GnEd	−0.635***	0.052	−0.514***	0.066	−0.466***	0.051	−0.352***	0.064
GnEd*GM	0.415***	0.079	0.324***	0.105	0.155**	0.076	0.057	0.101
GM	−0.516***	0.050	−0.470***	0.065	−0.301***	0.048	−0.246***	0.062
No-label	1.306***	0.037	1.325***	0.045	1.242***	0.037	1.297***	0.045
BE*Symbol			0.333***	0.072			0.143**	0.071
BE*GnEd*Symbol			0.275***	0.081			0.157**	0.076
BE*GnEd*GM*Symbol			0.208***	0.079			0.317***	0.078
BE*GM*Symbol			0.161**	0.078			0.443***	0.078
GnEd*Symbol			−0.263***	0.093			−0.244***	0.089
GnEd*GM*Symbol			−0.159	0.096			−0.147	0.094
GM*Symbol			−0.093	0.088			−0.110	0.083
No-label*Symbol			−0.036	0.050			−0.111**	0.051
Price	−0.566***	0.015	−0.567***	0.015	−0.318***	0.008	−0.318***	0.008
Log pseudo likelihood	−22,159		−22,124		−22,533		−22,486	

Note: Estimates are from multinomial logit models with 107,811 observations and standard errors were adjusted for 1 331 clusters. *** and ** indicate a *p*-value less than 0.01 and 0.05, respectively.

statistic = 52, p-value<0.01) models, as determined by simultaneous Chi-square tests with Bonferroni-adjusted p-values on the symbol interactions with alternative specific constants.

For both products in Table 4, No-label had the only positive and significant alternative specific constant because it was the only choice option chosen more often than 'would not purchase.' Any product labeled with a GM disclosure had a negative and significant alternative specific constant (note: BE/GnEd/GM was only significant at alpha<0.10), as did the GnEd only disclosure. However, BE and BE/GnEd were not different from zero for both products. Therefore, products labeled GnEd or GM were not preferred and would need to be sold at a lower price to provide similar indirect utility as the no-label, no choice, or BE only options. In the second specification for avocados, the estimated symbol effect for BE and BE/GnEd were positive and significant. However, the alternative specific constant for BE was not different from zero. BE/GnEd/GM and BE/GM were positive and significant in V_2 for vegetable oil. Thus, evidence of a halo effect is mixed.

Table 5 shows the results for the multinomial logistic model specifications estimated to examine the incremental label effects in the choice experiments. Coefficients for the main effects (i.e., BE, GnEd, GM, and no-label) in Table 5 are, by construction, equal to the alternative specific constants when those labels appear in isolation from the specifications in Table 4. All interactions in V_3 are positive and significant for both products, except BE*GM in the vegetable oil model which is not significant. Therefore, combining the labels had a super-additive effect, i.e., the value rises when the two labels appear together. To illustrate, when an avocado appeared with a BE label alone, utility compared to 'would not purchase' was 0.017. Likewise, when an avocado appeared with a GnEd label alone, utility compared to "Would not purchase" was −0.635. When an avocado had both BE and GnEd labels, the utility was not the simple sum (0.017–0.635), but rather, 0.017–0.635 + 0.326 = −0.292. This matches the results in the first column of Table 4 for the BE/GnEd alternative specific-constant. However, the advantage of the re-specification in Table 5 is the ability to determine that the additive effect is positive and statistically significant. Another way to interpret the positive interaction effects between GnEd and GM is that whatever consumers find undesirable about one must carry over to the other. When the two appear together, a product isn't doubly penalized.

Including the Symbol Effect improved the fit for both avocado (X^2 statistic = 68, p-value<0.01) and vegetable oil (X^2 statistic = 94, p-value<0.01) model, as determined by simultaneous tests of added variables with Bonferroni-adjusted p-values. Generally, including the symbol significantly improved preferences for BE when the label appeared in isolation or when combined with other labels. However, including the BE symbol with the GnEd label alone tended to reduce the utility of this label.

5. Conclusions

Choice experiments are powerful tools as they use experimental design to systematically vary attributes and levels across different choices typically made by the same subject (thus involving within-subject comparisons). This paper contributes to the literature on choice experiments in two ways. First, we embed the choice experiment in a larger randomized group approach where subjects are randomly assigned to a treatment or control, which varies the presentation format of the choice experiment. This sort of approach is not uncommon when, for example, comparing responses across people exposed to different types of information, but is perhaps less widely used to compare presentation formats. Second, this study contributes to the literature on the effects of presentation format on choices by comparing attributes described by symbols as compared to text disclosure methods allowed by the NBFDS; whereas some studies have found text descriptors yielding higher willingness-to-pay (Delong et al., 2021), others have found that symbolic labels yield higher willingness-to-pay (Schmiess and Lusk, 2022).

Some advocates for mandatory labeling are opposed to the approved symbol because it could cause a positive perceptual bias, sometimes referred to as a halo effect, about the safety of products containing ingredients from genetically engineered crops. The hypothesis that products with the BE symbol will be viewed more favorably than text disclosures was partially supported by this study. While advocates for mandatory labeling may be dissatisfied with the approved symbol, the symbol may diminish the 'expert-novice' gap in risk perceptions through the halo effect.

The symbol was found to have a positive and significant effect on selection when considering the whole avocado product and BE or BE/GnEd labels. However, a significant effect was absent whenever GM appeared in the label combinations. The observed difference in effects between the avocado and vegetable oil products may be explained by one being a whole product and one being processed (Lusk et al., 2015; Kalaitzandonakes et al., 2018). Also, consumers may have existing associations with vegetable oil and/or processed products containing genetically altered ingredients but may not associate whole products, especially an avocado which could be but isn't currently available as a genetically altered product.

The hypothesis that respondents were more likely to interpret no-label products as a default option that was not GnEd or GM was supported. However, around 35% of respondents were unclear that the no-label option indicated a product did not contain GM or GnEd material. "Reduced consumer confidence in the integrity of the food system" may explain the perception that some products may contain genetically engineered ingredients or be genetically altered without disclosure (Wu et al., 2021). When examining the proportion of labels chosen by group, the no-label products were preferred by 25–30% of respondents. This preference may indicate willful ignorance, where people avoid information, as observed in previous research associated with food production (Kim et al., 2021; Bell et al., 2017). Nevertheless, it is important to note that while we find some evidence of a halo effect associated with the approved symbol, the 'no-label' and 'would not purchase' options were selected at a much higher frequency than other options across both groups.

This study is not without limitations. The randomized group design gives confidence in conclusions about a halo effect associated with the symbol; however, the choice experiments used were hypothetical, and this study cannot account for the disclosure options ultimately used by food manufacturers. This study did not examine if there is a halo effect associated with the symbol compared to QR codes. Although, a study conducted before the final rule of NBFDS examining the impact of QR codes versus text disclosures concluded products using a QR code instead of text may collect a premium (McFadden and Lusk, 2018). Likely because respondents did not typically scan QR codes, as previous research has concluded that many consumers may not be inclined to scan QR codes (Li and Messer, 2019). Intention to engage with QR codes on food packaging can increase if consumers perceive the information to be reliable and informative (Kim and Woo, 2016). Nevertheless, different methods of disclosure likely have heterogenous effects on choice.

It is also conceivable that implementing the NBFDS created price effects across labeled products and therefore likely causes substitution effects. Prices used in the choice experiments were balanced across labeled products and cannot account for price or substitution effects stemming from NBFDS. Furthermore, this study was not limited to those who regularly purchase avocado and vegetable oil; therefore, results may have been impacted by those who do not purchase these products regardless of labeling. We also did not assess directly whether consumers perceived labeled foods to be healthier, which could be a topic for future research, nor did we study interventions to help consumers understand the information provided in the labels.

Future research could examine the expert-novice gap in risk perceptions more directly. The small halo effect we found seems unlikely to have completely overcome the wide gap between the public and expert perception of risk. Future research could also examine the mechanisms of the halo effect associated with the approved symbol; for example, a possible explanation of the halo effect may rest in color theory. Colors are used in retail settings to attract and influence customers and the possible influence of the symbols cannot be discounted (Bellizzi and Hite, 1992). Cool colors, such as blue and green (the primary colors used in the BE symbol) have resulted in positive emotions in retail settings (Babin et al., 2003). Furthermore, green is known to have associations with nature or being natural (Birren, 1950), which could be further exaggerated by the field imagery in the symbol. Also, future studies involving the use of eye tracking could examine these influences as well as label position on product packaging.

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Author contributions

Brandon R. McFadden: Conceptualization, Methodology, Software, Formal analysis, Writing - Original Draft, Project administration, Funding acquisition. **Jayson L. Lusk**: Conceptualization, Methodology, Writing - Original Draft. **Adam Pollack**: Writing - Original Draft. **Joy N. Rumble**: Writing - Review & Editing, Funding acquisition. **Kathryn A. Stofer**: Writing - Review & Editing, Funding acquisition. **Kevin M. Folta**: Writing - Review & Editing, Funding acquisition.

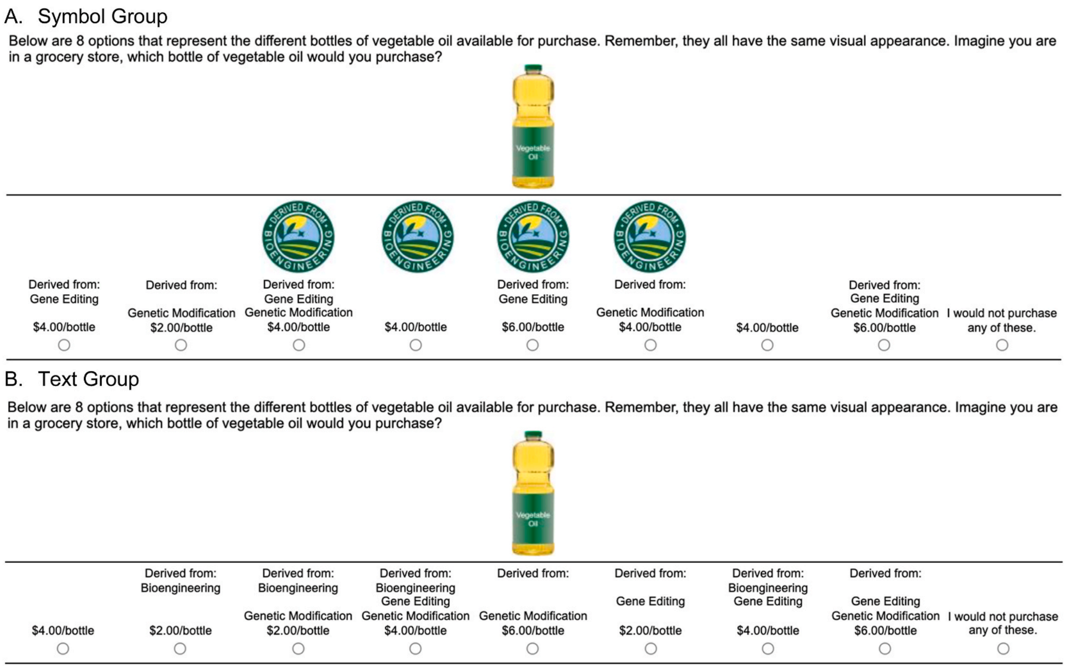
Declaration of competing interest

We have no potential conflicts of interest to disclose and there are no material transfer agreements or preprints associated with this manuscript.

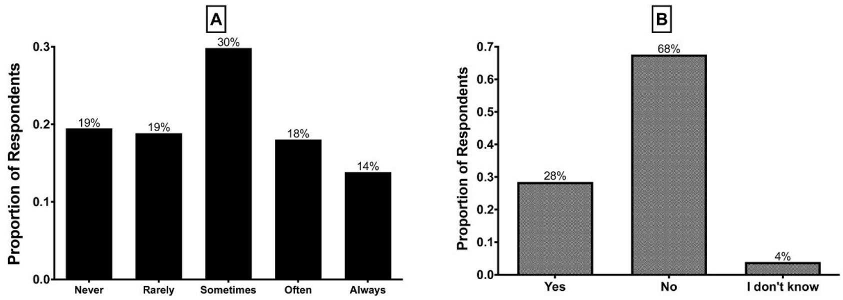
Data availability

Data will be made available on request.

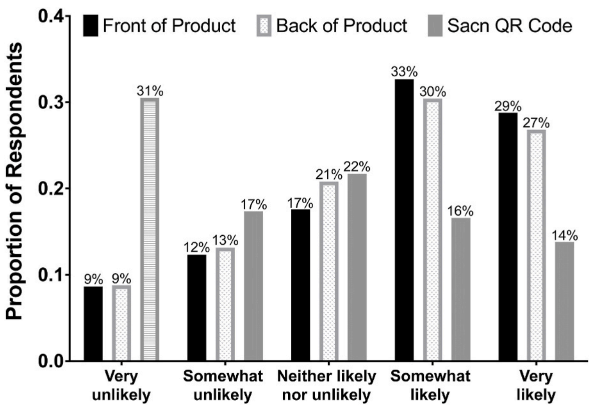
Appendix



Appendix Fig. 1. Example choice sets for the symbol (Panel A) and text (Panel B) groups completed by respondents in the vegetable oil choice experiment



Appendix Fig. 2. Stated searching frequency for GM labels (Panel A) and QR code scanning activity in the last year (Panel B).



Appendix Fig. 3. Likelihood to look for a disclosure by location on product or by scanning a QR code.

Appendix Table 1
Orthogonal coding for prices in the choice experiments

(*continued on next page*)

Appendix Table 1 (*continued*)

Choice Set	Choice Option 1	Choice Option 2	Choice Option 3	Choice Option 4	Choice Option 5	Choice Option 6	Choice Option 7	Choice Option 8	*Blocks*
Choice Set	Choice Option 1	Choice Option 2	Choice Option 3	Choice Option 4	Choice Option 5	Choice Option 6	Choice Option 7	Choice Option 8	*Blocks*
1	−1	0	0	0	0	0	−1	−1	*Choice Set*
2	1	−1	−1	0	1	−1	0	1	*Block 1*
3	0	−1	−1	1	0	−1	1	0	
4	−1	1	1	1	1	1	−1	−1	
5	1	1	1	−1	0	1	0	1	
6	0	1	1	0	−1	1	1	0	
7	1	0	0	1	−1	0	0	1	
8	−1	−1	−1	−1	−1	−1	−1	−1	
9	0	0	0	−1	1	0	1	0	
10	−1	1	0	−1	−1	−1	0	0	*Choice Set*
11	0	0	−1	0	−1	1	−1	1	*Block 2*
12	1	1	0	0	1	−1	1	−1	
13	1	0	−1	−1	0	1	1	−1	
14	0	1	0	1	0	−1	−1	1	
15	−1	0	−1	1	1	1	0	0	
16	0	−1	1	−1	1	0	−1	1	
17	1	−1	1	1	−1	0	1	−1	
18	−1	−1	1	0	0	0	0	0	
19	1	0	1	0	1	−1	−1	0	*Choice Set*
20	1	−1	0	−1	0	1	−1	0	*Block 3*
21	−1	0	1	−1	−1	−1	1	1	
22	1	1	−1	1	−1	0	−1	0	
23	0	0	1	1	0	−1	0	−1	
24	0	1	−1	−1	1	0	0	−1	
25	−1	−1	0	1	1	1	1	1	
26	−1	1	−1	0	0	0	1	1	
27	0	−1	0	0	−1	1	0	−1	

Balance (sum within a column)

Choice Option 1	Choice Option 2	Choice Option 3	Choice Option 4	Choice Option 5	Choice Option 6	Choice Option 7	Choice Option 8
0	0	0	0	0	0	0	0

Orthogonality (correlation across columns)

	Choice Option 1	Choice Option 2	Choice Option 3	Choice Option 4	Choice Option 5	Choice Option 6	Choice Option 7
Choice Option 2	0						
Choice Option 3	0	0					
Choice Option 4	0	0	0				
Choice Option 5	0	0	0	0			
Choice Option 6	0	0	0	0	0		
Choice Option 7	0	0	0	0	0	0	
Choice Option 8	0	0	0	0	0	0	0

Appendix Table 2

The Proportion of Respondents in each Choice Set Block by Group

Blocks		Avocado	Vegetable Oil
Choice Set Block 1	Symbol Group	0.165	0.168
	Text Group	0.167	0.165
Choice Set Block 2	Symbol Group	0.163	0.168
	Text Group	0.166	0.168
Choice Set Block 3	Symbol Group	0.171	0.162
	Text Group	0.168	0.168
	Proportion of Total Sample in Choice Set 1	0.332	0.334
	Proportion of Total Sample in Choice Set 2	0.329	0.337
	Proportion of Total Sample in Choice Set 3	0.339	0.330

Appendix Table 3

Mean responses by respondents in the Symbol Group and Text Group

Variables	Symbol Group	Text Group
Age	48.12	46.84
Gender	1.53	1.51
Income	6.78	6.78

(*continued on next page*)

Appendix Table 3 (*continued*)

Variables	Symbol Group	Text Group
Education	3.59	3.55
Employment Status	3.18	3.18
Residence Density	1.90	1.97
Residence Region	2.55	2.60
Race/Ethnicity	5.40	5.26
Political Affiliation	2.19	2.21
Religion	4.75	5.19
Ag Experience	0.18	0.19
Subjective Ag Knowledge	6.17	6.05
Primary Shopper	0.83	0.83
Avocado Purchaser	0.62	0.64
Vegetable Oil Purchaser	0.84	0.85
Perception of No Label versus Bioengineered	1.89	1.87
Perception of No Label versus Genetically Modified	2.16	2.17
Avocado 'No label' Perception	3.06	3.08
Vegetable Oil 'No label' Perception	3.05	3.07
Interest in Bioengineered Disclosure	0.72	0.73
QR Code Use in Last Year	0.27	0.30
Frequency of Searching for Disclosure of Genetic Modification	3.51	3.48
Likelihood to Look at Back of a Product for Disclosure	3.52	3.55
Likelihood to Look at Front of a Product for Disclosure	3.61	3.60
Likelihood to Scan a QR Code for Disclosure	2.62	2.70
n	667	664

Note: There was not a significant difference between groups, as determined by estimating a MANOVA (Wilks Lambda test statistic = 0.98, p value > 0.47).

Appendix Table 4
Symbol Effect across the *BECombined* models (full results)

Variables	Avocado Models						Vegetable Oil Models					
	BECombined$_1$		*BECombined*$_2$		*BECombined*$_3$		*BECombined*$_1$		*BECombined*$_2$		*BECombined*$_3$	
	Odds Ratio	Std. Error	Odds Ratio	Std. Error	Odds Ratio	Std. Error	Odds Ratio	Std. Error	Odds Ratio	Std. Error	Odds Ratio	Std. Error
Symbol Effect	**1.238*****	0.074	**1.274*****	0.071	**1.292*****	0.070	**1.264*****	0.072	**1.295*****	0.070	**1.305*****	0.067
Perception of No Label versus Bio			0.945	0.089	0.926	0.087			0.999	0.086	0.987	0.084
Perception of No Label versus GM			1.090	0.087	1.032	0.084			1.104	0.082	1.051	0.079
Avocado 'No label' Perception			0.940	0.055	0.938	0.053						
Vegetable Oil 'No label' Perception									**0.873****	0.047	**0.869*****	0.046
Interest in Bio Disclosure			0.940	0.076	0.892	0.070			0.958	0.070	0.924	0.066
Frequency of Searching for Disclosure of GM			1.011	0.029	0.986	0.028			1.004	0.029	0.981	0.028
Likelihood to Look at Back of a Product for Disclosure			0.944	0.034	**0.933****	0.032			0.941	0.033	**0.934****	0.030
Likelihood to Look at Front of a Product for Disclosure			**0.914****	0.032	0.942	0.031			**0.919****	0.031	0.953	0.030
QR Code Use in Last Year			**1.592*****	0.104	**1.217*****	0.084			**1.473*****	0.093	1.120	0.072
Likelihood to Scan a QR Code for Disclosure			**1.195*****	0.030	**1.133*****	0.028			**1.171*****	0.029	**1.108*****	0.027
Primary Shopper					1.183	0.110					1.078	0.091

(*continued on next page*)

Appendix Table 4 (*continued*)

Variables	Avocado Models						Vegetable Oil Models					
	BECombined$_1$		*BECombined*$_2$		*BECombined*$_3$		*BECombined*$_1$		*BECombined*$_2$		*BECombined*$_3$	
	Odds Ratio	Std. Error	Odds Ratio	Std. Error	Odds Ratio	Std. Error	Odds Ratio	Std. Error	Odds Ratio	Std. Error	Odds Ratio	Std. Error
Avocado Purchaser					**1.296*** **	0.094						
Vegetable Oil Purchaser											**1.334*** **	0.138
Age					**0.989*** **	0.003					**0.987*** **	0.003
Male					0.954	0.161					1.183	0.223
Female					0.752	0.128					0.888	0.168
Income					1.004	0.011					0.991	0.010
Education					**1.072** **	0.030					**1.122*** **	0.029
Employed					0.926	0.076					0.882	0.068
Retired					1.011	0.140					0.939	0.123
Urban					1.170	0.109					1.155	0.100
Suburban					1.049	0.091					1.150	0.092
Northeast					0.960	0.079					1.029	0.083
South					0.988	0.078					1.052	0.079
West					0.924	0.082					1.072	0.092
Black					0.904	0.131					1.036	0.135
Hispanic					1.027	0.158					1.083	0.161
White					1.025	0.112					1.044	0.110
Republican					1.134	0.094					1.137	0.091
Democrat					1.148	0.082					1.130	0.076
Protestant					0.939	0.070					1.001	0.071
Catholic					1.026	0.069					1.080	0.071
Agnostic					1.072	0.115					1.123	0.097
Ag Experience					1.112	0.072					**1.147** **	0.070
Subjective Ag Knowledge					**0.974** **	0.011					**0.972*** **	0.011
Constant	**0.030*** **	0.001	**0.027*** **	0.003	**0.041*** **	0.010	**0.032*** **	0.001	**0.030*** **	0.003	**0.032*** **	0.009
Log pseudo likelihood	−15,593		−15,331		−15,154		−16,185		−15,968		−15,764	

Note: Estimates are from logistic regression models with 107,811 observations and standard errors were adjusted for 1 331 clusters. Note: *** and ** denote significance at alpha <0.01 and < 0.05, respectively. Significant estimates are bolded for the reader's convenience.

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