A Multinomial Logit Model of Consumer Perceptions for Biotech Food Labeling

by

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The voluntary labeling system established by the U.S. Food and Drug Administration (FDA) in 1973 was replaced by the Nutritional Labeling Education Act (NLEA) of 1990. NLEA requires mandatory labeling for all packaged foods and strict regulations regarding health claims and nutritional contents. The U.S. Office of Technology Assessment defined biotechnology as "any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants or animals, or to develop micro-organisms for specific uses."(U.S. Congress, 1984:3)[1]. For example, animals may be genetically engineered to encourage growth and to have better quality characteristics. Bovine Somatotropin (BST) *or* bovine growth hormone is a naturally occurring protein made in the pituitary gland of the cow. Recombinant bovine somatotrophin (rBST) is BST produced by genetically modified bacteria in the laboratory (Aldrich and Blisard, 1998). A cow administered with rBST can produce 20% more milk than cows not give rBST (Schacter, 1995).

Most biotech products in the U.S. are not labeled as such, because FDA and the United States Department of Agriculture (USDA) require labeling only if biotech foods are determined materially different from conventional counterparts. Material differences contain different nutritional properties and safety contents from existing products, an allergen that consumers would not normally be presented based upon the name of the food, and so on. The current U.S. policy is based on the rationale that scientific results can confirm whether or not biotech products are materially different from traditional counterparts.

Some consumers view biotechnology as a risky process, and have hightened interest in food safety and qualities issues associated with biotech food. Some consumers concerned about

[1] The terms biotechnology, biotech, genetically modified, and genetically engineered are used interchangeably in this paper.

potential unknown health risks that science might not detect argue for the “right to know” whether or not products are produced using biotechnology. These concerns are related to perception of unknown health and safety risks. Since preferences for labeling come from the consumers’ desire to make an informed buying decision for biotech product. Uncertainties will have an impact on consumers’ choice for biotech product labeling.

Public Discussion

Based on the timing and type of information available to consumers, food products can be characterized as falling into three categories: these include search goods, where consumers can ascertain the attributes (or quality) of a product before they buy and consume it; experience goods, where consumers can judge the attributes of a product after they buy and consume it; and, credence goods, where consumers can not accurately determine the attributes of a product even after they inspect, buy, and consume it (Nelson, 1970; Darby and Karni, 1973). It is assumed that consumers would have considerable difficulty and could not measure the attributes of biotech products even after consumption. Most biotech attributes fall in the credence good category (Isaac and Phillips, 1999).

Concerns regarding biotechnology stem from potential unknown effects due to modifications of genes and nutritional content, environmental quality, morality and animal welfare owing to transgene and mistreatment of animals, and so on. According to a study by Hoban and Kendall (1992), about forty seven percent of respondents have heard about biotechnology. Respondents indicated they feel that transferring genes from plants to plants is acceptable, but transferring it from animals to plants, animals to animal, and human to animal is unacceptable. Opponents of biotechnology argue that the unknown risks outweigh the benefits.

Proponents tend to place greater weight on the benefits of the biotechnology (Wansink and Kim, 2001).

The issue of labeling biotech products is also being debated in many countries. The European Union, (EU), Australia, Canada, New Zealand, and Japan regulate genetically modified products in specific ways. The European Union (EU), with some exceptions, requires labeling on food containing ingredients genetically modified and produced through genetic modification techniques, and some European countries, such as Austria and Luxembourg, do not allow import and use of agricultural biotechnology (AB) products (Cunningham and Unnevehr, 1999; Shoemaker and et al, 2001). It is likely that when EU would require segregation of biotech products from non-biotech products, that will cause tremendous marketing costs to U.S. export, due to separate shipping, inspection, and handling cost besides different labeling cost.

The objective of this study to examine the relationship between consumers' risk perceptions of biotech products and their attitude toward the current U.S. labeling policy and purchasing behavior for GM foods

Literature Review

From an economic perspective, Caswell and et al. (1994) studied the development of agricultural biotechnology. Caswell and et al. said that the success of biotech products depends upon some factors, such as public policies, producer's expectation, and consumer demand on biotech products. The study suggested that if profitability of using the biotechnology is expected to be high, then demand for that by farmers and processors would increase. Caswell and et al. indicated that consumer demand on biotech products would, eventually, determine the demand of biotechnology in the farm sector.

Caswell (1999) stated that the initial direction and speed of development of market for foods produced using genetically modified organism (GMOs) are significantly influenced by the choice of labeling policy. However, Caswell argued that there are a few realistic and economic reasons for not requiring all information to be disclosed on food labels. For example, those include substantial difficulty to separate biotech ingredients from non-biotech ingredients, increased marketing cost due to segregation of biotech products from non-biotech products, and limit of information to display on a label.

Using nationwide consumer survey data, Grobe and et al. (1996) studied consumer risk perception associated with genetically modified product, recombinant Bovine growth hormone(rbGH), which is a food-related biotechnology used in milk production. The study investigated how consumers react to different typologies of risk perception toward the use of rbGH, and found the characteristics of consumers at each risk perception typology. Taking account of the complexity and unfamiliarity of biotechnology, consumers are distinguished into two groups. One group is about those with prior knowledge about rbGH's use, and the other group is those who are not conscious of rbGH's use. Grobe and et al. demonstrated that consumers with similar information showed the various risk perceptions. Consumer groups with shared information on rbGH displayed incoherent beliefs and roles relating to their own preferences. In addition, the study found that those who engaged in self-protective action were strongly correlated with environmentalist concerns.

Investigated are consumers' perceptions toward biotechnology in fifteen developed countries including U.S. and France. Hoban (1999) demonstrated that consumers from different areas of the world have quite diverse perceptions and understanding toward biotechnology. The study showed that consumer perceptions about biotech products are very different depending on type of information, government credibility, and cultural preferences. Especially, U.S. showed strong public support for biotechnology applications in comparison to other European countries. Most U.S. consumers expressed the circumspect optimism about benefits of biotechnology, and they will accept the biotech products if the price is appropriate and biotechnology benefits society.

FDA (2000) examined consumer perceptions and awareness in four cities: Calverton, MD; Burlington VT; Seattle, WA; and Kansas City, MS. Most of participants said that to tell whether a food is produced using biotechnology, all foods should be labeled. Their concern for labeling was not in specific effect of biotechnology but in unknown long-term health and safety risk which motivates the demand for biotechnology labeling. In terms of labeling approach, nearly all participants recognized value in having "mere disclosure" labeling, and many of them were aware of symbolic value when they decided not to purchase biotech products. In regarad to the practicability of labeling, most participants expressed that labeling should be simple and effective. This suggests that too wordy and complicated labeling might put burden on consumer to get more informed.

According to Hallman and Metcalfe (1995), eighty four percent of respondents supported special labels, that is, mandatory labeling, on biotech products. Sixty percent of participants answered that they would consider purchasing biotech vegetables if those are labeled as having been produced using biotechnology. Fifty eight percent said that they would spend time for looking at biotech labels while shopping. Forty two percent of respondents who said that they would search for produce labeled “not genetically engineered” also stated that if label conveys the information of biotech produce, then they would buy produce.

Mojduszka and Caswell (2000) examined the effectiveness of markets in providing information to consumers on nutritional quality of processed foods. The study found that voluntary labeling on nutritional quality of processed foods was ineffective. Mojduszka and Caswell demonstrated that incentives for voluntary labeling of nutrient content by food processing company did not provide the consistent and effective quality signals to consumers. Thus, Mojduszka and Caswell suggested that it is more likely that mandatory labeling for nutrition quality, in comparison with voluntary labeling, increases the information available to consumers. The other study investigated the impact of food labels on consumers’ intake of selected nutrients. Kim and et al. (2000) has compared the nutrient intakes of label users with the expected nutrient of intakes of label users in the absence of labels. The study showed that the use of mandatory labeling on nutrients reduced the average daily calories from total fat by 2.10 percentage points, the average daily cholesterol intake by 67.60 milligrams, and the average daily sodium intake by 29.58 milligrams. Kim and et al. demonstrated that mandatory labeling on the selected nutrients improved the intakes by consumers. The study provided the evidence that mandatory labeling is more likely to provide health benefits and society welfares, compared to voluntary labeling. However, none of the studies, including those of both Mojduszka and Caswell and Kim et al., has not been found to compare voluntary with mandatory labeling on biotech products. Thus, the present study is worthy in that consumer’s preferences for voluntary and mandatory labeling and their purchasing behavior on biotech products are analyzed.

Methodology

The multinomial logit model (MLM) is appealing for this study for three reasons. First, data for the study consist of individual specific characteristics, and the MLM is well suitable to analyze the characteristics of the individual. If the data is composed of alternative specific attributes, then the conditional logit model (CLM) is appropriate. Secondly, while the MLM is most popular as discrete choice model, it has a strict restriction in use. An assumption of both MLM and CLM is that the alternatives are distinct and independent of one another. That is, introducing a new alternative leaves the relative odds of choosing among the existing alternatives unchanged. This property is called the independence of irrelevant alternatives (IIA) assumption. The IIA assumption follows from the assumption that the stochastic disturbances are independent and identically distributed. However, if alternatives are close substitutes for one another, then the IIA assumption is violated. The MLM has suffered from the IIA assumption in many areas by restricting the correlation patterns among choice alternatives. The IIA assumption, however, can only be empirically tested when some respondents have different choice sets. That is, when everyone in the sample is presented with the same choice set, the IIA assumption is not a serious problem (Allison, 1999). For the study, six alternatives are presented to all individuals. Thus, this study is free from IIA assumption. In addition, the MLM is easy to estimate even for a large number of alternatives (Borsch-Supan, 1990). Third, one of the alternatives to the MLM is the nested logit model (NLM) developed by McFadden (1978), which relaxes the IIA restriction of the MNL by allowing alternatives to be correlated across, but not within, groups (Greene, 2003). However, if a larger number of independent variables are included, the NLM is difficult to employ. For the study, four types of independent variables are considered. The number of those variables is as follows: six variables for consumers' risk perception toward biotech foods, nine variables for socioeconomic/demographics factors, one variable for consumer awareness of biotech foods, and one variable for consumer use of food labels. Generally, it is recommended that seven variables plus or minus two are appropriate in nested logit models (George Institute Technology), so we use the MLM.

The basic framework for analysis is provided by the random utility model where consumers are assumed to choose among a range of discrete number of alternatives to maximize their utility. Random utility theory states that a consumer's utility can be decomposed into a systematic and random component of utility. That is, total utility is the sum of observable and unobservable components,

$$U_{ij}(\textit{choice } j \text{ for individual } i) = V_{ij} + e_{ij} \qquad (1)$$

The utility level U_{ij}, which is individual i's utility from choosing alternative j, is determined by the systematic component of utility of V_{ij} and random components, e_{ij}, which is assumed to be independently and identically distributed with type I extreme value (Gumbel) distribution (Greene,2003). The random component represents the unknown components the consumers' utility function. Consumer i chooses alternative j if

$$U_{ij} > U_{ik} \text{ for all } k \neq j \qquad (2)$$

The probability of individual i choosing alternative j is equal to the probability that the utility of alternative j is greater than the utilities of all other alternatives in the choice set(Greene 2003).

$$P_{ij} = \Pr(U_{ij} > U_{ik}) \; \forall \; k \neq j \qquad (3)$$

The general form of the MLM model is described as

$$P_{ij} = \frac{\exp(x_i b_j)}{1 + \sum_{k=1}^{J} \exp(x_i b_k)} \quad , \qquad (4)$$

where P_{ij} is the probability that individual i chooses alternative j. The x_i is a vector of characteristics of individual i, J is the number of unordered alternatives, $ß_j$ measures the contribution of personal characteristic i to the probability of choosing alternative j, and $ß_k$ measures the contribution of personal characteristic i to the probability of selecting alternative k.

The log-likelihood function for the multinomial logit model is given by

$$\ln L = \sum_{i=1}^{n} \sum_{j=0}^{J} d_{ij} \ln \frac{\exp(x_i \beta_j)}{\sum_{k=1}^{J} \exp(x_i \beta_k)} \quad , \qquad (5)$$

where d_{ij}=1 if individual chooses i chooses alternative j and d_{ij}=0 otherwise (Greene, 2003).

Empirical Model

The MLM is used to investigate the significance of selected factors on individuals' purchasing behavior and labeling preferences on biotech foods. The model was estimated separately for two different types of biotech foods, nonmeat and meat products.

The model can be expressed as follows:

$$\Pr[Y_i = j] = \frac{\exp(x_i \beta_j)}{1 + \sum_{k=1}^{J} \exp(x_i \beta_k)} \quad , \qquad (6)$$

where J is the dependent variable and the number of alternatives in the choice set. Respondent are asked to choose between a voluntary labeling and a mandatory labeling policy for biotech food. Another question asks respondents if they are willing to buy nonmeat and meat products produced using biotechnology. The model is estimated with six alternatives: j=1 if the respondent indicated they prefer voluntary labeling and they would buy a biotech food; j=2 if the respondent indicated they prefer mandatory labeling and they would buy a biotech food; j=3 if the respondent indicated they prefer voluntary labeling and they would not buy a biotech food; j=4 if the respondent indicated they prefer mandatory labeling and they would not buy a biotech food; j=5 if the respondent indicated they prefer voluntary labeling and they are uncertain about buying biotech food; j=6 if the respondent indicated they prefer mandatory labeling and they are uncertain about buying biotech food. The second alternatives, j=2, which is that the respondent indicated they prefer mandatory labeling and they would buy a biotech food, is used as the reference choice. The independent variables, x_i, hypothesized to influence the alternatives are summarized as follows: (1) consumers' perceptions variables toward biotech foods; (2) socioeconomic and demographic factors; (3) variables in regard to consumers' use of food label; (4) consumer awareness variable of biotech foods. $ß_j$ is a vector of the estimated parameters, and $\Pr[Y_i=j]$ is the probability of individual i choosing j alternative among six alternatives in the choice set.

Coefficients of the MLM are difficult to interpret because of the proliferation of parameters, which results in increased complexity in interpreting the estimates (Greene, 2003). The, marginal effects of the MLM are also difficult to derive. For continuous variables, marginal effects are calculated as follows:

$$\delta_j = \frac{\partial P_j}{\partial x_i} = P_j\left[\beta_j - \sum_{k=0}^{J} P_k \beta_k\right] = P_j[\beta_j - \bar{\beta}] \qquad (7)$$

The derivatives of the probabilities of the alternatives with respect to each of the explanatory variables are obtained at the sample means of the explanatory variables. For the binary explanatory variables, the difference between two computed probabilities is acquired at the sample means of all other explanatory variables, one conditional on the variable being equal to unity and one conditional on the variable being equal to zero.

$$\frac{\Delta \Pr(y = m|x)}{\Delta x_k} = \Pr(y = m|\mathrm{x}, x_k = x_E) - \Pr(y = m|\mathrm{x}, x_k = x_S) \qquad (8)$$

where $\Pr(y=m|x, x_k)$ is the probability that $y=m$ among J alternatives given x, x_S (starting value) = 0 and x_E(ending value) = 1(Long, 1997).

However, calculating marginal probabilities are not very useful to evaluate the magnitude of ß in MLM. First of all, discrete change represents the change for a particular set of values of the independent variables. Thus, the changes will not be the same at different levels of the variables. Another problem with marginal probability is that the dynamics among the dependent outcomes can not be captured from measures of discrete change (Long, 1997). Therefore, for the study, results are interpreted using the odds ratio, which is the exponentiated coefficient. The odds ratio is calculated by contrasting each category with the reference category. The odds ratio shows a multiplicative change in the odds for a unit change in an independent variable.

For the binary logit model,

$$\log\left(\frac{P}{1-P}\right) = x\boldsymbol{b} \qquad (9)$$

where *xß* is vector of independent variables and the estimated parameters.
This ratio is called the odds, thus the left-hand side of (9) equation is referred to the log of odds or *logit*. The logistic coefficient is interpreted as the change in the logit associated with a one-unit change in the independent variable, holding all other variables constant. The exponential of the logistic coefficient is the effects on the odds rather than probability. It is interpreted as for a one unit change in the independent variable, the odds are expected to change by a factor of exp(ß) when other things are equal.

The multinomial logit is an extension of binary logit. For multinomial logit, the odds of outcome of *m* versus outcome *n* given **x**, specified by ? $_{m|n}(\mathbf{x})$, is as follows:

$$\Omega_{m|n}(\mathrm{x}_i) = \frac{\Pr(y_i = m|\mathrm{x}_i)}{\Pr(y_i = n|\mathrm{x}_i)} = \frac{\exp(\mathrm{x}_i b_m)}{\exp(\mathrm{x}_i b_n)} \qquad (10)$$

where *m* is one of the six alternatives, and *n* is a reference category.

This equation can be expressed as

$$\Omega_{m|n}(\mathrm{x}_i) = \exp(\mathrm{x}_i[b_m - b_n]) \qquad (11)$$

Taking logs demonstrates the multinomial logit is linear in the logit:

$$\ln\Omega_{m|n}(\mathrm{x}_i) = \mathrm{x}_i(b_m - b_n) \qquad (12)$$

The difference $ß_m$- $ß_n$ is called a contrast, which is the effect of **x** on the logit of outcome *m* versus outcome *n* (Long, 1997).

The exponential of positive number is greater than one, and the exponential of negative number is less than one. Thus, the threshold between positive and negative effect is one in interpreting odds ratio. If exponentiated coefficient is greater than one, that implies increased odds. On the other hand, as exponentiated coefficient between zero and one, odds decrease. The distance of exponentiated coefficient from one in either direction explains the size of the effect on the odds for unit change in the independent variable (Pampel, 2000). Alternatively, the percentage change in the odds can be calculated (Long, 1997) as follows:

$$\text{The Percentage Change in the Odds} = 100[\exp(b_k) - 1] \qquad (13)$$

The equation (13) is interpreted as the percentage change in the odds in independent variable, holding all other variable constant.

The dependent variable, *y*, is defined as six alternatives as was mentioned earlier. Thus, y_{ij}=1 if the *i* individual chooses alternative *j*, otherwise 0. Independent variables, ***x***, characterize consumers' perceptions toward biotech foods, consumer use of food labels, demographics, and consumer awareness of biotech foods. Variables indicating consumers' perceptions of biotech products are those regarding human health, morality, environmental biodiversity, religious motivation, and so on. Frequency of food label use of respondents is the other explanatory variable. Demographic variables are gender, age, income, marital status, and etc.. Consumer awareness factor of biotech foods are the level of being informed.

The coding for demographic variables is as follows: Age_{ij}=1 if the i^{th} respondent's age corresponds to the j^{th} group, otherwise Age_{ij}=0; Inc_{ij}=1 if i^{th} respondents' income falls into j^{th} category, otherwise Inc_{ij}=0; Eth_{ij} =1 if the i^{th} respondent's race corresponds to j^{th} category, otherwise Eth_{ij} =0; Edu_{ij}=1if the i^{th} respondents' education level indicates the j^{th} category, otherwise Edu_{ij}=0; Mar_i=1 if i^{th} respondent is married, otherwise Mar_i= 0; $Male_i$=1 if the i^{th} individual is male, otherwise $male_i$= 0; Infant=1 if i^{th} respondent has infants, otherwise Infant=0; and $Awareness_i$ =1 if i^{th} respondent is more than somewhat informed about biotech foods, otherwise = $Awareness_i$ =0. In addition, the coding for respondents' perceived level of risks and benefits associated with biotechnology is expressed as ranging from 5 (strongly agree) to 1(strongly disagree). The coding for consumer use of food labels is represented as raging from 5 (never) to 1 (always).

The Questionnaire and Data Collection

A questionnaire was developed that included questions on mandatory and voluntary labeling preferences; questions on consumer awareness of biotech foods; questions on consumer risk perceptions of biotech foods; questions on purchasing biotech foods; questions regarding the consumers' use of food labels; and questions on consumer demographic.

The first part of the questionnaire presented background information on biotechnology. It contains a definition of biotechnology, present and future uses (benefits), and example of present application of biotechnology. This was followed by several questions in regard to the respondents' general knowledge of, and their attitudes toward biotechnology. In the following section respondents were asked whether they are in favor of either voluntary or mandatory labeling policy for biotech products. Next section describes a question on consumers' willingness to purchase biotech foods and a question on how often they read food labels while shopping. In the last section, information is collected regarding respondents' socioeconomic and demographic characteristics (e.g., age, income, marital status, education, and so on).

In order to meet the objectives of the study, a mail survey was conducted during the month of July 2002. Questionnaires were mailed to randomly selected 3,450 households for the seven metropolitan regions in the U.S.: Atlanta, Denver, Houston, Chicago, Los Angeles, New Orleans, and New York. Number of surveys mailed to Atlanta is 450, Denver 500, Houston 500, Chicago 500, Los Angeles 500, New Orleans 500, and New York 500. Five hundred twenty four (15% of sample) individuals responded, but not all of the returned surveys were completed. Only five hundred nine usable surveys were returned, for an overall response rate of 14.75%.

Results

Summary statistics and frequency distributions of the socioeconomic and demographic variable information of the sample are presented in table 1. Out of 509 respondents, 54 % (274) are male and 46% (235) are female. About 64 % of those surveyed were married. All age groups are represented in the sample, with the 45-54 age groups representing 27% of the sample, and the majority of respondents (about 80%) were white. Most of the respondents are highly educated, as more than 80% finished some college course, completed bachelor degree, and did post graduate work. Thus, the responding sample is somewhat biased toward the white and higher-educated. The median income of respondents ranged from $30,000 to $44,999, accounting for 20% of the sample. Frequency distributions concerning respondents' agreement or disagreement with the mandatory labeling versus voluntary labeling question are presented in Table 2. As shown, of the 509 respondents, 80% (409) support mandatory labeling policy for biotech products. Only 20% of respondents favor the voluntary labeling policy.

The estimated models fit the data fairly well with a Chi-squared value of 482.941 for biotech nonmeat and 416.783 for biotech meat product, which are statistically significant at the a=0.01 level. For the analysis, the differences of coefficients between indicator and reference choice are reported in tables 3, 4, and 5. For consumers' preferences of labeling policy in both biotech crops and biotech meat products, voluntary labeling policy is an indicator choice and mandatory labeling policy is a reference choice. For consumers' willingness to purchase biotech products, depending on voluntary and mandatory labeling policy, an indicator choice is when consumes are in the market, and a reference choice is when consumers are out of the market. The magnitudes of the differences are obtained from multinomial logit results by testing the null hypothesis that the differences between indicator and reference category are equal. Consumers' labeling preferences for biotech foods from crops are presented in table 3, depending on whether consumers are in the market, they are out of the market, and they are uncertain about purchasing biotech foods.

<u>Consumer Preferences of Labeling Policy for Biotech Crops</u>

Consumers in the market

The coefficient on statement S1 is significant at the a=0.10 significance level, and positive which suggests that as consumers consider that biotech foods are safe for human consumption, they are more likely to favor the current voluntary labeling policy. The estimated odds for individuals agreeing with statement S1 to support current labeling policy was 1.90 times higher than a mandatory labeling policy. The coefficients on statement S2 and S5 have the expected signs and are significant at the a=0.01 level of significance. The odds ratio for adverse effects on the environment is 0.52, indicating that as respondents are aware of side effects of biotech crops on the wildlife and the environment, the odds in favor of current voluntary labeling decreases by a multiplicative factor of 0.52. This results support research hypothesis that unfavorable effect on the wildlife and the environment has negative effects on the probability of favoring current voluntary labeling policy. As consumers believe the U.S. Food and Drug Administration (FDA) as inspection agency of biotech foods, the odds of supporting current labeling policy is 1.51 times larger than mandatory labeling policy, which is consistent with our expectation.

Consumers are out of the market

The coefficients on consumer awareness of biotech foods and side effects on the environment of biotech foods are significant at the a=0.01 significance level. Results show that as consumers are well informed of biotechnology, they have stronger risk perceptions for biotech foods. A coefficient on consumer awareness of biotech biotechnology has a negative sign, as expected. The odds ratio that consumers of being informed more than somewhat are in favor of current labeling policy are 0.01, implying the more they are aware of biotechnology, the less they support current labeling by a multiplicative factor of 0.01. The estimated odds for those who recognize adverse effect on the environment of biotech foods to support current labeling policy is 0.03 smaller than mandatory labeling policy. The estimated coefficient on infant, age3, and income3 are statistically significant at the 0.01 level of significance. The odds ratio for consumers with infants, age group between 18 and 34, and income group more than $90,000 to support current labeling policy is extremely low compared to mandatory labeling policy, indicating that they are very concerned about health risk due to biotechnology.

Consumers uncertain about purchasing biotech foods

The estimated coefficients on statement S4 and S5 are statistically significant at the a=0.10 and a=0.01 level of significance, respectively. Results demonstrate that even though consumers agree that biotechnology benefits society by producing food more efficiently, they have an unfavorable attitude to current labeling policy, which is unexpected. The estimated odds for the current labeling policy is 0.55 times lower than mandatory labeling policy. One possible explanation is that consumers may distinguish society benefit from their own interest. However, the odds ratio of consumers supporting FDA as scientific and regulatory institution of biotech foods are in favor of current labeling policy is 2.88 times greater than mandatory labeling policy, which is consistent with our expectation. In terms of use of foods labels, which is significant at the a=0.01 significance level, the study reveals, as expected, that the more consumers read food labels of new products, the less they support current labeling policy. The estimated odds for the voluntary labeling policy are 0.18 times lower than the mandatory labeling policy, suggesting that consumers who are interested in reading food labels of new products are in favor of the mandatory labeling policy.

Consumers' labeling preferences for meat biotech foods are presented in table 4, according to consumers in the market, out of the market, and uncertain about purchasing biotech foods.

Consumer Preferences for a Biotech Labeling Policy- Biotech Meat Products

Consumers in the market

Results show that as consumers are concerned adverse effects on the environment of biotech foods, they are more likely to support a mandatory labeling policy, which is expected. Statement S2 and S3 are statistically significant at the a=0.01 confidence level. The odds ratio of consumers who are conscious of side effects of biotech on wildlife and the environment support current labeling policy is 0.51 times lower than mandatory labeling policy, as predicted. However, results show that consumers agreeing with the statement that biotech meat products are more likely to pose health risk than biotech nonmeat products are in favor of current labeling policy by 1.70 times higher than mandatory labeling policy, which is unexpected. It is not clear how this result is obtained. Male respondents are significantly related to the probability of choosing mandatory labeling policy at the 0.05 significance level. The estimated odds for male is 0.34, suggesting the predicted odds for male to support current labeling policy decreases by a multiplicative factor of 0.34.

Consumers out of the market

Results reveal that the age of the respondent has a significant effect on the probability of choosing a labeling policy. The age group more than 55 is statistically significant at the a=0.10 level of significance, and of expected negative sign. This suggests that older respondents more than 55 be worry about unknown health risk of biotech foods, and thus are more likely to support mandatory labeling policy. The odds ratio is 0.27, indicating that that the odds for them to be in favor of current labeling policy decreases by a multiplicative factor of 0.27. The estimated coefficient on statement S2 is statistically significant at the 0.01 level of significance. The estimated odds of consumers recognizing adverse effects on environment of biotech foods favor current labeling policy is 0.20 times smaller than mandatory labeling.

Consumers uncertain about purchasing biotech foods

Respondents' trust for FDA as regulatory agency for biotech foods has positive and significant effect on the probability of choosing labeling policy. A coefficient on statement S5 is significant at the a=0.01 significance level and has expected positive sign. The odds ratio of consumers trusting the U.S. Food and Drug Administration (FDA) as an inspection institution of biotech foods support current labeling policy is 2.17 times higher than mandatory labeling policy. This suggests that they are unfavorable of purchasing biotech foods, but they have confidence in government institution as regulatory agency of biotech foods.

The results from table 3 and 4 suggest that in both biotech food from crops and meat biotech foods, when consumers are out of the market, they have relatively stronger risk sensitivity on environment of biotech foods. This results support research hypothesis that if consumers are out of the market, they are less in favor of current labeling policy, and they have stronger risk perceptions on wildlife and environment of biotech foods. Thus, they are more likely to support mandatory labeling policy. In addition, research hypothesis that risk sensitivity in biotech meat foods is greater than that in nonmeat biotech foods is supported from results in Table 3 and 4. Results demonstrate that when consumers are in the market and uncertain about purchasing biotech foods, the probability of supporting current labeling policy in biotech meat foods is lower than in biotech foods from crops.

Table 5 presents consumers' purchasing behavior for both crops and meat biotech foods according to the labeling preferences.

Consumer Willingness to Purchase – Food from Biotech Crops

Support current labeling policy

The estimated coefficients on consumer awareness of biotech foods and statement S1 are statistically significant at the a=0.01 confidence level, and of expected positive sign, respectively. The odds ratio for consumer awareness of biotech foods is 126.1, which suggests that the odds of buying biotech foods is 126.1 times larger than not buying as they get more informed of biotechnology. The estimated odds of consumers who feel safety of the biotech food for human consumption are willing to buy biotech foods is 112.7 times higher than not willingness to buy the same foods, indicating that these consumers are very favorable of purchasing biotech foods. For the adverse effect on environment of biotech foods, we expected lower odds of buying biotech foods, but the results shows higher odds. Education level of consumers, which is significant at the 0.10 confidence level, has positive and significant effect on the probability of purchasing biotech foods. Consumers with education level of more than college are more likely to be willingness to buy biotech foods. The odds ratio for education is 14.1, implying that the odds that consumers with more than college level buy biotech foods is higher by a multiplicative factor of 14.1.

Support mandatory labeling policy

Results show that the estimated coefficients on statement S4 and S6 are statistically significant at the 0.01 confidence level, and of the expected positive and negative sign, respectively. This suggest that as consumers believe that biotechnology provides benefit to society by allowing farmer to produce more efficiently with less waste and fewer pesticides, they are more likely to purchase biotech foods. The estimated odds of consumers agreeing biotechnology benefit for society purchase biotech foods is 2.56 times greater than not purchasing those. However, consumers who believe that biotechnology is morally wrong by producing hybrid plants and animal are less likely to buy biotech foods. As consumers recognize immorality of biotechnology, the odds for them to buy biotech foods is 0.38 times lower. This result suggests that morality of biotechnology is significant factor to determine consumers' purchasing behavior of biotech foods.

<u>Consumer Willingness to Purchase – Biotech Meat Products</u>

Support current labeling policy

It is expected that if consumers believe that biotech meats are more likely to pose health risks relative to nonmeat food, then they are less likely to purchase biotech meats. A negative sign of statement S3, which is statistically significant at the 0.05 significance level, provides evidence. Results show that the estimated odds that consumers who are aware of more likely health risk from biotech meat foods purchase biotech meats is 0.28 times lower relative to not buying that foods. As consumers trust FDA as regulatory agency of biotech foods, it is expected a positive impact on the probability of purchasing biotech foods. However, result shows unexpected negative sign.

Support mandatory labeling policy

The race variable turned out to be significant in purchasing biotech meats at the 0.05 confidence level. The estimated odd for white is 2.68, indicating that the odds for white to purchase biotech foods rather than not purchasing is 2.68 times higher. It is anticipated that the more consumer read foods labels of new products, the less they purchase biotech foods when they prefer mandatory labeling policy. This expectation is supported from a negative sign and

0.38 odds ratio of consumer use of foods labels variable, which is significant at the 0.05 significance level.

From the analysis in table 5, two important implications have been drawn. First, when consumers indicate they prefer the current FDA policy in agreement with statement S1, S2, S3, and S5, all lead to smaller odds that a consumer would buy a biotech meat products, relative to nonmeat product. This is also the case for the statement S1 through S4 if consumer indicates they prefer a mandatory labeling policy. Therefore, consumers are generally less willing to purchase biotech meat under either labeling relative to biotech nonmeats. Thus, research hypothesis that consumers are more concerned about biotech meat foods relative to nonmeat foods is supported. This finding is consistent with Hallman and Metcalfe's study (1994), which demonstrated consumers are less likely to accept the use of biotechnology with meat products produced using biotechnology. Secondly, table 5 shows that the odds ratio in mandatory labeling relative to voluntary labeling policy is generally smaller for both nonmeat and meat cases, which means that consumers are less likely to purchase biotech foods under a mandatory labeling policy.

Conclusions

This study conducted a national survey to investigate the effects of consumers' risk perceptions of biotech foods on attitudes toward the current U.S. labeling policy for biotech foods. A multinomial logit analysis is used to examine the effects of risk perceptions of biotech foods on consumer preferences for mandatory and voluntary labeling and consumers' purchasing behavior of biotech foods depending on labeling policy. Results show that if consumers are not willing to buy biotech foods, then they are less likely to favor voluntary labeling policy and have stronger risk sensitivity to potential negative effects of biotech foods on wildlife and the environment. In addition, this study reveals that when consumers are in the market or uncertain about purchasing biotech foods, the odds of them supporting the current labeling policy for biotech meats is lower than in biotech foods made from crops. Results support the hypothesis that consumers are less likely to purchase biotech foods under a mandatory labeling policy.

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Table 1. Frequency Distribution of Socio-Demographic Characteristics of Survey Respondents of Biotech Labeling Survey

Demographic Characteristics Sample (n= 509)	Number	Percentage
Gender		
Male	274	54.0
Female	235	46.0
Age (years)		
18-24	12	2.36
25-34	56	11.00
35-44	99	19.45
45-54	135	26.52
55-65	93	18.27
65 or older	114	22.40
Education		
Less than high school	2	0.39
Completed High school	58	11.39
Technical school	37	7.27
Some college	119	23.88
Completed bachelor degree	150	29.47
Post graduate work	143	28.09
Income		
Less than $15,000	33	6.48
$15,000 -$29,000	47	9.23
$30,000 - $44,999	101	19.84
$45,000 - $59,999	99	19.45
$60,000 -$74,999	76	14.93
$75,000 -$89,999	53	10.41
$90,000 -$104,999	32	6.29
$105,000 -$119,999	19	3.73
More than $120,000	49	9.63

Table 2. Respondent's Responses to a Mandatory or Voluntary Labeling Policy.

	Number of Respondents	Percentage of Respondents
Voluntary Labeling	103	20
Mandatory Labeling	406	80

Table 3. Consumers' Labeling Preferences Given Purchasing Behavior for Biotech Foods from Crops

Variable	In the Market: Current Policy vs. Mandatory		Out of the Market: Current Policy vs. Mandatory		UNCERTAIN: Current Policy vs. Mandatory	
	Coeff. (Std.Err.)	*Exp(ß)*[1]	*Coeff. (Std.Err.)*	*Exp(ß)*	*Coeff. (Std .Err)*	*Exp(ß)*
Constant Term	-2.484	0.08	14.855	[2]	-0.695	0.50
	(1.754)		(6.772)		(2.285)	
Consumer Awareness of Biotech Foods	0.478	1.61	-4.405***	0.01	-0.259	0.77
	(0.342)		(1.490)		(0.516)	
S1. Biotech Foods are reasonably safe for human consumption.	0.644*	1.90	-2.087	0.12	-0.312	0.73
	(0.366)		(1.703)		(0.371)	
S2. Biotech crops may have adverse effects on wildlife and the environment.	-0.657***	0.52	-3.453***	0.03	-0.062	0.94
	(1.193)		(0.943)		(0.249)	
S3. Meat products produced using biotechnology are more likely to pose health risks than foods made from biotech crops.	0.200	1.22	-0.189	0.83	-0.265	0.77
	(0.208)		(0.684)		(0.273)	
S4. Biotechnology benefits society because it allows farmers to produce food more efficiently.	-0.277	0.76	1.099	3.00	-0.592*	0.55
	(0.339)		(0.711)		(0.328)	
S5. There is no need to be concerned about the safety of biotech foods because the U.S. Food and Drug Administration (FDA) would not let these products be sold in supermarket if they were not safe.	0.410***	1.51	0.372	1.45	1.059***	2.88
	(0.157)		(0.538)		(0.231)	
S6. It is unethical to produce a food using biotechnology.	-0.146	0.86	-0.340	0.71	0.237	1.27
	(0.237)		(0.589)		(0.269)	
Infants	-0.797	0.45	-29.111***	2.28^{-13}	-1.724*	0.18
	(0.868)		(1.791)		(0.944)	
Male	-0.371	0.69	-1.701	0.18	-0.611	0.54
	(0.352)		(1.390)		(0.509)	
Age						
Age1 (age group between 18 and 34)	-0.561	0.57	-33.964***	1.78^{-15}	-0.186	0.83
	(0.574)		(3.215)		(0.718)	
Age3 (age group more than 55)	-0.391	0.68	0.596	1.81	-0.499	0.61
	(0.362)		(2.537)		(0.562)	
Income						
Income1 (income group less than $44,999)	0.142	1.15	1.210	3.35	0.775	2.17
	(0.423)		(0.957)		(0.546)	
Income 3 (income group more than $90,000)	0.687*	1.99	-29.479***	1.58^{-13}	-0.168	0.85
	(0.388)		(1.294)		(0.865)	

* ,**,***, indicates estimated coefficient is significant at the 0.10, 0.05, and 0.01 level, respectively. N = 509; Chi-square (χ^2)= 482.941; Log-L=-519.414; [1] is odds ratio. [2] indicates large odds ratio.

Contiuned.

Variable	In the Market: Current Policy vs. Mandatory		Out of the Market: Current Policy vs. Mandatory		UNCERTAIN: Current Policy vs. Mandatory	
	Coeff. (Std.Err.)	*Exp(ß)*[1)]	*Coeff. (Std.Err.)*	*Exp(ß)*	*Coeff. (Std.Err.)*	*Exp(ß)*
Education	0.313	1.37	-2.290	0.10	0.163	1.18
	(0.598)		(1.421)		(0.576)	
Married	-0.463	0.63	-0.592	0.55	0.464	1.59
	(0.371)		(0.866)		(0.450)	
White	0.220	1.25	-0.156	0.86	0.133	1.14
	(0.472)		(0.919)		(0.496)	
How often do you read the ingredient section of	-0.291	0.75	-1.653	0.19	-1.734***	0.18
food labels before buying a new product?	(0.368)		(1.760)		(0.518)	

* ,**,***, indicates estimated coefficient is significant at the 0.10, 0.05, and 0.01 level, respectively. N = 509; Chi-square (χ^2)= 482.941; Log-L=-519.414; [1)] is odds ratio

Table 4. Consumers' Labeling Preferences Given Purchasing Behavior for Meat Biotech Foods

Variable	In the Market		Out of the Market		UNCERTAIN	
	Current Policy vs. Mandatory		Current Policy vs. Mandatory		Current Policy vs. Mandatory	
	Coeff. (Std.Err.)	*Exp(ß)*[1)]	*Coeff. (Std.Err.)*	*Exp(ß)*	*Coeff. (Std .Err)*	*Exp(ß)*
Constant Term	-1.467 (2.562)	0.23	3.012 (2.857)	20.3	-1.245 (1.807)	0.29
Consumer Awareness of Biotech Foods	0.667 (0.442)	1.95	-0.122 (0.554)	0.89	0.065 (0.430)	1.07
S1. Biotech Foods are reasonably safe for human consumption.	0.720 (0.485)	2.05	-0.034 (0.582)	0.97	-0.165 (0.306)	0.85
S2. Biotech crops may have adverse effects on wildlife and the environment.	-0.680*** (0.227)	0.51	-1.616*** (0.443)	0.20	-0.136 (0.219)	0.87
S3. Meat products produced using biotechnology are more likely to pose health risks than foods made from biotech crops.	0.528*** (0.265)	1.70	0.701 (0.478)	2.02	-0.219 (0.235)	0.80
S4. Biotechnology benefits society because it allows farmers to produce food more efficiently.	-0.052 (0.440)	0.95	-0.396 (0.422)	0.67	-0.210 (0.78)	0.81
S5. There is no need to be concerned about the safety of biotech foods because the U.S. Food and Drug Administration (FDA) would not let these products be sold in supermarket if they were not safe.	0.117 (0.192)	1.12	1.094*** (0.319)	2.99	0.777*** (0.170)	2.17
S6. It is unethical to produce a food using biotechnology.	-0.265 (0.308)	0.77	-0.550 (0.413)	0.58	0.165 (0.207)	1.18
Infants	-0.986 (0.878)	0.37	-28.443*** (0.728)	4.44^{-13}	-1.247 (1.042)	0.29
Male	-1.091** (0.485)	0.34	-0.085 (0.644)	0.92	-0.227 (0.414)	0.80
Age						
Age1 (age group between 18 and 34)	0.067 (0.709)	1.07	-1.101 (0.844)	0.33	-0.581 (0.681)	0.56
Age3 (age group more than 55)	0.081 (0.453)	1.08	-1.310* (0.687)	0.27	-0.637 (0.473)	0.53
Income						
Income1 (income group less than $44,999)	0.422 (0.531)	1.53	0.327 (0.745)	1.39	0.582 (0.464)	1.79
Income 3 (income group more than $90,000)	0.512 (0.475)	1.67	0.327 (0.855	1.39	0.372 (0.574)	1.45

* ,**,***, indicates estimated coefficient is significant at the 0.10, 0.05, and 0.01 level, respectively. N = 509; Chi-square (χ^2)= 416.783; Log-L=-568.967; [1)] is odds ratio

Contiuned.

Variable	In the Market Current Policy vs. Mandatory		Out of the Market Current Policy vs. Mandatory		UNCERTAIN Current Policy vs. Mandatory	
	Coeff. *(Std.Err.)*	*Exp(ß)*[1)]	*Coeff.* *(Std.Err.)*	*Exp(ß)*	*Coeff.* *(Std.Err.)*	*Exp(ß)*
Education	-0.212 (0.765)	0.81	-0.215 (0.804)	0.81	-0.367 (0.543)	0.69
Married	-0.261 (0.456)	0.77	-1.524*** (0.469)	0.22	0.505 (0.450)	1.66
White	0.416 (0.724)	1.52	0.365 (0.599)	1.44	-0.404 (0.433)	0.67
How often do you read the ingredient section of food labels before buying a new product?	-0.529 (0.442)	0.59	-1.101 (0.698)	0.33	-0.639 (0.443)	0.53

* ,**,***, indicates estimated coefficient is significant at the 0.10, 0.05, and 0.01 level, respectively. N = 509; Chi-square (χ^2)=416.783; Log-L=-568.967; [1)] is odds ratio

Table 5. Consumers' Purchasing Behavior for Both Crops and Meat Biotech Foods Given Labeling Preferences

Variable	NONMEAT				MEAT			
	Current Policy		Mandatory		Current Policy		Mandatory	
	In the Market vs. Out of the Market		In the Market vs. Out of the Market		In the Market vs. Out of the Market		In the Market vs. Out of the Market	
	Coeff. (Std. Err)	*Exp(ß)*[1)]	*Coeff. (Std. Err)*	*Exp(ß)*	*Coeff (Std. Err).*	*Exp(ß)*	*Coeff. (Std. Err)*	*Exp(ß).*
Constant Term	-23.534	6.01^{-11}	-6.195	2.04^{-03}	-7.205	7.43^{-04}	-2.719	0.07
	(6.429)		(2.120)		(1.944)		(2.195)	
Consumer awareness of biotech foods	4.837***	126.1	0.385	1.47	-0.181	0.83	-0.370	0.69
	(1.409)		(0.415)		(0.171)		(0.437)	
S1. Biotech Foods are reasonably safe for human consumption.	4.725***	112.7	1.994***	7.34	1.943***	6.98	1.189***	3.28
	(1.698)		(0.388)		(0.693)		(0.238)	
S2. Biotech crops may have adverse effects on wildlife and the environment.	2.757***	15.8	-0.039	0.96	0.574	1.78	-0.363	0.70
	(0.927)		(0.267)		(0.448)		(0.241)	
S3. Meat products produced using biotechnology are more likely to pose health risks than foods made from biotech crops.	0.218	1.24	-0.171	0.84	-1.274**	0.28	-1.101***	0.33
	(0.651)		(0.318)		(0.506)		(0.282)	
S4. Biotechnology benefits society because it allows farmers to produce food more efficiently.	-0.188	0.83	0.939***	2.56	0.799	2.22	0.455	1.58
	(0.752)		(0.281)		(0.552)		(0.300)	
S5. There is no need to be concerned about the safety of biotech foods because the U.S. Food and Drug Administration (FDA) would not let these products be sold in supermarket if they were not safe.	-0.125	0.88	-0.163	0.85	-0.748**	0.47	0.230	1.26
	(0.524)		(0.226)		(0.333)		(0.192)	
S6. It is unethical to produce a food using biotechnology.	-0.777	0.46	-0.972***	0.38	-0.299	0.74	-0.584**	0.56
	(0.612)		(0.334)		(0.465)		(0.258)	
Infants	28.185***	2)	-0.130	0.88	28.434***	4)	0.982	2.67
	(2.065)		(1.085)		(1.009)		(0.953)	
Male	2.151	8.60	0.821*	2.27	0.511	1.67	1.517***	4.56
	(1.381)		(0.431)		(0.696)		(0.443)	
Age								
Ag1 (age group between 18 and 34)	33.663***	3)	0.260	1.30	0.959	2.61	-0.209	0.81
	(3.265)		(0.644)		(0.918)		(0.667)	
Age3 (age group more than 55)	-0.660	0.52	0.327	1.39	1.689**	5.41	0.297	1.35
	(2.527)		(0.441)		(0.722)		(0.423)	
Income								

*,**,***, indicates estimated coefficient is significant at the 0.10, 0.05, and 0.01 level, respectively. N = 509. For crop Chi-square (χ^2)= 482.941; Log-L=-519.414, and for meat Chi-square (χ^2)=416.783; Log-L=-568.967; 1) is odds ratio. 2), 3), and 4) indicate large odds ratio.

Continued.

Variable	NONMEAT				MEAT			
	Current Policy		Mandatory		Current Policy		Mandatory	
	In the Market vs Out of the Market		In the Market vs Out of the Market		In the Market vs Out of the Market		In the Market vs Out of the Market	
	Coeff. (Std. Err.)	*Exp(ß)*[1]	*Coeff. (Std. Err.)*	*Exp(ß)*	*Coeff. (Std. Err.)*	*Exp(ß)*	*Coeff. (Std. Err.)*	*Exp(ß)*
Income 1 (income group less than $44,999)	-0.369	0.69	0.699	2.01	0.078	1.08	-0.018	0.98
	(0.947)		(0.461)		(0.808)		(0.449)	
Income 3 (income group more than $90,000)	30.186***	[2]	0.021	1.02	0.599	1.82	0.414	1.51
	(1.284)		(0.534)		(0.877)		(0.496)	
Education (more than college)	2.648*	14.1	0.045	1.05	1.306	3.69	1.303*	3.68
	(1.416)		(0.681)		(0.905)		(0.702)	
Married	0.541	1.71	0.413	1.51	0.873	2.39	-0.392	0.68
	(0.845)		(0.465)		(0.531)		(0.436)	
White	0.469	1.60	0.093	1.10	1.035	2.82	0.984**	2.68
	(0.945)		(0.489)		(0.839)		(0.476)	
How often do you read the ingredient section of food labels before buying a new product?	1.771	5.88	0.410	1.51	-0.396	0.67	-0.967**	0.38
	(1.724)		(0.527)		(0.679)		(0.488)	

* ,**,***, indicates estimated coefficient is significant at the 0.10, 0.05, and 0.01 level, respectively. N = 509. For crop Chi-square (χ^2)= 482.941; Log-L=-519.414, and for meat Chi-square (χ^2)=416.783; Log-L=-568.967; [1] is odds ratio. [2] indicates large odds ratio.