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Consumer Response to Genetically Modified Foods: Market Segment Analysis and Implications for Producers and Policy Makers

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Conjoint analysis is used to elicit consumer preferences for attributes of genetically modified foods. Market segments are identified based on a cluster analysis of respondents' preferences for brand, price, and GMO content. A logit analysis is used to analyze consumer characteristics associated with the acceptance of GMO foods. Those consumers who were most risk averse, most likely to believe that GMOs improved the quality or safety of food, and most knowledgeable about biotechnology were the most likely to be accepting of GMO foods. These findings are used to develop implications for producers and regulators of GMO foods.

Key words: conjoint analysis, consumer behavior, genetically modified food, genetically modified organisms, GMO

Introduction

Over the past decade or so, U.S. consumers have exhibited a high level of concern regarding the safety of the food supply. Consumers and consumer activist groups have increasingly called for assurances that food is free from substances such as pesticides, chemical additives, hormones, and antibiotics. Most consumers apparently accept and reap the benefits of chemicals used in food production resulting in cosmetically perfect fruits and vegetables at low prices. However, some consumers prefer organic produce, and producers have responded by developing a niche market to serve their needs. Recently, the U.S. Department of Agriculture (USDA) issued the final rule which will govern the production and sale of organic foods in the United States.

The threat of foods that are the product of genetically modified organisms (GMOs) has been the source of consumer fears in the United States and Europe. Incidents such as the inadvertent introduction of the genetically modified StarLink corn into taco shells have served to heighten consumer awareness regarding GMO foods. There is a need to understand what consumers want, and want to avoid, with respect to GMO foods as well as the consumer characteristics associated with concern for GMOs.

Such an understanding of the relationships between consumer characteristics and food safety concerns is important for several reasons. It may be used to guide the

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The authors wish to note that the products and product characteristics described in this research are hypothetical. We do not intend to imply that any actual products on the market are derived from genetically modified organisms.

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development of food safety policies and regulations, to develop products which address consumer needs, to target informational programs, and to design promotional or advertising campaigns. This research is especially important because of the pace of GMO adoption and because it will soon be difficult, if not impossible, to maintain separate products based on the presence or absence of GMO content (Barboza).

Many studies have been undertaken to develop an understanding of the relationship between consumer characteristics and the level of consumer concern for various food safety risks. Most of these studies have focused on socioeconomic factors. Table 1 summarizes the results from 10 such studies (Ott; Byrne, Gempesaw, and Toensmeyer; Misra, Huang, and Ott; Baker and Crosbie; Huang, Kan, and Fu; Nayga; Baker; McGuirk, Preston, and McCormick; Lin; Kaiser, Scherer, and Barbano) for six socioeconomic factors (age, presence of children in the household, educational level, ethnicity, gender, and income).

While the table serves as a convenient device to illustrate the relationships between consumer characteristics and the concern for food safety, caution should be used in interpreting the table since the presentation masks the many differences among the studies. For example, seven of the studies focused on the risk due to pesticides; two studies examined consumer concern for food safety in general; the remaining study explored consumer concern due to bovine somatotropin (bST). Furthermore, other differences—including how the dependent variables were measured, the measure and measurement method of the independent variables, statistical methods employed, sample size, and the type of sample—may have contributed to differences in the studies' conclusions. Several of the studies reported in table 1 also elicited responses to non-socioeconomic questions regarding participants' knowledge or attitudes.

Clearly there is little consistency in the results reported in table 1. In approximately half of the cases, no statistical association was found between the socioeconomic factors and the measures of consumer concern. Perhaps the most consistent result, supported by six of the nine studies where gender was included as an attribute, is that women tended to be more concerned with food safety than men. Less compelling were the results regarding income and education—these were found to be negatively associated with the concern for food safety in three and four studies, respectively, and positively associated with the concern for food safety in two other studies each.

While some insight has been gained in understanding consumers' concerns for food safety, much remains to be learned. Most of the research has focused on the impact of socioeconomic variables and has largely neglected the impact of factors such as consumer knowledge, beliefs, and attitudes. Furthermore, little information is available concerning the relationship between consumer characteristics and the acceptability of GMO foods.

One study, a recently published article by Lusk et al., examined factors influencing consumer willingness to pay for nongenetically modified corn chips. In a sample of 50 college students, the authors found participants' concern about genetically modified foods was statistically significant in explaining the size of a participant's willingness-to-pay bid to avoid genetically modified corn chips. None of the socioeconomic variables examined were statistically significant.

The purpose of this analysis is to develop a better understanding of consumer preferences for GMO food products, both in terms of the attributes influencing consumer choice as well as the underlying factors affecting these preferences. The findings will serve to inform policy makers as they debate questions such as what type of regulatory scrutiny

Table 1. Relationships Between Socioeconomic Characteristics and Concern for Food Safety in Ten Published Research Studies, by Type of Food Safety Concern

Research Study	Type of Food Safety Concern	Socioeconomic Characteristic[a]					
		Age	Children Present	Education Level	Ethnicity (White)	Gender (Female)	Income
Ott (1990)	Pesticides	0	NA	0	+	0	0
Byrne, Gempesaw & Toensmeyer (1991)	Pesticides	0	NA	–	NA	+	–
Misra, Huang & Ott (1991)	Pesticides	+	NA	–	+	0	+
Baker & Crosbie (1993)	Pesticides	0	NA	0	0	+	+
Huang, Kan & Fu (1996)	Pesticides	0	+	+	NA	NA	0
Nayga (1996)	Pesticides	+	0	–	NA	+	–
Baker (1999)	Pesticides	0	NA	0	+	+	0
McGuirk, Preston & McCormick (1990)	Food Safety	+	+	–	0	+	–
Lin (1995)	Food Safety	+	+	+	0	+	0
Kaiser, Scherer & Barbano (1992)	bST	+	0	0	NA	0	NA

Notes: Each study's author(s), date of publication, and the type of consumer safety concern are identified in the first two columns. The results of the various studies are not directly comparable because of differences in the dependent variables, differences in what the independent variables measured and how they were measured, statistical methods employed, sample size, and the authors' interpretation of the studies' results.

[a] Statistically significant relationships are denoted by a plus (+) for a positive or a minus (–) for a negative relationship; a zero (0) denotes no statistically significant relationship; NA indicates not applicable.

GMO foods should undergo before they are approved for sale, and whether GMO foods should be labeled based on the technology used to produce them. This information will also serve to inform food manufacturers and marketers in making decisions regarding whether and how to introduce GMO foods.

The specific objectives of this study are: (*a*) to determine the extent to which consumers' purchasing decisions are affected by whether a food product contains GMOs, and to identify groups of consumers based on their valuation of GMO product attributes; and (*b*) to examine the relationship between consumer preferences for GMOs and consumer characteristics, and determine whether socioeconomic or cognitive variables are the most important determinants of consumer preferences for GMOs.

Conceptual Frameworks

Consumer Choice Framework

Lancaster's theory of consumer demand, as extended by Ladd and Zober, and further extended by van Ravenswaay and Hoehn, provides the conceptual basis for this study. In this model, consumers purchase products because of the characteristics they possess and the consumption services they provide. Consumers make product choices to maximize utility based on the consumption services provided by the product's attributes. Foods, for example, provide the consumption services of nutrition, taste, appetite fulfillment, and aesthetic appeal, based on attributes such as the ingredients, preparation, packaging, and presentation.

Mathematically, the model may be defined as follows. Consumers have available to them a product x_1 offered at price p_1, and alternative products represented by the vector $\mathbf{x} = (x_2, ..., x_I)$ offered at prices corresponding to vector $\mathbf{p} = (p_2, ..., p_I)$. The product x_1 provides J product attributes represented by the vector $\mathbf{a}_1 = (a_{11}, ..., a_{1J})$. Similarly, the product attribute matrix $\mathbf{A} = [a_{ij}]$ $(i = 2, ..., I; j = 1, ..., J)$ represents the amount of each attribute available in alternative products. For example, a_{23} would represent the amount of the third attribute present in one unit of the second product.

Consumers receive K consumption services. The amount of each consumption service depends on the quantity of each product the consumer chooses and the attribute bundle associated with each product. This may be expressed as:

$$\text{(1)} \qquad \mathbf{s} = s_k(x_1, \mathbf{a}_1, \mathbf{x}, \mathbf{A}), \qquad k = 1, ..., K.$$

The consumers' utility function is expressed as a function of these consumption services:

$$\text{(2)} \qquad U = u(s_1, ..., s_K),$$

subject to the budget constraint:

$$\text{(3)} \qquad p_1 x_1 + \mathbf{p}'\mathbf{x} \leq m.$$

The consumer's choice process may be expressed in terms of the indirect utility function:

$$\text{(4)} \qquad V = (p_1, \mathbf{a}_1, \mathbf{p}, \mathbf{A}, m),$$

such that the consumer chooses among the various attribute bundles to maximize utility.

Market Segmentation Framework

Markets are typically segmented by developing groups of consumers with similar needs and wants. Ideally, the segments will differ in their product needs or buying responses (Kotler and Armstrong). Market segmentation is used to develop a better understanding of consumers' motives and to facilitate the design of marketing plans. Socioeconomic (or demographic) and psychographic variables are two of the most common bases for market segmentation.

Socioeconomic variables include factors such as age, educational level, race, and gender. They are probably the most commonly used variables in market segmentation because consumers' "needs, wants, and usage rates often vary closely with demographic variables" (Kotler and Armstrong, p. 242). Moreover, socioeconomic data are easy to measure and convenient to collect (Gaedeke and Tootelian).

Psychographic segmentation uses lifestyles (including factors such as activities, interests, and opinions), personality characteristics, and social class to categorize consumers. The VALS (Values and Life Style) measurement approach, recently replaced by VALS 2, has been widely used by marketing researchers as a way of classifying consumers into lifestyle groups (Kahle, Beatty, and Homer). The appeal of using psychographic variables as the basis for segmentation is that the cause and effect relationships between the consumer descriptors and consumer preferences are more easily identified than for segmentation based on demographics (Gaedeke and Tootelian).

Methods and Procedures

Consumer Choice Model

Conjoint analysis was used as the basis for the experimental design of the consumer choice model. Conjoint analysis has been widely used in consumer marketing and is especially appropriate for evaluating hypothetical products or attributes. The conjoint analysis methodology is ideal for use with Lancaster demand studies because it rests on the premise that consumers value products based on their valuation of the products' attributes. (For a detailed description of conjoint analysis see Green and Srinivasan.)

The first step in the conjoint analysis experimental design is to define the product by determining what attributes should be included in the study and what attribute levels should be represented. A high degree of realism is achieved by including every attribute relevant to consumers at several different levels. However, this approach results in a great number of products, making the respondent's task of evaluating the products very complex. In practice, it is necessary to limit the number of attributes and attribute levels so respondents are not overwhelmed by the number of choices.

An 18-ounce box of corn flakes cereal was chosen as the basic product. While consumer concerns about GMOs may apply to a broad range of products and issues, consumers express their preferences by purchasing specific products. Corn flakes cereal was chosen because of the familiarity of this product to a broad range of consumers.

To determine the most important product attributes, a class of 30 undergraduate students was surveyed. One-half of the class was asked to rate the importance of several attributes in their purchasing decisions. The attributes included brand, freshness, nutrition, price, sweetness, and taste. The other half of the class was given an open-ended question asking them to list, in order of importance, the product attributes most important to their purchasing decision. Based on the results of the survey, the two most important attributes identified were price and brand. Each was selected to be included in the following analysis. A third attribute, capturing the focal research issue, described the corn as coming from either a GMO or non-GMO source.

The second step in the conjoint analysis design is to determine the attribute levels. These levels are typically chosen to reasonably represent the levels a consumer may face in the marketplace, given the other attributes and attribute levels chosen. Two levels of the brand attribute were selected, a national brand and a store brand. The national brand was described as Kellogg's brand, the leading national brand producer of corn flakes. The second brand alternative was described as a store brand consumers would find in their local supermarket. Several of the leading supermarket chains were given as examples of the labels of store brand corn flakes (Kroger, Albertsons, and Safeway).

The price levels were selected by surveying supermarket prices for 18-ounce boxes of both store brand and national brand corn flakes. The price surveys were conducted in several regions of the country in May 2000. The lowest price level was established at $2.75 because it was slightly below the lowest non-sale price identified. Likewise, the highest price level was set at $4.25 because it slightly exceeded the highest price found in the survey. The third price level of $3.50 was selected because it represented the midpoint between the low and high prices.

The third product attribute described the source of the corn used to make the corn flakes. GMO corn was described as corn that was grown from corn seed developed using modern biotechnology or genetic engineering techniques. Non-GMO corn was described as corn that was grown from corn seed developed from traditional breeding techniques.

In order to determine whether there were any interaction effects between the variables, a pilot survey was subsequently conducted with a group of 20 people. The group was composed of faculty, staff, and students known to the authors. For each pair of attributes, respondents were asked to rate their degree of preference for each level of one attribute at each level of the second attribute. A strong interaction effect is indicated when the rank order of the ratings for the first attribute varies with different levels of the second attribute. The consistency in the rank order of attribute levels at different levels for each other attribute indicated no interaction effects were present among the three variables.

The consumer choice model, which follows from equation (4), was specified as follows:

$$(5) \qquad P_i = \beta_{i1} + \beta_{i2}BRAND + \beta_{i3}PRICE + \beta_{i4}GMO + \varepsilon_i, \qquad i = 1, \ldots, I,$$

where P is the preference rating of the hypothetical product for the ith individual; *BRAND* is a binary variable for the brand of corn flakes (1 if Kellogg's, 0 if store brand); *PRICE* is the price per 18-ounce box of corn flakes cereal; *GMO* is a binary variable for the GMO content of the corn flakes (1 if produced from GMO corn, 0 if produced from non-GMO corn); and ε is a random error term.

A full factorial design was used, since the rating of the resulting 12 possible hypothetical products, based on all possible combinations of the product attribute levels, was deemed to be a manageable task for most people. The survey was pretested on a small sample to ensure the instructions were clear and the survey was easy to complete. A follow-up discussion with the group was used to improve the clarity of the instructions and to ensure the respondents' understanding of the questions was consistent with the researchers' intent.

The conjoint analysis survey was conducted in June and July of 2000. Two thousand individuals were mailed a survey packet consisting of a brief letter explaining the purpose of the survey, an instruction sheet, a product attribute description sheet, a product rating form, a data sheet, and a postage-paid return envelope. As an incentive to participate in the survey, a $1 incentive payment was included in the mailing and participants were told they could fill out an entry form for a drawing of one of two Palm Pilots. Follow-up postcards were mailed one month and two months after the initial mailing to encourage nonrespondents to respond to the survey.

The product attribute description sheet contained narrative descriptions of each attribute and attribute level. The product rating form asked respondents to rate each of the 12 hypothetical products, as defined by the various attribute levels for each attribute, on a scale of 1 to 10, with 1 representing the least preferred and 10 representing the most preferred. Furthermore, participants were informed each number in the scale could be used more than once or not at all. Respondents were also asked to provide information on their socioeconomic status, risk preferences, and knowledge and opinions of GMO foods.

A mailing list of 2,000 randomly selected names and addresses was purchased from a company maintaining the names and addresses of people in over 110 million U.S. households. The list was compiled using multiple sources including census data, telephone

Table 2. Socioeconomic Characteristics of Survey Respondents (N = 383)

Characteristic	Sample Statistic	Characteristic	Sample Statistic
Gender (% female)	59.0	Ethnicity (%):	
Mean Age (years)	51.5	▸ White non-Hispanic	82.2
Median Household Income Category ($)	25,000–39,999	▸ Black	6.3
		▸ Hispanic	5.2
Completed High School (%)	96.6	▸ Other	6.3

directories, credit card records, courthouse records, and other public sources in order to ensure the representation of all types of households.

Of the 2,000 surveys mailed, 175 were returned as undeliverable. Of the remaining surveys, 448 were completed and returned, yielding a response rate of 24.6%. After discarding the incomplete or otherwise unusable surveys, there were 383 usable responses for a net response rate of 21% (net of the unusable responses and undeliverable addresses).

Nonresponse bias was evaluated using the limited available information. The only socioeconomic information given by the mailing list provider for the addressee was the year of birth. The mean age of all people in the sample of 2,000 was 50.5 years. The mean age of the respondents who provided usable responses was 51.5. The mean age of the entire sample and the respondents was not significantly different at the 10% level of probability, indicating there was no evidence of nonresponse bias. Sample socioeconomic statistics for the 383 respondents are presented in table 2.

Market Segmentation Model

Output from the conjoint analysis experiment, in the form of the product coefficients, may be used as the basis for describing consumer preferences. Potential segmentation schemes may be explored by examining the relationship between consumer preferences and consumer characteristics. The following market segment analysis uses some of the socioeconomic factors most commonly associated with consumer behavior. These variables were listed in table 1 and include age, the presence of children in the household, educational level, ethnicity, gender, and income level. Additional variables studied by other researchers and also used in this study include marital status (Baker and Crosbie; McGuirk, Preston, and McCormick) and whether the residence is located in a rural or urban area (Misra, Huang, and Ott; Nayga; Lin).

It has also been argued that psychographic and knowledge variables influence consumer preferences because of their influence on consumer behavior (Schaffner, Schroder and Earle; and Engel, Blackwell and Miniard). The cognitive variables examined in this study include the respondent's level of knowledge regarding biotechnology, opinion regarding GMOs, and level of risk aversion. Several studies have included a variable measuring the respondent's knowledge of a technology to explain the respondent's preferences (Kaiser, Scherer, and Barbano; Blend and van Ravenswaay). The respondent's opinion regarding GMO technology was used by Lusk et al. as a determinant of consumers' preferences regarding GMOs. The risk-aversion variable was included here in order to explore the relation between the level of risk aversion and acceptance of a new technology which is often portrayed as risky.

Results

Consumer Choice Model

The results of the conjoint analysis experiment were analyzed using the SAS TRANSREG procedure (SAS Institute, Inc.). A main-effects ANOVA model was estimated based on equation (5). Because 12 observations were available for every respondent, it was possible to estimate separate coefficients for each variable in equation (5) for each individual. The average R^2, a common measure of goodness of fit for conjoint analysis models, for all estimated preference functions for the 383 respondents was 0.79, indicating a relatively good fit.

The results may be analyzed in several ways. One method is to calculate an aggregate preference function by averaging the coefficient estimates across all individuals. The aggregate results are presented in table 3.

Conjoint analysis results are often interpreted by calculating relative factor importance scores. These scores are obtained by dividing the variation in preference ratings over the range of each attribute as a percentage of the total variation in preference ratings for all attributes. For each attribute, the variation in the preference rating is calculated by multiplying the difference in the attribute levels between the most and least preferred options by the attribute's coefficient and then taking this product's absolute value. The total variation in preference ratings for all factors is calculated by summing the variations due to the individual factors.

For example, in table 3, the variation due to the *PRICE* variable is calculated by multiplying the coefficient on the variable (-1.42) by the variable's range (1.50), and taking the product's absolute value to arrive at a value of 2.13. The variation due to the binary variables *BRAND* and *GMO* is 1.68 and 1.98, respectively. The total variation across all variables is the sum of the variable totals, or 5.79. The relative factor importance score for the price variable is 2.13 divided by 5.79, or approximately 37%.

The relative factor importance scores for the aggregate preference function give an indication of the relative importance of each attribute. Over all respondents, the three attributes were approximately equal in terms of their influence on consumer preferences. The relative importance scores for *PRICE*, *GMO* (corn source), and *BRAND* were 36.86%, 34.18%, and 28.97%, respectively.

Market Segmentation Model

While the aggregate preference function provides important information regarding the relative importance of various attributes across all respondents, it masks the variation between the preference functions of the individuals who form it. In order to better understand consumer preferences, it is necessary to examine the preference functions of individual respondents. By identifying groups of respondents with similar preference functions, market segments can be developed around the attributes important to specific groups of consumers.

Cluster analysis was used to identify groups of respondents with similar preference functions. Ward's minimum-variance method was used to analyze the relative factor importance scores for the *BRAND*, *PRICE*, and *GMO* variables for all respondents using the SAS CLUSTER procedure (SAS Institute, Inc.). To ensure consumers' preferences

Table 3. Aggregate Preference Function for Corn Flakes Cereal (N = 383)

Variable	Coefficient	Standard Error	Relative Factor Importance Score[a]
Intercept	10.06	2.05	—
BRAND	1.68	0.71	28.97%
PRICE	-1.42	0.58	36.86%
GMO (corn source)	-1.98	0.71	34.18%

[a] The sum of the relative factor importance scores does not equal 100% due to rounding error.

Table 4. Preference Functions for Corn Flakes Cereal by Market Segment (N = 383)

Variable	Coefficient	Standard Error	Relative Factor Importance Score
Cluster 1: Brand Buyers (n = 155)[a]			
Intercept	6.60	2.11	—
BRAND	1.51	0.73	75.09%
PRICE	-0.20	0.59	15.20%
GMO (corn source)	-0.41	0.73	9.71%
Cluster 2: Safety Seekers (n = 116)[a]			
Intercept	7.96	2.10	—
BRAND	0.47	0.72	12.22%
PRICE	-0.89	0.59	17.40%
GMO (corn source)	-2.68	0.72	70.38%
Cluster 3: Price Pickers (n = 112)[a]			
Intercept	17.02	1.94	—
BRAND	0.29	0.67	9.26%
PRICE	-3.39	0.54	80.12%
GMO (corn source)	-0.34	0.67	10.62%

[a] n represents the sample size of each cluster.

were accurately represented, the sign on the relative factor importance score for each attribute was made to match the sign on the coefficient for each attribute. In other words, the relative factor importance scores were not expressed as absolute values. In this way, for example, consumers who preferred a national brand product could be differentiated from consumers who preferred a store brand product.

Three clusters were identified based on the pseudo F-statistics, pseudo t^2-values, and the researchers' interpretation of the clusters. There was a peak for the pseudo F-statistic at four clusters and a peak for the pseudo t^2-value at two clusters. Ultimately, the three clusters presented in table 4 were chosen because they resulted in the most meaningful groupings.

The three clusters are formed around the three attributes utilized in the study and are designated Brand Buyers, Safety Seekers, and Price Pickers. In each case, one attribute was far more important than the other two factors combined. This finding indicates consumers expressed their preferences primarily along one dimension. For example, the preferences of consumers in cluster 1, the Brand Buyers, were largely determined by whether the corn flakes were a national brand or a store brand, with these consumers expressing a strong preference for a national brand over a store brand. The brand factor had a relative factor importance score of 75.09% compared to the relative factor importance scores of 15.20% and 9.71% for the price and corn source factors, respectively. Brand Buyers were the largest segment, accounting for 40.5% of respondents.

It is notable that in all of the clusters, consumers' preferences were basically one-dimensional. No cluster represented consumers whose strongest preferences were weighted equally on two or three factors. In the Safety Seekers segment, the group with the greatest balance between preferences, the importance score for corn source of 70.38% was more than double the combined importance scores of the price and brand factors of 29.62%.

In order to examine the relationship between consumer preferences for GMOs and consumer characteristics, a qualitative choice model was estimated based on the market segmentation model discussed earlier. Respondents were assigned to one of two categories based on the segment to which they belonged. Consumers in the Safety Seekers segment were assigned to one category based on their strong preference for avoiding GMOs. Consumers in the other two segments, the Brand Buyers and Price Pickers, were assigned to the second category based on their willingness to accept GMOs. Assuming a logistic probability distribution, a binomial logit model is defined as:

$$(6)\qquad P(ACCEPT = 1) = \frac{\exp(\mathbf{x}'\beta)}{1 + \exp(\mathbf{x}'\beta)},$$

$$P(ACCEPT = 0) = \frac{1}{1 + \exp(\mathbf{x}'\beta)},$$

such that the dependent variable, *ACCEPT*, is assigned the value of 1 if the respondent belongs to the Brand Buyers or the Price Pickers segment, and 0 if the respondent belongs to the Safety Seekers segment; $\mathbf{x}'$ is the vector of independent variables including a constant; and β is the coefficient vector. The independent variables included respondents' socioeconomic characteristics, risk preferences, and knowledge and opinions of GMO foods (tables 5 and 6).

The logit analysis was performed using the SAS LOGIT procedure (SAS Institute, Inc.). The results of the logit model are presented in table 7. The summary statisitics indicate the model provides a good fit. The model χ^2 statistic is significant at the 1% probability level and the percentage of correct predictions was acceptably high at 77.20% (model 1, table 7).

In order to determine the impact of the socioeconomic and cognitive variables as groups of variables, two restricted logit models were estimated, and summary statistics are also reported in table 7. In model 2, the cognitive variables are omitted. The likelihood-ratio test indicates that as a group these variables are statistically significant at the 1% level of probability (χ^2 of 71.70 with three degrees of freedom). Likewise, in model 3, the socioeconomic variables are omitted. In this case, the likelihood-ratio test is not statistically significant (χ^2 of 5.05 with eight degrees of freedom), indicating that as a group, the socioeconomic variables have relatively little explanatory power.

The model with only the cognitive variables (model 3) also compares favorably with unrestricted model 1 in terms of the number of correctly predicted probabilities (75.9% and 77.2%, respectively). However, model 2, which included only the socioeconomic variables, performed little better than flipping a coin, with 58.6% correctly predicted probabilities.

Table 5. Description of Variables for Logit Model of GMO Acceptance

Variable Name	Description	
Dependent Variable:		
ACCEPT	1 if member of Brand Buyers or Price Pickers segment 0 if member of Safety Seekers segment	
Independent Variables:		
GENDER	1 if female	0 if male
AGE	Years	
INCOME	Annual household income: 0 if $0 to $9,999 1 if $10,000 to $24,999 2 if $25,000 to $39,999 3 if $40,000 to $54,999	 4 if $55,000 to $69,999 5 if $70,000 to $84,999 6 if $85,000 to $99,999 7 if $100,000 or more
MARRIED	1 if married	0 otherwise
CHILDREN	1 if children present in household 0 otherwise	
EDUCATION	Highest level of education completed: 0 if grade school 1 if high school	 2 if bachelor's degree 3 if graduate degree
RACE_WHITE	1 if White non-Hispanic	0 otherwise
RESIDE_RURAL	1 if rural	0 if urban
RISK[a]	Level of risk aversion: 1 if very low 2 if low 3 if moderate	 4 if high 5 if very high
GMO_KNOWLEDGE	Knowledge of biotechnology: 1 if nothing at all 2 if a little	 3 if some 4 if a lot
GMO_OPINION[b]	Opinion of GMO's impact on food quality: 1 if negative effect 2 ... 3 ...	 4 ... 5 if positive effect

[a]The *RISK* variable is a composite index of respondents' answers to three questions. Respondents were asked to rate on a scale of 1 to 5 (with 1 corresponding to strongly disagree and 5 corresponding to strongly agree) their level of agreement with the following statements: (1) I don't like to take chances if I don't have to; (2) I like to experiment with new ways of doing things; and (3) I am cautious in trying new/different products. In calculating the index, the responses to the second question were inverted so that a low number corresponded to a low level of risk aversion and a high number corresponded to a high level of risk aversion, to be consistent with the scale used for the first and third questions. The answers to all three questions were then averaged for each respondent to generate the *RISK* variable.

[b]The *GMO_OPINION* variable is a composite index of respondents' answers to two questions. Respondents were asked to express their response on a scale of 1 to 5 (with 1 corresponding to negative effect and 5 corresponding to positive effect) to the following questions: (1) What effect do you think the use of GMOs will have on food quality, i.e., taste, freshness? and (2) What effect do you think the use of GMOs will have on food safety, i.e., food allergies, unknown effects? The answers to both questions were then averaged for each respondent to generate the *GMO_OPINION* variable.

From table 7, it is interesting to note that in the unrestricted model, none of the socioeconomic variables were significant at the 10% level of probability. The three cognitive variables (*RISK*, *GMO_KNOWLEDGE*, and *GMO_OPINION*) were statistically significant at the 1%, 10%, and 1% levels of probability, respectively.

Table 6. Mean Response for Selected Variables by Cluster

Variable Name	Brand Buyers (n = 155)	Safety Seekers (n = 116)	Price Pickers (n = 112)
GENDER (% female)	61.29	57.76	57.14
AGE (years)	53.37	52.24	48.27
INCOME ($000s per household)	51.84	51.16	60.09
MARRIED (% married)	63.87	68.97	60.71
CHILDREN (present in household, %)	39.35	42.24	41.07
EDUCATION (years)	13.60	14.03	15.09
RACE_WHITE (% white)	80.65	80.17	86.61
RESIDE_RURAL (% rural)	32.90	39.66	31.25
RISK	3.03	3.52	2.99
GMO_KNOWLEDGE	2.46	2.28	2.69
GMO_OPINION	3.08	2.43	3.23

Note: Refer to table 5 for complete definitions of variables.

Table 7 also allows a comparison of the magnitudes of each variable's influence on GMO acceptance. The *RISK* and *GMO_OPINION* variables had the largest impact on the probability a consumer would find the GMO product acceptable. The coefficient on the *RISK* variable was negative, indicating consumers with lower levels of risk aversion were more likely to be accepting of GMO foods and fall into the Brand Buyers and Price Pickers segments than were consumers with higher levels of risk aversion. In contrast, the sign on the *GMO_OPINION* variable was positive, suggesting those consumers who tended to believe GMOs enhance the quality or safety of foods are consequently more likely to be accepting of GMO foods.

Five other variables had marginal probabilities with an absolute value of at least 0.02: *GENDER*, *MARRIED*, *RACE_WHITE*, *RESIDE_RURAL*, and *GMO_KNOWLEDGE*. However, only the coefficient on the variable representing consumers' knowledge of biotechnology, *GMO_KNOWLEDGE*, was statistically significant. The positive sign on this coefficient indicates respondents with relatively greater knowledge of biotechnology are the most likely to find GMO foods acceptable.

In any study relying on voluntary consumer participation, it is important to address the possibility of respondent bias. This was a concern in our study, and an effort was made to minimize the effects of such bias. Information and questions were conveyed to participants in a neutral manner. As discussed earlier, the sample statistics showed no evidence of nonresponse bias. Moreover, the use of cluster analysis serves to mitigate the effects of a potentially higher response rate among consumers who are especially concerned about GMOs. One would expect response bias would be more likely to affect the relative size of a cluster than the preferences of consumers within a cluster.

Discussion

The results of this research, based on a nationwide sample of consumers, have implications for policy makers as well as for producers and marketers of GMO products. Importantly, the cognitive variables had a greater influence on consumer preferences

Table 7. Summary Statistics: Logit Models of GMO Acceptance

	MODEL 1		MODEL 2		MODEL 3	
Variable	Coefficient (Significance)	Marginal Probability	Coefficient (Significance)	Marginal Probability	Coefficient (Significance)	Marginal Probability
Constant	1.1558 (0.3201)	—	0.0914 (0.2472)	—	0.4398 (0.5890)	—
GENDER	-0.1450 (0.5916)	-0.0277	0.1088 (0.6481)	0.0228	—	—
AGE	-0.0028 (0.7624)	-0.0005	-0.0053 (0.5235)	-0.0011	—	—
INCOME	0.0038 (0.3935)	0.0007	0.0049 (0.2378)	0.0010	—	—
MARRIED	-0.4459 (0.1211)	-0.0852	-0.3604 (0.1705)	-0.0756	—	—
CHILDREN	-0.0105 (0.9712)	-0.0020	-0.0393 (0.8818)	-0.0083	—	—
EDUCATION	0.0421 (0.3893)	-0.0080	0.0005 (0.9908)	-0.0001	—	—
RACE_WHITE	0.2034 (0.5305)	0.0389	0.2733 (0.3592)	0.0574	—	—
RESIDE_RURAL	-0.1847 (0.4740)	-0.0353	-0.2536 (0.2785)	-0.0532	—	—
RISK	-0.7401*** (0.0001)	-0.1414	—	—	-0.7308*** (0.0001)	-0.1411
GMO_KNOWLEDGE	0.2530* (0.0948)	0.0483	—	—	0.2235 (0.1255)	0.0431
GMO_OPINION	0.8293*** (0.0001)	0.1585	—	—	0.8058*** (0.0001)	0.1555
-2 Log Likelihood	391.86		463.56		396.91	
χ^2	77.91***		6.21		72.86***	
Correct Predictions	77.20%		58.60%		75.90%	

Note: Single and triple asterisks (*) denote significance at the 10% and 1% levels of probability, respectively.

than did the socioeconomic variables. When considered with the summary results of 10 published research studies (reported in table 1), which demonstrate that socioeconomic variables show no consistent pattern of influence on consumer preferences for food safety, our findings suggest future research should explore more deeply the relationship between cognitive variables and consumer preferences.

Implications for Policy Makers

An important implication of this research is that the market for GMOs, like the market for many food products, may be usefully characterized by distinct market segments. Market segments may be formed on the basis of many variables, including socioeconomic and cognitive variables. The results of this study show cognitive variables may be especially useful in understanding consumer preferences for GMO foods. One explanation for the better performance of cognitive variables, relative to socioeconomic variables, is that they are more closely related than socioeconomic variables to factors affecting consumer motivation and the underlying reasons consumers purchase products.

Based on our results, there is a substantial segment of the population for which the use of genetic engineering technology in the production of food is an important consideration in food purchase decisions. Approximately 30% of the respondents in this study based their preference for corn flakes on the GMO content of the corn when presented with three factors: brand, price, and GMO content. The importance of GMO content for this segment reveals that consumers in this group would likely base their purchasing decisions on this factor if they were provided with the necessary information. A label informing consumers of a food's GMO content would make it easy for consumers to evaluate a food based on its GMO content in much the same way nutritional labels enable consumers to evaluate a food's nutritional content. On the other hand, drawing attention to a food's GMO content may unnecessarily increase consumers' fears of GMO products.

Our analysis also found the level of risk aversion to be a significant factor in determining which consumers were accepting or disapproving of genetic engineering technology. This finding provides policy makers with an opportunity to design a credible regulatory process for assuring consumers that products reaching the market are safe. Such a process might involve process documentation, animal testing, environmental testing, or labeling prior to a product's approval. A stringent regulatory process and the government's stamp of approval may make GMO foods more acceptable to risk-averse consumers. Furthermore, the opportunity to gain consumer confidence by way of strong regulations may be a unique opportunity for U.S. policy makers due to the country's strong regulatory institutions and the high level of public confidence in institutions such as the Food and Drug Administration (FDA), the Environmental Protection Agency (EPA), and the USDA. In contrast, such an approach would likely face a much greater challenge in Europe, where regulatory institutions suffer from a low level of public confidence.

Implications for Producers and Marketers

Producers of GMOs can focus on three types of genetic modifications: yield enhancement traits, such as improved photosynthesis properties or greater environmental tolerance; input substitution traits, such as disease resistance or herbicide resistance; and quality traits, such as enhanced nutritional value or greater shelf-life (some genetic modifications fall into more than one category).

Based on the results of this research, a positive opinion regarding the quality and safety benefits of GMO foods is important to GMO acceptance. It follows that, at least initially, plant developers should focus on beneficial quality traits which are readily observed by consumers if plant developers are interested in consumer acceptance. GMOs shown to result in greater yields or lower input use may benefit consumers through lower product prices; however, consumers may not perceive lower prices as a direct benefit of GMOs. Consumers who are unaware of the benefits of GMOs may be reluctant to accept even small perceived risks associated with the products of genetic engineering. On the other hand, by making the benefit tangible and observable, possibly with the aid of educational programs or industry advertising, consumers may more easily compare the benefits and costs associated with GMOs and thus be more willing to accept the risks connected with these products.

The results of this study also have implications for marketing GMO foods. Education is often proposed as the remedy for consumers who make "uninformed" decisions. The influence of the *GMO_KNOWLEDGE* variable on consumer acceptance of GMOs supports this prescription. However, the magnitude of this variable's influence was roughly one-third that of the *GMO_OPINION* variable. This suggests consumer behavior is determined less by *how much consumers know*, and more by *what they believe*.

Accordingly, marketers should focus less of their efforts on educating the public regarding GMO foods or biotechnology and more on differentiating GMO foods based on the beneficial characteristics desired by consumers. Furthermore, if labeling is required, the genetically modified nature of the food products will be readily apparent to consumers, making it even more important for marketers to ensure that consumers understand the benefits offered by GMO products relative to their non-GMO counterparts.

Summary and Conclusions

Using conjoint analysis, this study has examined the importance of GMO content in consumer purchasing decisions. Consumers selected randomly from a nationwide sample were requested to respond to a mail survey asking them to rate hypothetical corn flake products defined by different levels of brand, price, and GMO content attributes. Results of the cluster analysis showed consumers belonged to one of three segments. Consumers in one segment (Brand Buyers) had a very strong preference for a national brand product. Consumers in a second segment (Price Pickers) strongly preferred a low-priced product, while consumers in a third segment (Safety Seekers) sought to avoid corn flakes with GMO content.

From results of the logit analysis, socioeconomic variables were not significant in explaining the segment to which a consumer belonged. However, the cognitive variables, including the respondents' level of risk aversion and opinions regarding GMO foods, were strong indicators of whether consumers belonged to a segment that accepted or rejected GMO corn flakes. Consumers with relatively high aversion to risk were more likely to belong to the Safety Seekers segment than those with low aversion to risk. Likewise, those consumers who tended to believe GMO foods would have a positive effect on food quality or food safety were more likely to be in one of the segments which approved of GMO foods (i.e., the Brand Buyers or the Price Pickers).

This research has important implications for policy makers and producers and marketers of GMO foods. The concern about GMO content among consumers in the Safety Seekers market segment indicates this consumer segment might support the use of labels clearly identifying the GMO content of foods. This feature would enable members of this segment to make choices consistent with their preferences. Moreover, regulatory processes designed to ensure the safety of GMO products may lower the perceived risk of these products and make them more acceptable to risk-averse consumers. Further, producers of GMO foods may increase the acceptability of their products by focusing on traits demonstrated to offer clear, observable benefits to consumers—such as foods with increased shelf-life, better taste, or improved nutrition. Finally, marketing efforts that tout specific beneficial characteristics of individual GMO foods should receive greater emphasis than more general educational campaigns intended to increase consumers' understanding of biotechnology and the safety of GMO products.

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