Consumer Acceptance of Genetically Modified Foods: The Role of Product Benefits and Perceived Risks

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This study examines consumer willingness to consume genetically modified food products with clearly stated benefits and risks. Results suggest that males, Caucasians, Southerners, and those with some college education are more likely to consume genetically modified foods. Trust in government, the biotech industry, and the medical profession on matters relating to GM foods also has a positive impact on the willingness to consume GM foods; such trust allays fears associated with risks posed by GM technology.

Conversely, risk seems to negatively influence the willingness to consume GM products. Once the respondents were well-informed of the risk of the product, their willingness to consume such products greatly diminished. Respondents older than 55 years, those taking time to read food labels, and those with either high or low scores on a simple scientific quiz testing actual knowledge of GM technology are less enthusiastic toward GM foods. Income, religion and political affiliation did not play any significant role in influencing the willingness to consume GM fresh fruits and vegetables.

The application of biotechnology to agriculture and food production is often viewed as the future of the food system, with the potential for enormous economic and social implications. Food biotechnology promises to bring forth a wide range of products with nutritional, environmental, and other economic benefits. Despite such potential, genetically modified (GM) foods have so far received mixed regulatory and public acceptance in the U.S. and elsewhere (Hallman et al. 2002). While public debate remains embroiled in the controversy about the risks and benefits of biotechnology, consumer acceptance of GM foods remain a critical factor in determining the future of this technology.

The overall state of public attitudes towards food biotechnology is best described as an ongoing tension between optimism about the benefits and fear of unforeseen risks from its use in plants and animals. Public debates on the subject have focused not only on the risks and benefits associated with biotechnology but also on social, moral and ethical issues. Biotechnology advocates emphasize the potential benefits to society in terms of improved products that will deliver distinct benefits to mankind; opponents often view biotechnology as an unnecessary interference with nature that has unknown and potentially disastrous consequences (Nelson 2001).

Despite the enormous importance of public acceptance of GM food products for the future of agricultural biotechnology, only a handful of studies have addressed the issue. In a recent study, Lusk et al. (2001) examined the factors influencing consumer willingness to pay for non-GM corn chips. They found participants' willingness to pay to avoid GM corn chips was significantly related to their concerns about GM food products. However, none of the socio-economic variables were found to be statistically significant.

In another study, Moon and Balasubramanian (2001) reported that consumers' acceptance of biotechnology was significantly related not only to their perceptions of the risks and benefits associated with GM products but also to their moral and ethical views. In addition, public views about multinational corporations, knowledge of science and technology, and trust in government were found to have significant influence on consumer acceptance of biotechnology. Baker and Burnham (2001) reported that consumers' cognitive variables (e.g., respondents' levels of risk aversion, opinions about GM foods) were important determinants of their acceptance of foods containing GM products, whereas the socio-economic variables did not have significant influence.

Although the studies above provide some insight into public acceptance of agricultural biotechnology, none directly explore the issue of consumers' willingness to consume GM food products in light of a product's risks and benefits. This study explores the willingness to consume GM foods that bring tangible benefits to consumers. We examine

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consumers' stated willingness to consume GM food products under two scenarios: consumers are told only about the benefit of the GM food, and consumers are told about both benefits and potential risks of the GM food product. Recent research on public attitudes toward biotechnology indicates that consumer acceptance of GM products is affected by factors such as the type of product—e.g., whole or processed food--and the organisms involved—i.e., plant- or animal-based products (Hallman et al. 2002; Hamstra 1998). Since public acceptance GM foods may differ across food product types, we compare the willingness to consume two GM products involving biotechnology: meat products from animals (cows and chickens) fed on GM corn or soybeans, and GM fruits or vegetables that are consumed fresh.

Conceptual Framework and Empirical Model

In the random-utility framework, it is assumed that a consumer faces a choice between consuming or not consuming on the basis of the stated benefits and risks of the GM product. The utility derived from consuming the GM product with only the benefits stated and the utility derived from consuming the GM product with benefits and risks stated are given by U_B and U_{BR}, respectively. However, these utility levels are not directly observable. The observable variables are the product attributes $a = B, BR$ and a vector of consumer characteristics x. The random-utility model assumes that the utility derived by consumer i from the product with attribute a = B, BR can be expressed as

$$(1)\quad U_{ai} = V_{ai} + \varepsilon_{ai},$$

where U_{ai} is the latent utility level attained by the i[th] consumer by choosing the product attribute $a = B,BR$, V_{ai} is the explainable part of the latent utility that depends on the product attribute and the consumer characteristics, and ε_{ai} is the "unexplainable" random component in U_{ai}.

The utility-maximizing consumer will choose to consume the benefit-only GM variety of the product if and only if $V_{Bi} + \varepsilon_{Bi} > V_{BRi} + \varepsilon_{BRi}$ or, equivalently, if $\varepsilon_i = \varepsilon_{BRi} - \varepsilon_{Bi} < V_{Bi} - V_{BRi}$. Since ε is unobservable and stochastic in nature, the consumer's choice is not deterministic and cannot be predicted exactly. Instead, the probability of any particular outcome can be derived. The probability that consumer i will consume the GM-product variety with benefit is given by

$$(2)\quad P_i = \text{Prob}(\varepsilon_{BRi} - \varepsilon_{Bi} < V_{Bi} - V_{BRi}) = \text{Prob}(\varepsilon < V_{Bi} - V_{BRi}).$$

To empirically implement the above conceptual framework, it is assumed that ε_{ai} is identically and independently distributed as type I extreme value (also known as Gumbel distribution), in which case $\varepsilon_i = \varepsilon_{BRi} - \varepsilon_{Bi}$ follows the logistic distribution (Train 2002). Under this distributional property ε_i, the probability that consumer i chooses the GM food product with benefit is given by the standard logit model discrete choice (MacFadden 1974, 1984).

The indicator variable Z_i for the i[th] consumer is modeled as a function of his willingness to consume the GM-food variety with benefit and his personal, socioeconomic, and value attributes as follows:

$$(3)\quad Z_i = \boldsymbol{\beta}\mathbf{X}_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ik} + \nu_i,\quad i = 1, 2, \ldots, n,$$

where x_{ij} denotes the j[th] attribute of the i[th] respondent, $\beta = (\beta_0, \beta_1, \ldots, \beta_k)$ is the parameter vector to be estimated, and ν_i is the disturbance term.

Survey Methodology, Variable Definition, and Empirical Model

Data for this study comes from a national telephone and mail survey carried out between February 27, 2003 and April 1, 2003[1]. A sample size of 1200 was targeted so as to allow for a sampling error rate of ±3 percent[2]. Using a computer-assisted telephone interview (CATI), a total of 1201 telephone surveys were completed; the average cooperation rate for both versions of the survey was 65%[3]. At the end

[1] Interviewing was not conducted on March 21 and 22 due to the start of "Operation Iraqi Freedom" and the coverage it was receiving on television.

[2] The sampling error associated with a nationwide sample of 1200 people is approximately ±3 percent with a 95-percent confidence interval. This means that if 50 percent of the respondents gave a particular response, the likely percentage of the entire adult population giving a similar response should be between 47 percent and 53 percent, 95 out of 100 times.

[3] The cooperation rate is the percentage of completed interviews (1201) over completed interviews (1201) + refusals (636). A more rigid calculation of response rate, defined as the percentage

of the telephone survey, respondents were asked if they were interested in further participation through a mail survey. Those who agreed received a five-dollar incentive for their additional participation. A screener for respondents who had consumed ground beef, bananas, or cornflakes occasionally was used to recruit mail-survey participants. This resulted in 1199 potential respondents of the original 1201 phone subjects. Of the resulting 1199 potential respondents, 661 (55.1%) agreed to respond to this additional questionnaire in exchange for a nominal compensation of $5. Of the 661 who agreed, 409 (61.9%) returned a completed survey. A split-sample approach was employed where half of the respondents were mailed a survey with questions related to the benefits of the GM product (206) and the other half were given questions related to both the benefits and the potential risks of the product (203). There were 312 observations used for this analysis due to non-response to certain questions by some respondents.

In the mail survey, respondents were asked to state their willingness to consume (eat) food products produced using genetic modification. The purpose or benefits of genetic modification and the potential risks were stated. The food products chosen were meant to represent a broad food category. A short description was included in the mail survey to let people know that genetic modification has no impact on taste, appearance, or cost of the product.

In the case of meat products from cows and chickens fed on GM corn or soybeans the respondents were asked "*Suppose cows or chickens are fed genetically modified corn or soybeans that are* ***grown using less pesticide or herbicide****. However, because the pesticide or herbicides are built into the plants,* ***there is a chance that insects that feed on them could be harmed****. Please state your willingness to consume meat products from these cows and chickens.*" Using consumers' response to the above question, the binary dependent variable *EATGM* was defined by assigning a value of 1 if the respondent chose "*I would be completely willing to consume these products*" or "*I would be somewhat willing to consume these products*" and 0 if the response was either *"I would be somewhat unwilling to consume these products"* or *"I would be completely unwilling to consume these products*." A similar procedure was used to create a binary dependent variable (i.e., *EATGM*) for the GM fresh fruits and vegetables that are grown using less pesticides/herbicides.

The following model is specified to predict the probability that an individual consumer would be willing to consume (eat) a specific GM food product:

$$\text{(4)}\quad EATGM = b_0 + b_1MALE + b_2RISK + b_3LOWSCORE + b_4HISCORE + b_5GMDISCUS + b_6ORGBUY + b_7LABELTIM + b_8AGELT34 + b_9AGE35\_44 + b_{10}AGE45\_54 + b_{11}HSCHOOL + b_{12}SCOLLEGE + b_{13}COL\_GRAD + b_{14}SRELIG + b_{15}LIBERAL + b_{16}CENTRIST + b_{17}WHITE + b_{18}BLACKAFR + b_{19}INCLT25 + b_{20}INC25\_50 + b_{21}INC51\_75 + b_{22}WEST + b_{23}SOUTH + b_{24}NOR\_EAST + b_{25}TRUIND + b_{26}TRU\_GOV + b_{27}TRU\_SCI + b_{28}TRU\_MED + \varepsilon.$$

The descriptive statistics and definitions of the explanatory variables included in the empirical models are presented in Table1.

Model Estimation and Results

Two logistic models were estimated to explain and predict willingness to consume a GM product. The maximum-likelihood estimates of the model parameters are obtained by using the econometric software LIMDEP (2002). The estimated model coefficients, the associated t-ratios, and the marginal impacts of the explanatory variables on the dependent variable are reported in Table 2. Reported also in this table are the estimated log-likelihood functions of the unrestricted and restricted (i.e., all slope coefficients are zero) models, and McFadden's R^2.

Willingness to Consume Cows and Chickens Fed on Genetically Modified Corn or Soybeans: *Using Less Pesticides and Herbicides (Benefit): May Harm Insects Feeding on Them (Risk)*

Among the 312 responses to the question relating to the willingness to consume meat products from cows and chicken fed on GM corn or soybean, 211(68%) are categorized as willing to consume (*EATGM*=1) and the remaining101 (32%) are classified as unwilling to consume meat products from

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of completed interviews (1201) over total numbers in-frame telephone number (3120) yields a response rate of 38.5%.

Table 1. Descriptive Statistics of Variables.

Variable	Description of the variable	Mean	Std. Dev
MALE	1 = respondent is male; 0 = otherwise	0.44	0.50
RISK	1 = respondent to both stated product risk and benefit question on willingness to consume; 0 = otherwise (respondent answered only the benefit question)	0.51	0.50
LOWSCORE	1 = correctly answered less than 6 (out of 11) basic question on biological science; 0 = otherwise	0.24	0.43
MIDSCORE*	1 = Correctly answered between 7 to 9 (out of 11) basic questions on biological science; 0 = otherwise	0.38	0.49
HISCORE	1 = correctly answered more than 9 (out of 11) basic question on biological science; 0 = otherwise	0.38	0.48
GMDISCUS	1 = participated in GM debates; 0 = otherwise	0.48	0.50
ORGBUY	1 = respondent buys organic food regularly; 0 = otherwise	0.16	0.37
LABELTIM	1 = respondent takes time to read the label contents; 0 = otherwise	0.68	0.47
AGLT34	1 = age less than 35 years; 0 = otherwise	0.25	0.43
AGE35_44	1= age between 35-44 years; 0 = otherwise	0.22	0.42
AGE45_54	1 = age between 45-54 years; 0 = otherwise	0.25	0.43
AGE_A55*	1 = age above 55 years; 0 = otherwise	0.28	0.45
BHSCHOOL*	1 = below high school; 0 = otherwise	0.04	0.20
HSCHOOL	1 = high school education; 0 = otherwise	0.29	0.46
SCOLLEGE	1 = college education (including graduate degree); 0 = otherwise	0.25	0.43
COL_GRAD	1 = four year college and graduate degree; 0=otherwise	0.42	0.49
SRELIG	1 = attends church at least once a week to several times a month; 0 = otherwise	0.72	0.45
LIBERAL	1 = identifies himself/herself as liberal; 0 = otherwise	0.19	0.39
CENTRIST	1 = identifies himself/herself as conservative; 0 = otherwise	0.54	0.50
CONSERV*	1 = identifies him/herself in between; 0 = otherwise	0.27	0.44
WHITE	1 = respondent is white (Caucasian); 0 = otherwise	0.87	0.34
BLACKAFR	1 = respondent is African American; 0 = otherwise	0.06	0.25
OTH_RACE*	1 = respondent is other race; 0 = otherwise	0.07	0.25
INCLT25	1 = (annual) respondent with income less than $ 25,000; 0 = otherwise	0.18	0.39
INC25_50	1 = (annual) income between $26,000–$50,000; 0 = otherwise	0.27	0.45
INC51_75	1 = (annual) income between $50,000–$74,000	0.26	0.44
INC_A75*	1 = (annual) income between above $75,000	0.28	0.45
WEST	1 = respondent resides in western states; 0 = otherwise	0.24	0.43
MID_WEST*	1 = respondent resides in Midwest; 0 = otherwise	0.29	0.46
SOUTH	1 = respondent resides in southern U.S.; 0 = otherwise	0.31	0.46
NOR_EAST	1 = respondent resides in north eastern U.S.; 0 = otherwise	0.16	0.36
TRUIND	1 = that responded can trust industry (tell truth, provide useful information, has expertise, and protect society) on GM Issues; 0 = otherwise	0.46	0.50
TRU_GOV	1 = that responded can trust Government (tell truth, provide useful information, has expertise, and protect society) on GM Issues; 0 = otherwise	0.58	0.49
TRU_SCI	1 = that responded can trust scientists (tell truth, provide useful information, has expertise, and protect society) on GM Issues; 0 = otherwise	0.81	0.39
TRU_MED	1 = that responded can trust Medical professionals (tell truth, provide useful information, has expertise, and protect society) on GM Issues; 0 = otherwise	0.74	0.44

Notes: Asterisk implies that the variable is the base group and was dropped to avoid dummy variable trap

Table 2. Maximum Likelihood Estimates of Model Coefficients.

	Less Pesticides/Herbicides: May harm insects feeding on corn or soybeans			**Less Pesticides/Herbicides: May eventually replace traditional varieties**		
	Cows and chicken Fed on GM corn or Soybean			**GM Fresh fruits and vegetables**		
	Coefficient	t-ratio	Marginal Effects	Coefficient	t-ratio	Marginal effects
Constant	0.0134	0.011	0.003	-0.9333	-0.652	-0.150
MALE	0.6793*	2.182	0.128	0.3122	0.898	0.050
RISK	-1.0748*	-3.537	-0.205	-2.1316*	-5.658	-0.339
LOWSCORE	-0.7853*	-2.026	-0.165	-0.6483**	-1.492	-0.114
HISCORE	-0.2117	-0.622	-0.041	-0.0321	-0.083	-0.005
GMDISCUS	0.5606**	1.788	0.108	0.4487	1.244	0.072
ORGBUY	-0.4250	-1.09	-0.087	-0.4615	-1.089	-0.081
LABELTIM	-1.4986*	-3.913	-0.251	-1.4236*	-3.239	-0.197
AGLT34	-0.0194	-0.046	-0.004	-0.0642	-0.134	-0.010
AGE35_44	-0.7110**	-1.692	-0.149	-0.2227	-0.464	-0.037
AGE45_54	-0.2017	-0.496	-0.040	-0.7100**	-1.563	-0.126
HSCHOOL	0.9751	1.258	0.170	1.3038	1.348	0.179
SCOLLEGE	1.1876**	1.522	0.196	1.1451	1.188	0.154
COL_GRAD	0.8809	1.116	0.164	1.3362	1.371	0.202
SRELIG	0.1937	0.571	0.038	0.5302	1.405	0.091
LIBERAL	0.0719	0.148	0.014	0.1508	0.279	0.024
CENTRIST	-0.4873	-1.359	-0.093	0.0001	0.000	0.000
WHITE	1.2205*	2.142	0.274	1.1544*	1.915	0.229
BLACKAFR	1.1955	1.56	0.173	-0.2883	-0.344	-0.050
INCLT25	-0.1960	-0.413	-0.039	-0.2416	-0.447	-0.041
INC25_50	-0.5484	-1.356	-0.112	-0.2973	-0.634	-0.050
INC51_75	0.1860	0.446	0.035	0.2210	0.473	0.034
WEST	0.3190	0.784	0.059	0.0061	0.013	0.001
SOUTH	0.2386	0.631	0.045	0.6810*	1.554	0.101
NOR_EAST	0.0360	0.081	0.007	0.5690	1.120	0.081
TRUIND	-0.1765	-0.544	-0.034	0.6979**	1.890	0.111
TRU_GOV	0.7526*	2.356	0.149	1.4795*	4.101	0.254
TRU_SCI	0.0946	0.231	0.019	-0.4958	-1.072	-0.072
TRU_MED	0.1877	0.541	0.037	1.1523*	2.921	0.214
LL	-152.54			-124.67		
Restricted LL	-196.45			-193.38		
Chi-Square	87.81			137.43		
DF	28			28		
McFadden's R^2	0.22			0.36		

cows and chicken fed on GM corn or soybeans (*EATGM*=0).

Coefficients of *MALE, GMDISCUS, SCOLLEGE, WHITE, BLACKAFR*, and *TRU-GOV* are positive and statistically significant at the 10% or lower level. These estimated coefficients suggest that those respondents with some college education, who discuss GM issues, are male, or are white or African-American are more likely to consume meat products of cows and chicken fed on GM corn or soybeans than are females or those who don't discuss GM, are of other races (e.g., Hispanic), or who have less than a high school education. Similarly, individuals who trust the government to tell the truth, to provide reliable information, to have expertise, and to protect society's interests are more likely to consume these meat products than those who do not trust the government.

The statistically significant (at 10% or lower level) negative coefficients are *RISK*, *LOWSCORE, LABELTIM*, and *AGE35_44*. The coefficients suggest those individuals who are risk-averse (i.e. those who based their consumption decision on the basis of the benefits and risks of the product being stated), those who take time to read labels when shopping, and those of middle age are less likely to consume such products. Similarly, respondents who achieved a low score on 11 scientific questions measuring actual knowledge of GM, will also be less willing to consume meat products from cows and chicken fed on genetically modified feed. The results suggest that region, organic purchasing behavior, religion, political affiliation, and various dimensions of trust (in scientists, industry, and medical professionals) do not have any influence on the willingness to consume the products.

The estimated marginal effects of the independent variables suggest that respondents who based their consumption decisions on the stated benefits and risks were 21 percent less likely to consume these meat products. Those individuals who take time to read labels when shopping, are between 35 and 44 years old, scored low on the GM quiz are also respectively 25, 15, and 17 percent less likely to consume these products than are those who do not read labels, are over 55 years old, or are average scorers on the GM quiz. Males are 13 percent more likely thanare females to consume beef and poultry fed on GM corn or soybeans. Individuals with some college education are 20 percent more likely than are those with less than a high school to consume beef and poultry fed on GM corn or soybeans. Similarly, individuals who discuss GM issues, are white, or African-American, are respectively 11, 27, and 17 percent more likely to consume these products than are those who have not discussed the issues or are of other races (Hispanic, Asian, or Pacific Islander). Those individuals who trust the government to tell truth, to have expertise on GM, to provide useful source information on GM issues, and to protect society are 15 percent more likely to consume GM products.

The likelihood-ratio test of overall model significance (i.e., all coefficients except the intercept are simultaneously zero) yields a test statistic of 87.81, which is higher than the 95-percent critical value of chi-square distribution with appropriated degrees of freedom, implying that the model has significant explanatory power. Estimated McFadden's R^2 is 0.22. The estimated model correctly predicts 242 out of 312 sample observations with a prediction success rate of 78 percent.

Willingness to Consume GM Fresh Fruits and Vegetables: *Using Less Pesticides/herbicides (Benefit): May Eventually Replace Traditional Varieties (Risk)*

Among the 312 responses to the question relating to the willingness to consume GM fresh fruits and vegetables using less pesticides and herbicides, 215(69%) are categorized as willing to consume (*EATGM*=1) and the remaining 97 (31%) are classified as unwilling consume (*EATGM*=0).

Coefficients of *WHITE, SOUTH, TRUIND, TRU_GOV*, and *TRU_MED* are positive and statistically significant. These estimated coefficients indicate that white people are more willing to consume GM fresh fruits and vegetables than are other races (Hispanic, Asian, or Pacific Islander). People with confidence in the biotech industry, the government, and medical professionals are more likely to consume such genetically modified fresh fruits and vegetables. Similarly, people living in the southern region are more willing to consume GM fruits and vegetables than are those living in the Mid-West.

The statistically significant (at 10% or lower level) negative coefficients of *RISK*, *HISCORE*, and *AGE45_54* suggest that individuals who are risk-averse (i.e. those to whom the benefits and risks of the product were stated), those with a high score in the GM quiz, and those between 45 and 54 years of age are less willing to consume GM fruits and vegetables than are those who were only told about the product benefits, those who had an average score on the quiz, and those more than 55 years old. Income, gender, GM discussions, organic foods purchasing behavior, religion, and confidence in scientists do not have any influence on the willingness to consume GM fresh fruits and vegetables.

The estimated marginal effects of the independent variables suggest that individuals who are risk-averse—i.e., those individuals to whom risks and benefits of the product were stated—and those between 45 and 54 years of age are respectively 34 and 13 percent less likely to consume GM fresh fruits and vegetables. Similarly, individuals who scored highly on the GM quiz are 11 percent less likely to consume such fruits and vegetables. On the other hand, whites and those from the southern region are respectively 23 and 10 percent more likely to consume GM fresh fruits and vegetables. Individuals who have confidence in the biotech industry, the government, and medical professionals are 11 to 25 percent more likely to consume such fresh fruits and vegetables than those who do not have such confidence.

The likelihood-ratio test of overall model significance (i.e., all coefficients except the intercept are simultaneously zero) yields a test statistic of 137.43, which is higher than the 95-percent critical value of chi-square distribution with appropriated degrees of freedom. This implies that the model has significant explanatory power. Estimated McFadden's R^2 is 0.36. The estimated model correctly predicts 254 out of 312 sample observations with a prediction success rate of 81 percent.

Conclusions

This study examines the influence of consumers' socio-economic characteristics and personal values on their willingness to consume GM food products. Empirical results indicate that consumer acceptance of GM food critically depends on the perceived risks and benefits of the product; their education and actual knowledge of GM; and their trust in the government, biotech industry, and medical professionals on matters relating to GM foods.

These findings have important implications for the scientific community, government, and policymakers, as well as for producers and marketers of GM food products. The results show that benefits and perceived risks may have a strong influence on the consumption of the GM food products. Trust in institutions to protect public interest is critical for boosting consumption of the GM food products, and a lack of this trust may seriously hinder complete acceptance of transgenic technology.

This study analyzes consumer willingness to consume GM food products that confer clear benefits but also involve inherent risks. Future research should explore issues such as consumer acceptance of GM products involving gene transfer between plant and animal species and appropriate regulatory and labeling policy for GM food products.

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