A Comparison between Perception of Risk and Willingness to Serve Genetically Modified Foods

William Nganje, Cheryl Wachenhiem, and William Lesch

The dichotomy between perceptions of the acceptability of risk associated with genetically modified (GM) foods and willingness to consume GM foods is investigated. Results indicate that some consumers are willing to consume GM foods even though they may perceive such foods as somewhat unsafe, with determinants such as self-perceived knowledge about the availability of GM foods and altruistic motives having positive and significant effects on their consumption decisions. Efforts toward decreasing perception of risk and ultimately increasing acceptance of and demand for GM foods should address issues related to their altruistic characteristics and outrage.

A decade after commercialization, genetically modified (GM) seed varieties have permeated modern production agriculture. There has been double-digit growth in hectares planted to GM varieties every year since their introduction, resulting in an estimated 81 million hectares, five percent of the world's cultivatable acres, planted to GM varieties worldwide (James 2004). Farmers in the United States and elsewhere continue to rapidly adopt GM varieties because of their agronomic and economic advantages.[1]

In spite of its widespread use, a majority of consumers continue to be relatively uninformed about biotechnology and the resulting prevalence of GM ingredients in processed food products (Wachenheim 2004). For example, Doering (2005) reports that 58 percent of Americans are unaware of the difference between GM and conventional foods. This is not particularly surprising, because food products are not labeled with their GM content.

Consumer acceptance of GM products has been mixed, and research efforts have been devoted to defining its sources. Opposition to GM foods is driven primarily by concerns about food safety and environmental risks associated with their use (Onyango and Nayga, 2004). Not yet well addressed is whether consumer acceptability as motivated by perception of risk translates into willingness to consume products with GM ingredients.

We used a phone survey to elicit consumers' risk perceptions and intended consumption behaviors and test whether a gap exists between respondents' perceptions and their willingness to consume GM foods. Furthermore, multinomial logit models are developed to determine the marginal effects of variables affecting risk perception and willingness to serve or consume GM foods, extending the three major categories of factors affecting perceived risk (social and cultural characteristics, personal health influence, and perceived locus of control) to include outrage and altruism. The risk-communication literature suggests that outrage—how upset an occurrence is likely to make people—is a major contributing risk factor and that factors that tend to increase knowledge or information about a product will reduce risk attributable to outrage (Sandman 2000).[2] Altruism, specifically benefits to poorer populations, may affect risk perception, as these populations may be in dying need for subsistence, as in the case with Golden rice. It is hypothesized in this study that gaps exist between levels of perceived risks associated with GM foods and willingness to serve these foods, and information that reduces outrage or identifies altruistic benefits plays a significant role in the consumption decision of GM foods.

[1] Reports show an increasing trend of GM crops for agronomic (e.g., disease resistance and better yields) and economic (e.g., commercialization of desirable traits) reasons. Examples of such GM crops include cotton, maize, papaya, potato, rapeseed, rice, soya bean, and wheat. Some of these crops have had approval for application in the U.S., E.U, Canada, Africa, Asia, and Mexico (GMO Compass 2008; Hao 2006). GM Acreage for soybean and corn are also on the rise for economic reasons (Consumer Choice 2001). These reports indicate that these increasing trends will continue.

Nganje is associate professor, Morrison School of Management and Agribusiness, Arizona State University. Wachenheim is associate professor, Department of Agribusiness and Applied Economics, North Dakota State University. Lesch is professor, Department of Marketing, University of North Dakota.

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[2] Outrage describes effects caused by lack of personal knowledge of facts associated with biotechnology, its use, and the resultant products.

Previous Literature

Perceptions of GM Foods

Research considering consumer acceptance of GM food products has grown during recent years as these products have become a part of our regular food supply. For years, the literature argued that there was a lack of information about consumer acceptance of GM food products and that what was available was, in general, too specific in product and/or audience to be considered of general use. More recently, Wachenheim (2004) notes that while there is a growing body of literature, it remains somewhat difficult to synthesize this research because of differences in what is measured. In particular, she notes that several proxies have been used in the literature to represent consumer acceptance including awareness of, attitudes about, acceptance of, and willingness to pay for GM food products or those containing GM ingredients. Also confounding general conclusions is the variability in how GM products and processes are introduced, ranging from biotechnology in general to specific products with attributes defined by type and value to the consumer.

Nevertheless, several conclusions from the literature are noteworthy. First, consumers are still not well informed about biotechnology and the availability of GM food products. For example, Hallman et al. (2003) reported that only half of Americans were aware that GM food products were available in grocery stores, even after genetic modification had been defined to them in the survey instrument. Second, consumer acceptance of, or resistance to, GM foods and processes depends, sometimes considerably, on how the applications or their results are described (Hossain et al. 2003; Onyango and Nayga 2004). Approval in general grows when specific products or attributes are noted or when GM products are positioned to provide some specifically defined benefit such as providing more nutritious grain to help feed those in poor countries, but declines with others. This second conclusion corresponds with the third, that providing information about biotechnology, and in particular its benefits with specific attributes, can increase acceptance of and demand for GM foods.

Furthermore, consumer attributes also affect attitudes about and willingness-to-pay for GM foods. Demographics considered in the literature include, but are not limited to, gender, income, education, and race. In general, men and those with higher levels of education and income are more accepting of biotechnology than are their counterparts (Wachenheim 2004). Other factors such as age and location of residence have been shown to have an effect, although the strength and even direction of the effect is not conclusive. In fact, while often statistically significant in effect, demographics alone generally are not very useful in predicting acceptance of GM foods (Wachenheim 2004). Also considered have been behaviors (e.g., whether the respondent reads labels, participates in organized religion), knowledge about agricultural processes (especially biotechnology), and attitudes (e.g., degree of trust in government regulation of food). Some authors have used their results to hypothesize about market segments for (non-)GM products.

A final conclusion is that perception of risks associated with biotechnology and the resultant food products are different. Those perceived as involuntary, wherein the consumer is without choice in accepting the risk, can be especially troublesome to consumers, and perceived long-term risks to society and the environment may not correspond with current reluctance to consume GM foods (Anderson, Wachenheim, and Lesch 2005).

Risk Perception and Consumption Decision

The literature identifies categories of factors influencing consumers' risk perceptions: social and cultural characteristics, personal health influence, and perceived locus of control (Grobe, Douthill, and Zepeda 1997; Adu-Nyako and Thompson 1999; Nganje, Kaitibie, and Taban 2005). Social and cultural factors include gender, race, family size, and membership in consumer, scientific, or environmental groups, as well as economic factors such as income level and price of the product (Adu-Nyako and Thompson 1999). Personal health influence represents factors that characterize health attributes like added vitamins and hormones to reduce diseases (Weinstein 1988; Bernard, Pan, and Sirolli 2005). Finally, perceived locus of control represents factors characterizing consumers' perceptions of how food-safety risks are managed, like labeling and identity preservation, and prior risk experience. In the case of GM foods, the above characterization of risk is

limited by the fact that risk is viewed basically as hazard, rather than hazard plus outrage.

Sandman (2000) points out that risk can only be effectively measured when categories of variables are identified to measure hazard and outrage. For example, irradiation has been shown to be very effective in eliminating microbial risks (reduced hazard), yet some consumer surveys show that consumers perceive irradiated products as somewhat unsafe because of unknown risks (outrage) associated with irradiation and cancer. Consumers' perception of risk with irradiated beef ultimately affects their consumption decisions. We investigate the role of consumer knowledge on risk perception of, and willingness to serve, GM foods.

Furthermore, we are witnessing an emerging trend with factors that affect the consumption decision, as individuals or groups take on a more active role in affecting or attempting to affect the products they and others consume. For example, animal welfare groups have increasingly become more active participants in making sure animals are handled well. Consumer groups will pay a premium for organic produce to support healthy farming practices or for altruistic reasons (develop markets for poor farmers), although health claims for these products have not been validated by current research. Others will pay a premium to support products that will address nutrition issues for poorer communities and populations. The marginal contribution of these "feel-good set of attributes or actions" on consumption decisions is a new and growing area of investigation. To address this emerging consumer behavior trend, we test the hypothesis that altruistic factors significantly affect consumption decisions. The inclusion of risk communication and altruistic variables in consumer-choice theory may provide a better understanding of current and future consumption-decision analysis.

Survey Design, Methodology, and Estimation Procedure

Survey Design and Sample Characteristics

A telephone survey was used to elicit perceptions of North Dakota shoppers 18 years or older about GM foods. The survey was conducted by the Social Science Research Institute at the University of North Dakota. Data were collected between November 20 and December 8, 2003. The target population was randomly selected adults in North Dakota who reported they had performed most of the household grocery shopping in the prior month.

The majority of interviews were conducted on weekday and Sunday evenings. Efforts to complete interviews with selected respondents were extensive. The number of callbacks to complete an interview with an eligible respondent ranged from one to nine. Using the most conservative approach to calculate response rate, that adopted by the Council of American Survey Research Organizations (CASRO), the response rate was 64 percent. The response rate increases to 67 percent if calculated by the Upper Bound method used by the federal government. The average telephone interview time was approximately 16.5 minutes. Additional details of the survey and its implementation can be referenced from Wachenheim and Lesch (2004).

Information collected included demographic and social characteristics, health influence and product characteristics, altruistic benefits, perceived locus of control and food safety risk, and outrage (lack of the true knowledge of reality) related to GM processes and products. Table 1 summarizes the variables used in this study.

Prior to responding to the introduction of the main elements of the questionnaire, participants were read the following definition of genetic modification.

> "Here is a description used by food scientists. GMO stands for genetically modified organism. It refers to the process of modifying plants or animals by adding genes to change the makeup of the original organism. The traditional plant development process uses cross breeding, which requires plants be similar, and it takes time. The genetic modification process moves genetic material from one organism to another, desirable genes to plants or between dissimilar plants or animals. It produces plants with desired characteristics faster than traditional cross breeding."

The pool of 408 respondents was predominantly female (67 percent) and mostly Caucasian (89 percent). Most persons were married (62 percent), with 57 percent of households reporting that their annual household income was above $40,000, al-

Table 1. Variables Used in the Multinomial Logit Models.

Variable	Description
Dependent variables	
Risk involved in GM foods is acceptable	0 = Neutral; 1 = agree; 2 = disagree
Willing to serve or consume GM foods	0 = Neutral; 1 = agree; 2 = disagree
Health influence and product characteristics	
GM hormones that enable cows to produce beef with less cholesterol	1 = approve; 2 = undecided; 3 = disapprove
Willing to buy GM product containing added vitamins and minerals for better nutrition	1 = much more willing; 5 = much less willing
GM fruits and vegetables that are less expensive	1 = approve; 2 = undecided; 3 = disapprove
Willing to buy GM product with a better flavor.	1 = much more willing; 5 = much less willing
Altruistic and manufacturer benefits	
GM for more nutritious grain that could feed people in poor countries	1 = approve; 2 = undecided; 3 = disapprove
GM food will benefit many people	1 = strongly agree; 5 = strongly disagree
Companies involved in GM crops believe profits more important than safety	1 = strongly agree; 5 = strongly disagree
Perceived locus of control and food safety risk	
Feel about animals created using GM	1 = strongly approve; 5 = strongly disapprove
GM food presents no danger for future generations	1 = strongly agree; 5 = strongly disagree
Risks of GM have been greatly exaggerated	1 = strongly agree; 5 = strongly disagree
Outrage	
Is GM on food label?	1 = yes; 2 = unsure; 3 = no
Any GM food products in grocery stores?	1 = unsure; 0 = otherwise
Should GM foods be labeled?	1 = yes; 2 = unsure;3 = no
I am adequately informed about biotechnology	1 = strongly agree; 5 = strongly disagree
Government regulators have best interests of public in mind	1 = strongly agree; 5 = strongly disagree
Social and demographic characteristics	
Number of people shop for	1 = 1; 2 = 2; 3 = more than 2
Grow up on farm	1 = yes; 2 = no
Married	1 = yes; 2 = no
Gender	1 = male; 2 = female
Race	1 = Caucasian; 0 = other
Income	Categories from less than 20,000 (0) to greater than 75,000 (5)
Member of environmental group	1 = yes; 2 = no
Member of scientific group	1 = yes; 2 = no
Member of consumer group	1 = yes; 2 = no

though 27.5 percent reported an income of $20,000 or less. Forty-one percent reported children in the household under age 18, and the average age of interviewees was 50. As North Dakota is a decidedly agricultural state, it was not surprising that roughly one-half of those participating in the survey had grown up on a farm and that approximately 10 percent were active farmers.

Level of awareness of GM foods assessed through unaided recall was low, and few respondents—less than five percent—could accurately define GM. However, those accurately reporting that GM was absent on food labels increased to 61 percent once the definition of genetic modification was offered. Only 37 percent of shoppers correctly reported the presence of GM-based foods in grocery stores; 41 percent were unsure. Hallman et al. (2003) reported that 52 percent of adults nationwide reported such foods could be obtained in grocery stores. Nationwide, a lower percentage of respondents was unsure. In the current study, 83 percent of shoppers thought GM food products should be labeled as such. Sixty-three percent disagreed that they were adequately informed about biotechnology; only 22 percent agreed.

Shoppers reported a relatively high level of propensity to purchase GM products when they were offered an enhanced health trait. Seventy-eight percent were more willing to purchase an enhanced GM pasta product (than a same-priced traditional pasta product) when it contained added vitamins and minerals, although this declined to 59 percent for pasta enhanced to provide only better flavor. Respondents were more accepting of biotechnology in plants than in animals. Two-thirds of respondents approved of plants created using GM, while only 28 percent approved of animals created using GM. The national study by Hallman et al. (2003) reported similar proportions (49 percent and 27 percent, respectively).

Degree of shopper acceptance as measured by approval for GM applications also varied by product. Applications involving an altruistic element received the strongest support. For example, 72 percent approved of GM methods to develop more nutritious grain to feed people in poor communities and countries.

In general, respondents had some concern about risks. Only one in four agreed that the risks involved in GM foods are acceptable; nearly half disagreed. However, 40 percent agreed that the risks associated with GM foods have been greatly exaggerated, and only one in four disagreed. Only 21 percent agreed that GM food presents no danger for future generations; 51 percent disagree. Nearly 40 percent indicated a willingness to consume GM foods in their family; An equal number disagreed.

Sixty-one percent agreed that firms involved in creating GM crops believe profits are more important than safety (21 percent disagreed). Only 27 percent of respondents agreed that government regulators have the best interests of the public in mind; 56 percent disagreed. This is surprising given the general opinion that consumers in the United States trust the government to protect the food supply. In-depth analysis of the data is presented to further explore the link between perceptions of risk and willingness to consume GM foods.

Economic Model and Methodology

Individuals will consume more of a particular bundle of a good if they perceive their utility will increase from that obtained from an initial consumption bundle if cost and associated risks do not change. Identifying perceived risk associated with alternative consumption bundles is challenging because it is intangible and includes outrage, a qualitative risk factor. As a result, consumption-decision models often focus on pricing strategies. However, in light of its importance, understanding the effect of risk perception on consumption decisions is essential for designing strategies to increase demand for a product. In the present context, the goal is to assess the relationship between risk perception and consumption decisions as an input towards assessing the efficacy of reduction in perceived risk to increase demand for GM food products.

For risk-reduction strategies to increase demand, they must increase the difference in expected utility between goods with higher and lower perceived risks. Essentially, providing information on food labels and identity preservation that reduces perceived risk and/or increases perceived benefits of GM foods should increase demand for GM food products. However, since consumers respond differently to changes in food-safety risks, such as outrage, there is no *a priori* theoretical indication of the direct effect of reduced risk and increased consumption. Consequently, an empirical model is necessary.

It is not necessary to estimate each consumer's utility function. The probability of choosing a particular GM food consumption bundle, as a function of risk-perception attributes, can be estimated instead using a discrete-choice model. Translating the difference in expected utility into a workable limited discrete-choice model requires assuming a distribution for the difference between the error-term coefficients. Assuming the error terms are random independent variables following a Weibull distribution, the distribution of the difference between the errors is logistic (Domenich and McFadden 1975). Since consumers are assumed to choose among three alternative risk levels (GM risks are acceptable, GM risks are not acceptable, and uncertain) and three consumption levels (will serve GM foods to my family, will not serve GM foods to my family, and uncertain), the model reduces to a multinomial logit model, where the probability of choosing alternative risk or consumption levels is a function of all three categories of risk-perception variables and outrage and altruism proxies.

A multinomial logit model was used to evaluate the marginal effects of risk perception and other attributes on acceptability of risks. The model is also used to evaluate the effect of risk perception attributes on consumers' willingness to serve GM foods. A similar model was used by Schupp, Gillespie, and Reed (1998); Moutou and Brester (1998); and Nganje, Kaitibie, and Taban (2005).

The probability of the *i*th risk-perception category on an individual's choice of *j*th GM risk or consumption decision follows the logistic distribution

$$(1)\quad P_{ij} = \frac{e^{X_i'\beta_j}}{1+\sum_{k=1}^{m-1} e^{X_i'\beta_k}},\ \mathrm{j}=1,\ 2,....,\mathrm{m\text{-}1}\ ,$$

where X is a vector of perceived risk and other characteristics (specified in Table 1), β is the set of estimated parameters, and m is the number of choices. The marginal effects, which are partial derivatives of probabilities with respect to the set of characteristics, were calculated from multinomial logit results according to

$$(2)\quad \frac{\partial P_j}{\partial X_i} = P_j(\beta_j - \sum_{i=1}^{m} P_i\beta_i),\ \mathrm{j}=1,\ 2,.....,\mathrm{m}\ .$$

Estimation Procedure

The multinomial logit models were estimated using the Nlogit software package (Greene 2004). Nlogit uses the full-information maximum-likelihood estimation procedure to ensure that parameter estimates are efficient and unbiased. We also used a choice-based sampling-estimation procedure to correct for potential multicollinearity problems. A two-level nested multinomial logit model was estimated to determine model fitness and to test the independence of irrelevant alternative (IIA) assumption. In Level One consumers choose a risk level and in Level Two they make consumption decisions (whether or not to serve GM foods). The test hypothesis was rejected in favor of multinomial logit models.[3]

While the survey responses from consumers show a gap in risk perception and consumption decisions, additional tests to support the use of separate multinomial logit models for perceived risks and consumption were necessary. These tests are also used to determine whether the dichotomy between perceived risk and willingness to serve GM foods is significant. Traditional tests for the equality of multinomial logit models (e.g., Swait and Louviere 1993; Hearne and Salinas 2002) were not applicable because of major differences between perception of risks and consumption. A non-parametric Mann-Whitney test was used to compare the distribution of responses regarding consumers' GM risk perceptions and their willingness to serve GM foods. To carry out the test measures, consumers are assembled into a single set of size $N = n_a + n_b$. The N-size measures are then ranked in ascending order and the rankings returned to the original samples in place of the raw measures, so that n_a is the number of ranks in group A (the consumers' perceptions of risks), and n_b is the number of ranks in group B (their consumption decision). In addition, we define T_A as the sum of n_a ranks in group A, T_B as the sum of n_b ranks in group B, and T_{AB} as the sum of N ranks in groups A

[3] To perform a likelihood-ratio test for IIA, we considered the multinomial logit model with its implied IIA as a restricted version of the general nested logit model estimated with full-information maximum likelihood (Greene 2004). The restricted model gives a log likelihood value of −151.126, while the unrestricted model gives a log likelihood value of −147.112. The resulting likelihood-ratio test statistic ($\chi = 4.003$) fails to reject IIA when compared with the tabular value ($\chi = 5.99$, $\alpha = 0.05$, 2df).

and B. The Mann-Whitney test used here is based on the z test, which is defined as

$$(3)\quad z = \frac{\left(T_{obs} - \mu_T\right) \pm 0.5}{\sigma_T},$$

where T is the observed value for either T_A or T_B, m_T is the mean of the corresponding sampling distribution of T, σ_T is the standard deviation of that sampling distribution, and 0.5 is used as a correction for continuity (with −0.5 used when $T_{obs} > {}_T$ and +0.5 used when $T_{obs} < m_T$).

Results and Discussion

Dichotomy of Response

The Mann-Whitney test compared the distribution of responses to consumers' GM risk perceptions and their willingness to serve GM foods. With a calculated symmetric z-value of 0.6155 and a p-value of 0.0001, we conclude the dichotomy is significant. Some consumers who perceive GM to be risky would continue to serve GM foods to their family.

Regression Results

Table 2 provides additional details about the dichotomy. Overall, only 25 percent of respondents agreed that the risk associated with GM foods is acceptable. Among them, most (78 percent) were willing to serve GM foods to their families; 12 percent were not. However, a lower percentage of those who did not believe risks were acceptable (68 percent) were unwilling to serve GM foods. Further supporting the argument that willingness to serve GM foods is not contingent on a belief that risks are acceptable, only 52 percent of those willing to serve GM foods believe risks are acceptable; 33 percent were neutral risks are acceptable; and 15 percent did not believe risks are acceptable. Correlation of level of agreement between the two statements was 0.649 (p = 0.000).

Results of the multinomial logit models identify the marginal effects of factors contributing to the gap between food-safety risk perceptions and consumption. Results are presented in Table 3. The models had good fits. The likelihood-ratio value was −150.35 and −141.34 for the risk-perception and willingness-to-serve models, respectively, with significant chi-squared values. The pseudo R-squared for the risk-perception model was 39.8 percent, with 73.3 percent of observations predicted correctly. The pseudo R-squared for the willingness-to-serve model was 42.4 percent with 73.7 percent of observations predicted correctly. Only those relationships that are significant are discussed here. They are also summarized in Table 4.

Social and Demographic Characteristics

Demographic variables influencing the likelihood a respondent would (dis)agree that the risk associated with GM foods is acceptable differed from those associated with (un)willingness to serve GM foods.

Table 2. Risk Perception and Willingness to Serve, Crosstabs* (%).

		Willingness to serve			
		Willing	Neutral	Unwilling	Total
Risk Perception	Acceptable	19.5	2.7	2.9	25.1
	Neutral	12.4	10.0	5.3	27.7
	Unacceptable	5.6	9.4	32.2	47.2
	Total	37.5	22.1	40.4	

* Percentage of respondents in both categories shown (e.g., 19.5 percent of respondents considered level of risk acceptable and were willing to serve GM foods to their families.

Table 3. Risk Perception and Willingness to Serve.

Risks involved in GM food acceptable				Variable	Willing to serve GM foods to my family			
Agree		Disagree			Agree		Disagree	
Coefficient and std. error	Marginal effect	Coefficient and std. error	Marginal effect		Coefficient and std. error	Marginal effect	Coefficient and std. error	Marginal effect
				Health influence and product characteristics				
-.321 (.331)	.020	-.887 (.254)	-.195	GM hormones for beef with less cholesterol	.413 (.305)	.032	.452 (.294)	.042
-.219 (.318)	.004	-.468 (.252)	-.099	Buy GM product with vitamins and minerals	.516 (.327)	.116	.060(.282)	-.064
.322 (.315)	.014	.422 (.267)	.081	Less expensive GM fruits and vegetables	-1.48 (.399)	-.317	-.276 (.275)	.161
.338 (.301)	.003	.594 (.246)	.122	Willing to buy GM product for better flavor	.279 (.333)	.007	.397 (.253)	.050
				Altruistic and manufacturer benefits				
.921 (.476)	.067	.824 (.423)	.136	GM to feed people in poor countries	.884 (.430)	.179	.233 (.376)	-.080
-.597 (.299)	-.111	.397 (.212)	.141	GM food will benefit many people	-1.081 (.276)	-.337	.494 (.264)	.279
.-.164 (.200)	-.026	.054 (.192)	.025	Profits more important	-.018 (.239)	-.009	.032 (.235)	.010
				Perceived locus of control and food safety risk				
-.003 (.188)	-.044	.604 (.230)	.149	Feel about animals created using GM	-.700 (.245)	-.196	.169 (.239)	.146
.017 (.228)	-.047	.686 (.202)	.168	GM food no danger for future generations	.158 (.244)	-.012	.330 (.216)	.053
-.804 (.264)	-.106	.055 (.241)	.045	Risks of GM greatly exaggerated	-.440 (.297)	-.084	- .148 (.250)	.032
				Outrage				
-.104 (.295)	.008	-.305 (.253)	-.068	GM on food label?	-504 (.333)	-.088	-.228 (.344)	.023
-.222 (.519)	-.062	.443 (.423)	.125	Any GM food products in grocery stores?	-.987 (.511)	-.234	-.034 (441)	.142
.355 (.421)	.073	-.330 (.378)	-.107	Should GM foods be labeled?	.826 (.479)	.103	.640 (.411)	.023
-.820 (.230)	-.087	.352 (.177)	-.028	I am adequately informed about biotechnology	- .082 (.237)	-.031	.074 (.210)	.030
.064 (.213)	-.017	.358 (.185)	.084	Government has best interests of public	-.009 (.212)	-.015	.085 (.187)	.021

Table 3. Risk Perception and Willingness to Serve (Continued).

Risks involved in GM food acceptable				Variable	Willing to serve GM foods to my family			
Agree		Disagree			Agree		Disagree	
Coefficient and std. error	Marginal effect	Coefficient and std. error	Marginal effect		Coefficient and std. error	Marginal effect	Coefficient and std. error	Marginal effect
				Social and demographic characteristics				
-.781 (.423)	-.087	-.286 (.372)	-.014	Number of people shop for	-.524 (.449)	-.092	-.231 (356)	.026
.459 (.534)	.123	-.823 (.453)	-.236	Grow up on farm	388 (.509)	.068	.170 (.447)	-.019
-.357 (.569)	-.078	.407 (.526)	.126	Married	-.022 (.706)	.041	-.303 (.577)	-.067
-.441 (.559)	-.005	-.786 (.452)	-.157	Gender	-.244 (.549)	-.000	-.388 (.486)	-.053
-.269 (.871)	-.043	.081 (.871)	.039	Race	-3.290 (1.476)	-.529	-1.77 (1.234)	.088
.204 (.147)	.020	.116 (.120)	.014	Income	.029 (.172)	.022	-.102 (.141)	-.028
-2.34 (1.675)	-.175	-2.019 (1.250)	-.328	Member of environmental group	1.411 (1.182)	.304	.256 (.797)	-.155
4.15 (1.370)	.485	1.175 (1.152)	-.011	Member of scientific group	-.979 (1.600)	.280	-3.406 (1.07)	-.642
.846 (1.206)	.165	-.669 (1.520)	-.226	Member of consumer group	4.498 (1.490)	.780	2.050 (1.229)	-.207
16.4 percent		44.0 percent		Estimated probabilities	41.4 percent			
			73.3 percent	Percentage correct prediction	73.7 percent			
			-150.35	Loglikelihood statistics	-141.34			
			39.8 percent	Pseudo R-square	42.4 percent			

Table 4. Risk Perception and Willingness to Serve, Significant Variables*.

Risk involved in GM food is acceptable		Variable	Willing to serve GM foods to my family	
Agree	Disagree		Agree	Disagree
		Health influence and product characteristics		
	- (.001)	GM hormones for beef with less cholesterol		
	- (.063)	Buy GM product with vitamins and minerals	+ (.115)	
	+ (.114)	Less expensive GM fruits and vegetables	- (.000)	
	+ (.016)	Willing to buy GM product for better flavor		+ (.116)
		Altruistic and manufacturer benefits		
+ (.053)	+ (.051)	GM to feed people in poor countries	+ (.040)	
- (.046)	+ (.061)	GM food will benefit many people	- (.000)	+(.061)
		Perceived locus of control and food safety risk		
	+ (.009)	Feel about animals created using GM	- (.004)	
	+ (.001)	GM food no danger for future generations		
- (.002)		Risks of GM greatly exaggerated		
		Outrage		
		Any GM food products in grocery stores?	- (.053)	
		Should GM foods be labeled?	+ (.084)	+ (.119)
- (.000)	- (.046)	I am adequately informed about biotechnology		
	+ (.054)	Government has best interests of public		
		Social and demographic characteristics		
-(.065)		Number of people shop for		
	- (.069)	Grow up on farm		
		Married		
	- (.090)	Gender		
		Race	- (.026)	
		Income		
	- (.106)	Member of environmental group		
+(.002)		Member of scientific group		- (.002)
		Member of consumer group	+ (.003)	+ (.095)

***** Indicates sign (and level of significance) of coefficient. For two significant variables in the willingness to serve estimate (buy GM product with vitamins and minerals for the agree estimate, and member of consumer group for the disagree estimate), the coefficient is positive, but the marginal effect is negative.

Only one demographic variable was significant in influencing the likelihood a respondent would *agree* that the risk associated with GM foods is acceptable. Respondents shopping for more people were less likely to agree the risk is acceptable. This variable, coded 1 for a single-person household, 2 for a two-person household, and 3 for all others, differentiated not only single-, dual-, and multiple-person households but also served as a proxy for households with children. Most (90.7 percent) of respondents shopping for only one or two individuals did not have children under 18 years of age living at home. (The relationship is not perfect because of single-parent households with one child and households with children 18 years of age or older living at home.)

Two demographic variables were significant in influencing the likelihood a respondent would *disagree* that the risk associated with GM foods is acceptable: farm background and gender. Somewhat surprisingly, those growing up on a farm were more likely to disagree that the risk of GM is acceptable, and the marginal effect was large, with those coming from a farm 23.6 percent more likely to disagree. In part, this may be due to the fact that commercialized applications in agriculture of biotechnology are relatively new and older shoppers, despite their farm background, may not be as familiar with and, in fact, suspicious of the technology. The marginal-effect analysis also revealed that females were 15.7 percent less likely to disagree that the risk is acceptable than are males. This is also unexpected given that previous literature supports that, in general, females are more concerned with the risks of new technologies (Gaskell et al. 2004; Bernard, Pan, and Sirolli 2005; Hwang, Roe, and Teisl 2005). As the primary shoppers, women may be more familiar with the current use of GM commodities in food products.

Race was a significant demographic variable in the willingness-to-serve model. Importantly, Caucasian respondents were 52.9 percent less likely to be willing to serve GM foods to their families than others. This contrasts with Hossain et al. (2003), who reported that whites were more accepting of GM foods and Hwang, Roe, and Teisl (2005) who found lower levels of concern about food technologies among whites. However, as noted by Bernard, Pan, and Sirolli (2005), there is little in the literature regarding the effect of race on acceptance of GM foods. Non-Caucasians in North Dakota are not representative of the United States, especially because of the higher-than-average American Indian population. American Indian and Alaska Natives make up 6.2 percent of the North Dakota population, compared to 1.8 percent for the United States as a whole (U.S. Census Bureau 2004). No demographic variables were significant in their influence on the likelihood a respondent would *disagree* that they would serve GM foods to their family.

Variables representing membership in groups were significant and important in both models. As expected, those who are members of an environmental group were 32.8 percent more likely to disagree that the risks of GM foods are acceptable. Those who are members of a scientific group were 48.4 percent less likely to agree that the risk is acceptable and were 64.2 percent more likely to disagree that they are willing to serve GM foods to their families. This could be somewhat unsettling, based on the industry's notion that a consumer educated about biotechnology will be more accepting of such, if one makes the assumption sometimes extended in the literature that those who are members of a scientific group are, on average, better educated about biotechnology or the science involved in agriculture in general. Membership in a consumer group influenced only the likelihood of respondents agreeing or disagreeing that they were willing to serve GM foods to their families, but the effect was important. As expected, membership in a consumer group decreased by 78 percent the likelihood that a shopper agreed that they were willing to serve GM foods and increased by 20.7 percent the likelihood that they disagreed.

Health Influence and Other Product Characteristics

Variables representing the intent of using biotechnology and the results of such in terms of product characteristics were significant in each model, particularly the likelihood that a respondent would disagree that the risks involved in genetic modification are acceptable, or agree that they were willing to serve GM foods to their families. Somewhat unexpectedly, those less approving of the use of biotechnology for health benefits (to decrease cholesterol level in beef or to increase vitamin and mineral content of a product) were less likely to disagree that the risks involved with genetic modification are acceptable. These variables did not have a significant effect on the likelihood that

respondents would agree that risks are acceptable. Also unexpected was that those less willing to buy an enhanced GM product with more vitamins and minerals were more likely to agree that they would be willing to serve GM foods. This may imply that consumers who are more concerned about their diet (e.g., those most interested in added vitamins and minerals) may be less accepting of GM food products in general.

As expected, those less supportive of genetic modification to produce less expensive fruits and vegetables or provide better flavor were more likely to disagree that the risks are acceptable, although the latter result was not significant. Those less supportive of genetic modification to produce less expensive fruits and vegetables were also less likely to agree that they were willing to serve them to their families.

Altruistic Motives for Biotechnology

Beliefs about GM based on altruistic motives were significant in both models. As expected, those with a stronger belief that GM food will benefit many people were more likely to agree that the risks are acceptable and more willing to serve GM foods to their families and were less likely to disagree with each statement. Perceptions about the potential of GM had particularly large marginal effects on the level of (dis)agreement that respondents were willing to serve GM foods. Those who were more supportive of the use of GM to feed people in poor countries also were less likely to disagree that the risks are acceptable. Unexpectedly, they were also less likely to agree that the risks are acceptable and that they would serve GM foods to their families. The former result had a relatively small marginal effect. The link between altruistic characteristics and consumption is important in unraveling the marginal contribution of a "feel-good set of attributes or actions" on consumer decisions and is a new and growing area that needs to be addressed for other goods. Figure 1 reveals that a willingness to serve GM foods increases with increased awareness of altruistic attributes of GM foods.

Risk Perception

Variables reflecting risk perception had the expected influence. Disapproval of animals created

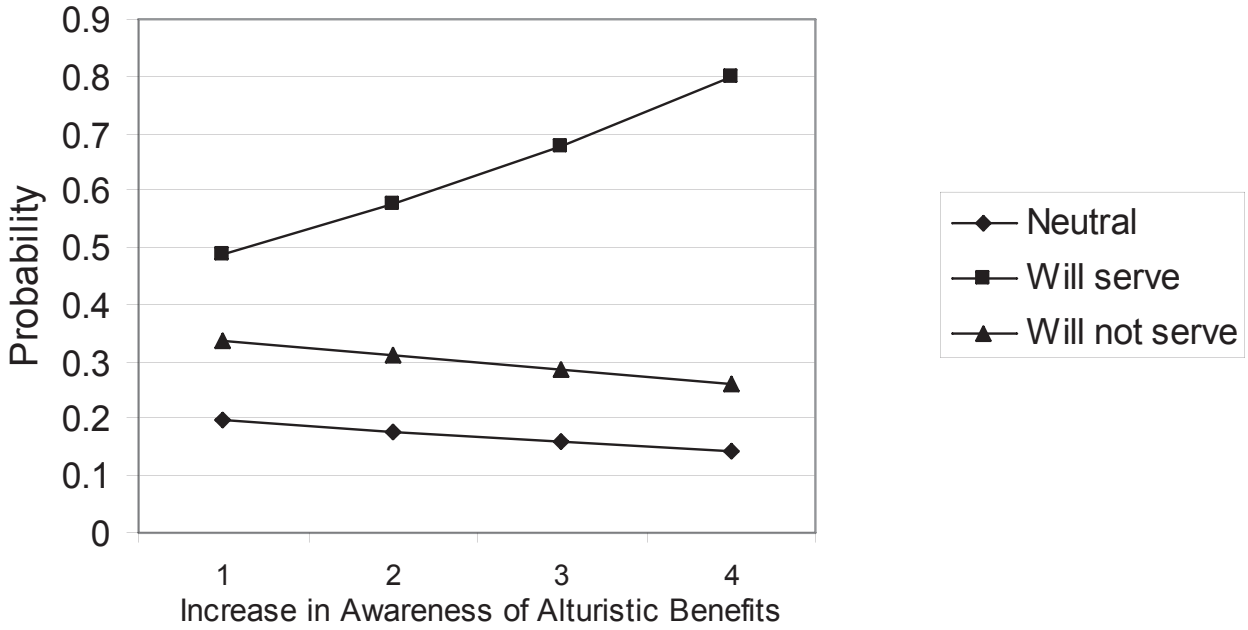

Figure 1. Consumption of GM Foods and Awareness of Altruistic Benefits.

using biotechnology and disagreement with the statement that GM food presents no danger for future generations increased the likelihood that a respondent would disagree that risks are acceptable. The former result also decreased the likelihood that a respondent agreed that they would serve GM foods. Disagreement that the risks of GM have been greatly exaggerated decreased the likelihood that the respondent would agree that the risks are acceptable.

Outrage

Significant variables representing outrage included the respondents' knowledge regarding GM food products and whether they knew these products were available in grocery stores, whether they supported labeling of GM foods, and their level of trust in the government to protect the public. The variables significant in the risk-perception model were different from those significant in the willingness-to-serve model. Respondents who did not feel adequately informed about biotechnology were less likely to both agree and disagree that risks are acceptable, although the effect was not large in either case. As expected, those disagreeing that the government has the best interests of the public in mind were more likely to disagree that the risks are acceptable. While this supports the work of Onyango and Nayga (2004), who found that those who trust government regulators are more likely to consume nutritionally-enhanced GM cereals, trust in the government was not significant in the willingness-to-serve estimate in the current study. Consumer-level knowledge was more important for willingness to serve. Those unsure if GM products were available in grocery stores were less likely to agree to serve them to their families. Those who were of the opinion labeling was less necessary than others were more likely to serve GM foods to their families (Figure 2).

Conclusion

There is evidence of a dichotomy between shopper's agreement that level of risk associated with GM foods is acceptable and willingness to serve them to their families. More North Dakota shoppers are will-

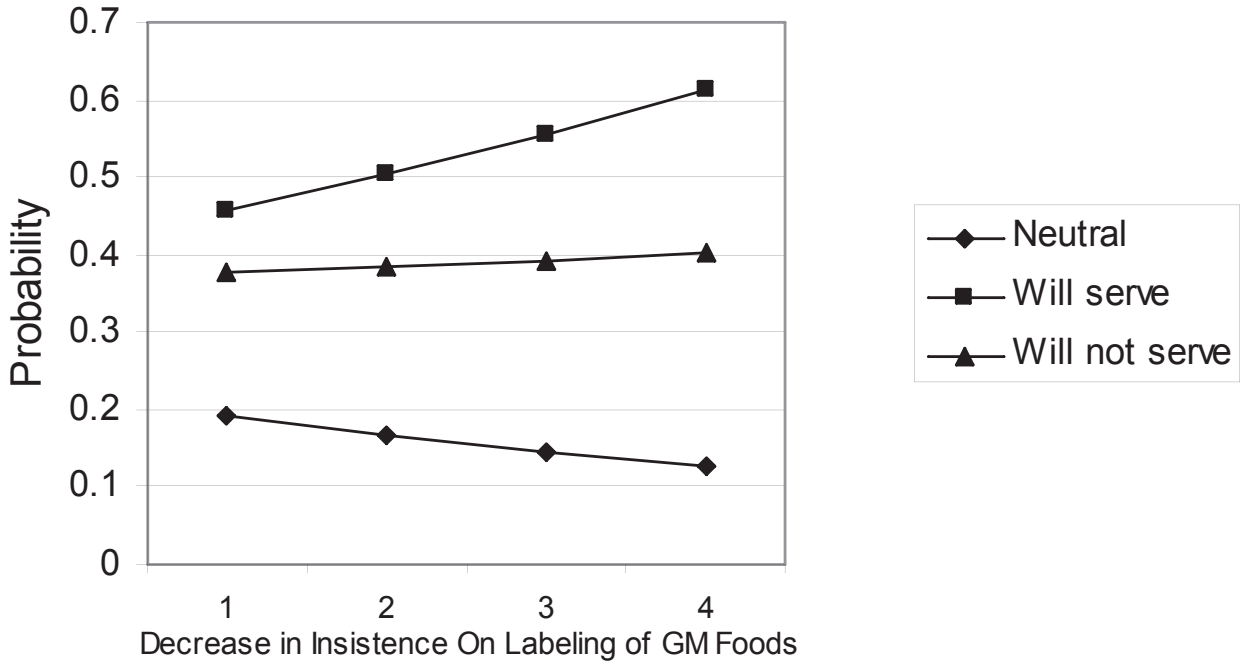

Figure 2. Consumption of GM Foods with Decreasing Outrage/Increasing Labeling Awareness.

ing to serve GM foods to their families than believe the risks involved in GM foods are acceptable. Variables with a significant influence on the probability that shoppers will (dis)agree that risk is acceptable differ from those influencing the probability that they (dis)agree that they are willing to serve them to their families. In general, the variables specific to each model, when different, are supported. Different demographic variables influenced each model, with household size, gender, and whether the shopper was raised on a farm influencing risk perception and race influencing willingness to serve. As expected, those who were members of an environmental group were more likely to disagree that risk is acceptable, while membership in a consumer group influenced the probability of willingness to serve.

Interestingly, those less approving of the use of biotechnology to enhance the health-related characteristics of food were less likely to disagree that the risks involved with genetic modification are acceptable. One hypothesis is that individuals not concerned in general about the risks of biotechnology may not be motivated by its potential to improve what they already may believe to be a nutritious food supply.

Variables reflecting a shopper's risk perception in general were more important in predicting the likelihood that a shopper would (dis)agree that the risks involved in GM food are acceptable than in predicting the likelihood that they would serve GM foods. However, variables related to altruistic attributes and outrage provided some important clues on emerging trends with factors that effect the consumption decision, as consumers take on a more active (feel-good) role in the products they consume. Outrage variables were important in both models, but significant variables differed. Those significant in the risk-perception model were whether shoppers thought they were adequately informed and whether they tbought the government protects them. Increased knowledge of the availability of GM foods and belief that they should be labeled as such—consumption considerations—were significant in the willingness-to-serve model.

Overall, evidence of a dichotomy and the finding that more shoppers are willing to serve GM foods to their families than agree that the risks involved in GM food are acceptable may in part be explained by the notion that perceived risk extends both in time and in context beyond food-consumption risk. Perceived environmental risks and those associated with society, moral, or ethical grounds (e.g., potential impacts on the "family farm") may have been identified by respondents and contributed to less support than would be justified based on only the risks they associate with consumption of GM products. It also supports the idea that consumption, even intended consumption, may not fully consider the long-term affects on human health. This is akin to tobacco use. From a societal standpoint, additional research efforts may be warranted into more carefully identifying the sources of support for or concern about the use of biotechnology in agriculture and its associated industries and to consider how these are related to consumer behavior in the marketplace. This is particularly important as we observe emerging trends with consumers taking a more active role in the food they consume.

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