AGRIBUSINESS AND APPLIED ECONOMICS REPORT NO. 621 JANUARY 2008

COMPARISON OF PERCEPTION OF RISK AND WILLINGNESS TO CONSUME GM FOODS

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ACKNOWLEDGMENTS

Thanks are extended to our colleagues Cheryl DeVuyst and Saleem Shaik for reviewing this manuscript, and to Edie Nelson for document preparation.

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ABSTRACT

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 impacts on their consumption decision. Efforts towards decreasing perceptions of risk and ultimately increasing acceptance of, and demand for, GM foods should address issues related to their altruistic characteristics and outrage.

Keywords: Genetic modified foods, multinomial logit, risk perception, willingness to consume GM foods

JEL Classification: Q19, D12

COMPARISON OF PERCEPTION OF RISK AND WILLINGNESS TO CONSUME GM FOODS

CHERYL J. WACHENHEIM, WILLIAM E. NGANJE, AND WILLIAM C. LESCH[1]

INTRODUCTION

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 102 million hectares planted to GM varieties worldwide in 2006 (James, 2006). Farmers in the United States and elsewhere continue to rapidly adopt GM varieties because of their agronomic, economic, and environmental advantages.

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% 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 what affects acceptance. Opposition to GM foods is driven primarily by concerns about food safety and environmental risks associated with their use (Onyango and Nayga, 2005). These perceived risk factors seem to outweigh objections based on moral, ethical, and social grounds. Not yet well addressed is whether perceptions of risk associated with biotechnology translates into willingness to consume products with GM ingredients.

In this study, a phone survey is used 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. Further, multinomial logit models are developed to determine the marginal impacts 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, the fear of the unknown, 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). Altruism, specifically benefits to poorer populations, may impact risk perception, as these populations may be in dying need for subsistence. It is hypothesized in this study that (1) gaps exist between levels of perceived risks associated with GM foods and willingness to serve

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these foods and (2) information that reduces outrage or identifies altruistic benefits plays a significant role in the consumption decision of GM foods.

PREVIOUS LITERATURE

Perceptions of GM Foods

Research considering consumer acceptance of GM food products has grown during the latter years of the decade within which they have been 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.

Regardless, 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. 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 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 is, providing information about biotechnology and, in particular, its benefits with specific attributes, can increase acceptance of and willingness-to-pay for GM foods.

Fourth, 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 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 are not in general 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, and 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, et al., 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, et al., 1997; Adu-Nyako and Thompson, 1999; Nganje, et al., 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, et al., 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) pointed 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 perceptions of risk with irradiated beef ultimately affects their consumption decision. 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 impact the consumption decision, as consumers take on a more active role in 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 this "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 impact 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 Council of American Survey Research Organizations method of calculation, the response rate was 64%. The average telephone interview time was approximately 16.5 minutes. Additional details of the survey and its implementation can be referenced from Lesch, Wachenheim, and Stillerud (2005)

Information collected included demographic and social characteristics, health influence and product characteristics, altruistic benefits, perceived locus of control and food safety risk, and outrage 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%) and mostly Caucasian (89%). Most persons were married (62%), with roughly equal numbers reporting that their annual household income was at or below $40,000 and above $40,000, although 27.5% 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 an 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% were active farmers.

Level of awareness of GM foods assessed through unaided recall was low, and few respondents, less than 5%, could accurately define GM. However, those accurately reporting that GM was absent on food labels increased to 61% once the definition of genetic modification was offered. Only 37% of shoppers correctly reported the presence of GM-based foods in grocery stores; 41% were unsure. Hallman, et al. (2003) reported that 52% 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% of shoppers thought GM food products should be labeled as such. Sixty-three percent disagreed that they were adequately informed about biotechnology; only 22% agreed.

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	1=much more willing; 5=much less willing
better nutrition	1=approve; 2=undecided; 3=disapprove
GM fruits and vegetables that are less expensive	1=much more willing; 5=much less willing
Willing to buy GM product with a better flavor	
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	1=strongly agree; 5=strongly disagree
safety	
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

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% 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% approved of animals created using GM. The national study by Hallman et al. (2003) reported similar proportions (49% and 27%, 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% 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. Less than one in four agreed that the risks involved in GM foods are acceptable; nearly half disagreed. However, 40% agreed that the risks associated with GM foods have been greatly exaggerated, and only one in four disagreed. Only 21% agreed that GM food presents no danger for future generations; 51% disagree. Approximately 40% 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% disagreed). Surprising given the general opinion that consumers in the United States trust the government to protect the food supply, only 27% of respondents agreed that government regulators have the best interests of the public in mind; 56% disagreed. 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, the fear of the unknown. As a result, consumption decision models often focus on pricing strategies. However, in light of its importance, understanding the impact 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 food 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 to changes in food safety risks, such as outrage, differently, 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 instead estimated 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 between 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 are 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 impacts 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, et al. (1998); Moutou and Brester (1998); and Nganje, et al. (2005).

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

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

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 following equation 2.

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

Estimation Procedure

The multinomial logit models were estimated using Nlogit software package (Greene, 2004). Nlogit uses full information maximum likelihood estimation procedure to ensure 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 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.[1]

While the survey responses from consumers show a gap in risk perception and consumption decision, 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, 1998; 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 distribution of responses regarding consumers' GM risk perception 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' perception 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 and B. The Mann Whitney test used here is based on the z test which is defined as

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

where T is the observed value for either T_A or T_B, μ_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 $T_{obs}>\mu_T$ and +0.5 used when $T_{obs}<\mu_T$).

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. Only 16.4% of consumers perceive GM foods to be safe while 41.4% are willing to serve GM foods to their families. Results of the multinomial logit models identify the marginal impacts of factors contributing to the gap between food safety risk perceptions and consumption.

RESULTS AND DISCUSSION

Results of the multinomial regression models for shopper risk perception and willingness to serve GM foods are presented in Table 2. The models had a good fit. The likelihood ratio value was -150.35 and -141.34 for the risk and consumption models, respectively, with significant chi-squared values. The standard errors for all estimated coefficients were low. The pseudo R-squared for the risk perception model was 39.8%, with 73.3% of observations predicted correctly. The pseudo R-squared for the willingness to serve model was 42.4% with 73.7% of observations predicted correctly. Only those relationships that are significant are discussed here. They are also summarized in Table 3.

Table 2. Risk Perception and Willingness to Serve

Risks involved in GM food acceptable					Willing to serve GM foods to my family			
Agree		Disagree			Agree		Disagree	
Coefficient and Std. Error	Marginal Effect	Coefficient and Std. Error	Marginal Effect	Variable	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
				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	-.529	-1.77 (1.234)	.088
.204 (.147)	.020	.116 (.120)	.014	Income	(1.476)	.022	-.102 (.141)	-.028
-2.34 (1.675)	-.175	-2.019 (1.250)	-.328	Member of environmental group	.029 (.172)	.304	.256 (.797)	-.155
4.15 (1.370)	.485	1.175 (1.152)	-.011	Member of scientific group	1.411	.280	-3.406 (1.07)	-.642
.846 (1.206)	.165	-.669 (1.520)	-.226	Member of consumer group	(1.182)	.780	2.050 (1.229)	-.207
					-.979 (1.600)			
					4.498			
					(1.490)			
16.4%		44.0%		ESTIMATED PROBABILITIES	41.4%			
			73.3%	PERCENTAGE CORRECT PREDICTION	73.7%			
			-150.35	LOGLIKELIHOOD STATISTICS	-141.34			
			39.8%	PSEUDO R-SQUARE	42.4%			

Table 3. 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)	+(0.61)
		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.

Social and Demographic Characteristics

Demographic variables influencing the likelihood a respondent would (dis)agree with the risk associated with GM foods as acceptable, differed from those associated with (un)willingness to serve GM foods. Only one demographic variable was significant in influencing the likelihood a respondent would *agree* the risk associated with GM foods is acceptable. An increased number of people the respondent shopped for decreased the probability the respondent would 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%) 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* the risk associated with GM foods is acceptable: farm background and gender. Somewhat surprising, those growing up on a farm were more likely to disagree the risk of GM is acceptable. And, the marginal impact was large with those coming from a farm 23.6% 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, suspect of the technology. The marginal impact analysis also revealed that females were 15.7% less likely to disagree the risk is acceptable than 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, et al., 2005; Hwang, et al., 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% 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, et al. (2005) who found lower levels of concern about food technologies among whites, but, as noted by Bernard, et al. (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% of the North Dakota population as compared to 1.8% 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* they would serve/consume GM foods with 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% more likely to disagree the risks of GM foods are acceptable. Those who are members of a scientific group were 48.4% less likely to agree the risk is acceptable, and were 64.2% more likely to disagree they were willing to serve GM foods to their family. 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 made the assumption sometimes extended in the literature that those who were members of a scientific group were, on average, better educated about biotechnology

or the science involved in agriculture in general. Membership in a consumer group influenced only the likelihood of agreeing or disagreeing they were willing to serve GM foods to their family, but the effect was important. As expected, membership in a consumer group decreased by 78% the likelihood a shopper agreed they were willing to serve GM foods and increased by 20.7% the likelihood 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 a respondent would disagree the risks involved in genetic modification are acceptable, or agree they were willing to serve GM foods to their family. Somewhat unexpectedly, in the area of health, those less approving of the use of biotechnology (to decrease cholesterol level in beef or to increase vitamin and mineral content of a product) were less likely to disagree the risks involved with genetic modification are acceptable. These variables did not have a significant effect on likeliness they would agree risks were acceptable. Also unexpected, was that those less willing to buy an enhanced GM product with more vitamins and minerals were more likely to agree 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 the risks are acceptable, although the latter was not significant. Those less supportive of genetic modification to produce less expensive fruits and vegetables were also less likely to agree they were willing to serve them to their family.

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 the risks are acceptable and more willing to serve GM foods to their families and less likely to disagree with each statement. Perceptions about the potential of GM had particularly large marginal effects on the level of (dis)agreement they were willing to serve GM foods. And, as expected, those more supportive of the use of GM to feed people in poor countries were less likely to disagree the risks are acceptable. Unexpectedly, they were also less likely to agree the risks are acceptable and that they would serve GM foods to their families. The former had a relatively small marginal effect. The link between altruistic characteristics and consumption is important in unraveling the marginal contribution of "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.

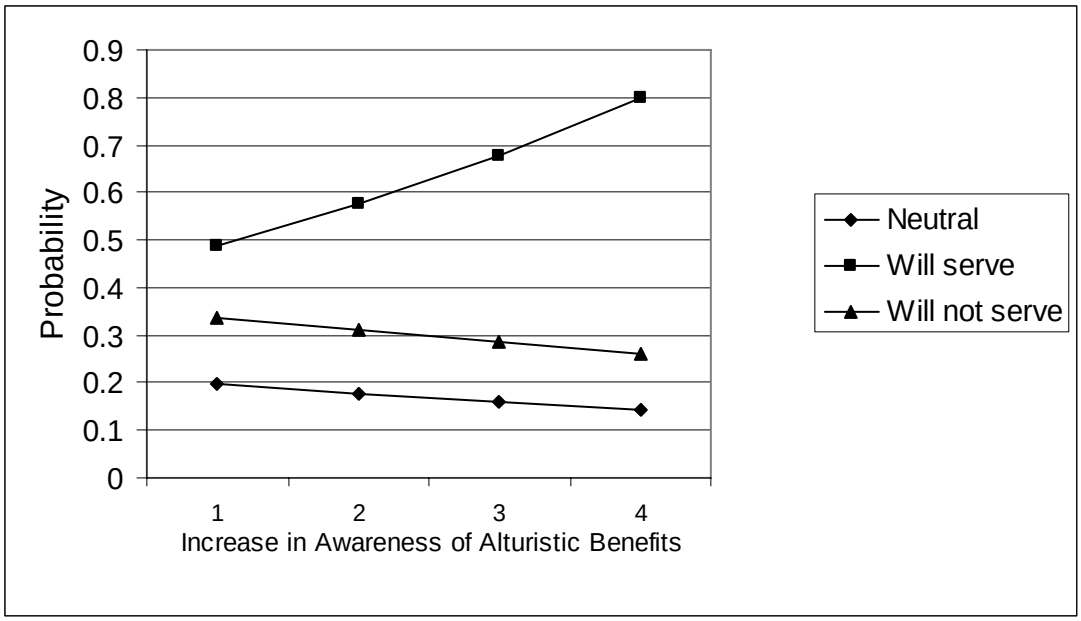

Figure 1. Consumption of GM foods and awareness of altruistic benefits

Risk Perception

Variables reflecting risk perception had the expected influence. Disapproval of animals created using biotechnology, and disagreement with the statement that GM food presents no danger for future generations, increased the likelihood a respondent would disagree risks are acceptable. The former also decreased the likelihood that a respondent agreed they would serve GM foods. Disagreement that the risks of GM have been greatly exaggerated decreased the likelihood the respondent would agree the risks are acceptable.

Outrage

Significant variables representing outrage included the respondents' knowledge regarding GM food products and whether they knew they 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 model were different than 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 risks are acceptable, although the impact was not large in either case. As expected, those disagreeing the government has the best interests of the public in mind were more likely to disagree 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 family. Those who felt labeling was less necessary than others were more likely to serve GM foods to their family (Figure 2).

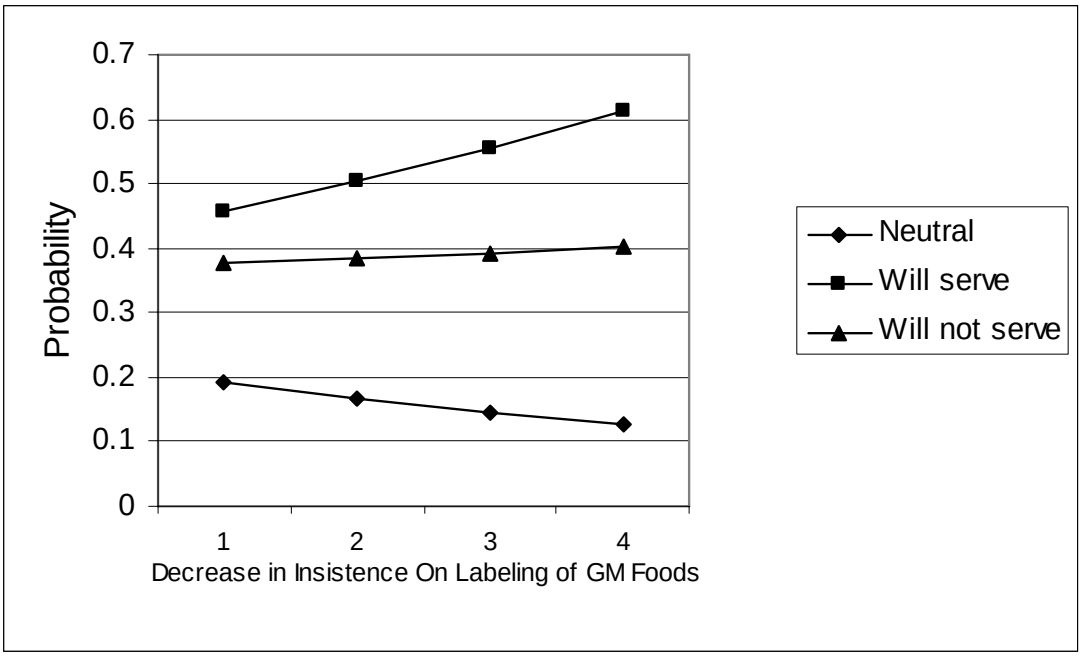

Figure 2. Consumption of GM foods with decreasing outrage/increasing labeling awareness

CONCLUSIONS

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 willing to serve GM foods to their family than believe the risks involved in GM foods are acceptable. Variables with a significant influence on the probability shoppers will (dis)agree that risk is acceptable differ from those influencing the probability they (dis)agree they are willing to serve them to their families. And, 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. Intuitively, 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 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 a shopper would (dis)agree the risks involved in GM food are acceptable than the likelihood they would serve GM foods. However, variables related to altruistic attributes and outrage provided some important clues on emerging trends with factors

that impact 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 model were whether shoppers felt adequately informed and if the government protects them. Increased knowledge of the availability of GM foods and if 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 family than agree 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 impacts on even 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, particularly, for those involved in production agriculture and its associated industries and 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.

End Note

1. 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).

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