Consumer Acceptance of Genetically Modified Foods*

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Introduction

Introducing biotechnology into agricultural production is one of the most prominent benchmarks in the history of agricultural development. The application of genetic modification (GM) technology on agricultural crops and the resulting genetically modified organisms (GMOs) are considered one of the most important yet controversial advancements in science and technology. Despite all the promises and benefits proclaimed by many biotech companies and the governments such as reduced pesticide usage, higher crop yields, enhanced nutritional values and many more, the controversy surrounding its application to food production persists in many countries.

Studies have shown that many consumers in countries like those in the European Union (EU) and Japan have difficulties accepting GM products (Macer and Ng, 2000). Consumers are hesitant to buy GM foods largely because of concerns about the uncertain effects of GM foods on human health. There are also religious and ethical concerns about the possible intake of genes from animals contained in GM foods, and consumers have no means to identify these products. These concerns in turn have generated a strong demand for the labeling of GM products in the EU and countries like Japan and Taiwan. In addition, the potential environmental endanger of GM products appears to be one of the major hindrances for consumers to accept GM foods.

Consumer acceptance of GM products, therefore, has become a vital factor on how prosperous the market for GM foods will be in the future. It will affect the future course for the private and public investments in the development and use of GM technology. Thus, consumer perception of and acceptance toward GM technology and GM foods are crucial for the global market of GM products, agricultural trade, and the future development of agricultural biotechnology.

Despite the seemingly ample information available, research on consumer perception and attitudes toward biotechnology in general or GM foods in particular, has been limited. In most cases, the methodology adopted heavily relied on qualitative questions and descriptive comparisons. Few attempted to quantify the consumer's purchase behavior and to investigate the willingness to buy GM foods. Also, the constantly changing attitudes expressed by consumers signify the need to investigate and obtain more up-to-date data on consumer attitudes toward GM foods. Further, few studies have attempted to estimate the consumer's willingness to pay (WTP) for GM or non-GM foods in the literature. This study, therefore, is aimed at providing the WTP estimates based on consumer attitude toward GM foods and other characteristics. Actually this study is part of a research project attempting to provide a more global perspective by conducting a multi-country survey in four countries of Japan, Norway, Taiwan and the U.S. This paper, however, presents only the analysis of a survey conducted in Columbus Metropolitan Area, Ohio under this project.

Specifically, the objectives of this study are to analyze an Ohio survey on the consumer acceptance of GM foods and to conduct a contingent valuation of the willingness to pay for three selected products with and without GMO ingredients, i.e., vegetable oil, salmon, and corn flake breakfast cereal.

Background and Literature

Consumer acceptance toward GM foods varies greatly among countries. Studies in the U.S. mostly show that its consumers have a higher acceptance rate toward biotechnology and GM foods than those in other countries. One of Hoban's studies (1998) indicates that two-thirds of American consumers are positive about plant biotechnology, and this support is the highest among men and people with more formal education. National surveys conducted in recent years

also show that roughly between 35% to 45% of American consumers consider themselves heard or read a lot or some about biotechnology (International Food Information Council Foundation, 2001) In Europe, on the other hand, the supports for GM technology in general and GM foods in particular are relatively low as compared to the U.S. Based on a European consumer survey conducted in 1999, Gaskell (2000) shows that Europeans are mostly neutral about agricultural biotechnology but opposed to both GM foods and cloning of animals, especially in countries such as Greece, Austria, and Luxemburg. Specifically, the survey indicates that only 22% of the Europeans respondents are supporters of GM foods, 25% are risk tolerant supporters, and up to 53% are opponents. A study in the U.K. shows that while 11% of the respondents would not try GM foods, 42% say they might still try, indicating that U.K. consumers are not highly opposed to GM foods (Loader and Henson, 1998). Another study conducted by Nordic Industrial Fund (2000) for Denmark, Finland, Norway and Sweden also suggests that Nordic consumers are united in their negative attitudes toward GM foods. Another study by Burton et al. (2001) based on a survey of residents in Manchester, United Kingdom shows that the average willingness to pay to achieve a reduction in risk associated with GM products is 9.8% of the respondent's food expenditure, and the average willingness to pay to achieve a GM free diet is 13% of their food expenditure. Their study also finds that gender is a significant determinant of attitudes towards the GM technology and female respondents are willing to pay more to reduce risk.

In Asian countries, a study by Hoban (1996) concludes that Japanese consumers have similarly optimistic attitudes toward GM biotechnology as American consumers, as 87% of the Japanese respondents in his study were positive about the use of biotechnology. However, a recent study by Macer and Ng (2000) indicates that a small majority of Japanese respondents in the past three years have been favorably inclined to GM technology and consider it as means of improving the quality of life (54% in 1997 and 59% in 2000), implying the changing attitudes

among the Japanese consumers. In Taiwan, even though the knowledge of GM foods is not pervasive, a Gallup Poll (2000) shows that Taiwanese consumers are not against GM technology on food production and are willing to purchase GM foods.

Studies on other agricultural technologies have been done. Wang et al. (1997) attempted to measure the WTP for rBST-free milk in Vermont and their results show that for rBST-free milk, 37.4% of the respondents do not want to pay any premium, 50.6% are willing to pay a premium up to 40 cents per gallon, and 12.0% would pay a premium of 41 cents or more. Also, the authors find that the consumer WTP is affected by several demographic variables, such as income, education, and gender. Halbendt, et al. (1995) conducted a nationwide CV survey to measure the consumer willingness to purchase pork with lower saturated fats, and their results show that the survey respondents are willing to pay an average 16 to 23 cents more per pound for fresh pork with reduced levels of saturated fats. Buzby, et al. (1995) investigated the consumer willingness to pay for grapefruit with reduced chemical residue. Their results indicate that respondents are willing to pay an average of 31% more for grapefruit under the 50 % risk reduction scenario, and 38% more if there is a 99% reduction in the risk associated with chemical residue.

Methodology

The contingent valuation (CV) has been used to elicit consumer willingness to pay for non-market goods, such as water quality improvement (Carson and Mitchell, 1981) or air pollution control (Loehman and De, 1982). CV is also widely used in evaluating consumer willingness to pay for food safety, such as reduced food-borne risks (Hammitt, 1986). Although there are several economic tools to value non-market goods, CV is generally considered as the most appropriate choice for measuring food safety (Buzby, et al., 1995).

Among the most important tasks for a CV analysis are questionnaire design and survey procedure (Haab and McConnell, 2001). The CV method uses surveys in which people are asked how much they are willing to pay for a change in the condition of some environmental resources or a service that is meaningful to the respondent in a hypothetical situation (Diamond, et. al., 1993; Haab and McConnell, 2001). Early CV designs involve open-ended question such as, "What is the maximum amount you would pay for…?" More recently, the commonly used methods include iterative bidding, payment cards, and dichotomous choice questions. Several studies reveal that different techniques of asking CV questions provide significantly different estimates of Hicksian surplus (Boyle and Bishop, 1988).

In this study, the CV is employed to estimate the WTP for non-GM food products. The CV scenario in the survey conducted in this study contains both the dichotomous choice and polychotomous choice questions. Food products used in the survey include vegetable oil, salmon, and corn flake breakfast cereal. Vegetable oil and corn flake breakfast cereal used a dichotomous response question, as the respondents were asked to choose between GM and non-GM alternatives given the price scenario. For salmon, a polychotomous response question was designed, as surveyed respondents were asked to rank within three different types of GM, non-GM but fed with feed containing GM corn or soybeans, and non-GM fed with non-GM feed alternatives. In this study, we only analyze a model for the dichotomous choice between GM and non-GM products. Thus, the GM salmon and GM-fed salmon are combined as the same category in this study.

The Random Utility Model

We adopt a random utility model for analyzing dichotomous CV responses. Following Haab and McConnell (2001), the indirect utility function for respondent j can be written as:

$$U_{ij} = u\ (y_j,\ Z_j,\ \varepsilon_{ij}) \qquad (1)$$

where i is the dichotomous choice (1 as the preferred state and 0 the status quo) and j refers to respondent. The determinants of utility are y_j, the jth respondent's income, Z_j, a vector of respondent characteristics and attributes of the choice, and ε_{ij}, a component of preferences known to the individual respondent but not observed by the researcher.

Based on this model, respondent j chooses the non-GM food if the utility of non-GM food exceeds the utility of the status quo (GM food), given prices:

$$U_{1j}(Z_j,\ y_j - Pngm_j, 1,\ \varepsilon_{1j}) > U_{0j}\ (Z_j,\ y_j - Pgm_j,\ 0,\ \varepsilon_{0j}) \qquad (2)$$

where 1 denotes the respondent j choosing the non-GM food, 0 denotes the respondent j choosing the status quo (GM food), $Pngm_j$ is the price of non-GM food, Pgm_j is the price of GM food. All other variables were defined previously.

Therefore, the probability that the respondent thinks he/she is better off by choosing the non-GM food, given its price can be expressed as:

Prob (Respondent j chooses non-GM food)

$$= \text{Prob}\ [U_{1j}(Z_j,\ y_j - Pngm_j, 1,\ \varepsilon_{1j}) > U_{0j}\ (Z_j,\ y_j - Pgm_j, 0,\ \varepsilon_{0j})] \qquad (3)$$

The Logistic Model

With a further assumption of the linear form for the utility function, the utility of respondent j choosing the non-GM food can be specified as:

$$U_{1j} = \alpha_1 Z_j + \beta_1\ (Y_j - Pngm_j) + \varepsilon_{1j} \qquad (4)$$

And the utility of respondent j choosing the GM food is:

$$U_{0j} = \alpha_0 Z_j + \beta_0\ (Y_j - Pgm_j) + \varepsilon_{0j} \qquad (5)$$

If respondent j chooses the non-GM food, it implies that the utility of choosing the non-GM food is greater than that of choosing GM food:

$$U_{1j} > U_{0j} \qquad (6)$$

By assuming the marginal utilities of money (income) for non-GM food and GM food are identical, i.e. $\beta_1 = \beta_0 = \beta$, the probability of choosing non-GM food is:

$$Prob\ (Non\text{-}GM) = Prob\ [\alpha_1 Z_j + \beta_1 (Y_j - Pngm_j) - \alpha_0 Z_j - \beta_0 (Y_j - Pgm_j) > 0]$$

$$= Prob\ [(\alpha_1 - \alpha_0) Z_j - \beta(Pngm_j - Pgm_j) + (\varepsilon_{1j} - \varepsilon_{0j}) > 0]$$

This can be written more compactly as:

$$Prob\ (Non\text{-}GM) = Prob\ [\alpha Z_j - \beta(\Delta P) + \varepsilon_j > 0] \qquad (7)$$

where,

$\alpha = (\alpha_1 - \alpha_0)$

$\Delta P = (Pngm - Pgm)$

$\varepsilon_j = (\varepsilon_{1j} - \varepsilon_{0j})$

Assume further that the error term has a logistic distribution and it is symmetrical. Therefore, we can derive the probability of choosing non-GM food as:

$$Prob\ (non\text{-}GM) = Prob\ [\alpha Z_j - \beta\Delta P + \varepsilon > 0]$$

$$= Prob\ [-(\alpha Z_j - \beta\Delta P) < \varepsilon] = 1 - Prob\ [-(\alpha Z_j - \beta\Delta P) > \varepsilon]$$

$$= Prob\ [\varepsilon < (\alpha Z_j - \beta\Delta P)] \qquad (8)$$

Furthermore, with a logistic distribution, ε has a mean of zero and variance $\pi^2\sigma^2/3$. Normalizing by σ creates a logistic variable with mean zero and variance $\pi^2/3$. Equation (8) becomes:

$$Prob\ (non\text{-}GM) = Prob\ [\theta < (\alpha Z_j - \beta\Delta P)/\sigma] = \Psi[\alpha Z_j / \sigma - (\beta\Delta P/\sigma)] \qquad (9)$$

where $\theta = \varepsilon/\sigma$, σ is the standard error, Ψ is the cumulative distribution function.

Therefore, by using a logistic distribution, the probability of choosing the non-GM product is:

$$Prob\ (non\text{-}GM) = [1 + exp\ (-(\alpha Z_j / \sigma - \beta\Delta P/\sigma))]^{-1} \qquad (10)$$

Calculating Willingness to Pay

For calculating the WTP, we need to estimate the parameters α and β for the vector of explanatory variables (Haab and McConnell, 2001). A CV question induces the respondent to choose between the proposed condition at the required payment, and the current state. The required payment therefore states the respondent's wiliness to pay in order to achieve the proposed scenario. In our case, the WTP is the proposed price of non-GM product that would make the respondent indifferent between consuming GM (paid with the current price of GM product) and non-GM product. Based on this principle, the WTP for non-GM food product can be defined as:

$$\alpha_1 Z_j + \beta (y_j - WTPngm_j) + \varepsilon_{1j} = \alpha_0 Z_j + \beta (y_j - WTPgm_j) + \varepsilon_{0j} \qquad (11)$$

Solving equation (11) for WTP yields:

$$WTPngm_j - WTPgm_j = \alpha Z_j / \beta + \varepsilon_j / \beta \qquad (12)$$

Where: $\alpha = \alpha_1 - \alpha_0$

$\varepsilon_j = \varepsilon_{1j} - \varepsilon_{0j}$

However, the parameters are unknown and therefore must be estimated. In the expression for mean, only the ratio of parameter estimates is required. Relying on Slutsky's theorem on consistency, the logit maximum likelihood estimates for $\theta = \{\alpha/\sigma, \beta/\sigma\}$ are consistent (Haab and McConnell, 2001). Therefore, a consistent estimate of expected willingness to pay for non-GM food product derived from equation (12) is:

$$E (WTPngm_j - WTPgm_j | \alpha, \beta, Z_j) = \alpha Z_j / \beta \qquad (13)$$

where α is the vector of the estimated coefficients of the explanatory variables, and β is the estimated coefficient of the price difference between non-GM and GM food product. Note that the estimated price coefficient obtained from equation (9) is (-β), and therefore the calculation of WTP needs to reverse the sign for β.

By adopting the logistic model to estimate the probability of choosing the non-GM food, the econometric model can be specified as the logit model:

$$y = \alpha k + \beta p + \varepsilon \qquad (14)$$

where $y = \begin{cases} 1 & \text{if the respondent chooses non-GM food product} \\ 0 & \text{otherwise,} \end{cases}$

Also, k is a vector of explanatory variables and p is price factor. In our empirical model, the price factor is defined as the "price difference" between non-GM and GM food in order to capture the price effect and WTP can be estimated as the expected premium for non-GM food.

The Survey and Data

A mail survey was conducted in the Columbus Metropolitan Area, Ohio in March 2001. A three-wave procedure combined with mailing and telephone was used in order to maximize the response rate. The sampling frame was obtained from the Center for Survey Research at The Ohio State University. The center randomly selected 650 telephone subscribers in the Columbus Metropolitan Area based on the zip code. The questionnaires and postage-paid return envelopes were mailed to these randomly selected households. In total, 141 completed survey questionnaires were returned, along with 120 undeliverable returning questionnaires, yielding an overall response rate of 26.6%. Four versions of questionnaire with different prices in the CV section were equally distributed among the 650 mailings. Among the 141 returned respondents, we collected 39 copies of version 1, 28 of version 2, 26 of version 3, and 48 of version 4. (These four versions of prices will be discussed later.)

Survey Questionnaire

In the first part of the questionnaire, consumer knowledge and awareness of biotechnology and GM foods are being elicited. Next, respondents were asked about their attitudes and acceptance toward GM foods, as well as other GM food-related issues such as environmental concern and pesticide usage. For most of these questions, five options for response are typically given along with an option of "Do not know". For example, in the question, "To what extent do you feel that GM foods are risky, or safe, for human health?," the respondent was given the choices of "Extremely risky", "Very risky", "Somewhat risky/Somewhat safe", "Very safe", "Extremely Safe", and "Do not know". Thirdly, respondents were asked about their support for GM food labeling and type of labeling.

Afterward, a CV scenario was presented along with the food products and price combinations. Surveyed respondents were first asked about their consumption habit and frequency of the food product. Then, they were asked to select or rank among the food products according to different GM-contents, given the prices. In designing the price matrix, we assumed that GM food products are cheaper than their non-GM counterparts. Therefore, we specified the prices of GM food products by taking a discount of those of non-GM food products, which were based on the market prices. The discount ranged from 10% to 25%. Table 1 presents the four price scenarios used in the survey. Note that the market prices observed in Columbus, Ohio at the time of survey were used as the base prices. In two versions, these base prices were changed slightly to provide more variations in prices. Even though this range of the differences between the GM and non-GM products seems reasonable, the specific price variations chosen are somewhat subjective.

The last part of the questionnaire contained the demographic information such as age, sex, race, income, education, religion, and occupation, etc. (A copy of questionnaire is available upon request).

Variables

In the logistic model, the dependent variable is a binary variable having one if the respondent chose the non-GM food and zero, otherwise. Note that in the case of salmon, our survey collected data on the ranking of the three types of salmon i.e., GM salmon, non-GM but fed with GM feed, and non-GM fed with non-GM feed. However, in the regression model, we simply estimated the probability of choosing non-GM vs. GM salmon. We grouped GM salmon and non-GM salmon but fed with GM feed together as GM salmon in the analysis. An extension of the model dealing with three separate choices in a multinomial Logit model would be desirable for future research.

From the survey data, various explanatory variables can be grouped into six categories: "Knowledge and Awareness", "Attitude", "Perception", "Labeling", "Demographic", and "Price". Variable definitions and the sample means used in the econometric model are presented in Table 2. Since the models for vegetable oil and corn flakes are based on a slightly different sample size than the model for salmon, different descriptive statistics are shown. It is interesting to note that only 58% of the respondents considered themselves as either "very well" or "somewhat" informed about GMOs or GM foods. Furthermore, a majority of the respondents thought GM foods are "somewhat risky" to human health (53%), while only 19% replied "extremely or very safe."

Empirical Results

Table 3 presents the regression results for the three food products: vegetable oil, salmon, and corn flake breakfast cereal. The results show that the variables related to *Attitude*, *Perception*, *Labeling, Demographic*, and *Price* have significant effects on consumer choices between GM and non-GM food products. The knowledge and awareness variables, however, appear to be not statistically significant. Let us discuss these findings in more details.

Attitude- Results indicate that the risk perception of GM foods places an important impact on GM food consumption, as higher risk perception generates lower GM food consumption. The percentage of organic food purchase, used as an indicator of attitude toward risk, is insignificant in the corn flake cereal model but significant in the vegetable oil and salmon models. Environmental concern of GM foods is also a significant factor determining GM food consumption, so as religious or ethical concern. Further, the perceived difference between GM and non-GM food affects the willingness to consume GM foods, implying that if the perceived difference is not huge, consumers are more willing to consume GM foods.

Perception- Price attribute is a significant determinant for willingness to consume GM foods, as the respondent's concern on price tends to induce them to consume more GM food, which is assumed to be cheaper than their traditional counterpart. Interestingly, those who think it is most important to reduce saturated fats in GM vegetable oil still tend to consume more non-GM vegetable oil. On the other hand, those who believe the most important benefit of GMOs is to reduce pesticide usage tend to consume more GM salmon and GM corn flake breakfast cereal.

Labeling- The opinion on labeling is a significant factor in the salmon and corn flake breakfast cereal models, showing that the more important the respondents think that GM food labeling is, the more non-GM salmon and corn flake breakfast cereal they are going to consume.

Demographic- Demographic characteristics turned out to be insignificant with respect to age, gender, marital status and education, except age and education in the salmon model. Income dummies are highly significant in the corn flake breakfast cereal model and have negative effects, implying that the people with higher income tend to consume more GM corn flake breakfast cereal. This result is somewhat surprising. Note that the number of children within the household has a significant negative effect on respondents' willingness to consume GM foods, as the concern for younger children in the household would certainly decrease the consumption of GM foods.

Price- Price is highly significant in the three models, suggesting that lower prices of GM foods encourage consumers to consume more GM products.

McFadden R^2's in these models range from 0.5944 to 0.6537, which are actually quite high for this type of cross-sectional data. In general, the results indicate that the willingness to purchase GM foods is heavily influenced by the risk perception of GM foods to human health, environmental and religious concern when consuming GM foods, as well as the perceived difference between GM and non-GM foods. Also, the importance of food characteristics such as "price" will affect consumers on their GM food consumption. The sensitivity to price is also reflected by the significance of the price factor, showing that more GM food product will be chosen if the price difference between non-GM and GM foods increases.

Demographic variables are not very significant. Only income and the number of children in the household affect the consumer's purchase decision. Surprisingly, the respondents with higher income tend to consume more GM corn flake breakfast cereal, implying that wealthy people are more confident on this GM product, and would not view it as particularly risky. We are not sure whether or not this result is caused by the fact that higher income households in the

U.S. tend to consume more breakfast cereals. Furthermore, breakfast cereal is considered as a relatively expensive food item.

Willingness to Pay for Non-GM Foods

Based on the methodology described above, the willingness to pay (WTP) for the three non-GM foods can be computed for the entire sample and the results are presented in Table 4. Note that we compute first the WTP household by household. The figures presented in the table are simply means or averages of all households in the sample. The WTP for non-GM product reflects the premium for the non-GM food that the consumer is willing to pay. We also compute the percentage of premium using the price of GM food as the base. Since there are different prices for GM foods used in the four versions of price scenarios, the percentage figures vary depending on the base price. The results show that the survey respondents are willing to pay a premium of 5-8% for non-GM vegetable oil, 15-28% for non-GM salmon, and 12-17% for non-GM corn flake breakfast cereal.

Table 5 shows the computed WTP premiums for various demographic groups by sex, age, and race. It is interesting to observe that the WTP premiums for non-GM foods vary by demographic groups. Note that even though some demographic variables may not be significant in the Logit model, the computed WTP premiums can still be different among demographic groups. This is because the WTP is based on the entire model and the entire set of estimated parameters, not just the coefficient related to a particular demographic variable. The results are very telling that female respondents are always willing to pay a higher premium for non-GM food products than male respondents, especially in the case of vegetable oil and corn flake breakfast cereal. This finding is in accordance with previous studies regarding consumer WTP on organic food produce (Huang, et al., 1993).

Survey respondents between 35 to 60 years old tend to pay higher premiums for non-GM salmon and non-GM vegetable oil than those who are younger than 35 years old or older than 60 years old. Furthermore, the respondents younger than 35 years old are willing to pay more for non-GM corn flake breakfast cereal than the other age groups. The senior respondents, however, are the least willing to pay higher prices for non-GM vegetable oil and corn flake breakfast cereal, but willing to pay more premiums for non-GM salmon than those who are younger than 35 years old. This finding suggests that middle-aged consumers tend to put more concern on food safety issue than those who are younger or older and therefore are willing to pay more for non-GM foods. Besides, their income sources are more stable as compared to younger and older generations, and therefore middle-aged consumers are more willing to pay a premium for non-GM food products. On the other hand, senior citizens are less willing to pay more for non-GM vegetable oil and corn flake breakfast cereal than that for non-GM salmon indicates that senior people are less sensitive to food safety, especially those food products that are less relevant to their consumption compared to younger generations, such as corn flake breakfast cereal.

Results also show that non-While respondents are more likely to pay a premium for non-GM food products than White respondents. Note that the difference in WTP between the two racial groups is dramatic. Non-White respondents are willing to pay a premium of at least 24% for the three food products, while White respondents are only willing to pay a premium less than 26%. This finding is somewhat surprising and it may suggest that the non-White respondents may lack confidence on food safety and therefore are willing to pay a higher premium for non-GM foods than the While respondents.

Implications and Discussion

The purposes of this study are to conduct an analysis on GM food consumption and to measure consumer willingness to pay for non-GM vs. GM foods. The empirical results show that the willingness to consume GM foods depends on risk perception, environmental concern, religious and ethical concern of GM foods, opinion on labeling of GM foods and perceived difference between GM and non-GM foods. Also, the number of children within the household is a key determinant on GM food consumption. In addition, the price factor of GM foods is fairly significant to the respondents in the survey, suggesting that by advertising GM food products with a lower price, the consumption of GM foods might be substantially increased.

These results imply that in order to gain the consumer acceptance of GM foods, it is important to change their risk perception of GM foods and to deviate their other concerns. The survey results show that only 59% of the respondents indicated that they are either very well or somewhat informed on GMOs or GM foods. In fact, the majority of consumers are still not very well informed about the GM foods. Therefore, how can we change the consumer's perception? The government, the food industry, and consumer groups have to provide unbiased information to the consumer. If the information can change the consumer's perception, then the willingness to buy GM foods would increase. Therefore, the effectiveness of the information is very crucial to the success of the GM foods in the future.

The econometric results also show that the respondents are willing to pay a premium, ranging from 5% for non-GM vegetable oil to 28% for non-GM salmon. Clearly, these results imply that the consumer must see the tangible benefit in order for them to buy GM foods. Therefore, the future of GM foods is critically dependent upon the ability to reduce the price for GM foods as compared to their traditional non-GM counterparts. Therefore, the stress on the

indifference between the GM and non-GM foods is unlikely to induce the consumer's willingness to buy GM foods.

Our results also show that the consumer WTP for non-GM foods varies among demographic characteristics. Specifically, female respondents, those aged between 35 and 60, and non-White respondents are willing to pay a higher premium for non-GM foods than other groups. This finding is useful to the government, food industry and consumer groups for designing appropriate programs to educate the consumer about GMOs and GM foods targeted to different demographic groups.

Conclusions

In this study, we attempt to investigate consumer attitudes toward GM foods and to elicit WTP for non-GM foods. The empirical results indicate that the consumer acceptance toward GM foods is affected by attitudinal factors, such as risk perception, environmental impacts, opinion on GM food labeling, perceived difference between GM and non-GM foods, and the potential benefits of GM foods. Among all, the high risk associated with GM foods as perceived by the respondents is found to be the main hindrance to the consumer's acceptance of such foods, which reinforces the necessity to educate the general public to be more aware of GM foods with more unbiased scientific information. Also, the result points to the importance of GM food labeling, implying the need to provide the consumer with more information on GM foods so that the consumer confidence can be established. Moreover, the price factor is significant in determining consuming GM foods, suggesting that lower price can be a useful tool to stimulate GM food consumption.

The results of WTP indicate that the survey respondents are willing to pay a premium in order to differentiate between GM and non-GM foods. This implies that producers of non-GM

foods might be benefited from the labeling policy. If consumers are willing to bear the premium for non-GM foods, producers do not need to fully absorb the cost of segmenting the market. From the government standpoint, labeling of GM foods might cause a warfare loss to the society in the long run if the market is not competitive for both GM and non-GM food products. Consumers would pay a higher price in order to avoid GM foods and the market does not reach to the optimal equilibrium for product prices. The warfare loss in the long term might discourage the government to enforce a mandatory labeling policy regarding GM foods. Therefore, it is crucial to educate the general public about the characteristics of GM foods so that the risk perception associated from consuming such foods can be mitigated.

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Table 1. Price Matrix for CV Design

Version	Vegetable Oil Price ($/32 Fl oz)		Salmon Price ($/lb)			Corn Flake Cereal Price ($/18 oz)	
	Non-GM	GM	Non-GM	GM-fed	GM	Non-GM	GM
1 (10% difference)	$2.49*	$2.24	$6.99*	$6.29	$5.66	$4.39*	$3.95
2 (20% difference)	2.49*	1.99	6.99*	5.59	4.47	4.39*	3.51
3 (15% difference)	2.19	1.86	5.99	5.09	4.33	3.79	3.22
4 (25% difference)	2.19	1.64	5.99	4.49	3.37	3.79	2.84

*These are the observed reference market prices of the products during the survey period.

Table 2. Variable Definition and Sample Means

Variable/ Category	Definition and Coding	Sample Mean (Vegetable oil & corn flake cereal)	Sample Mean (Salmon)
Knowledge and Awareness			
KNOW	1 if very well/somewhat informed of GMOs or GM foods; 0 otherwise	0.58	0.59
OIL	1 if aware of GM vegetable oil; 0 otherwise	0.35	
CF	1 if aware of GM vegetable corn flake cereal; 0 otherwise	0.36	
GMS	Percentage of GM foods sold in the market place (guessed)	38%	38%
Attitude			
RP1	1 if GM foods are extremely/very risky; 0 otherwise	0.09	0.08
RP2	1 if GM foods are somewhat risky; 0 otherwise	0.53	0.57
RP3	1 if GM foods are extremely/very safe; 0 otherwise	0.19	0.20
(Focus Group: Do Not Know)			
O1	1 if 1- 20% organic food purchase; 0 otherwise	0.57	0.58
O2[a]	1 if more than 20% (or 21-40%) organic food purchase; 0 otherwise	0.10	0.06
O3[b]	1 if more than 40% organic food purchase; 0 otherwise		0.06
(Focus Group: 0% and Do Not Know)			
EN1	1 if GM technology is extremely/very beneficial to the environment; 0 otherwise	0.21	0.22
EN2	1 if GM technology is extremely/very risky to the environment; 0 otherwise	0.11	0.12
(Focus Group: Somewhat risky)			
REL	1 if religious concerns are extremely/ very important; 0 otherwise	0.18	0.21
PESTICID	1 if large/some pesticide decrease after applying GM technology; 0 otherwise	0.43	0.48
DIF1	1 if GM and non-GM foods are extremely/very different; 0 otherwise	0.39	0.39
DIF2	1 if GM and non-GM foods are not very/not at all different; 0 otherwise	0.26	0.28
(Focus Group: I have no idea)			
CON	1 if excellent/good government performance in food safety; 0 otherwise	0.38	0.38

(Continued)

Table 2. (Continued)

Perception			
SATFB	1 if the respondent believes the potential to reduce saturated fats in foods is the most important benefit of GM foods; 0 otherwise	0.17	
PESTB	1 if the respondent believes the potential to reduce pesticides on foods is the most important benefit of GM foods; 0 otherwise	0.67	0.74
PRICE	1 if the respondent ranks "price" as the first and second important food attribute; 0 otherwise	0.25	
SAFETY	1 if the respondent ranks "safety" as the first and second important food attribute; 0 otherwise	0.45	
TASTE	1 if the respondent ranks "taste" as the first and second important food attribute; 0 otherwise	0.56	
Labeling			
LABEL	1 if labeling of GM foods is extremely/very important; 0 otherwise	0.67	0.65
Demographic			
AGE1	If < 34 years old; 0 otherwise	0.11	0.11
AGE2	If 35-60 years old; 0 otherwise	0.57	0.65
(Focus Group: > 60 years old)			
GENDER	1 if males; 0 otherwise	0.44	0.44
MARITAL	1 if married; 0 otherwise	0.53	0.56
EDU1	1 if some college and associate degree; 0 otherwise	0.27	0.25
EDU2	1 if bachelor degree, some graduate school and graduate degree; 0 otherwise	0.44	0.46
(Focus Group: No high school, some high school and high school diploma)			
IN1	1 if income $30,001-$50,000; 0 otherwise	0.27	0.27
IN2	1 if income $50,001-$70,000; 0 otherwise	0.24	0.25
IN3	1 if income more than $70,001; 0 otherwise	0.21	0.23
(Focus Group: Less than $30,000)			
RACE	1 if Caucasian; 0 otherwise	0.86	0.86
RELIGION	1 if Protestant; 0 otherwise	0.45	0.42
CHD	1 if there is one or more children under 18 years old in the household; 0 otherwise	0.31	0.33
Price			
POIL	Price difference between non-GM and GM oil	0.42	
PSAL	Price difference between non-GM and GM salmon		1.62
PCF	Price difference between non-GM and GM corn flake cereal	0.72	
Sample Size		105[c]	92[c]

[a]O2 = 1 if 21-40% organic food purchase in the salmon model.

[b]O3 = 1 if more than 40% organic food purchase in the salmon model.

[c] The usable sample sizes are smaller than 141 because of missing data in the CV section of the survey.

Table 3. Regression Results

Variable/ Category	Vegetable Oil		Salmon		Corn Flake Cereal	
	Coeff.[a]	T-Ratio[b]	Coeff.[a]	T-Ratio[b]	Coeff.[a]	T-Ratio[b]
Constant	0.2420	0.069	10.6209	1.806	8.6643	1.744
Knowledge and Awareness						
KNOW	-0.8311	-0.758	1.6416	1.008	0.9009	0.662
OIL	-0.3423	-0.331				
CF					-0.0907	-0.082
GMS			0.0322	1.059		
Attitude						
RP1	6.0563	2.073***	2.7625	0.756	9.3633	1.879**
RP2	3.9027	1.985**	-1.3237	-0.870	1.7853	1.173
RP3	-0.6010	-0.260	-6.0145	-1.518*	-2.4177	-0.916
O1	-0.2036	-0.172	0.4022	0.250	1.3369	1.074
O2	-2.9776	-1.370*	-10.9137	-2.631***	-1.8885	-0.894
O3			0.6134	0.205		
EN1	-8.5130	-2.051***	-4.3476	-1.512*	-4.1532	-1.697*
EN2	3.7732	1.444*	-0.0407	-0.014	-0.1628	-0.079
REL	7.5893	2.148***	5.2668	1.972**	2.6617	1.165
PESTICIDE	1.2412	1.021	1.9062	1.312*	-0.2328	-0.249
DIF1	-0.3020	-0.277	-0.5385	-0.387	-0.5233	-0.465
DIF2	-2.4975	-2.011**	-2.7618	-1.515*	-3.8577	-1.767**
CON	-0.5099	-0.523	1.4127	1.003	-0.1416	-0.140
Perception						
PRICE	-5.3223	-2.591***			-6.2551	-2.317***
SAFETY	2.5639	1.525*			-0.2956	-0.208
TASTE	-0.6826	-0.624			0.3861	0.268
SATFB	2.8779	2.016**				
PESTB			-2.8351	-1.551*	-1.7446	-1.487*
Labeling						
LABEL	0.6757	0.641	3.8607	1.871**	2.6327	2.085***
Demographic						
AGE1	-1.3395	-0.592	-4.4977	-1.033	-0.2374	-0.070
AGE2	0.3099	0.173	-2.6670	-1.509*	-1.7804	-0.955
GENDER	-1.3487	-1.157	0.5547	0.313	0.3989	0.341
MARITAL	0.5832	0.592	1.3714	0.816	1.2198	1.071
EDU1	-0.8810	-0.522	-1.8517	-0.826	-0.2328	-0.151
EDU2	1.1396	0.823	-2.2280	-1.324*	1.2022	0.866
IN1	-1.7423	-1.127	-0.2659	-0.147	-6.8875	-2.247***
IN2	-2.8542	-1.646*	0.4146	0.166	-5.7335	-2.021**
IN3	-1.1893	-0.753	-1.8905	-0.861	-5.6907	-1.940**
RACE	0.7852	0.499	-0.7364	-0.446	-1.6685	-1.004
RELIGION	-1.4551	-1.254	-5.1121	-2.044**	-1.4260	-1.056
CHD	2.6626	1.969**			3.9305	2.491***
Price						
POIL	-7.7657	-1.775**				
PSAL			-5.8891	-2.215***		
PCF					-5.8173	-1.702**
Number of Observation		105		92		105
McFadden R^2		0.5944		0.6537		0.6177

[a] Coeff. = Coefficient.

[b] *** 2.5% significance level; ** 5% significance level; * 10% significance level

Table 4. Estimated WTP Premiums for Non-GM Food Products

Item	**Vegetable Oil** *($/32Fl oz)*	**Salmon** *($/pound)*	**Corn Flake Breakfast Cereal** *($/18 oz)*
WTP Premium	$0.13	$0.96	$0.49
Percentage of premium[a]	5~8%	15~28%	12~17%

[a] Percentage of Premium = (WTP Premium/ Price of GM Food Product) X100.

Table 5. Estimated WTP Premiums for Non-GM Food Products by Demographic Groups

Product/Item	Sex		Age			Race	
	Female	Male	<35 years old	35-60 years old	>60 years old	Non-White	White
Vegetable oil (32 Fl oz)							
WTP Premium	$0.34	-$0.16	-$0.27	$0.39	-$0.31	$0.54	$0.08
Percentage of Premium	15~21%	(-7) ~ (-10)%	(-12)~(-16)%	17~24%	(-14)~(-19)%	24~33%	4~5%
Salmon (per pound)							
WTP Premium	$1.13	$0.74	$0.51	$1.05	$0.90	$1.53	$0.86
Percentage of Premium	18~34%	12~22%	8~15%	17~31%	14~27%	24~45%	14~26%
Corn Flake Breakfast Cereal (18 oz)							
WTP Premium	$0.70	$0.16	$0.66	$0.59	$0.15	$1.28	$0.38
Percentage of Premium	18~25%	4~6%	17~23%	15~21%	4~5%	32~45%	10~13%