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The Empirics of Consumer Risk Attitudes and Genetically Modified Foods

Yau-Yuh Tsay*, Ming Hsin University of Science and Technology

Abstract

The debate over genetically modified organisms (GMOs) and GM foods has gained greater prominence recently. However, potential health and environmental risks, lack of trust in regulatory mechanisms, social and ethical concerns associated with GM foods have led to a rejection of GM foods by some consumers worldwide. In this study, we examine consumer attitudes and purchase intentions towards GM foods, using survey data of 624 consumers in Taiwan in 2002. Survey results show that reduced use of pesticide was considered the most important benefit of GM products, and unknown health problems associated with GM foods was the most important risk concern. The results also show the majority of respondents preferred GM product labeling to be mandatory, and of positive labeling. About 45 percent of respondents conceptually accepted GM foods. Given GM food prices were lower than those of non-GM foods, however, 73 percent of respondents revealed to be potential buyers.

To quantify the effect of demographic, socioeconomic, and attitudinal factors on GM food consumption, a joint probit and ordered probit model is estimated, taking account of joint decision making by consumers, i.e., if or not one is willing to purchase GM foods by paying less; and how much less to pay. The results of joint estimation, however, show the estimate of ρ (cross-equation correlation) is not significantly different from zero. Separate estimation results of probit model indicate that respondents who care more about GMOs and GM products issues after being informed of benefits and potential risks of GMOs and GM products, are more likely to be willing to purchase GM foods, while older consumers are less likely to be willing to make purchase of GM foods. For the ordered probit model of price premium (how much less to pay relative to non-GM foods), the parameter estimates of all socioeconomic and demographic variables are not significant. In order to better understand consumer conceptual acceptability, we formulate and estimate another ordered probit model. The estimation results show that consumers who rank unknown health risk or allergic problems as top two risk concerns or who have attained a higher educational level are less likely to conceptually accept GMOs and GM products.

Key words: Genetically Modified (GM) Foods, Risk Attitudes, Market Segmentation.

* Department of International Business, Ming Hsin University of Science and Technology, Hsin Chu, 304, TAIWAN. Email: yauyuh@must.edu.tw.

Introduction

The debate over genetically modified organisms (GMOs) and GM foods has gained greater prominence recently.[1] The production and use of GMOs in agriculture provide benefits to farmers, consumers and the environment through increased yields, lower food prices and a reduction in pesticide use. However, potential health and environmental risks, lack of trust in regulatory mechanisms, social and ethical concerns associated with GM foods have led to a rejection of GM foods by some consumers worldwide.

As an introduction of GM foods into markets is a relatively new phenomenon, issues on food safety, environmental risks, social and ethical concerns associated with GM foods need to be addressed, regarding consumer's right to be informed and consumer's right to choose GM foods. Previous research on food safety issues has mostly focused on examining consumer attitudes towards chemical residues on fresh produce (Huang, Kan, and Fu, 2000; Buzby, Skees and Ready, 1995; Eom, 1994; Huang, 1993; Misra, Huang, and Ott, 1991). Several studies have tried to explain the formation of consumer attitudes towards GM foods in attitude and purchase intention models build on consumer behavior theory (Bredahl, 2001; Wohl, 1998; and Bredahl et al., 1998).

This study is intended to analyze consumer risk attitudes towards GM foods by empirically estimating a qualitative response (QR) model. We intend to quantify the effects of demographic, socioeconomic, and attitudinal factors on consumer attitudes towards GM foods. In specific, a joint probit and ordered probit model is estimated, taking account of joint decision making by consumers, i.e., if or not one is willing to purchase GM foods by paying less; and how much less to pay relative to non-GM foods, following an approach developed by Huang, Kan and Fu (2000). We first conduct a survey to collect data from consumers in Taiwan in 2002. Survey results are expected to provide descriptive information for a better understanding of consumer perceptions, attitudes, and behavioral intentions towards GM foods. Next, a joint probit and ordered probit model would be estimated using collected survey data. The estimation results are expected to be of use for government policy making[2] and for market segmentation in response to different degrees of GM foods acceptance in the business sector.

Benefits and Risks of GM foods, and Related Issues

Genetically modified organisms (GMOs)[3] have been created by modern biotechnology with advances in the field of molecular biology and the application of recombinant DNA technology over the past decades. Agricultural biotechnology is that area of biotechnology involving applications to agriculture. The commercial cultivation

[1] Foods grown from genetically modified crop varieties are called GM foods.
[2] These policies affect research, intellectual property rights, regulatory approval, labeling, and trade.
[3] An organism that has been modified, or transformed, using modern techniques of genetic exchange is commonly referred to as a genetically-modified organism (GMO).

of transgenic plant varieties has commenced since 1995. In 1999, it is estimated that approximately 40 million hectares of land were planted with transgenic varieties of over 20 plant species.

Benefits of GM Foods

The most commercially important GM crops include cotton, corn, soybean, and rapeseed containing new and desirable traits such as increased yields, disease resistance, insect resistance, herbicide resistance, delayed fruit ripening, and enhanced product quality. These benefits accrue primarily to farmers while there are also economic benefits accruing to consumers due to higher agricultural productivity and hence lower food prices; and to the environment with a more sustainable agriculture and better food security through reduced use of pesticides and fertilizers. GM foods can also provide consumers with improved taste. In addition, GM crops with traits that confer improved nutritional quality such as "Golden Rice" can be beneficial to millions of people in developing economies who suffer from malnutrition and deficiency disorders (Luijk, Lefferts, and Groth, 1998). Moreover, increasing agricultural productivity of GM crops and foods means lower prices of basic foods in developing world where the majority of food-insecure people depend heavily on agriculture for their livelihood and exports.

Potential Risks of GM Foods

There are, however, potential health and environmental risks associated with GM foods. Transfer of genes from one species to another may also transfer allergic risk and these risks need to be evaluated and identified prior to commercialization. Labeling would be required in such cases to inform consumers of what is the content of the GM foods and how it was produced. One of the potential ecological risks identified is increased weediness, due to cross pollination whereby pollen from GM crops spreads to non-GM crops in nearby fields, causing the non-target plants to potentially develop into weeds. Other potential ecological risks could result from the widespread planting of GM corn and cotton with insecticidal genes from the Bt genes, leading to the development of resistance to the Bt genes in insect populations and non-target species, such as birds and butterflies, exposed to the GM crops. There is also concern that GMOs may pose a risk to biological diversity, leading to a legally binding biosafety protocol negotiated by governments under the Convention on Biological Diversity (CBD). Other risks include the social and ethical concerns. The introduction of GMOs may increase the prosperity gap between the rich and the poor and the moral dimensions of patenting living organisms and the cross-species movement of genes would be evaluated (Bonny, 2001; Knudsen and Scandizzo, 2001; and Olubobokun, Phillips, and Hobbs, 2001).

Segregation and Identity Preservation of Non-GM Foods from GM Foods

Given the potential risks involved in the production and use of GM foods, some

consumers worldwide have rejected GMOs and required segregation and identity preservation of non-genetically modified foods from genetically modified foods. In response to negative public reactions to GM foods in some countries, measures of labeling some or all biotechnology-based products have been introduced in a number of countries, especially in Europe, and most recently Japan. However, other governments express different views and approaches regarding GMOs, particularly the U.S. The current debate on labeling emphasizes on the issues of whether product labeling should be mandatory or voluntary, and what information should be on the label so as to inform consumers and give consumers more choice.

Impact of GM Crops Varieties and Foods on International Trade

With the introduction of GM crops and foods, the structure of international grain trade market is expected to change (Nielsen et al., 2001b; Strauss, 2001). Given the situation that some consumers in the world market resist to accept GM crops and foods, one would expect the future development of markets to be two-tiered. Such development of more tailored types of markets will affect the economic benefits of bulk handling substantially from producers to end-users to adjust for segregation and identity preservation of non-GM foods from GM foods, thereby altering international supply and demand pattern. To grow productivity-enhancing GM crops may bring profits to agricultural-exporting developing countries, however, the policy choices of and consumer attitudes towards GM crops and foods in world markets should be taken into account before being able to realize such benefits (Nielsen et al., 2001a).

Conceptual Framework

In the case of food safety, non-market valuation techniques to measure consumers' willingness to pay (WTP) for reduced food risks are needed since market data and observed purchase data on risk-reducing foods are not available. Contingent valuation (CV) is generally considered as the most appropriate choice to value non-market goods such as measuring food safety (Misra et al., 1991; van Ravenswaay, 1990).[4] Through personal interviews, mail surveys, or telephone survey, consumer's WTP for non-market goods "contingent" on a given hypothetical scenario is elicited (Carson et al., 1994).[5]

In the process of forming consumer risk attitudes and purchase intentions with regard to GM products, consumers are assumed to face a binary choice of willingness to purchase GM foods. Only if an individual is willing to purchase GM foods, a choice among discrete alternatives of price premium is to be made. The conceptual framework

[4] Certain potential biases, however, may be resulted with CV. Because the questions are given in a hypothetical scenario, consumers' subjective responses may not be consistent with what they would actually pay. In addition, consumers may not well understand and process risk information before responding to questions.

[5] Estimates from CV technique can provide a better understanding of the factors that influence the polarity of views from different consumers to be used in cost/benefit analyses for policy choices of GM foods.

draws in part on information processing theory (Sternthal and Craig, 1982).

To avoid presupposition effects, respondents in a survey were first queried if they would be willing to purchase GM foods based on a filter design (Sterngold, Warland, and Herrmann, 1994). Only respondents with positive response were asked to indicate an interval of price premium from a checklist of three hypothetical scenarios (or categories) of price premium. The price premium indicates *the least* that they are willing to pay *below* the normal purchase price of a non-GM food to accept a particular GM food due to potential risks, in a sense of compensation. It measures consumers' willingness to accept (WTA) but not WTP for potential increased risks associated with GM foods.

A willingness to accept model is specified based on the model developed by van Ravenswaay et al. (1991). It is assumed that utility is derived from the attributes or characteristics that a good possesses (Lancaster, 1966). Under a budget constraint, the consumer's choice problem is to choose attributes that maximize utility through consumption of a bundle of products with certain attributes. Assuming the demand function is linear or semi-algorithmic for product X_1, a consumer's willingness to accept (WTA) for a change in the level of one of its attributes from initial attribute S_0 (offered at equilibrium price P_1^0) to S_1 is given as:

(1) $WTA = (P_1^0 - P_1^1) * X_1(S_1)$,

where P_1^1 is the willingness- to- pay price of X_1 after the attribute changes.

A consumer's preference for goods is a function of price, attributes, socioeconomic, and demographic characteristics. For empirical study, cross-sectional data is usually obtained to analyze the impact of various factors on consumption. However, such data usually exhibit minimal price variations and hence the demand function is specified as a function of non-price variables:

(2) $X_1 = X_1(Z)$,

where Z is a set of socioeconomic and demographic variables, including income. Hence, WTA can be expressed as:

(3) $WTA = (P_1^0 - P_1^1) * X_1(Z|S_1)$,

implying that willingness to accept is a function of attributes of X_1, the socioeconomic and demographic factors.[6]

Model Specification

To analyze consumer risk attitudes and purchase intentions, a joint probit and ordered probit model is formulated, taking into account joint decision making by consumers, i.e., if or not one is willing to purchase GM foods by paying less; and how much less to pay. An individual *i* is assumed to make choice 1 of willingness to

[6] Further study may employ CV technique to focus on valuing food safety for specific GM crops varieties and foods categories, such as soybeans, corn, potato, processed soybeans products, processed corn products, processed potato products, etc.

purchase because of its higher utility attainable compared to the alternative choice of 0. According to Greene (2003), the univariate probit model for a binary outcome is

$$\text{Unobserved} \quad y_i^* = U_1 - U_0 = \beta' x_i + \varepsilon_i \ , \quad \varepsilon_i \sim N[0,1],$$

$$\text{(4)} \quad \text{Observed} \quad y_i = 1, \text{ if an individual is willing to purchase GM foods. (i.e., } U_1 > U_0);$$

$$= 0, \quad \text{otherwise;}$$

where U_0 denotes utility derived from choice 0 and U_1 denotes utility derived from choice 1. y_i is an observed response (or choice) variable, and x_i is a set of explanatory (demographic, socioeconomic, and attitudinal) variables. β is a vector of parameters to be estimated, reflecting the impact of changes in x_i on the probability.

To analyze how the price premium accepted by an individual is determined given an individual is willing to purchase GM foods, an ordered probit model is specified:

$$\text{Unobserved} \quad m_i^* = \alpha' z_i + \xi_i \ , \quad \xi_i \sim N[0,1],$$

$$\text{(5)} \quad \text{Observed} \quad m_i = 0, \text{ if } m_i^* \le \mu_0$$
$$= 1, \text{ if } \mu_0 < m_i^* \le \mu_1$$
$$= 2, \text{ if } m_i^* > \mu_1 \ ,$$

where μs are unknown threshold parameters to be estimated with α. There are three price premium categories (m_i = 0, 1, or 2), indicating an individual would make purchase of GM foods if the prices of GM foods are lower than non-GM foods by 20% or less, between 21% and 49%, and 50% or more, respectively. The disturbance terms of equations (4) and (5) ,ε_i and ξ_i, are distributed as standard bivariate normal, with correlation ρ. Equations (4) and (5) are to be estimated jointly by maximum likelihood approach to avoid of a loss of efficiency of parameter estimates according to Meng and Schmidt (1985).

Data

To analyze the risk attitudes towards GM foods of consumers in Taiwan, we design questionnaire, conduct survey, and collect data from personal interviews. A questionnaire of twenty questions was designed to collect data on consumer risk attitudes towards GM foods in Taiwan.[7] The survey was conducted through personal interviews with a total of 700 questionnaires given out for data collection in 2002. The survey consisted of two parts.[8] The first part of the questionnaire was designed to gather

[7] The survey questions are presented in Appendix 1.

information on consumers' awareness of, general knowledge about GM foods, and about benefits and potential risks associated with GM foods; what consumers concern the most and the least about the benefits and potential risks; consumers' conceptual acceptance of GM foods; consumers' opinions of labeling policy; and willingness to purchase GM foods by paying less for GM foods. The second part contained questions to collect socioeconomic and demographic data.

Sample Profile

A total of 624 samples (out of 700) were complete and available for analysis, giving an effective response rate of 89.14 percent. Table 1. shows the profile of the respondents in survey. Female and male respondents accounted for 53 percent and 47 percent of total survey sample, respectively. The age group of 20 or under 20 had the greatest representation (40.9 percent), followed by the age group of 21-30 (34.1 percent). It indicated that most of respondents were young consumers. 68.8 percent of the respondents had attained an educational level beyond the 12th grade, and about 73.9 percent of respondents had annual income less than NT$ 400,000. Students were the majority of respondents in survey (54.7 percent), followed by those who were employed in service industry (21 percent). Only 8.3 percent of respondents were engaged in food-related business.

Survey Results

As summarized in Table 1, more than half of respondents (55.6%) reported they were aware of or knew about GMOs and GM products. Respondents were also asked if they could name some products that contain GMOs, and most respondents stated soybeans, corn, and processed products made from soybeans and corn. The majority of respondents were not sure about having ever purchased GM products, accounting for 57.1 percent of respondents. While, there were about 20 percent of respondents who were aware of having ever purchased GM products. Less than 30 percent (27.5%) of respondents knew about benefits and potential risks of GMOs and GM products before being informed in questions that followed. The majority (83.7 %) of respondents stated that they would care more about GMOs and GM products, after being informed of their benefits and potential risks. It is quite surprising to learn that nearly 17 percent of respondents would not care more.

Respondents were asked to ***rank*** the ***benefits*** of GMOs and GM foods. The results of ranking are given in ( ) as follows, with **1** indicating **the most important** benefit considered, and **5 the least**:

(**3**) GM crops varieties can increase agricultural productivity and hence lower prices of basic foods in developing world where the majority of food-insecure people depend heavily on agriculture for their livelihood and exports.

(**5**) GM foods can provide consumers with improved taste.

(**4**) food prices can be lower due to increased yields by planing GM crops varieties.

(**1**) pesticide use can be reduced by planing GM crops varieties.
(**2**) GM crops with traits conferring improved nutritional quality can help millions of people in developing countries who suffer from malnutrition and deficiency disorders.

Respondents were also asked to ***rank*** the ***potential risks*** associated with GMOs and GM foods. The results of ranking are given in ( ) as follows, with **1** indicating **the most important** potential risk considered, and **4 the least**:
(**2**) GMOs and GM products may pose risks on ecosystem and biological diversity.
(**3**) GM products may cause allergic problems.
(**1**) GM products may cause other unknown health problems.
(**4**) social and ethical concerns about GMOs and GM products.

44.7 percent of respondents indicated they would *conceptually accept* GM products, after being informed of benefits and potential risks of GM products, and 21.5 percent of respondents would *not* accept GM products conceptually. While, there were about one third of respondents were undecided if they would conceptually accept GM products. A large majority (93.1 percent) of respondents required products with GM contents to be labeled. 81.1 percent of respondents preferred GM product labeling to be mandatory. 83.2 percent of the respondents demanded GM product labeling to be positive labeling, i.e., labeling GM products. 72.3 percent of respondents would not make purchase of products without reading the labels on products that may contain GMOs. 73.1 percent of respondents were willing to purchase GM foods, provided that the prices of GM foods were cheaper than those of non-GM foods. 36 percent, 34 percent and 30 percent of respondents demanded prices of GM foods to be lower than those of non-GM foods by *20% or less*, *21%-49%*, and *50% or more* (three price premium categories) for them to switch to purchase GM foods, respectively.

Estimation Results

The empirical results of joint estimation of probit and ordered probit models show the estimate of ρ (cross-equation correlation) is not significantly different from zero, suggesting the unexplained residuals of the probit and ordered probit equations were uncorrelated. We then proceed to estimate the probit model and ordered probit model separately.

Table 2 presents separate estimation results of two equations of willingness to purchase (probit model) and of price premium for GM vs. non-GM products (ordered probit model). The parameter estimates represent the marginal effect of a change in an explanatory variable on the probability distribution of the dependent variable. As shown in Table 2, parameter estimates of probit model indicate that respondents who care more about GMOs and GM products issues (CARE) are more likely to be willing to purchase GM foods, while older consumers (AGE) are less likely to be willing to make purchase of

GM foods. Model significance is verified through a chi-squared test of the difference between the restricted and unrestricted log likelihood values. With degrees of freedom of 9, the chi-squared statistic was 22.384 and highly significant at the 1 percent level.[9] For the ordered probit model of price premium (how much less to pay), the parameter estimates of all socioeconomic and demographic variables were not significant in explaining differences in price premium demanded among consumers who are willing to make purchase of GM foods with lower price relative to non-GM foods.

Our survey design has intended to identify the consistency in responses for questions 8 and 13 in the questionnaire. In question 8, the respondents were asked if they would *conceptually accept* GM products, after being informed of benefits and potential risks of GM products. While, in question 13, the respondents were asked if they would *be willing to purchase* GM foods, provided that the prices of GM foods were cheaper than those of non-GM foods. Table 3 shows a comparison in sample counts of both questions. It is found that 67 respondents who answered "no" (ACCEP=1) to question 8 were still potential buyers (PURCH=1) given a lower price of GM vs. non-GM foods. Similarly, it is also interesting to find that 43 respondents who answered "yes" (ACCEP=3) to question 8 would not make purchase of GM foods (PURCH=0) given a lower price of GM vs. non-GM foods. It indicates that purchase decision may be determined by factors other than price, such as consumers' subjective perceptions of the actual product characteristics as discussed in equation (3).

In order to better understand consumer conceptual acceptability, we formulate and estimate another ordered probit model of consumer *conceptual* acceptance.[10] The results are summarized in Table 4. The estimated parameter of CARE variable was positive and highly significant at the 5 percent level. While, parameter estimates of both RISK and EDU variables were negative and significantly different from zero. The results suggested that respondents who care more about GMOs and GM products issues (CARE) after being informed of benefits and potential risks of GMOs and GM products, are *more likely* to conceptually accept GMOs and GM products. However, consumers who ranked unknown health risk or allergic problems as top two risk concerns (RISK) or who had attained a higher educational level (EDU) are *less likely* to conceptually accept GMOs and GM products. Threshold parameter (μ_1) estimate was also presented and was highly significant. Model significance is verified through a chi-squared test of the difference between the restricted and unrestricted log likelihood values. With degrees of freedom of 9, the chi-squared statistic was 21.524 and highly significant.

Table 5 provides estimated probabilities of conceptual acceptance of GM products associated with each level of conceptual acceptability (ACCEP=1, 2, 3), using the parameter estimates from Table 4. The results indicated about 86, 11, and 3 percent of

[9] A pseudo-R^2 can be calculated based on the ratio of the unrestricted and restricted log-likelihood values for a measure of goodness-of-fit (Long, 1997).

[10] It is noted that consumers' willingness to purchase given a price premium incentive does not necessarily mean consumers' conceptual acceptance as discussed above and presented in Table 3.

the probability distribution was associated with the category representing positive (ACCEP=3), neutral (ACCEP=2), and negative (ACCEP=1) conceptual acceptance of GM foods, respectively. This is evidence that consumers have a tendency to conceptually accept GM products.

Table 6 presents the estimated marginal probabilities[11] (marginal effects) of the ordered probit model of consumer conceptual acceptability of GM foods. The results showed that a change in health risk concerns had the greatest impact on the marginal probabilities associated with each category of conceptual acceptance. As the level of health risk concerns increases, consumers would shift from positive conceptual acceptance category to neutral and to negative conceptual acceptance categories. Similarly, as the level of education attained increases, consumers would shift from positive to neutral and then to negative conceptual acceptance category. However, as the level of consumers' care about GMOs and GM foods increases, consumer will shift from negative to neutral and to positive conceptual acceptance category.

Summary and Conclusions

In this study, consumer awareness and attitudes towards GM foods has been examined. From the survey results, we know there is a need to provide more information on GMOs and GM products to the public, including knowledge about the benefits and potential risks associated with GM products. Survey results show that reduced use of pesticide was considered the most important benefit of GM products. It is followed by the humane care for people in developing world. GM crops with traits conferring improved nutritional quality can help millions of people in developing countries who suffer from malnutrition and deficiency disorders. In addition, GM crops varieties can increase agricultural productivity and hence lower prices of basic foods in developing world where the majority of food-insecure people depend heavily on agriculture for their livelihood and exports. Cheaper food prices and improved taste provided by GM foods are found the last two important benefits concerned. Unknown health problems associated with GM foods was the most important risk concern, followed by environmental concerns. The least concerns are social and ethical ones.

Regarding consumers' opinions of labeling GM products, the results show the majority of consumers in Taiwan required products with GM contents to be labeled. They also preferred GM product labeling to be mandatory, and of positive labeling. The results would provide government with information for labeling policies that best suit consumers' needs. From the survey results, consumers' willingness to purchase GM foods by paying less and how much less were elicited. About three fourth of respondents were willing to purchase GM foods, provided that the prices of GM foods were cheaper than those of non-GM foods, indicating the majority of respondents being

[11] The marginal probability measures the change in the probability of each discretive choice (ACCEP=0,1,2) with respect to a change in an explanatory variable.

risk-insensitive. While, in terms of price premium demanded, all respondents were almost evenly divided in sample counts to fall into three price premium categories (*20% or less*, *21%-49%*, and *50% or more*) for them to switch to purchase GM foods, revealing different levels of price-sensitivity among consumers.

To quantify the effect of demographic, socioeconomic, and attitudinal factors on GM food consumption, a joint probit and ordered probit model is estimated, taking account of joint decision making by consumers, i.e., if or not one is willing to purchase GM foods by paying less; and how much less to pay. The results of joint estimation, however, show the estimate of ρ (cross-equation correlation) is not significantly different from zero. Separate estimation results of probit model indicate that respondents who care more about GMOs and GM products issues after being informed of benefits and potential risks of GMOs and GM products, are more likely to be willing to purchase GM foods, while older consumers are less likely to be willing to make purchase of GM foods. For the ordered probit model of price premium (how much less), the parameter estimates of all socioeconomic and demographic variables were not significant. In order to better understand consumer conceptual acceptability, we formulate and estimate another ordered probit model of conceptual acceptability of GM foods. The results show that consumers who ranked unknown health risk or allergic problems as top two risk concerns or who had attained a higher educational level were less likely to conceptually accept GMOs and GM products. While, consumers who care more about GMOs and GM products issues after being informed of benefits and potential risks of GMOs and GM products, were more likely to conceptually accept GMOs and GM products. The findings of this study are expected to be of use for government policy making and for market segmentation in response to different degrees of GM foods acceptance among consumers through efficient marketing strategies in the business sector.

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Appendix 1.

Part I. Twenty questions were asked in survey. In specific, respondents were

A1. asked if they were aware of or knew about GMOs and GM products.

A2. asked if they could name certain products in market that contain GMOs.

A3. asked if they were aware of having ever purchased GM products.

A4. asked if they knew about benefits and potential risks of GMOs and GM products.

A5. asked if they would care more about GMOs and GM products, being informed of benefits and potential risks of GMOs and GM products stated in the same question.

A6. asked to *rank* the following *benefits* of GMOs and GM foods.

a. GM crops varieties can increase agricultural productivity and hence lower prices of basic foods in developing world where the majority of food-insecure people depend heavily on agriculture for their livelihood and exports.
b. GM foods can provide consumers with improved taste.
c. Food prices can be lower due to increased yields by planing GM crops varieties.
d. Pesticide use can be reduced by planing GM crops varieties.
e. GM crops with traits conferring improved nutritional quality can help millions of people in developing countries who suffer from malnutrition and deficiency disorders.

A7. asked to *rank* the following *potential risks* of GMOs and GM foods.

a. GMOs and GM products may pose risks on ecosystem and biological diversity.
b. GM products may cause allergic problems.
c. GM products may cause other unknown health problems.
d. GMOs and GM products would cause social and ethical concerns.

A8. asked if they would *(conceptually) accept* GM products, after being informed of benefits and potential risks of GM products.

A9. asked if they required any products with GM contents to be labeled.

A10. asked if they preferred GM product labeling to be voluntary or mandatory.

A11. asked if they preferred GM product labeling to be

a. positive labeling, i.e., labeling GM products; or
b. negative labeling, i.e., labeling non-GM products.

A12. asked if they would not make purchase of products without reading the labels on products that may contain GMOs.

A13. asked if they would *be willing to purchase* GM foods, provided that the prices of GM foods were cheaper than those of non-GM foods.

(**Those who answered yes to question 13 were asked to answer question 14.)**

A14. You would demand the price of GM foods to be lower than that of normal purchase

of non-GM foods by
1) 20% or less:_____; 2)between 21% and 49%:_____; 3)50% or more:_____ for you to switch to purchase GM foods.

Part II. Each respondent is asked to provide demographic and socioeconomic information as below.

B1. What is the gender of the respondent?

B2. What is the age of the respondent?
a) 20 or under 20; b) 21-30; c)31-40; d)41-50; e)51-60; f)61 or over

B3. What is the last grade of school that the respondent completed?
a)Some high school or less; b) High school graduate/equivalent;
c)Some college/technical degree;
d)Bachelors degree; e)Graduate work/degree

B4. What is the category that best describes the respondent's annual income in New Taiwan (NT) Dollars?

a)<200,000	b)200,000-399,999	c)400,000-599,999
d)600,000-799,999	e)800,000-999,999	f)>1,000,000

B5. What is the occupation of the respondent?

a) Primary industry	b) Manufacturing industry	c) Service industry
d) Military, government, or school		
e) Student	f) Unemployment	g)Others

B6. Was the respondent engaged in food-related business?

Table 1. Variable Definition, Coding, and Descriptive Statistics (n = 624)

Variable	Definition and Coding	Mean	Standard Deviation
ACCEP	**Question 8:Would the respondent *accept* GMOs and GM products *conceptually*?**	2.232	0.780
(n=279)*	=3, Yes;		
(n=211)	=2, Undecided;		
(n=134)	=1, No.		
PURCH	**Question13: Was the respondent willing to *purchase* GM foods, provided that the prices of GM foods were cheaper than those of non-GM foods?**	0.731	0.444
	=1, Yes;		
	=0, No.		
PERCT**	**Question14: The respondent who answered "yes" to question 13 would switch to purchase GM foods if the prices of GM foods were *lower* than those of non-GM foods by**	2.057	0.813
(n=164)	=3, 20% or less;		
(n=154)	=2, between 21% and 49%;		
(n=138)	=1, 50% or more.		
AWARE	=1, if the respondent was aware of (or knew about)GMOs and GM products;	0.556	0.497
	=0, otherwise.		
CARE	=1, if the respondent would care more about GMOs and GM products, being informed of benefits and potential risks of GMOs and GM products;	0.837	0.370
	=0, otherwise.		
RISK	=1, if the respondent ranked unknown health and allergic problems as top two potential risks concerns of GMOs and GM foods;	0.458	0.499
	=0, otherwise.		
REGUL	=1, if the respondent required any products with GM contents to be labeled;	0.931	0.254
	=0, otherwise.		

* Sample counts are shown in parentheses. ** Number of observations for PERCT = 456.

Table 1. Variable Definition, Coding, and Descriptive Statistics (Continued)

Variable	Definition and Coding	Mean	Standard Deviation
LOOK	=1, if the respondent would not make purchase of products without reading the labels on products that may contain GMOs; =0,otherwise.	0.723	0.448
GENDER	=1, if the respondent is male; =0, if the respondent is female.	0.466	0.499
AGE	=6, if the age of the respondent is 61 years old or over; (age ≥61) =5, 60 ≥ age >51 =4, 50 ≥ age >41 =3, 40 ≥ age >31 =2, 30 ≥ age >21 =1, 20 ≥ age	1.994	1.076
EDU	=5, educational level attained by the respondent: graduate work/degree; =4, bachelors degree; =3, some college/technical degree; =2, high school graduate/equivalent; =1, some high school or less.	2.960	0.981
INCOME	=6, if the respondent's annual income is greater than 1,000,000 New Taiwan dollars; =5, 800,000 - 999,999 =4, 600,000 - 799,999 =3, 400,000 - 599,999 =2, 200,000 - 399,999 =1, <200,000	1.965	1.373

Table 2. Parameter Estimates of Willingness to Purchase and Price Premium for GM vs. Non-GM Products Equations: Separate Estimation of Probit and Ordered Probit Models

Variable	Probit	Ordered Probit
Constant	0.256	0.461
	(0.838)	(2.225)
AWARE	0.103	
	(0.911)	
CARE	0.385***	
	(2.586)	
RISK	-0.075	
	(-0.674)	
REGUL	0.184	
	(0.858)	
LOOK	0.139	
	(1.125)	
GENDER	-0.137	-0.040
	(-1.183)	(-0.351)
AGE	-0.137**	0.089
	(-2.117)	(1.388)
EDU	-0.001	-0.048
	(-0.013)	(-0.885)
INCOME	0.050	0.025
	(0.955)	(0.053)
μ_1		0.883***
		(14.298)
χ^2	χ^2_9=22.384***	χ^2_4=5.569
Sample size	624	456

Note: The joint estimation of probit and ordered probit equations yields the estimate of $\rho = 0.213$, and is not significantly different from zero, with *t*-ratio value of 0.585.
Note: *t*-ratios are in parentheses.
* denotes significance at the 10% level.
** denotes significance at the 5% level.
*** denotes significance at the 1% level.

Table 3. Conceptual Acceptance (ACCEP) vs. Consumption Decision (PURCH)

	PURCH=0	PURCH=1	Total
ACCEP=1	67	67	134
ACCEP=2	58	153	211
ACCEP=3	43	236	279
Total	168	456	624

Table 4. Parameter Estimates of Conceptual Acceptance of GM Products Equation: Ordered Probit Model (ACCEP=1, ACCEP=2, ACCEP=3)

Variable	Parameter Estimate	*t*-ratio
Constant	0.842	3.246
AWARE	-0.063	-0.669
CARE	0.332	2.446**
RISK	-0.172	-1.849*
REGUL	0.223	1.229
LOOK	0.018	0.168
GENDER	-0.018	-0.181
AGE	0.001	0.014
EDU	-0.107	-2.243**
INCOME	-0.047	-1.046
μ_1	0.944	16.649***
χ^2_9=21.524**		
Sample size=624		

Note: * denotes significance at the 10% level.
** denotes significance at the 5% level.
*** denotes significance at the 1% level.

Table 5. Estimated Probabilities of Conceptual Acceptance of GM Products

	Probability
Consumers would conceptually accept GM Products.(ACCEP=3)	0.857
Consumers were undecided.(ACCEP=2)	0.111
Consumers would not accept GM Products conceptually.(ACCEP=1)	0.032

Table 6. Marginal Effects: Conceptual Acceptance of GM Products

	Would consumers *conceptually accept* GM products?		
	No	Undecided	Yes
AWARE	0.0182	0.0068	-0.0251
CARE	-0.0955	-0.0357	0.1313
RISK	0.0494	0.0185	-0.0678
REGUL	-0.0640	-0.0239	0.0880
LOOK	-0.0050	-0.0019	0.0069
GENDER	0.0051	0.0019	-0.0070
AGE	-0.0002	-0.0001	0.0003
EDU	0.0308	0.0115	-0.0423
INCOME	0.0137	0.0051	-0.0188