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Consumers' Purchasing Intentions for Vegetable Oil in the Presence of Generic or Specific Information on Genetic Modification

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In combination with the emergence of genetically modified (GM) food, there has been an urgent call for GM labeling to provide relevant information disclosure. Using data collected in Beijing, China, this study attempts to address the issue of whether different types of information may have distinct impacts on consumers' stated purchasing decisions. Three types of information are used in this study: one is generic and the other two are linked with two important implications of GM technology—human health and the environment. Results verify that consumers' purchasing decisions are affected by different types of information through their attitudes and personal characteristics. This finding has potential implications for establishing various GM marketing strategies and information campaigns.

Key Words: China, genetically modified (GM) food, labeling information, probit model, vegetable oil

A controversial issue in current agricultural production and marketing is related to the emergence of foods produced through genetic modification (GM) or, to use the more general term, biotechnology. Debates on GM in agriculture are often related to the cost of production, human health, the environment, ethical implications, and market power concentration (Brookes and Barfoot, 2006; Knight, 2006). Whether the introduction of GM technology into food production is successful depends critically on consumers' acceptance.

Economic studies have developed a general theory of choice-making for products (including food items) with novelty attributes. The implicit benefit-cost of consumers' choice-making is translated into their utilities, and a choice will be made if the resulting expected utility is greater than the alternative decision. However, food products with a GM attribute pose a unique problem in decision making due to the uncertainties it stimulates. Such a trait has been defined as the credence attribute (Darby and Karni, 1973). When credence attributes appear, market failure (known as lemon market functioning, as implied by Gresham's law) often

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occurs (Akerlof, 1970). Information is particularly crucial in this circumstance to relax the distortions in the market.

Labeling is an important means of providing necessary product information to consumers. Due to various economic, political, or cultural reasons, different countries have adopted different policies for GM labeling, such as the voluntary labeling regime in North America and the mandatory requirements in Europe and Asia (Hu, Adamowicz, and Veeman, 2006). There are concerns that products which specify the presence of GM attributes, as required by mandatory labeling, may decrease purchases by consumers due to the uncertainties surrounding the GM attributes. However, supplementary information may be included on the product label in addition to information concerning whether the product contains GM ingredients. Doing so offers an opportunity for GM product growers or processors to launch information campaigns to provide favorable information on GM products, while within the limits of the regulations, to lower consumers' concerns and to increase purchases. It is therefore necessary to understand how consumers may treat and react to different types of information about GM foods.

Relying on data collected through a recent consumer survey in China, this study examines potential changes in consumers' stated purchase of GM vegetable (canola) oil given three different types of GM-related information. The first type of information is generic, i.e., it advises consumers that the GM vegetable oil they purchase does not contain any traceable GM contents. The second type of information is human-health specific, pointing out that GM oil may contain higher nutritional values than its non-GM counterparts. The last type of information is environment-specific, explaining that GM oil may help protect the environment because less pesticide is used in growing GM canola seeds.

GM canola oil was selected as the target product in this study because the vegetable oil market in China is expected to be affected substantially by the appearance of GM technology (Lin et al., 2006). In the year 2000, China accounted for 20% of world soybean imports and 35% of rapeseed imports [U.S. Department of Agriculture/Foreign Agricultural Service (USDA/FAS), 2007]. Chinese GM regulations and consumers' acceptance of GM oil will no doubt have profound impacts on the international trade of oil products.

Review of Literature

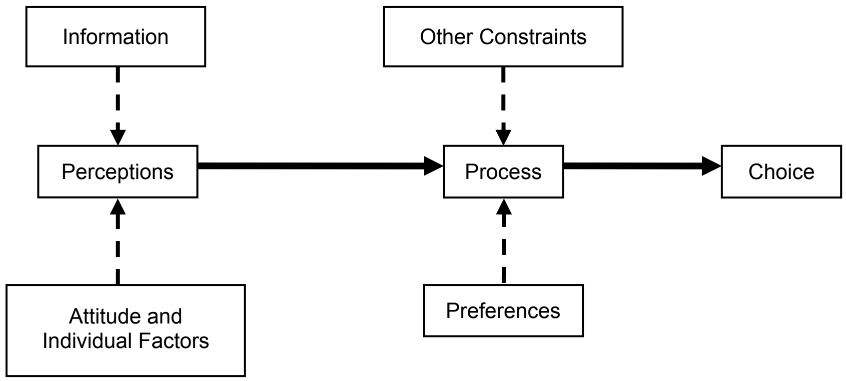
Several past studies have examined the effects of information on consumers' perceptions of and demand for GM foods. Frewer (2003) and Scholderer and Frewer (2003) investigated the effect of information about risks of GM food production on consumer acceptance of the technology in a social psychology framework. Antle (2001) and Crespi and Marette (2003) studied whether a positive or a negative GM labeling scheme may result in different consumer reactions through both theoretical and empirical analysis. Hu, Adamowicz, and Veeman (2006) explored the difference between implications of voluntary and mandatory GM labeling policies in the European Union and North America through consumers' reference point effects.

However, the above studies assumed information given by researchers or product labels is equivalent to information eventually received by the consumers. Noussair, Robin, and Ruffieux (2004) showed that an average consumer does not always process information on product labels as well as researchers often assume. An explanation for this finding could be that consumers do not actually understand the information provided or they ignore such information altogether. Huffman et al. (2004) and Rousu et al. (2007) found consumers may treat the information more seriously if it contains more details or is verified by an authority. These authors concluded that for a product label to work effectively with its audience, the label needs to contain information readily accessible by consumers both physically and cognitively.

Because the adoption of a GM technology is often associated with particular benefits and costs (Brookes and Barfoot, 2006), which may be either privately or socially relevant, some authors have made the effort to communicate these benefits and costs of GM food in their research together with the simple labeling scheme which states only whether the product in question contains GM ingredients. This additional information serves the purpose of explaining product labels, thereby making it less challenging for consumers to interpret the labels. Scholderer and Frewer (2003) and Hu et al. (2004) highlighted the benefits of GM food in terms of the environment and human health advantages and found that consumers' acceptance of GM food may increase after given this information. Traill et al. (2006) and Lusk et al. (2003), on the other hand, provided information on both the positive and negative impacts of GM food, and found consumers were quite sensitive to this type of information exposure. All of these studies verify the role additional information plays in the position of a GM technology, as often observed in the debate between GM and organic food (Anderson, Wachenheim, and Lesch, 2006).

Still, very few past studies have examined the difference between generic versus specific GM information on consumer perceptions. For GM food producers to increase their sales, do they need to convey specific information on human health or environmental benefits to consumers? or will a generic statement that the product has no trace of GM ingredients achieve a similar result? For consumers, if they accept/reject a GM product, is it because they accept/reject the product in its entirety? or because they simply focus on specific features of the product?

This study seeks to contribute to the literature by testing the impact of three clearly defined types of GM information on consumer acceptance of GM food: one generic and two specific. Our results also have important implications for the GM food industry since the costs involved with qualifying for generic and specific labels are likely to differ considerably. This study provides a foundation for a more elaborate cost and benefit analysis of these labeling approaches.



Source: McFadden (2001).

Figure 1. Human decision-making process: A simplified representation

Conceptual Framework and Expected Results

Description of the interaction between information and consumer choices can find its root in judgment and decision-making (JDM) theories, which formulate the basic structure of consumers' decision making (e.g., Howard, 1977; Bettman, 1979). Based on the JDM literature, McFadden (2001) synthesized this process into a succinct diagram with an emphasis on economic and psychological aspects. Figure 1 depicts a simplified version of this diagram, which shows that consumers' perceptions are formed by product information and their own attitudes and personal factors, such as their opinions/perceptions, socioeconomic status, and demographic characteristics. As described by the diagram, consumers process information by integrating their true preferences and considering other economic and noneconomic constraints. Final choices are made after the process. Our empirical analysis has been developed around this decision-making framework.

Existing empirical literature on consumer perceptions of GM food offers support for the above theoretical framework. Li et al. (2002), Traill et al. (2006), and Poortinga and Pidgeon (2006) showed that consumers are likely to incorporate their prior attitude when evaluating GM food: i.e., individuals with positive prior views toward GM techniques are willing to pay more for GM food than those with less positive opinions. Curtis, McCluskey, and Wahl (2004), Poortinga and Pidgeon (2006), and Lin et al. (2006) demonstrated consumer trust in the government's food safety and labeling regulation system and the mass media may be an important factor in their food choices, particularly when additional information is available—such as that for the GM technology. The higher their level of trust, the greater the likelihood an average consumer may accept GM food.

Hu and Chen (2004) and Huffman et al. (2007) independently noted that in addition to their attitudes, consumers' cognitive stage may also affect their processing ability of GM information. These studies concluded that consumers' knowledge level about the GM technique may enable or set a constraint on consumers' overall risk perceptions of GM food, and thus affect their choice behavior. Consumers may also compare what (they think) they know with the information provided. Discrepancies between these sources may generate different responses. Specifically, the direction of impact may not be linear and will depend on each specific case.

Through a meta analysis, Lusk et al. (2005) showed that consumers' opinion toward GM food is generally negative, but varies moderately across different countries—with European consumers being the most critical. Chinese consumers often represent one of the most lenient groups, and may even express positive views toward GM foods (Curtis, McCluskey, and Wahl, 2004). Most of the above studies (and many others, e.g., Hu et al., 2004; Hu, Adamowicz, and Veeman, 2006; Knight, 2006; and Rousu et al., 2007) have also incorporated consumers' socioeconomic and demographic characteristics into their analysis to help explain the variation in consumer attitudes across the globe. Findings of the impacts of these variables slightly varied across studies, but generally male consumers were found to be more positive toward GM food than their female counterparts; consumers with higher income and education, as well as older consumers, were more skeptical.

Although these earlier studies did not offer a direct comparison between generic and specific GM information, they serve as valid sources of reference and also provide a consistency check for the current analysis. Accordingly, it is expected that consumers with positive/negative views on GM techniques are most/least likely to purchase GM food; individuals with a higher level of trust in the government's food safety regulation system are also more likely to accept GM food; the impact of consumers' knowledge level potentially may be different, depending on which type of information is given; if consumers are generally not favorable toward GM food, then the more important this attribute is to them, the less likely they are to purchase GM food; and male, lower income, younger, and less educated consumers may be more supportive of GM food. How these variables interact with the generic and specific information examined here relies considerably on the empirical results.

Data and Sample Characteristics

Data used for this study were obtained from a survey implemented in the capital city of Beijing, China, and completed in the spring of 2003. Two pilot studies were also conducted in Beijing in 2002. In the final survey, trained enumerators were hired to conduct random interviews at various shopping malls and supermarkets in Beijing. A total of 628 consumers returned a usable survey.

The central part of the survey is a set of questions concerning purchases. First, without any new information, respondents were asked whether they would like to purchase a bottle of canola oil that might contain GM ingredients. If their answer was positive, they were directed to the last section of the survey where they could fill in their demographic information and leave the survey. If their answer was negative, a second round of inquiry commenced in which they were given additional information about the GM ingredients. A total of 556 respondents belonged to this latter category and were offered additional information. Survey purchasing questions are provided in the appendix.

The new information in the questionnaire was carefully designed and worded to reflect the reality of GM oil products while also attempting to fulfill our research goal. There were three types of new information incorporated, one with generic information and two with specific information. The respective information statements were as follows:

- No actual GM protein can be scientifically detected in the final oil made from GM oilseeds (generic).
- Oil made from GM oilseeds is more nutritious (human-health specific).
- Oil made from GM oilseeds may reduce pesticide usage and therefore help protect the environment (environment specific).

Respondents were then asked to indicate their purchasing intentions after each of these three types of information was given. The order of this information was randomized to minimize the ordering effect. Respondents were allowed to choose from "buy" or "do not buy," or express uncertain decisions by choosing "do not know." Following a common practice in the literature, we dropped the "do not know" responses from the analysis.[1] Note that uncertain responses can be dropped only if one believes the occurrence of "don't know" responses does not have a systematic pattern; otherwise, it may bias welfare measures. However, since our goal in this study was not to analyze welfare implications, this potential bias is not further investigated. This procedure reduced our sample size to 491 observations.

Respondents' attitudes were also directly collected through the survey. A dummy variable (*ENV*) equal to one was used to capture those respondents who had a concern with the environmental impact of GM oil. Whether GM oil may pose a risk to human health (*HEALTH*), whether a government's labeling and regulation system is trustworthy (*TRUST*), and whether the GM attribute is an important factor in making a purchasing decision (*IMPT*) were all evaluated through 1–5 Likert scale responses. Respondents' knowledge about GM technology pertinent to food products (*KNOW*) was elicited through four objective

[1] Alternative methods include coding "don't know" as "no" or fitting a multinomial response model and others. See Haener and Adamowicz (1998) for a comparison of these methods.

Table 1. Definitions and Descriptive Statistics of the Original Independent Variables (N = 628)

Variable	Definition	Mean	Std. Dev.	Median
ENV	= 1 if respondent has environmental concerns about GM foods; otherwise = 0	0.065	0.247	0.0
HEALTH	1–5 scale variable on human health concerns about GM foods: 1 = "not at all risky" and 5 = "very risky"	2.635	1.076	2.0
TRUST	1–5 scale variable on trustworthiness of the government food safety regulating system: 1 = "not at all trustworthy" and 5 = "very trustworthy"	2.739	1.154	3.0
KNOW	1–4 count variable for respondent's GM knowledge level	1.305	1.357	1.0
IMPT	1–5 scale variable capturing how important a respondent thinks the GM attribute is in his/her food purchase decision making	3.189	1.091	3.0
MALE	= 1 if the respondent is male	0.502	0.500	1.0
MARRI	= 1 if the respondent is married	0.763	0.426	1.0
INCOME	Continuous variable (yearly)	2,836.049	2,053.425	2,500.0
AGE	Continuous variable (years)	36.935	10.441	35.0
EDU	Continuous variable (years)	14.373	2.681	16.0

questions. The number of questions respondents managed to answer correctly was taken as a proxy for their degree of knowledge.

The four questions asked were the following: (*a*) Can GM technology change the nutritional components of a food item? (*b*) Can GM technology reduce the amount of saturated fat content of a food item? (*c*) Can GM technology reduce the amount of pesticide applied to crops? and finally, (*d*) Can GM technology increase productivity? To complete the steps listed in figure 1, information on respondents' demographic characteristics was also collected. Descriptive statistics (based on 628 observations) for these attitude and demographic variables are given in table 1.

Compared with Beijing's 2003 population statistic yearbook, the sample in our study is slightly biased toward younger and higher income individuals, and moderately biased toward residents having a high education level. The sample respondents had almost no environmental concerns about GM food, as indicated by the zero median and small mean of the *ENV* variable. In contrast, a significant portion of the respondents did care about the human health impact of GM food. Sampled consumers also trusted the government's food labeling and regulation system moderately, with a median trustworthy indicator of 3 out 5. Consumers had very limited actual knowledge of GM technology in oil production. On average, a consumer could answer only one out of four questions related to GM technology correctly. Given their limited knowledge about GM foods, these

Table 2. Correlation Matrix of Independent Variables

Variable	*ENV*	*HEALTH*	*TRUST*	*KNOW*	*IMPT*	*MALE*	*MARRI*	*INCOME*	*AGE*	*EDU*
ENV	1									
HEALTH	−0.010	1								
TRUST	−0.040	0.173	1							
KNOW	0.105	−0.168	−0.060	1						
IMPT	−0.031	0.493	0.073	−0.114	1					
MALE	−0.037	0.050	0.088	0.128	0.037	1				
MARRI	0.092	−0.134	−0.181	−0.006	−0.033	0.019	1			
INCOME	0.103	0.126	−0.050	0.011	0.120	−0.045	0.182	1		
AGE	−0.009	−0.057	−0.103	0.000	−0.046	−0.086	0.518	0.059	1	
EDU	0.019	0.312	0.114	0.090	0.203	0.039	−0.112	0.400	−0.148	1

consumers reported that whether a product they purchased may contain GM contents was a fairly important criterion for determining their choices.

Table 2 displays the correlation matrix for these variables. Correlations in general are small, with several exceptions. First, consumers' concerns about health risks associated with GM food are positively correlated (with a coefficient of nearly 0.5) with whether they think GM is an important attribute for their decision making. This correlation is not surprising given a concerned consumer will likely treat that attribute as being important. Second, health concerns are also correlated with consumers' education level (with a coefficient of 0.3), although there appears to be no apparent explanation for this correlation. Third, as expected, respondents' age and marital status are positively correlated, as are education level and income.

Table 3 reports the percentage of consumers who decided to purchase GM oil under each type of information, including the stage prior to additional information. Based on results of a series of statistical tests (χ^2 tests on proportions), the percentage of consumers who agreed to purchase GM oil was higher under any type of information compared with the situation when no information was provided. Among the three types of information, the yes-saying percentage is the highest (27.3%) under the generic information situation.

Econometric Model

Respondents were asked to express their purchasing intentions before and after receiving three new pieces of GM information. In other words, the binary dependent variables are not in direct response to a price offer. If such a price is provided in the survey, consumers' stated willingness to pay (WTP) can be estimated using approaches such as Cameron's (1988) WTP model. Other revealed preference methods also may be used where consumers will be asked to make real product choices; however, such a method is often confronted by a limited sample size due to high collection costs (Lusk et al., 2003). In this study, the binary purchasing intention variables reflect the trade-offs consumers make between

Table 3. Percentage of Yes-Saying Consumers Under Various Information Contexts

Description	Percentage	*N*
Prior to information	11.5% [a]	628
Generic information	27.3% [b]	491
Health-specific information	20.6% [c]	491
Environment-specific information	19.8% [c]	491

Note: Superscripts a, b, and c indicate statistical differences among percentages. Percentages with different superscripts are statistically different: e.g., 11.5% is different from any other percentages in the table; 27.3% is also different from other percentages; and 20.6% is not statistically different from 19.8%.

whether to accept the GM product. Thus, McFadden's (1974) random utility model (RUM) fits the data.

In the RUM, the utility of individual i purchasing a GM oil product can be expressed as:

$$(1) \qquad U_{iY} = \beta_0 + \boldsymbol{\beta}'\mathbf{X}_i + \varepsilon_i = V_{iY} + \varepsilon_i,$$

where $\mathbf{X}_i$ is a vector of factors that may affect choices, and in this study, they can be attitude and individual demographic characteristics. The βs are coefficients associated with vector $\mathbf{X}_i$; β_0 is a constant, representing the average impact on choices from other factors in addition to those included in $\mathbf{X}_i$; ε_i is a stochastic term; and V_{iY} summarizes the deterministic portion of the random utility where subscript Y stands for different information treatment. Variables in vector $\mathbf{X}_i$ are respondents' individual attitude and demographic variables. These variables already reflect the heterogeneities that may exist among respondents (Severin, Louviere, and Finn, 2001). However, the constant β_0 characterizes the average appeal of saying yes (relative to saying no) from other factors, which have not or cannot be included in $\mathbf{X}_i$. It could be argued that respondents may be different in those omitted factors, and heterogeneity may arise around their average evaluation of the choice.

Following Train (2003), we therefore specify a random parameter variant of model (1).[2] In this random parameter specification, the average effect is decomposed into a fixed component and a random component:

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[2] We recognize that a random parameter model for cross-section data with only the constant being the random "coefficient" is essentially the same as a random effect model with a fixed panel size of one. Yet, these two models bear slightly different interpretations. A random parameter model is used to identify the heterogeneities surrounding the mean coefficient (taste) estimates, while the random effect model is designed to capture specifically the randomly distributed mean effects across the full population. In general, the random parameter model is more flexible than the random effect model, in that any coefficient can be specified as random in addition to the constant term. However, in this study, as variables in vector **X** have already expressed heterogeneity themselves, there is no strong additional need to specify random coefficients for these variables.

(2) $$U_{iY} = \mu_i\left(b_0, \sigma_\mu\right) + \boldsymbol{\beta}'\mathbf{X}_i + \varepsilon_i,$$

where b_0 is a fixed constant term and μ_i is independently distributed with ε_i. If one wishes to assume μ_i is normally distributed, then $\mu_i \sim N(b_0, \sigma_\mu^2)$, and b_0 and σ_μ are two other parameters to be estimated with other model parameters. If the remaining stochastic term ε_i in (2) is i.i.d. normally distributed across individuals, conditional on μ_i, the probability of individual *i* saying yes to GM oil can be expressed via a familiar binary probit model:

(3) $$P_{iY}\left(yes \mid \mu_i\right) = \Phi\left(\boldsymbol{\beta}'\mathbf{X}_i\right).$$

The conditional and unconditional joint probability likelihood for the random parameter binary probit (RPBP) model specified in (2) is given by:

(4) $$\text{LL}_i \mid \mu_i = \left[\Phi\left(\boldsymbol{\beta}'\mathbf{X}_i\right)\right]^S \left[1 - \Phi\left(\boldsymbol{\beta}'\mathbf{X}_i\right)\right]^{1-S},$$

(5) $$\text{LL}'_i = \int_{-\infty}^{+\infty} \left[\Phi\left(\boldsymbol{\beta}'\mathbf{X}_i\right)\right]^S \left[1 - \Phi\left(\boldsymbol{\beta}'\mathbf{X}_i\right)\right]^{1-S} f\left(\mu\right) d\mu,$$

where S is a signal variable, which equals one for an answer of "yes"; $f(\mu)$ is the density function of μ. Let d be an indicator of a random draw from $f(\mu)$. Train (2003) described that the method of simulation can be applied to approximate the likelihood given in (5):[3]

(6) $$\text{LL}'_i \approx \frac{1}{D}\sum_{d=1}^{D} \text{LL}_i \,.$$

Taking the logarithm of (6) and summing over all individuals in the sample yields the overall simulated log-likelihood function of the RPBP model:

(7) $$\text{SLL} = \sum_{n=1}^{N} \ln\left[\frac{1}{D}\sum_{d=1}^{D} \text{LL}_i\right].$$

Lee (1992) showed that when the number of draws increases with the sample size, the simulated likelihood yields consistent estimates. Furthermore, when the number of draws is greater than the square root of the sample size, the estimator is consistent, efficient, and asymptotically normal. In order to achieve the desired properties of the simulated likelihood estimator, a large number of random draws ($d > 2{,}000$) should be used (e.g., Breffle and Morey, 2000). However, this requires a significant amount of computing effort. Sándor and Train (2002) advocated the use of quasi-random draws, known as the Halton sequence. It is demonstrated that

[3] In a binary choice situation, other methods can be used to evaluate the likelihood function, such as various quadrature methods. However, the simulation method is more general, and with the development of more efficient random sampling techniques (e.g., the Halton sequence), high asymptotic efficiency based on a large number of simulations can be achieved reasonably quickly.

a simulation with 100 draws from a Halton sequence is approximately as efficient as a draw of 1,000 from a computer random number generator, but with a speed 10 times faster than the equivalent random draws. In a Halton sequence, each draw is not completely random. Rather, it is related to the position of the previous draw through a predefined formula. The formula ensures the entire drawing space will be evenly covered with draws. Sándor and Train offer much more detail on this technique. In this study, we evaluate the simulated log-likelihood function in (7) with 120 draws[4] from a Halton sequence.

Conditional on the mean of μ, marginal effects of a vector of continuous variables on the choice probability can be obtained by taking the derivatives of the probability expression in (3) after fitting the RPBP model. For an average respondent, represented by the sample mean $\bar{\mathbf{X}}$, the marginal effects and associated variances are designated by:

(8) $$\frac{\partial P_Y}{\partial \mathbf{X}^{continuous}} \mid_{\bar{\mathbf{X}}} = f\left(\hat{\boldsymbol{\beta}}'\bar{\mathbf{X}}\right)\bar{\mathbf{X}}$$

and

(9) $$V\left[\frac{\partial P_Y}{\partial \mathbf{X}^{continuous}} \mid_{\bar{\mathbf{X}}}\right] = \left[f\left(\hat{\boldsymbol{\beta}}'\bar{\mathbf{X}}\right) + f'(\cdot)\bar{\mathbf{X}}'\hat{\boldsymbol{\beta}}\right] V\left[\hat{\boldsymbol{\beta}}\right] \left[f\left(\hat{\boldsymbol{\beta}}'\bar{\mathbf{X}}\right) + f'(\cdot)\bar{\mathbf{X}}'\hat{\boldsymbol{\beta}}\right]^{-1},$$

where $f(\hat{\boldsymbol{\beta}}'\bar{\mathbf{X}})$ is a $k \times k$ matrix, where k is the number of variables in $\mathbf{X}$ and $f'(\cdot)$ is the first-order derivative of a standard normal density function. The marginal effect of a dummy variable can be evaluated by taking the probability difference between situations when the effect represented by the dummy variable is present and absent (Anderson and Newell, 2003):

(10) $$\frac{\partial P_Y}{\partial \mathbf{X}^{dummy}} \mid_{\bar{\mathbf{X}}} \equiv \Phi\left(\hat{\boldsymbol{\beta}}^{dummy}\right).$$

Empirical Results

Table 4 gives the estimated coefficients of the three RPBP models under each information scenario.[5] The RPBP model estimation result for the situation when no information was given to respondents is also included in table 4. The likelihood-ratio test suggests all four models are significant. The model under no information has the best fit, with an adjusted McFadden's pseudo-R^2 of 0.2276.

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[4] Sándor and Train (2002) pointed out that numerical results based on different numbers of Halton draws (e.g., 100 and 120) can be slightly different with no obvious explanation. We compared our results based on 120 and 100 Halton draws, respectively, and found no significant differences in coefficient and standard error estimates.

[5] To test the validity of estimating separate models, a test for parameter equality was conducted using the approach suggested by Swait and Louviere (1993). A calculated χ^2 statistic suggests rejecting the null hypothesis that parameters are equal across models under different information scenarios.

Table 4. Estimated Coefficients of the RPBP Models

Variable	No Information	Generic Information	Health-Specific Information	Environment-Specific Information
Mean of Constant	2.636***	−4.222***	−4.178***	−3.356***
	(0.252)	(0.449)	(0.554)	(0.492)
Std. Dev. of Constant	0.050	0.391***	1.291***	0.363***
	(0.038)	(0.060)	(0.111)	(0.068)
ENV	−0.144	0.396**	−0.056	0.083
	(0.144)	(0.194)	(0.273)	(0.218)
HEALTH	−0.254***	0.274***	0.212***	0.093
	(0.040)	(0.049)	(0.071)	(0.058)
TRUST	−0.019	0.087**	0.166***	−0.047
	(0.028)	(0.037)	(0.048)	(0.037)
KNOW	0.188***	−0.116***	−0.761	−0.068
	(0.025)	(0.039)	(0.050)	(0.041)
IMPT	−0.303***	0.236***	0.106	0.102*
	(0.033)	(0.048)	(0.066)	(0.054)
MALE	0.134**	0.067	−0.149	−0.192*
	(0.064)	(0.092)	(0.126)	(0.105)
MARRI	−0.035	−0.064	0.346**	0.175
	(0.084)	(0.131)	(0.172)	(0.144)
INCOME	−3.133E-05*	−5.638E-07	−8.256E-05**	−2.486E-05
	(1.870E-05)	(2.442E-05)	(3.695E-05)	(2.898E-05)
AGE	−0.010***	0.013***	0.012*	0.014***
	(0.003)	(0.005)	(0.064)	(0.005)
EDU	−0.055***	0.098***	0.080***	0.107***
	(0.014)	(0.025)	(0.029)	(0.028)
N	671	491	491	491
Likelihood Ratio	232.6348	89.1496	21.988	30.1032
Pseudo-R^2	0.2276	0.1373	0.0242	0.0423

Notes: Single, double, and triple asterisks (*,**,***) denote statistical significance at the 10%, 5%, and 1% levels, respectively. Values in parentheses are standard errors.

Note that although all four pseudo-R^2 measures are relatively small, this is not uncommon in a binary choice model. A model with a pseudo-R^2 higher than 0.2 is often viewed as a good fit, equating to 0.7 in a linear model (Domencich and McFadden, 1975). The model estimated for consumers prior to the provision of any information showed remarkably consistent predictions, as expected. Specifically, respondents who were relatively more skeptical about the GM technique, as represented by those who believed GM is risky to human health, were less likely to purchase GM oil; consumers who were concerned about whether there are GM contents in a product were also less likely to purchase GM oil; older and better educated individuals were more reluctant to accept GM oil; but for male respondents and for those who had more GM-related knowledge, GM oil was more likely to be purchased.

Constant terms are strongly significant in all four models and negative in the three cases with additional information. The sign of these constants does not offer much information about the consumers because the constants represent the average impacts from all other factors that are not included in the models. The constants must be interpreted jointly with other estimated coefficients. All standard deviation estimates of the constant are significant except for the situation with no information. This verifies the preferred use of the random parameter version of the probit model; otherwise, these significant estimates may not be captured. As shown by this result, given a certain type of information, respondents did not have the same standard for evaluating how (un)attractive the GM product is. In other words, the sampled respondents are heterogeneous. The difference among respondents is significant under all three types of new information. It is also noticeable that under all three types of new information, the standard deviation is small relative to the mean. This suggests that although heterogeneities exist in respondents' evaluation of GM products within each new information context, the majority of the respondents behaved similarly. The difference among respondents' evaluations is reflected by how much (dis)utility may be brought to a particular respondent by choosing a GM product.

Table 5 reports the marginal effects of the explanatory variables on the probability of purchasing GM oil under four different information treatments. The marginal effects of dummy variables are relatively larger within all three types of information. This is because these marginal effects show the changes of probability between the presence and absence of the entire impact of a factor represented by its corresponding dummy variable, rather than a small change in its level. Except for the variables *ENV* (having environmental concerns), *MALE* (being male), and *MARRI* (being married), all other variables were treated as continuous, and their marginal effects and associated standard errors can be calculated through equations (8) and (9). Marginal effects of dummy variables were calculated using (10). Since the signs of the marginal effects are consistent with the parameter estimates, we interpret these results jointly. Also, because the standard errors of the coefficients were directly obtained by inversing the Hessian (rather than by the approximation method for marginal effects), we use the coefficient estimates to determine whether a variable has significant impact on the choice probabilities.

In Table 4, given the generic information that the final oil products do not contain traceable GM contents, if respondents had environmental concerns on the application of GM technology, their purchasing probabilities might be significantly increased (up to 65%, as indicated in Table 5). However, environment-sensitive respondents were not significantly more likely to purchase GM oil under the health-specific information compared with those who were not specifically concerned about the environment. Interestingly, for the same respondents who

Table 5. Marginal Effects of Explanatory Variables on Purchasing Probability

Variable	No Information	Generic Information	Health-Specific Information	Environment-Specific Information
ENV	0.477	0.654	0.478	0.532
	—	—	—	—
HEALTH	−0.101***	0.082***	0.032	0.023
	(0.016)	(0.0313)	(0.0266)	(0.0190)
TRUST	−0.008	0.026**	0.025	−0.012
	(0.011)	(0.0122)	(0.0182)	(0.0124)
KNOW	0.075***	−0.035**	−0.011	−0.017
	(0.010)	(0.0160)	(0.0114)	(0.0120)
IMPT	−0.121***	0.071***	0.016	0.025*
	(0.014)	(0.0255)	(0.0134)	(0.0151)
MALE	0.521	0.508	0.491	0.512
	—	—	—	—
MARRI	0.494	0.493	0.521	0.518
	—	—	—	—
INCOME	−1.247E-05*	−1.693E-07	−1.231E-05	−6.203E-06
	(7.412E-06)	(7.316E-06)	(9.908E-06)	(7.165E-06)
AGE	−4.003E-03***	3.933E-03***	1.741E-03	3.581E-03**
	(1.409E-03)	(1.466E-03)	(1.287E-03)	(1.771E-03)
EDU	−0.022***	0.029***	0.012*	0.027***
	(5.658E-03)	(6.165E-03)	(7.000E-03)	(8.075E-03)

Notes: Single, double, and triple asterisks (*,**,***) denote statistical significance at the 10%, 5%, and 1% levels, respectively. Values in parentheses are standard errors and are calculated by the delta method.

had environmental concerns, when environment-specific information was provided to relieve their concerns, their purchasing probabilities still remained the same despite their concerns. For respondents who believed that GM food is risky to human health, when this concern is raised one level up from the current level, consumers would have 8% higher purchasing probability for GM oil when given generic information. When notified that the GM oil is "healthier" than the non-GM alternative, these health-sensitive respondents also would be likely to increase their purchasing intentions but with less margin (3% for one level up). In contrast, environment-related information did not significantly change these respondents' purchasing probabilities.

Compared to respondents who had little trust in the government's food labeling and regulation system, those who had faith in the government were more likely to be convinced to purchase GM oil when the generic or the health-specific information was given, but not under the environment-specific information scenario. For one level higher trust in the government, consumers would be approximately 2.5% more likely to purchase GM oil under either the generic or health-specific information scenarios. Respondents who had relatively more knowledge about

GM technology in oil production significantly lowered their purchasing intentions for GM oil when the generic information was given, but not under either of the other two types of specific information. Corresponding to one additional knowledge question answered correctly, respondents would be 3.5% less likely to purchase a GM product under the generic information treatment.

The finding that more knowledge will decrease purchasing probabilities when new information is given may be explained by the attribution theory (Mizerski, 1982): the persuading power of a piece of information depends on both its volume and credibility. Educated respondents in terms of GM-related knowledge may be more likely to judge the credibility of the information according to their own standard. If the information provided is not being perceived as completely factual, then that information may be discounted and even counter-effective in their purchasing decisions (Roe et al., 2001). Note that respondents will judge the trustworthiness of the information based on their own standard, but not according to whether the information is actually true or not. In this sense, knowledgeable respondents in the sample might feel that the generic information was the most counterintuitive to their beliefs and therefore react against accepting the product (Lusk et al., 2003).

The last attitudinal variable (*IMPT*) is how important respondents think the GM attribute is in their purchasing decision. Under the generic information ensuring the absence of detectable GM contents in the final product, respondents significantly leaned toward buying GM oil compared with those who did not care very much about the GM attribute. For a one-level increase in the importance rating, respondents would be 7% more likely to purchase GM oil when this generic information is provided. This difference is not significant under the health-specific information treatment, and only marginally significant under the environment-specific information treatment.

The impact of gender was not shown to be strongly significant under any of the information scenarios. Married respondents had a significantly greater tendency (52% according to table 5) to purchase GM oil compared to unmarried respondents when they were told that GM oil may contain more nutritious substances under the health-specific information. The impact of household income was also only significantly different from zero when no information was given: for a 1,000 yuan increase in annual income, respondents would be about 1% less likely to purchase GM oil when no information was provided. With the exception that age was not significant under the health-specific information treatment, the impacts of age and education were both positive and significant under all information scenarios. We can conclude that within the situations studied here, older respondents with higher education levels were more likely to accept GM oil when new information was given to them for clarifying the usage of GM canola seeds. For each 10 years increase in age, respondents would be approximately 4% more likely to consume GM oil under generic or environment-specific information. For each additional year increase in education level, the respondents would be 3%, 1%, and 3% more likely to purchase GM oil under the three respective information treatments.

Conclusions and Managerial Implications

Since GM ingredients present a credence attribute to consumers, product labeling becomes a crucial tool in resetting the asymmetric information between producers and consumers. However, a plain label noting the presence or absence of GM ingredients may not provide enough information for consumers. This study compares the effects on consumer choices of GM canola oil from three types of information that may be provided in addition to a GM label.

First, in order to obtain a baseline understanding of Chinese consumers' purchasing intentions for GM canola oil, consumer choices for GM canola oil are studied before any additional information on GM. Previous literature has reported different overall opinions on GM food from Chinese consumers compared to other countries in the world. Attitudes toward GM techniques range from the most unfavorable in Europe (Anderson, Wachenheim, and Lesch, 2006) to less critical in North America (Hu et al., 2004), and even to positive in China (Lin et al., 2006). Despite these differences in overall attitude, our study found that factors determining individual Chinese consumers' purchasing intentions are consistent with other studies.

For the three types of additional information, the first is generic—i.e., it simply notes the absence of GM contents/particles in a product. The other two information types are aimed at certain specific implications of GM technology—i.e., human health and the environment. A random parameter version of the binary probit model was used to analyze these effects. Results strongly support the use of such a model. Significant heterogeneities among consumers' purchasing decisions for GM oil were observed under each information scenario. Results also suggest these types of information have varying impacts on different consumers, depending on their attitudes and demographic characteristics. For consumers who initially did not wish to purchase GM oil, the generic information achieved the best result in converting the respondents to buyers. To qualify for different claims, such as the three types of information in this study, products generally must be subject to certain inspections. The inspection and labeling administration costs associated with different types of claims can be diverse. Our analysis identifies the potential benefits these claims may bring to the sellers in terms of increased sales, laying the groundwork for a cost-benefit analysis for producers and retailers who want to use additional information/claims to increase sales of canola oil using GM oilseeds.

Specifically, the generic information is most helpful in increasing purchasing probabilities for consumers who had environmental and health concerns, who trusted the government's food labeling and regulation system, who viewed GM contents as an important attribute, and who were older and had received more education. The health-specific information is most effective for increasing purchasing probabilities of consumers who were concerned about health, who trusted the government's labeling and regulation system, and who were married, older, and had more education. For the environment-specific information, consumers who valued the GM attribute appreciably and who were older, with more education, were more likely to be persuaded to purchase. Consumers' GM knowledge level, income, and gender (males in this case) had negative impacts on their purchasing intentions under the generic, health-specific, and environment-specific information scenarios, respectively.

The comparison across the impacts of the three types of information based on consumer profiles has potential important implications for both food producers and policy makers. For example, although consumers with concerns about the environmental impacts of GM foods may prefer not to purchase GM oil, they also comprise the group of individuals who are relatively easy to persuade via generic information telling them that no actual GM contents can be found in the product. If adequate consumer analysis identifies such a group, marketers and policy makers may develop a generic information strategy that best fits the interest of these consumers. Consumers who are older and who have relatively more education are more likely to increase their purchasing probabilities given any type of the three pieces of information in the survey. This finding suggests that under each information context, the potential GM oil market can be segmented according to consumers' purchasing intentions based on their demographic characteristics. Usually such information may be available through exploratory consumer studies initiated by a retailer. If producers or the government plan to initiate an information campaign, knowing the market segment structure may be helpful in better targeting the campaign. Based on our study results, GM food producers should be cautioned that although consumers' general attitudes toward GM food may be consistent over countries and product categories, how specific information interacts with consumers may not be known prior to a market analysis.

Finally, there are possible extensions for further research. We name only a few below. First, price was not included in the current study. Including product prices in the survey may facilitate the knowledge of consumers' willingness to trade concerns for the GM attribute with price and possibly even the WTP for different types of information. Second, the three types of information were offered sequentially to each individual in the survey. This method helped to control the within-subject variation and reduce the size of the sample required for statistical analysis. However, varying types of information may also be given to different respondents to allow for the treatment effect. This approach can be integrated with a spatial analysis of the impact of information since, in reality, different information may likely exist across different countries or regions. Third, the survey provided information only to respondents who refused to purchase GM oil in the initial query. Different information may have alternative impacts on GM product buyers as well. This effect cannot be examined based on the current data format, but future studies might incorporate this information. Fourth, the survey used in this study was conducted several years ago. Chinese consumers' attitudes toward and knowledge about GM food may have changed. Thus it would be useful to carry out a follow-up study.

References

Akerlof, G. (1970) "The market for 'lemons': Qualitative uncertainty and the market mechanism." *Quarterly Journal of Economics* 84, 488–500.

Anderson, J. C., C. J. Wachenheim, and W. C. Lesch. (2006). "Perceptions of genetically modified and organic foods and processes." *AgBioForum* 9, 180–194.

Anderson, S., and R. G. Newell. (2003). "Simplified marginal effects in discrete choice models." *Economic Letters* 81, 321–326.

Antle, J. M. (2001). "Economic analysis of food safety." In B. L. Gardner and G. C. Rausser (eds.), *Handbook of Agricultural Economics* (pp. 1083–1136). Amsterdam: North-Holland Publishing Co.

Beijing Statistical Yearbook. (2003). Beijing: China Statistics Press.

Bettman, J. R. (1979). *An Information Processing Theory of Consumer Choice.* Reading, MA: Addison-Wesley.

Breffle, S. W., and E. R. Morey. (2000). "Investigating preference heterogeneity in a repeated discrete choice recreation demand model of Atlantic salmon fishing." *Marine Resource Economics* 15, 1–20.

Brookes, G., and P. Barfoot. (2006). "Global impact of biotech crops: Socio-economic and environmental effects in the first ten years of commercial use." *AgBioForum* 9, 139–151.

Cameron, T. A. (1988). "A new paradigm for valuing non-market goods using referendum data: Maximum likelihood estimation by censored logistic regression." *Journal of Environmental Economics and Management* 15, 355–379.

Crespi, J., and S. Marette. (2003). "'Does contain' vs. 'does not contain': Does it matter which GMO label is used?" *European Journal of Law and Economics* 16, 327–344.

Curtis, K. R., J. J. McCluskey, and T. I. Wahl. (2004). "Consumer acceptance of genetically modified food products in the developing world." *AgBioForum* 7, 70–75.

Darby, M., and E. Karni. (1973). "Free competition and the optimal amount of fraud." *Journal of Law and Economics* 16, 67–88.

Domencich, T., and D. McFadden. (1975). *Urban Travel Demand: A Behavioral Approach.* Amsterdam: North-Holland.

Frewer, L. J. (2003). "Societal issues and public attitudes toward genetically modified foods." *Trends in Food Science and Technology* 14, 319–332.

Haener, M. K., and W. L. Adamowicz. (1998). "Analysis of 'don't know' responses to referendum contingent valuation questions." *Agricultural and Resource Economics Review* 29, 219–230.

Howard, J. A. (1977). *Consumer Behavior: An Application of Theory*. New York: McGraw-Hill.

Hu, W., W. L. Adamowicz, and M. M. Veeman. (2006). "Labeling context and reference point effects in models of food attribute demand." *American Journal of Agricultural Economics* 88, 1034–1049.

Hu, W., and K. Chen. (2004). "Can Chinese consumers be persuaded? The case of genetically modified vegetable oil." *AgBioForum* 7, 124–132.

Hu, W., A. Hünnemeyer, M. Veeman, and W. L. Adamowicz. (2004). "Trading off health, environmental, and genetic modification attributes in food." *European Review of Agricultural Economics* 31, 389–408.

Huffman, W., M. Rousu, J. Shogren, and A. Tegene. (2004). "Consumers' resistance to genetically modified foods: The role of information in an uncertain environment." *Journal of Agricultural and Food Industrial Organization* 2, 1–13.

———. (2007). "The effects of prior beliefs and learning on consumers' acceptance of genetically modified foods." *Journal of Economic Behavior and Organization* 63, 193–206.

Knight, A. J. (2006). "Does application matter? An examination of public perception of agricultural biotechnology applications." *AgBioForum* 9, 121–128.

Lee, L. (1992). "On the efficiency of methods of simulated moments and simulated likelihood estimation of discrete choice models." *Econometric Theory* 8, 518–552.

Li, Q., K. R. Curtis, J. J. McCluskey, and T. I. Wahl. (2002). "Consumer attitude toward genetically modified foods in Beijing, China." *AgBioForum* 5, 145–152.

Lin, W., A. Somwaru, F. Tuan, J. Huang, and J. Bai. (2006). "Consumers' willingness to pay for biotech foods in China: A contingent valuation approach." *AgBioForum* 9, 166–179.

Lusk, J. L., L. O. House, C. Valli, S. R. Jaeger, M. Moore, B. Morrow, and W. B. Traill. (2003). "Effect of information about benefits of biotechnology on consumer acceptance of genetically modified food: Evidence from experimental auctions in the United States, England, and France." *European Review of Agricultural Economics* 31(2), 179–204.

Lusk, J. L., M. Jamal, L. Kurlander, M. Roucan, and L. Taulman. (2005). "A meta analysis of genetically modified food valuation studies." *Journal of Agricultural and Resource Economics* 30(1), 28–44.

McFadden, D. (1974). "Conditional logit analysis of qualitative choice behavior." In P. Zarembka (ed.), *Frontiers in Econometrics* (pp. 105–142). New York: Academic Press.

———. (2001). "Economic choices." *The American Economic Review* 91(3), 351–378.

Mizerski, R. W. (1982). "An attribution explanation of the disproportionate influence of unfavorable information." *Journal of Consumer Research* 9, 301–310.

Noussair, C., S. Robin, and B. Ruffieux. (2004). "Do consumers really refuse to buy genetically modified food?" *The Economic Journal* 114, 102–120.

Poortinga, W., and N. F. Pidgeon. (2006). "Exploring the structure of attitudes toward genetically modified food." *Risk Analysis* 26, 1707–1719.

Roe, B., M. Teisl, H. Rong, and A. S. Levy. (2001). "Characteristics of consumer-preferred labeling policies: Experimental evidence from price and environmental disclosure for deregulated electricity services." *Journal of Consumer Affairs* 35(1), 1–26.

Rousu, M., W. Huffman, J. Shogren, and A. Tegene. (2007). "Effects and value of verifiable information in a controversial market: Evidence from lab auctions of genetically modified food." *Economic Inquiry* 45, 409–432.

Sándor, Z., and K. Train. (2002). "Quasi-random simulation of discrete choice models." Working paper, Department of Economics, University of California, Berkeley.

Scholderer, J., and L. J. Frewer. (2003). "The biotechnology communication paradox: Experimental evidence and the need for a new strategy." *Journal of Consumer Policy* 26, 125–157.

Severin, V., J. J. Louviere, and A. Finn. (2001). "The stability of retail shopping choices over time and across countries." *Journal of Retailing* 77, 185–202.

Swait, J., and J. J. Louviere. (1993). "The role of the scale parameter in the estimation and use of multinomial logit models." *Journal of Marketing Research* 30, 305–314.

Traill, W. B., W. M. S. Yee, J. L. Lusk, S. R. Jeager, L. O. House, B. Morrow, C. Valli, and M. Moore. (2006). "Perceptions of the Risks and Benefits of Genetically Modified Foods and Their Influence on Willingness to Consume." *Food Economics* 3, 12–19.

Train, K. (1999). "Halton sequences for mixed logit." Working paper, Department of Economics, University of California, Berkeley.

———. (2003). *Discrete Choice Methods with Simulation.* London/New York: Cambridge University Press.

U.S. Department of Agriculture, Foreign Agricultural Service. (2007, March). "Oilseeds: World markets and trade." Circular Series No. FOP 3-07, USDA/FAS, Washington, DC.

Appendix:
Purchasing Questions Used in Survey

Imagine you are shopping for groceries for your family and you have come across two bottles of canola oil. These two bottles of oil are identical in every respect (such as price, packaging, brand name, expiration date, etc.) except that one bottle may have used genetically modified oilseeds. Are you willing to purchase the bottle that may have used genetically modified oilseeds?

❍ Yes [*go to next section*] ❍ No [*continue to next question*] ❍ Don't Know

The order of the following questions in the actual survey was randomized.

For the same bottle of canola oil which may have used genetically modified oilseeds, are you willing to purchase it if you know that no actual GM protein can be scientifically detected in the final oil made from genetically modified oilseeds?

❍ Yes ❍ No ❍ Don't Know

For the same bottle of canola oil which may have used genetically modified oilseeds, are you willing to purchase it if you know that oil made from genetically modified oilseeds is more nutritious?

❍ Yes ❍ No ❍ Don't Know

For the same bottle of canola oil which may have used genetically modified oilseeds, are you willing to purchase it if you know that oil made from genetically modified oilseeds may reduce pesticide usage and therefore help protect the environment?

❍ Yes ❍ No ❍ Don't Know