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Willingness to Pay for Genetically Modified Oil, Cornflakes, and Salmon: Evidence from a U.S. Telephone Survey

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This paper reports results from a U.S. national telephone survey on genetically modified foods (vegetable oil, cornflakes, and salmon). The survey featured a contingent valuation in which respondents chose between the GM and non-GM alternatives with an option of indifference. The binomial and multinomial logit models yielded estimated willingness to pay (WTP) to avoid the GM alternatives. Respondents were willing to pay 20.9%, 14.8%, 28.4%, and 29.7% of the base prices to avoid GM vegetable oil, GM cornflakes, GM-fed salmon, and GM salmon, respectively. The inclusion of indifference option could increase the sample size and moderate the mean WTP.

Key Words: contingent valuation, GMO, multinomial logit model, telephone survey, willingness to pay

JEL Classifications: Q0, D1

Genetically modified organisms (GMOs) were introduced to the market as highly promising and beneficial products for both farmers and consumers. The adoption by U.S. farmers has been phenomenal, but the GMOs have not been embraced in some U.S. export markets, particularly the European Union (EU). The EU put a *de facto* moratorium on approval of GMOs since 1998. This became a trade dispute between the United States and the EU, and the EU justified its policy on the basis of precautionary principle, which was endorsed by the strong opposition toward GMOs among European consumers. It is estimated that U.S. exporters lost a product market worth $300 million per year (Pew 2003b). Although U.S. consumers have been neutral on the issue of GMOs, there is some indication that U.S. consumers are becoming somewhat opposed, or may become so in the future (Gaskell et al.; Pew 2001; Priest). Thus, it is important to understand U.S. consumers' acceptance of genetically modified (GM) foods because failure to do so would be vastly expensive for the stakeholders, particularly producers, the biotechnology industry, and policy makers.

Despite the growing interest in agricultural biotechnology and the rapid accumulation of opinion polls (Hoban; Hossain et al.; IFIC; Moon and Balasubramanian 2001; Pew 2001; Priest; Shanahan, Scheufele, and Lee), there has been a limited supply of economic valuation studies about GM foods, especially those

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estimating consumers' willingness to pay (WTP) for GM or non-GM foods. Huffman et al.; Li, McCluskey, and Wahl; Lusk, Roosen, and Fox; and Moon and Balasubramanian (2003) deal with American consumers' willingness to pay a premium for non-GM food or willingness to accept a discount on GM food, but Huffman et al. and Li, McClusky, and Wahl used regionally restricted samples of consumers. One of the benefits of survey research is its generalizability, which is better realized if the respondents are randomly sampled from a wider geographic area.

Another problem is the choice of welfare measure. Moon and Balasubramanian (2003) used a willingness to pay a premium on the non-GM food while Li, McCluskey, and Wahl used a willingness to accept a discount on the GM food. It is commonly observed in the valuation literature that the WTP and willingness to accept (WTA) differ in practice. Rather than taking either the WTP or WTA, we take a different approach in designing a contingent valuation survey: namely, the respondent is free to choose the non-GM or GM alternative without implied entitlement to consuming either. By adopting this design, we aim at extending the literature on the valuation of GM food by providing another mechanism for valuation.

The objective of this paper is to determine how American consumers' WTP for non-GM foods is influenced by their demographic and cognitive variables. We estimate consumers' willingness to pay a premium to avoid the GM alternative for vegetable oil made of soybeans, cornflakes, and salmon (non-GM salmon versus salmon fed with GM feed or salmon that is genetically modified). We then compare these estimates to examine if non-GM premiums are product specific. We also compare our estimates of non-GM premiums to other similar studies. Our results indicate that American consumers' WTP is influenced by cognitive variables and that demographic variables are not as influential as cognitive variables. The paper proceeds with a review of previous contingent valuation studies conducted on the subject of consumer preference on food safety and agricultural biotechnology. We then describe the contingent valuation survey and estimate non-GM premiums for alternative products. The paper concludes with a discussion of our findings.

Contingent Valuation Method

Contingent valuation (CV) has been widely used to evaluate food safety attributes (Buzby, Skees, and Ready; Eom; Huang, Kan, and Fu). This is because food safety attributes are embodied in the food products and not sold separately in the open market; the researchers need to collect primary data because market-level data are usually nonexistent. The CV method is flexible enough to accommodate researchers' diverse needs, and, in many instances, it is the only feasible method to elicit consumers' true WTP (Mitchell and Carson). The application of the CV technique has spread to the more general area of demand for food quality (Halbrendt et al.; Loureiro, McCluskey, and Mittelhammer). Recently, researchers have paid considerable attention to consumer acceptance of GM foods (Boccaletti and Moro; Grimsrud et al.; Li, McCluskey, and Wahl; Li et al.; McCluskey et al.; Moon and Balasubramanian 2003).

The dichotomous choice (DC) format has been used extensively by the CV researchers. The DC format provides the respondents with some threshold value and asks them if they are willing to pay that amount. The task of answering a yes–no question is similar to consumers' purchasing decision in the market, and it is expected that more reliable information is elicited with this format. The key characteristic is that the respondent makes a qualitative decision instead of a presumably more difficult quantitative decision as in the open-ended format (i.e., determining the price for a commodity).

There is an issue of how to pose a valuation question in the DC format. For instance, Moon and Balasubramanian (2003) asked the respondents if they were willing to pay a specified premium for the non-GM cornflake cereal. The answer "no" implied that the respondents were not willing to pay a premium, and therefore did not mind consuming the GM alternative, which was the implied status quo.

Table 1. Survey Design and Sample Distribution of Discounted Prices for GM or Non-GM Product

Item	Base[a]	5% off	10% off	20% off	30% off	50% off
Vegetable Oil (32 oz)	$1.90	$1.80	$1.70	$1.50	$1.30	$1.00
Cornflakes (18 oz)	$4.00	$3.80	$3.60	$3.20	$2.80	$2.00
Salmon (lb)	$6.00	$5.70	$5.40	$4.80	$4.20	$3.00
% of Sample	100	10	25	30	25	10

[a] Used for the initial questions in the contingent valuation survey.

On the other hand, Grimsrud et al.; Li, McCluskey, and Wahl; and McCluskey et al. asked the respondents if they were willing to accept the GM alternative, which implied the status quo was the non-GM alternative. It is not clear how much this difference in question wording affects the elicited contingent values, but it is known that WTP and WTA differ in many practical situations. Although Huffman et al. did not use the CV method, they took a different approach by choosing not to give the experimental subjects a product endowment. They asked the subjects to separately submit a bid for each of the two alternative products with different labels rather than a bid for exchanging one with the other. We took a similar approach in our design of contingent valuation; namely, the respondents were offered an opportunity to choose either the GM or non-GM alternatives at given prices instead of taking or leaving an offer of switching from an implied status quo to the other alternative.

Although the DC format is expected to collect more reliable responses, it is notoriously inefficient because the information obtained from a single yes–no response is quite limited: the researcher knows only whether the respondent's WTP for the proposed policy is greater or smaller than the threshold (Haab and McConnell). To mitigate this inefficiency without incurring the cost of increasing the sample size, one can pose another yes–no question with different threshold values after the initial yes–no question: If the initial response is yes (no), the respondent will be asked another yes–no question with a higher (lower) threshold value. Hanemann, Loomis, and Kanninen showed that the above "double-bounded" format would improve the precision on the welfare measure, but critics pointed out the inconsistency problem: that is, the respondent's willingness-to-pay function may not be identical between the initial and follow-up CV questions (Cameron and Quiggin; Herriges and Shogren). Several alternative explanations for the inconsistency have been proposed to defend the double-bounded format (Bateman et al.). Even though the double-bounded format is not impeccable, it still retains attractive features. Alberini showed that the format was robust for estimating the mean or median of the welfare measure, and Hanemann and Kanninen suggested that the gain in efficiency outweighed the potential incentive problems involved in providing a higher or lower threshold value in the follow-up question. We therefore decided to use a follow-up question.

The contingent valuation question proceeded as follows. First, respondents were asked to choose either the non-GM or GM alternative at the current market price ("base" price in Table 1).[1] The two alternative products were exactly the same except that the former contained at most 3% of GM ingredients while the latter had more than 90% of GM content.[2]

[1] We observed prices of the selected food items at several locations of supermarkets and specialty stores in Columbus, Ohio in October, 2001, to determine "market" prices.

[2] We conducted focus groups to pretest the questionnaire. The participants felt strongly that because the non-GM foods may contain some GM ingredients their answers to the contingent valuation questions in the survey were affected.

The respondents could choose either the non-GM or GM alternative, indicate indifference, or choose neither the non-GM nor GM alternative (see Appendix A for exact wording). The indifference option is somewhat unusual in this type of question. However, we included that option for two reasons. First, if the GM status is truly irrelevant to the respondent, then the two products are the same and indifference is a natural choice. Second, if the respondent is truly indifferent and yet forced to choose one of the two products, then he or she may simply say "don't know." A "don't know" answer does not provide useful information, and researchers usually omit respondents with "don't know" answers.[3] By admitting indifference, we could increase the number of observations.

The follow-up question was contingent upon the answer to the first question. If the respondent chose the non-GM alternative, then the price of the GM alternative would be reduced by 5%, 10%, 20%, 30%, or 50% randomly. We explicitly allowed the GM food to be superior to its non-GM counterpart. This feature distinguishes our survey from most other surveys in the literature.[4] If the GM was chosen instead, the non-GM price would be reduced similarly. When the respondents were indifferent between the two alternatives, then they randomly received either (1) a discount on the GM alternative or (2) a discount on the non-GM alternative, and were asked whether they were still indifferent or whether they would choose the cheaper alternative. If they were indifferent again, then we excluded them entirely from the analysis because they were insensitive to price incentives. The bottom row of Table 1 shows the percentages of the subsamples that were given various price discounts.

The CV design reflected the hypothesis that most consumers would change their choice when they faced substantial price discounts. The follow-up question provided the respondents with an opportunity to change their choices, given a price discount. However, some respondents may choose the non-GM alternative no matter how much the price is discounted on the GM alternative. This type of behavior could be a result of the respondent's underlying preference or simply a protest for being forced to consider the GM alternative as a choice. It is generally impossible to separate these two cases once the data have been collected, so we added an option of "neither" in the initial CV question in the hope of separating protesters from optimizers. A "neither" option was followed by a question of why "neither" had been chosen (more on this later).

Survey

The questionnaire consisted of three major components. The first sought to find respondents' knowledge, attitude, and perception with regard to GMOs and GM foods in general, and their preference on the type of GMO regulation. The second consisted of a series of CV questions involving vegetable oil, cornflakes, and salmon. The third was concerned with the demographic and income information of the respondents. In telephone interviews, the interviewer began with warm-up questions about the purchases of fast food and organic foods as well as recycling of paper, cans, or bottles. Then the interviewer introduced and defined the GM foods in layman's terms. Before getting into the questions related to information and knowledge about GMOs and GM foods, the interviewer told the respondents about three pros and three cons of genetic engineering and GMOs (see Appendix

[3] There was an attempt to incorporate the "don't know" responses into econometric analysis, however. Wang used the ordered response framework to incorporate the "don't know" responses into the analysis as the middle ground between the yes and no responses. We assume that the utility function is nonrandom on the part of the respondents, so we do not use the above framework.

[4] McCluskey et al. used a similar question to ours. Their question asked the respondents if they would like to purchase the GM alternative at the same price (not specified) as the non-GM alternative. The follow-up question was the same except that there was a discount on the GM alternative. The difference between their design and ours is that we let the respondents choose between the GM and non-GM alternatives rather than ask if they would accept the GM alternative at a discount.

B). The purpose of this introduction was to provide sufficient and yet impartial information on the subject matter in case the respondent had absolutely no knowledge of GMOs (a copy of the questionnaire is available upon request).

The CV part presented three food products. Huffman et al. recommended that the valuation exercise include several products in order to separate the dislike of the product from the dislike of the GM attribute. Vegetable oil (made mainly of soybeans) and cornflakes were chosen because soybeans and corn are the largest food crops for which GM varieties are widely cultivated in the United States. Salmon was included because of its relative popularity among Americans and its unique way of accommodating GM characteristics. Most salmon sold at supermarkets in the United States are farmed salmon, grown with feed derived from soybeans. If the soybeans are of GM variety, then the farmed salmon are technically considered of GM variety. These salmon are called GM-fed salmon. It is not the case that the genes of the salmon itself are altered with genetic engineering. Gene-altered salmon actually exist although they have not been approved for human consumption: We refer to these gene-altered salmon as GM salmon.[5] These salmon are so altered that they will grow faster than nonaltered salmon. Thus, the main difference between GM-fed and GM salmon is that the former involves alteration of plant genes only while the latter involves that of both plant and animal genes. It is interesting to observe how consumers respond to the difference in the degree of genetic modification.

There were four versions of the questionnaire. The first and second versions involved only vegetable oil and cornflakes. The only difference between the two was the order in which vegetable oil and cornflakes were presented. The third version involved vegetable oil and salmon, and the last version involved cornflakes and salmon. All CV questions were paired choices between the GM and non-GM alternatives. For salmon, there were two cases: (1) the non-GM and GM-fed salmon and (2) the non-GM and GM salmon. The number of each questionnaire was prespecified, and each version was distributed randomly among the respondents.

The telephone survey was administered in April 2002 with the random-digit dialing method. The total of 256 food shoppers of 18 years of age or older completed substantial portions of the questionnaire, with an effective response rate of 28.7% and a cooperation rate of 80.6%.[6] These respondents were drawn from 48 states (excluding Alaska and Hawaii). On average, it took 18 minutes to complete the telephone interview.[7]

Table 2 lists the definition of the variables used for econometric analysis, and Table 3 presents the means and standard deviations of the key variables. Note that the sample size and hence, descriptive statistics differed from product to product because of the split-sample design.[8] For comparison, data from Census 2000 (U.S. Census Bureau) are also provided. Because the targeted population (food shoppers of age 18 or older) was only a subset of the population for the census, there did not need to be an exact correspondence between the census and our sample. For example, the sample was overrepresented by women because grocery shopping is mainly done by a female member in most households. About 14% to 18% of the respondents were at least

[5] Gene-altered fish attract much attention these days because they are the most likely candidates of genetically modified animals to first hit the open market (Pew 2003a).

[6] This response rate is the most conservative measure of disposition of the survey according to the standard definition by the American Association of Public Opinion Research. Basically, every number of unknown eligibility is treated as eligible. On the other hand, the cooperation rate counts only those households in which the eligible respondent could be contacted.

[7] We kept the questionnaire to a minimum length to avoid respondents' fatigue. Even so, the cost per completed telephone interview was about $35, which is more expensive than a typical administration cost per person of a mail survey. Our relatively small sample was due to the limited budget for the survey.

[8] The sample sizes became smaller after eliminating those respondents who gave inconsistent responses or whose responses were missing.

Table 2. Variable Definition and Coding

Variable Name	Definition and Coding
Dependent Variable	
Y (binomial)	1 if GM is chosen; 0 if non-GM is chosen. (For vegetable oil and cornflakes.)
Y (multinomial)	1 if non-GM salmon is chosen (dropped): 2 if GM-fed salmon is chosen; 3 if GM salmon is chosen.
Behavioral Intention	(first question, given the same price)
NG	1 if non-GM is chosen initially; 0 otherwise.
GM	1 if GM (GM-fed or GM, for salmon) is chosen initially; 0 otherwise.
IND	1 if non-GM and GM are equally good initially; 0 otherwise.
Information and Knowledge	
INFO	1 if very well/somewhat informed about GMOs or GM foods; 0 otherwise.
TF	1 if one answered correctly to both of the two true or false questions: i) Nongenetically modified soybeans do not contain genes while genetically modified soybeans do; and ii) By eating genetically modified foods, a person's genes could be altered; 0 otherwise.
Attitude and Perception	
GOV	1 if the government's regulatory performance is excellent or good; 0 otherwise.
RP	1 if one thinks GM food is extremely or somewhat risky to human health; 0 otherwise.
Demographic	
AGE	Age of respondent as of 2002
FEMALE	1 if female; 0 if male.
EDU	1 if respondent achieves a bachelor's degree or more; 0 otherwise.
LINC	The natural logarithm of the midpoint of income cohorts.
WEST	1 if respondent is from West; 0 otherwise.
MIDWEST	1 if respondent is from Midwest; 0 otherwise.
NORTHEAST	1 if respondent is from Northeast; 0 otherwise.
SOUTH (dropped)	1 if respondent is from South; 0 otherwise.
KIDS	1 if respondent is living with children of age 17 or younger; 0 otherwise.
Price	
PRICE	Price of alternative product.
Survey Versions	
VER1 (for cornflakes)	1 if version 1 (vegetable oil then cornflakes); 0 otherwise.
VER2 (for vegetable oil)	1 if version 2 (cornflakes then vegetable oil); 0 otherwise.
VER3 (for salmon)	1 if version 3 (vegetable oil then salmon); 0 otherwise.
VER4 (never used)	1 if version 4 (cornflakes then salmon); 0 otherwise.

somewhat informed about GMOs and GM foods (The range was due to different samples for different products as shown in Table 3.) The self-reported (i.e., subjective) knowledge (measured by INFO) was quite low, but the level of objective knowledge (measured by TF) was not nearly as low. This disparity indicates that American consumers are conservative when they report their knowledge of GMOs. About 42% to 53% of the respondents said GM foods were risky to human health. These percentages were much lower than those provided by European and Japanese consumers (Chern et al.), which suggests that U.S. consumers do not hold negative views on GM foods. This is also confirmed by the high level

Table 3. Descriptive Statistics

Item	Census 2000[a]	Vegetable Oil		Cornflakes		Salmon	
		Mean	SD	Mean	SD	Mean	SD
NG		0.505	0.503	0.416	0.496	0.526	0.502
GM		0.077	0.268	0.135	0.343	0.035	0.185
IND		0.418	0.496	0.449	0.500	0.439	0.498
INFO		0.143	0.352	0.146	0.355	0.184	0.389
TF		0.451	0.500	0.416	0.496	0.412	0.494
GOV		0.604	0.492	0.596	0.494	0.518	0.502
RP		0.527	0.502	0.449	0.500	0.421	0.496
AGE	35.3*	42.692	13.610	49.921	14.784	46.491	15.608
FEMALE	0.491	0.692	0.464	0.809	0.395	0.763	0.427
EDU	0.244	0.516	0.502	0.438	0.499	0.474	0.502
LINC	0.699*	11.183	1.575	11.485	1.572	11.259	1.479
WEST	0.225	0.198	0.401	0.202	0.404	0.246	0.432
MIDWEST	0.229	0.209	0.409	0.258	0.440	0.237	0.427
NORTHEAST	0.190	0.220	0.416	0.169	0.376	0.184	0.389
SOUTH	0.356	0.374	0.486	0.371	0.486	0.333	0.473
KIDS	0.328	0.440	0.499	0.348	0.479	0.447	0.499
VER1		0.319	0.469	0.258	0.440		
VER2		0.242	0.431	0.180	0.386		
VER3		0.440	0.499			0.447	0.499
VER4				0.562	0.499	0.553	0.499
N[c]		91		89		114	

Sources: U.S. Census Bureau, Census 2000 and primary survey data.
[a] The symbol * indicates a median.
[b] Blanks indicate data not available or applicable.
[c] N is the number of respondents in the sample.

of confidence in the government (about 52% to 60%).

Model

The basic framework for analysis was provided by the random utility model (Haab and McConnell). Let U_{ij} denote consumer i's utility from choosing alternative j. Then, consumer i chooses alternative j if $U_{ij} > U_{ik}$ for all $k \neq j$. It is standard to assume that $U_{ij} = V_{ij} + \varepsilon_{ij}$, where V_{ij} is the deterministic component of the utility, and ε_{ij} is the random component that represents the researcher's ignorance about the consumer's utility function.

For soybeans and corn, the appropriate model was the binary logit model because the choice was between the GM and non-GM alternatives. For salmon, the choice was between non-GM and GM-fed salmon and between non-GM and GM salmon, which was better handled by a multinomial model although any choice was binomial. To make the model operational, we assumed that the random components ε_{ij} were independently and identically distributed as type I extreme value distribution. Then, the model for the choice of salmon was given by

$$(1) \quad \Pr(Y_i = j) = \frac{e^{V_{ij}}}{\sum_{k=1}^{3} e^{V_{ik}}},$$

where respondent i's observed choice (Y_i) took the value 1 (non-GM), 2 (GM-fed), and 3 (GM). The log-likelihood function for the multinomial logit model was then given by

$$(2) \quad \ln L = \sum_{i=1}^{n} \sum_{j=1}^{3} d_{ij} \ln \frac{e^{V_{ij}}}{\sum_{k=1}^{3} e^{V_{ik}}},$$

where $d_{ij} = 1$ if individual i chose alternative j, $d_{ij} = 0$ otherwise.[9]

We further assumed that the deterministic component was linear in parameters:

$$(3) \quad V_{ij} = \alpha_j + \beta P_{ij} + \boldsymbol{\gamma}_j' \mathbf{z}_i,$$

where P_{ij} was the price of the jth alternative and $\mathbf{z}_i$ was a vector of consumer i's demographic characteristics and subjective components (listed in Table 2). Then, the log-likelihood in Equation (2) was maximized with respect to the parameters to obtain the maximum likelihood estimates of the parameters. Not all of the α_j's and $\boldsymbol{\gamma}_j$'s were identifiable, so we adopted the normalization rule such that $\alpha_1 = 0$ and $\boldsymbol{\gamma}_1 = \mathbf{0}$ (see Greene, p. 860). For the salmon model, we had the following utility functions:

$$(4) \quad U_{i1} = \beta P_{i1} + \varepsilon_{i1} \quad \text{(non-GM salmon);}$$

$$(5) \quad U_{i2} = \alpha_2 + \beta P_{i2} + \boldsymbol{\gamma}_2' \mathbf{z}_i + \varepsilon_{i2} \quad \text{(GM-fed salmon); and}$$

$$(6) \quad U_{i3} = \alpha_3 + \beta P_{i3} + \boldsymbol{\gamma}_3' \mathbf{z}_i + \varepsilon_{i3} \quad \text{(GM salmon).}$$

For vegetable oil and cornflakes, the model for the paired choice could be formulated by using the latent variable defined as $Y_i^* = U_{i2} - U_{i1} = \alpha_2 + \beta(P_{i2} - P_{i1}) + \boldsymbol{\gamma}_2' \mathbf{z}_i + (\varepsilon_{i2} - \varepsilon_{i1})$. Then, respondent i chose GM ($Y_i = 1$) if $Y_i^* > 0$ and non-GM ($Y_i = 0$) if $Y_i^* \leq 0$. The latent variable approach would not work for the multinomial logit model, and hence the choice probabilities were not directly linked with the sign of utility coefficients.

There remained a problem of how the indifferent responses were handled by the econometric model. The most straightforward interpretation of indifference was such that

$$\Pr(i \text{ chooses non-GM}) = 0.5 = \Pr(i \text{ chooses GM})$$

for all i in the indifference group. This exact interpretation was problematic in that it did not allow respondent characteristics to influence the paired choice. To cope with this difficulty, we invoked the notion of weighted geometric mean and wrote the likelihood function (LL) for the indifferent individual as follows:

$$(7) \quad \text{LL} = [\Pr(i \text{ chooses non-GM})]^p \times [\Pr(i \text{ chooses GM})]^{1-p},$$

where $0 \leq p \leq 1$. Throughout the following analysis, we set $p = \frac{1}{2}$, but this did not mean that the two events had the probability exactly equal to ½; it simply meant that the likelihood was the weighted average of probabilities of the two events with equal weights. If $p \neq \frac{1}{2}$, then the indifferent individual was leaning toward choosing one alternative over the other.

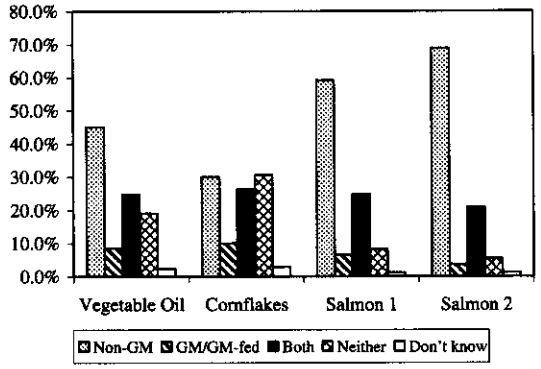
Once the parameters were estimated, we computed the sample mean WTP. Consider the case for salmon. The utility function for non-GM salmon was given by Equation (4) and that for GM-fed salmon by Equation (5). Let WTP_{i2} denote consumer i's willingness to pay a premium on the non-GM salmon to avoid the GM-fed salmon. Then the following equation had to hold:

$$(8) \quad \beta(P_{i2} + WTP_{i2}) + \varepsilon_{i1} = \alpha_2 + \beta P_{i2} + \boldsymbol{\gamma}_2 \mathbf{z}_i + \varepsilon_{i2}.$$

The left-hand side was the utility from consuming non-GM salmon purchased at the price of GM-fed salmon plus the premium (WTP_{i2}) while the right-hand side was simply the utility from consuming the GM-fed salmon purchased at its own price. Solving for WTP_{i2} and taking the expected value, we obtained

$$(9) \quad E(WTP_{i2} | \mathbf{z}_i) = \frac{\alpha_2 + \boldsymbol{\gamma}_2' \mathbf{z}_i}{\beta},$$

[9] Here, the log-likelihood is written as if there were only the initial responses. In the present analysis, both the initial and follow-up responses are pooled together as independent observations and treated as single responses from twice as many respondents. Alberini, Boyle, and Welsh used the random-effect probit model by treating the multiple-bound responses as a panel of independent draws from the same WTP function. They found that the correlation within the panel was close to zero, thereby justifying the estimation of the random valuation model of Wang by treating the multiple-bound responses as independent.



Source: Primary survey data.

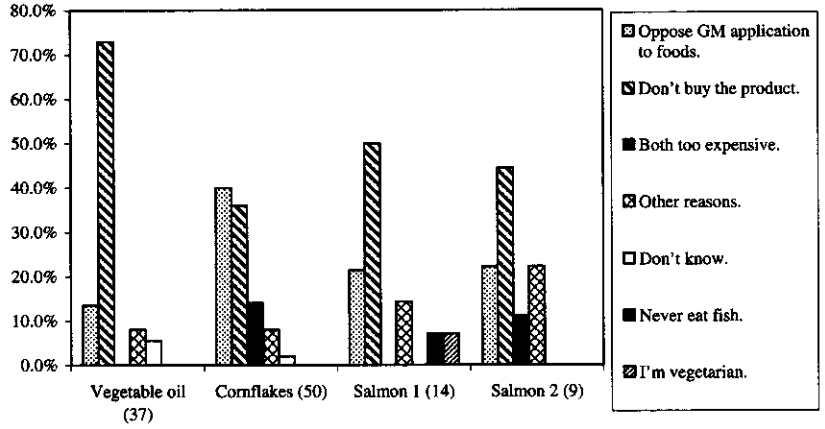
Figure 1. Initial CV Response at Equal Price

where we used the assumption that ε_{ij} had zero means. Consumer i's willingness to pay a premium on the non-GM salmon to avoid the GM salmon was computed similarly. The case for vegetable oil or cornflakes was also handled the same way.

The empirical model was obtained by specifying the components in the vector $\mathbf{z}_i$. We included a constant, INFO, TF, GOV, RP, AGE, FEMALE, EDU, LINC, WEST, MIDWEST, NORTHEAST, KIDS, and the variable for survey version; we also added behavioral intention variables NG and GM, which were group dummies obtained from the response to the initial CV question (see Table 2 for definition). These variables served as the linkage between the initial and follow-up questions in the model. Baker and Burnham found that demographic variables were not significant determinants of the choice between non-GM and GM alternatives, but cognitive variables were. Moon and Balasubramanian (2003) found that demographic variables influenced the choice but that they would become insignificant if they were included along with variables measuring the benefits and risks of GMOs (cognitive variables). This was because respondents' perception of benefits and risks were themselves influenced by demographic variables. Moon and Balasubramanian (2003) excluded the demographic variables and included only the variables measuring benefit and risk perceptions. On the other hand, Grimsrud et al. and Li, McCluskey, and Wahl found that demographic variables were generally significant even along with cognitive variables. We included both demographic and cognitive variables because we were interested not only in whether these variables affected respondents' WTP but also in how much they affected it.

Results

It is useful to examine the patterns of responses to the initial CV question. Figure 1 shows the percentages of the answer options. As is evident, the mode was the non-GM option for all of the products, and the GM option had a much smaller share. Next, the indifference op-



Source: Primary survey data.

Figure 2. Reason for Choosing Neither of the Products

Table 4. Parameter Estimates for Vegetable Oil, Cornflakes, and Salmon

	Vegetable Oil		Cornflakes		Salmon			
	Both[a]	Follow-up	Both	Follow-up	Both		Follow-up	
PRICE	−7.904**	−11.132**	−2.344**	−3.072**	−1.907**		−1.814**	
	(1.783)	(3.615)	(0.592)	(1.036)	(0.312)		0.397	
					GM-fed	GM	GM-fed	GM
Constant	0.263	5.313**	3.230	3.997**	0.080	−6.594*	1.623	−1.286
	(2.628)	(2.520)	(3.088)	(1.778)	(2.792)	(3.385)	(1.620)	(1.961)
NG	−4.762*	−5.469**	0.082	−4.257**	−4.998	−12.082**	−4.796**	−7.636**
	(2.877)	(2.170)	(3.005)	(2.011)	(2.896)	(3.609)	(1.245)	(1.868)
GM	3.836		7.175**		2.770	−4.198		
	(3.078)		(3.279)		(3.135)	(3.058)		
INFO	−2.417**	−5.651	−0.930	−2.144	0.340	0.542	0.833	−0.206
	(1.084)	(2.693)	(1.017)	(2.198)	(0.788)	(0.978)	(1.181)	(1.385)
TF	0.277	0.999	−0.943	−2.603	0.226	−0.280	0.096	−0.459
	(0.746)	(1.072)	(0.815)	(1.760)	(0.652)	(0.735)	(0.849)	(0.980)
GOV	−0.183	0.334	−0.443	−0.799	0.821	1.788**	1.025	1.414
	(0.734)	(1.045)	(0.691)	(1.130)	(0.584)	(0.865)	(0.729)	(0.938)
RP	−1.165	−2.029*	−2.110**	−5.647**	0.064	−0.155	−0.240	−0.634
	(0.808)	(1.121)	(0.874)	(2.276)	(0.840)	(0.843)	(0.964)	(0.961)
AGE	0.016	0.018	−0.040	−0.107**	−0.032	−0.019	−0.055**	−0.029
	(0.030)	(0.036)	(0.029)	(0.054)	(0.021)	(0.026)	(0.027)	(0.029)
FEMALE	−1.378	−3.236**	−1.163	−0.575	−0.039	0.811	0.294	0.770
	(0.858)	(1.594)	(0.802)	(1.368)	(0.678)	(0.878)	(0.935)	(1.195)
EDU	0.135	0.310	−0.476	−2.880	−1.666**	−1.678**	−2.448**	−2.561**
	(0.797)	(1.188)	(0.801)	(1.829)	(0.733)	(0.825)	(1.000)	(1.136)
LINC	0.075	0.149	0.236	1.254**	0.163	0.694**	0.307	0.482**
	(0.206)	(0.185)	(0.227)	(0.492)	(0.214)	(0.267)	(0.171)	(0.204)
WEST	−0.249	0.139	−0.909	−1.830	−0.465	0.172	−0.950	0.114
	(1.014)	(1.262)	(0.908)	(1.510)	(0.750)	(0.952)	(1.074)	(1.108)
MIDWEST	−0.954	−1.579	−0.277	1.078	−0.059	−0.888	−0.384	−1.585
	(0.879)	(1.253)	(0.903)	(1.711)	(0.789)	(0.851)	(1.057)	(1.229)
NORTHEAST	−1.284	−2.610*	−1.845*	−3.853*	0.109	−1.710	−0.067	−2.346
	(0.844)	(1.451)	(1.033)	(2.312)	(0.829)	(1.245)	(1.056)	(1.634)
KIDS	0.016	−0.884	−1.582*	−5.668**	−0.098	−0.792	−0.379	−1.033
	(0.755)	(1.039)	(0.830)	(2.538)	(0.633)	(0.748)	(0.801)	(0.998)

Table 4. (Continued)

	Vegetable Oil		Cornflakes		Salmon			
	Both[a]	Follow-up	Both	Follow-up	Both		Follow-up	
					GM-fed	GM	GM-fed	GM
VER1			−1.486*	−3.284**				
			(0.868)	(1.556)				
VER2	0.279	1.143						
	(0.802)	(1.124)						
VER3					−0.139	−0.185	−0.345	−0.330
					(0.586)	(0.765)	(0.733)	(0.928)
Log-likelihood	−38.728	−20.031	−40.054	−17.839	−84.283		−51.702	
Akaike's I.C.	111.456	72.062	114.108	67.679	234.566		165.403	
McFadden's R^2	0.400	0.500	0.376	0.566	0.344		0.395	
N[c]	160	71	155	68	390	176	390	176

[a] Numbers in parentheses are estimated standard errors.

[b] N is the number of observed choices.

* Indicates 5% level of significance.

** Indicates 10% level of significance.

tion was substantial; about 20% to 26% of respondents chose this option. In contrast, the "don't know" option had tiny percentages. For American consumers, Moon and Balasubramanian (2003) found that on average 33.3% of respondents chose the "don't know" option. Because they used a mail survey, they needed to include the "don't know" option while "don't know" was not explicitly provided in our telephone interviews. It is expected that the indifference option saved some of the "don't know" respondents from exclusion and therefore increased the number of usable observations and hence the representativeness of the sample.

Figure 1 also indicates that the neither option was nontrivial for vegetable oil (19.1%) and cornflakes (30.6%). To see if there were some specific problems involved with the products, we considered the follow-up question presented in Figure 2. The numbers in parentheses are the numbers of respondents who chose the neither option. For vegetable oil, by far the most respondents chose the option "I don't buy the product." This may have been because we explained to the respondents that vegetable oil was made mainly of soybeans. For cornflakes, the mode was the opposition to the GM technology, but it was closely followed by the "don't buy" option. The fact that the "don't buy" option was chosen by many respondents indicates that we could capture those individuals who disliked the product with the neither option; the dislike of the products indicated by the remaining respondents could be interpreted as the dislike of the GM status.

Table 4 presents the maximum likelihood estimates of parameters for vegetable oil, cornflakes, and salmon. The table presents two sets of results for each product: the first uses both initial and follow-up responses, and the second uses only follow-up responses.[10] The comparison of the two sets was not straightforward in terms of statistical significance of the variables; for all products, some variables increased but others decreased in statistical significance, and the pattern of increase and decrease was not the same across products. It should be noted that the first set was based on the responses from the non-GM choosers, GM choosers, and indifferent respondents while the second set included only the first two groups. Therefore, the second set presented the result of standard binomial logit model. It was expected that fewer variables became significant in the first set because we imposed the condition on the indifferent respondents that the same values of a set of variables led to the choice of both non-GM and GM alternatives. If the purpose of econometric analysis was merely obtaining more significant parameter estimates, leaving out the indifferent respondents should lead to a better result. However, such a result should be used to estimate the willingness to pay a non-GM premium for those who definitely choose either non-GM or GM alternatives but not for the entire population of consumers. Our survey indicated that 20% to 26% of respondents were indifferent, so leaving them out can produce a misleading result. Thus, we focus on the first set of results below.

For vegetable oil, the estimated price coefficient was negative and highly significant. The negative sign indicates that the higher the price was, the lower the utility of both non-GM and GM alternatives was. Furthermore, it implied that the respondent was more likely to choose the GM alternative if it was less expensive than the non-GM counterpart. The significance implied that this behavioral pattern was strong; even if some consumers might not choose a GM alternative no matter what, many were likely to switch products as they observed a price difference. Thus, a lower price would increase the acceptance of GM foods for many consumers. The coefficient on NG was significant at the 10% level, which indicated that those who chose the non-GM alternative obtained lower utility from the GM alternative. The coefficient on self-reported level of information was negative and signif-

[10] Note also that for indifferent respondents, only the initial responses were included, not the follow-up responses. This is because it was expected that the truly indifferent respondents should choose the cheaper alternative in the follow-up question no matter how small the discounts were. Otherwise, they were not truly indifferent. For this reason, the indifferent respondents were entirely excluded from the second set of regression.

icant at the 5% level. A negative sign implied that consumers were more likely to choose the non-GM alternative if they had more information, which indicated that they had more negative than positive information about GM foods. Risk perception (RP) and confidence in the government (GOV) did not achieve significance at conventional levels.

For cornflakes, the price coefficient was also negative and significant at the 5% level. Although the level of information was not significant, the risk perception was negative and significant. The dummy for the Northeast was slightly significant and negative, and so was that for the presence of children in the household. This indicated that consumers in the Northeast (as compared to those in the South) and those with children had higher aversion to GM foods. Presence of children in the household was significant and negative. This variable was not necessarily significant in the previous studies. We expected that the presence of children might increase the consciousness toward food safety and aversion to unfamiliar food alternatives. This was supported by the negative sign on the KIDS variable. The group dummy GM was positive and significant, but NG was not significant.

For salmon, the interpretation of the coefficients was tricky because the sign of a coefficient was not directly linked with the change in the choice probability in the multinomial logit model. Hence, we simply point out significant variables here and postpone the interpretation until we present marginal effects on the WTP in Table 6. The price coefficient was once again highly significant and negative. Self-reported level of information and risk perception were insignificant for both GM-fed and GM salmon. Here, education was a significant determinant for the choice between the non-GM and GM alternatives. The dummy for NG was also significant. Log-income and confidence in the government attained significance only for the utility function of the GM salmon (but not of the GM-fed salmon). Income was not necessarily significant in previous studies, and we already found that it was insignificant for vegetable oil and cornflakes.

To summarize the results presented in Table 4, we note that price was the most important determinant of the consumer acceptance of GM foods. The group dummy variables (either NG or GM) were significant, which suggests the presence of different market segments, consistent with Baker and Burnham. Level of information, risk perception, and education were not consistently significant across products, but they seemed to be important determinants of consumer acceptance. Demographic variables (except education) did not appear to be significant determinants of consumer acceptance. The received literature had mixed results on the effects of demographic variables. For instance, Huffman et al. found none of their demographic variables significant (the food label was the only significant variable in their study). We included the same set of variables for all the products to see the effects of individual characteristic variables. We observe that some variables were significant for a product but not for the other products.

Table 5 shows the mean willingness to pay a non-GM premium to avoid GM. The premiums are presented both in U.S. dollars and in percentages with regard to the relevant base prices. The expected WTP was computed for each respondent, which might be positive or negative. The sample mean of these individual expected premiums are presented in the table. The table also presents the standard errors of the premiums computed with the Delta method (see Greene, p. 298).

It was hypothesized that the WTP to avoid GM vegetable oil was lower than that to avoid GM cornflakes, which, in turn, was lower than that to avoid GM-fed salmon, with the WTP to avoid GM salmon being the highest. The reasons behind this hypothesis are the type of foods and the way they are consumed. Vegetable oil is never consumed by itself; cornflakes are plant products; and salmon are animal products. The consumers are expected to make distinction between these differences in foods. They should also be more willing to accept GM foods involving the alteration of plant genes only so that the WTP to avoid GM salmon is higher than that to avoid GM-fed

Table 5. Mean Willingness to Pay a Non-GM Premium to Avoid GM Alternative

Item	Both Initial and Follow-up				Follow-up Only			
	GM Oil[a]	GM Cornflakes	GM-fed Salmon	GM Salmon	GM Oil	GM Cornflakes	GM-fed Salmon	GM Salmon
	All Respondents				Non-GM and GM Choosers			
Mean ($)	0.397	0.593	1.704	1.779	0.458	0.807	1.941	1.827
SE	(0.052)	(0.158)	(0.202)	(0.221)	(0.061)	(0.219)	(0.281)	(0.381)
%[b]	20.9	14.8	28.4	29.7	24.1	20.2	32.4	30.5
	Non-GM Choosers				Non-GM Choosers			
Mean ($)	0.737	1.831	2.649	2.797	0.714	2.151	2.688	2.895
SE	(0.168)	(0.578)	(0.696)	(0.793)	(0.112)	(0.468)	(0.404)	(0.589)
%	38.8	45.8	44.2	46.6	37.6	53.8	44.8	48.3
	GM Choosers				GM Choosers			
Mean ($)	−0.371	−1.733	−1.452	−1.567	−0.287	−1.703	−0.941	−1.057
SE	(0.337)	(1.328)	(1.341)	(1.592)	(0.174)	(0.678)	(0.490)	(0.637)
%	−19.5	−43.3	−24.2	−26.1	−15.1	−42.6	−15.7	−17.6
	Indifferent Respondents							
Mean ($)	0.016	−0.034	−0.006	−0.072				
SE	(0.242)	(0.853)	(0.984)	(1.159)				
%	0.8	−0.9	−0.1	−1.2				

Note: All groups were used for estimating parameters, and these parameters were used for computing mean WTPs for different groups.

[a] Numbers in parentheses are estimated standard errors.

[b] Percentages are computed by dividing the point estimates of willingness to pay by the appropriate base prices.

salmon. Although the WTP to avoid GM cornflakes was lower than the WTP to avoid GM vegetable oil when all respondents were included, the result was not inconsistent with the expectation: The WTP to avoid GM vegetable oil, GM cornflakes, GM-fed salmon, and GM salmon were, respectively, 20.9%, 14.8%, 28.4%, and 29.7%. The WTP to avoid GM salmon was the highest of all the WTPs. In other words, respondents apparently had higher aversion toward products involving gene-modification of animals as in Burton et al. A pooled-variance t-test of difference rejected the null hypothesis of equality of WTPs between GM-fed and GM salmon ($p = 0.009$).[11] A pooled-variance t-test rejected the null hypothesis of equality of WTPs between vegetable oil and GM-fed salmon ($p < 0.001$), between vegetable oil and cornflakes ($p < 0.001$) and between cornflakes and GM-fed salmon ($p < 0.001$).

Table 5 also presents the mean WTPs for several subsamples. As is evident, the GM choosers had a negative non-GM premium, which was interpreted as a positive premium on the GM alternative. The indifferent respondents had either positive or negative non-GM premiums, but all of the premiums were statistically indistinguishable from zero. If the indifferent respondents were excluded altogether, the WTPs would be even higher, as indicated by the right-hand panel of Table 5. Thus, we prefer to include the indifferent respondents for estimating the sample mean WTP.

The mean WTP in Table 5 might appear absolutely large. Moon and Balasubramanian (2003) and Li, McCluskey, and Wahl obtained comparable values of 10% to 12% and 8%, respectively, by using contingent valuation, and Huffman et al. obtained values of 15% to 16% from their experimental auctions. Our design of contingent valuation featured the paired choice instead of dichotomous choice of yes and no. In this sense, our design may be somewhat similar in terms of respondent incentive to a choice-based conjoint analysis. Lusk, Roosen, and Fox obtained a non-GM premium of 38.9% for U.S. consumers, which is larger than our estimates.[12] As usual, a hypothetical bias may be a concern because our estimates were based on contingent valuation. Even so, comparison of WTPs across products should not be affected by such a bias.

Table 6 presents the estimated marginal effects (in U.S. dollars and in percentage of base price) of various individual characteristic variables on the mean WTP based on using the results from all respondents. Statistical significance of these variables corresponds to their significance in the logit models, and only those variables that attained significance for at least one product were included in Table 6. When significant, the variables had marginal effects of about 15% to 20% of the base price on the non-GM premium. The level of information (INFO), risk perception (RP), higher education (EDU), regional dummy for the Northeast (NORTHEAST), and the presence of children (KIDS) had a positive effect on the non-GM premium while confidence in the government and log-income had a negative effect. These results lend a support to the high WTP to avoid GM foods among European and Japanese consumers (Grimsrud et al.; McCluskey et al.); in Europe and Japan GM foods have received negative publicity that emphasized potential risks to human health. European consumers are particularly skeptical about the ability of the government to protect public health after the series of crises related to food safety. On the other hand, U.S. consumers have been exposed to much less negative press even after the StarLink incident in 2001. The key to successfully marketing GM foods is to reassure consumers about the safety of the product to human health as a way to

[11] The pooled-variance t-test of equality of means requires the independence of two samples, which is not exactly satisfied in our case because some (but not all) respondents appear in two samples (e.g., vegetable oil and GM-fed salmon if the version 3 questionnaire was used). Thus the t-test here serves only as an informal test for the equivalence of two sample means.

[12] Lusk, Roosen, and Fox did not report a non-GM premium in percentage terms. To obtain a comparable percentage figure, we used their middle price ($8.50) to divide the point estimate of non-GM premium ($3.31).

Table 6. Marginal Willingness to Pay for Non-GM Alternative in Value ($) and Percentage (%)

Variable	GM Oil[a]	GM Cornflakes	GM-Fed Salmon	GM Salmon
INFO	0.306**	0.397	−0.178	−0.284
	(0.128)	(0.426)	(0.415)	(0.515)
	16.1%	9.9%	−3.0%	−4.7%
GOV	0.023	0.189	−0.431	0.937**
	(0.093)	(0.291)	(0.300)	(0.435)
	1.2%	4.7%	−7.2%	−15.6%
RP	0.147	0.901**	−0.034	0.081
	(0.093)	(0.371)	(0.440)	(0.442)
	7.8%	22.5%	−0.6%	1.4%
EDU	−0.017	0.203	0.873**	0.879**
	(0.100)	(0.352)	(0.374)	(0.426)
	−0.9%	5.1%	14.6%	14.7%
LINC	−0.009	−0.101	−0.086	−0.364**
	(0.026)	(0.100)	(0.112)	(0.139)
	−0.5%	−2.5%	−1.4%	−6.1%
NORTHEAST	0.162	0.787*	−0.057	0.897
	(0.109)	(0.442)	(0.434)	(0.653)
	8.5%	19.7%	−1.0%	14.9%
KIDS	−0.002	0.675*	0.051	0.415
	(0.096)	(0.364)	(0.333)	(0.391)
	−0.1%	16.9%	0.9%	6.9%

[a] Numbers in parentheses are standard errors.
* Indicates 5% level of significance.
** Indicates 10% level of significance.

lower the consumer's risk perception. Publicizing the history of safe consumption is one way to increase consumer confidence because familiarity is a key to building confidence. Although confidence in the government is hard to control, at least in the short run, policy makers should try to win the trust of the consumers in order to achieve a higher consumer acceptance of GM foods.

Conclusions

This paper reported results from a U.S. national telephone survey on genetically modified (GM) foods. The survey questionnaire involved a contingent valuation of vegetable oil, cornflakes, and salmon. Despite its relatively small size, the sample was fairly dispersed among four regions of the United States and representative of the U.S. consumers as compared to the census data.

The survey data were analyzed with the binary and multinomial logit models. Even with the moderate sample size, we saw that consumers did care about the price even when the choice involved products as controversial as GM foods. American consumers were generally accepting of GM foods if sufficient price discounts were given. Among the determinants of choice, cognitive variables such as risk perception, confidence in the government, and level of subjective knowledge were important although they were not important for all the products. Consumers were less likely to accept GM foods if they rated them risky to human health and more likely if they rated favorably the government's performance in the food safety regulation. Risk perception and confidence in the government may be hard to control in the short run, but policy makers should focus on the consumer education programs that would reduce negative perceptions of GM foods. Rousu et al. found that impartial information could dampen the impact of negative perception (which corresponds to the self-reported level of information in our

study). Distributing the record of safe consumption of GM foods may be useful because many consumers in our survey felt reassured that they had been consuming GM foods and had never become ill because of them. Consistent with Baker and Burnham, cognitive variables were significant determinants of the choice between non-GM and GM foods as well as the magnitude of WTP, but demographic variables were not necessarily significant, except the variable for higher education, which was associated with higher willingness to pay a non-GM premium.

The willingness to pay a premium on the non-GM alternative to avoid the GM alternative was estimated for each food product. The mean WTPs to avoid were, respectively, 20.9%, 14.8%, 28.4%, and 29.7% of the base price for GM vegetable oil, GM cornflakes, GM-fed salmon, and GM salmon. The WTP to avoid GM salmon was the highest. It appeared that respondents felt weaker aversion to GM foods involving only modification of plant genes. In light of the design of contingent valuation based on paired choice, all of the estimated WTPs appeared reasonable in terms of magnitude.

The inclusion of the indifference option in the contingent valuation question was beneficial in incorporating those respondents who might otherwise register a "don't know" answer. As many opinion polls and attitudinal surveys have shown, most consumers are relatively unknowledgeable about advanced biotechnology. They are unlikely to be committed to either side of the GM controversy. Forcing them to make a substantive choice without the indifference option may affect the estimation of the mean WTPs. This topic should be explored further in future studies.

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Appendix A. Contingent Valuation Question

This is the case of vegetable oil. The cases for cornflakes and salmon are analogous.

Initial question:

Now, imagine that on your next shopping trip you want to buy some vegetable oil and there are only two kinds of oil available, both made with soybeans. Vegetable oil "A" is non-GM and costs $1.90. Less than 3% of the soybeans used to make it were genetically modified. It's almost impossible to ensure that the oil is absolutely free of GM soybeans. Vegetable oil "B" is GM and also costs $1.90. More than 90% of the soybeans used to make it were genetically modified. Would you . . .

(1) Choose "A,"
(2) choose "B,"
(3) would you consider both equally good, or
(4) consider neither "A" nor "B" attractive?
(9) Don't know (not explicitly provided, but admitted if volunteered).

Follow–up for those who chose A or B:

Suppose that "A," the non-GM oil, cost $X while "B," the GM oil, cost $Y. (If X is the base price, Y is the discounted price, and vice versa.) Now would you . . .

(1) Choose "A", or
(2) choose "B"?
(9) Don't know.

Appendix B. Description of Genetically Modified Foods

Genetically modified foods are foods from plants or animals created by altering their genes or DNA. They achieve some desirable properties, but they are controversial too.

First we want to provide you with some pros and cons of genetically modified foods.

Some advantages of genetically modified organisms are: crops may require less herbicides or pesticides, foods may be richer in vitamins or minerals and may contain less fat, and they may be cheaper.

Some disadvantages of genetically modified organisms are: they may create new allergies, weeds and bugs may become resistant to herbicides and pesticides, the variety of foods may decrease, and genetic engineering may violate some people's religious or ethical beliefs.