Consumer Acceptance of Genetically Modified Foods: A Telephone Survey

Naoya Kaneko

The Ohio State University

and

Wen S. Chern

The Ohio State University

Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Montréal, Canada, July 27–30, 2003

Naoya Kaneko and Wen S. Chern (contact author) are, respectively, a graduate research associate and a professor at the Department of Agricultural, Environmental, and Development Economics, The Ohio State University, 2120 Fyffe Road, Columbus, Ohio 43210-1067. Phone: (614) 292-6414. Fax: (614) 247-7066. E-mail: chern.1@osu.edu

CONSUMER ACCEPTANCE OF GENETICALLY MODIFIED FOODS: A TELEPHONE SURVEY

NAOYA KANEKO AND WEN S. CHERN

This paper reports results from a pilot U.S. national telephone survey on genetically modified foods (vegetable oil, cornflake cereal, and salmon). The survey featured contingent valuation in which respondents chose between the GM and non-GM alternatives. The binary and multinomial logit models yielded estimated willingness to pay to avoid the GM alternatives. Respondents are willing to pay 41.2%, 31.4%, 40.9%, and 52.5% of the base prices to avoid GM vegetable oil, GM cornflakes, GM-fed salmon, and GM salmon, respectively.

Keywords: Genetically Modified, Contingent Valuation, Willingness to Pay, Telephone Survey.

Funding for the pilot survey was provided by the Center for Survey Research at The Ohio State University.

Introduction

Genetically modified (GM) crops were introduced to the market in the mid-1990s. With all controversies they stirred, they seemed to have been endorsed by most U.S. farmers with their cost-saving benefits. In contrast, it is often mentioned that consumers are not receiving any direct benefit from them. Biotech companies may list a number of potential benefits to consumers, such as reduced use of herbicides and pesticides in crop production, improved nutritional values of foods, or reduced food prices. Such "benefits" do not seem compelling enough to offset potential risks required to take in consuming GM foods. Under the current circumstances, consumers must take an extra step to avoid GM foods, for instance, by purchasing foods labeled as non-GM products (rarity in the U.S.) or organic foods. These consumers are revealing their willingness to pay higher prices to avoid a GM alternative if they have such a choice at all. It is of much interest to policy makers and businesses what kind of consumers they are and how much more they are willing to pay to avoid GM foods. The question is relevant both for the proponents and opponents of GM foods.

To find an answer to the question, it is insufficient to analyze the market data. Since GM foods are not labeled as such in the U.S., consumers cannot choose between GM and non-GM foods. Some consumers may choose organic foods, which cannot use GM ingredients by regulation, but the price difference between regular and organic foods reflects more than just the presence or absence of GM technology. Moreover, those who purchase organic foods are not merely avoiding GM ingredients but making a kind of social statement (Senauer). If that is the case, the market data will lead us to a biased estimate of willingness to pay to avoid GM foods. Thus, it is important to draw a representative sample of consumers and conduct a survey to study their behavior, given a choice between GM and non-GM alternatives.

The objectives of the paper are to describe our pilot telephone survey using a variant of contingent valuation and to use the survey data for estimating the willingness to pay (WTP) of the U.S. consumers for the selected GM foods.

Contingent Valuation Method

Contingent valuation (CV) is a survey-based method to elicit consumers' valuation of nonmarketed resources (Mitchell and Carson). In the single-bounded dichotomous choice CV, introduced by Bishop and Heberlein, the respondent is asked whether or not to pay the given threshold dollar value to secure the proposed policy. This format has virtually become the standard with its incentive compatibility property (Haab and McConnell). However, the information obtained from the single-bounded CV question is quite limited in that the researcher only knows that the respondent's willingness to pay (WTP) for the proposed policy is greater or smaller than the threshold.

In order to overcome this inefficiency of information gathering without incurring the cost of increasing the sample size, Carson et al. proposed to use a follow-up question to the single-bounded CV question. If the initial response is yes (no), the respondent will be asked another CV question with a higher (lower) threshold value. Hanemann et al. showed that such a follow-up question would improve the precision on the welfare measure. Even though the "double-bounded" model used by Hanemann et al. is restrictive, as pointed out by Cameron and Quiggin, it has been shown that the model is robust if the purpose of the study is to estimate the mean or median of the welfare measure (Alberini). Thus, we adopt a double-bounded CV survey.

The treatment of nonparticipants, or *indifferent* respondents, has been an issue in the contingent valuation literature. In a typical dichotomous-choice question, the respondent is asked to say either yes or no to the given threshold value (ignore "don't know" for the moment). Given the uncertainty over how an indifferent respondent will answer such a question, researchers have proposed several econometric models to mitigate the effect of nonparticipants on the WTP measure (An and Ayala; Hanemann and Kriström; Kriström; McFadden, 1994). Haab shows that these models are sensitive to misspecification, so the researcher must take an extra caution in interpreting the model implications. Furthermore, such post hoc models are only the second best in nature because they could not improve the quality of data. More satisfactory approach should address the questionnaire design issues. Thus, we develop a CV question that explicitly admits indifference.

A problem with the referendum format is that incorporating indifference as an explicit option

is unrealistic. Contingent valuation usually provides a policy that represents an improvement upon the status quo. In the current article, we study consumers' willingness to pay to avoid the GM alternative. Switching from the GM to the non-GM alternatives may be analogous to a movement from the status quo to the improved state, but the former is not as clearly an improvement as the latter. The FDA's stance on the genetically modified food is that they are safe to consume, so, if we subscribe to that point of view, the difference between the GM and non-GM alternatives depends on the respondents' subjective valuation of risks. Because of the lack of objective difference, we designate neither of the two alternatives as the status quo: instead, we ask the respondent to choose either the non-GM or GM alternatives at the same price, based on observed market prices. This paired comparison format simulates a typical shopping trip and naturally gives rise to an indifference response. It can also easily incorporate rejection of both alternatives, which identifies nonparticipants as opposed to indifferent individuals. More detailed discussion of the questionnaire design is given below.

Previous Studies

There are a number of surveys conducted in various countries about consumers' attitudes toward biotechnology in general and genetic engineering in particular (Hoban; Priest; Burton et al.; Pew Initiative on Food and Biotechnology; Moon and Balasubramanian; Boccaletti and Moro, Hossain et al.; Mendenhall and Evenson). Some of these studies elicit consumer responses without proper scenario or budget constraint. The usefulness of such responses is limited in terms of policy implications. Consumers may say they will avoid GM foods but may in fact choose a GM food if they find it cheaper than a non-GM alternative by 50%, for instance.

It is essential that the scenario is realistic and easy to understand for the resondents. Burton et al. conduct a conjoint analysis survey, but they use a reduction in weekly food expenditure as payment vehicle, and, as a consequence, respondents were asked to choose between different commodities called "food futures." Their design poses a substantial task difficulty on the respondents in that they need to consider various trade-offs among characteristics. On the other hand, Boccaletti and Moro ask respondents to declare how many more percentages they are willing to pay for a number of

imaginary GM foods in a payment card format. Again, this is not the kind of decision consumers routinely make. Furthermore, the above two surveys do not consider particular products. It may well be the case that consumers' willingness to pay is product-specific. Thus, we consider imaginary shopping trips in which respondents are asked to purchase vegetable oil, cornflakes, or salmon fillets. The payment vehicle is the price of the product, and the respondents will choose one of the two alternative products, much the same way that they choose one from a few brands of a food product at a supermarket. Since consumers are used to making such a decision, our survey design is expected to elicit reliable data to analyze consumer behavior.

Questionnaire Design

The questionnaire consists of three major parts. The first seeks 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 consists of a series of contingent valuations involving particular food products — vegetable oil, cornflake cereal, and salmon. The third is concerned with the demographic information of the respondents.

It is important to elicit respondents' perception of and attitude toward biotechnology in general and genetic modification in particular. Demand analysis has traditionally dealt with demand for homogeneous food that is determined by a set of relevant prices and demographic variables. Demand for differentiated goods, or demand for quality, need not be determined by the same set of variables (Senauer). Even if there is an objective measure of a particular quality, it does not follow that all consumers perceive the quality in the same way. It is quite conceivable that some quality yields a positive utility for some people but negative utility for others. In short, demand for a quality depends on subjective elements. For this reason, the first part of the questionnaire asks respondents how they rate GM foods in terms of risk to human health, whether they think religious or ethical concerns are important in accepting GM foods, and whether they are willing to purchase GM foods if some desirable and undesirable qualities are embodied in them.

The main purpose of the second component is to identify which variables are determinants of the choice between GM and non-GM foods and to estimate respondents' willingness to pay

to avoid a GM alternative. Vegetable oil (made mainly of soybeans) and cornflakes are chosen because soybeans and corn are two of the largest food crops for which GM varieties are widely cultivated in the U.S. Salmon is included because of its relative popularity and its unique way to accommodate GM characteristics. Most salmon sold at supermarkets in the U.S. are farmed salmon usually grown with concentrated protein pellets made of 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 salmon are altered with genetic engineering. Gene-altered salmon actually exist although they have not been approved for marketing: we refer to these gene-altered salmon as GM salmon.[1] These salmon are so altered that they will grow several times faster than non-altered 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.

Telephone survey was selected because it allows the researcher to take control of how respondents answer the questions. Our survey design involves a number of nesting structures and randomization, which may be cumbersome for a mail survey but can be easily handled by a computer-assisted telephone interview.[2] Respondents answer one question at a time, and when they do so, they do not see other questions so that the likelihood of distraction will be reduced. Furthermore, deliberations or strategic responses are reduced because respondents cannot move back and forth within the questionnaire. Since respondents talk with the interviewers over the phone, they are expected to reveal their responses more truthfully than with mail survey. Thus we can put much confidence in the quality of data without incurring an excessive cost of personal interviews (Note that we are taking a U.S. national sample).

We adopt contingent valuation with a follow-up question. First, respondents are asked whether to choose the non-GM or GM alternative at the current market price ("base" price in table 1).[3] The two alternative products are exactly the same except that the former contains 0-3% of GM ingredients whereas the latter contains more than 90% of GM content. The next question is 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 percent in a random fashion. If the GM was chosen instead, the non-GM price would be reduced in the same fashion. It is conceivable that some respondents may be indifferent between the two alternatives if they do not care about the GM content at all. If that is the case, then those respondents are randomly directed to one of two cases: (1) discount on the GM alternative and (2) discount on the non-GM alternative. The price of one of the alternatives is now lowered. If those respondents are still indifferent, then it follows that they are insensitive to price differences. This is inconsistent with the basic economic principle: the cheaper, the better. Therefore we exclude those respondents who indicate indifference in a follow-up question. The bottom row of table 1 shows the percentage of the sample that gets various price discounts. For instance, 10% of the respondents obtain 50% price discounts.

The follow-up questions are beneficial, but they are not without limitations. The immediate benefit is an increase in the number of observed choices per respondent to enhance statistical efficiency. Another benefit is an ability to sort out patterns of choice responses. The CV design reflects the hypothesis that the choice between GM and non-GM alternatives is not nonnegotiable; it is hypothesized that most consumers will change their mind when they face substantial price discounts. A follow-up question provides respondents to change their choice, given a price discount. However, some respondents may choose the non-GM alternative no matter what the price discount on the GM alternative is. This type of behavior may be a result of the respondent's underlying preference or simply a protest of being forced to consider the GM alternative as a choice. It is generally impossible to separate these two cases, so we add an option of "neither" in the initial CV question. If some respondents reject the idea of considering a GM alternative as a possible choice, then they can choose neither GM nor non-GM. The "neither" option will lead the respondents to a follow-up question asking them why they have chosen "neither." At least some protest votes can be captured by the inclusion of the "neither" option. Another issue worth noting is the use of discount in the follow-up questions. Unlike the usual CV referendum, our question asks respondents to choose either the non-GM or GM alternative. Since the choice is not whether or not to accept the single offer but whether to accept one or the other offer, it is possible to use a price discount irrespective of which one has been chosen. Another approach is to use a price increase instead of

price discount. A problem with price increase is that respondents are less likely to switch to the alternative that has not been chosen. Even if switching occurs, incentive may be different between actively switching and passively switching. Respondents may feel exploited if the price of their chosen alternative is raised, which may provoke a feeling of protest or cause them to opt out of the choice altogether. A possible problem with a price discount is that respondents may feel the quality of the discounted product may have been compromised. If this is the case, the choice sets are different between the initial and follow-up questions (Alberini et al.). As price discounts are routinely used in supermarkets and food stores to induce purchases, the choice set effect does not seem to cause a big problem. Therefore, we adopt price discount because switching is more likely with it than with price increase.

Even though we would like to observe many consumers to choose GM foods, responding to price discounts, great care was taken to make the questionnaire neutral in tone and as free as possible from any elements that might augment or diminish consumers' attitude toward GMOs and GM foods. Because most consumers are not very well informed about what GMOs and GM foods are, we provide a basic definition of genetic modification along with pros and cons about it before asking question on perception and attitude. Furthermore, some respondents receive pros first and others cons first in order to control for a possible order effect.

There are four different questionnaires prepared for the survey. The first and second questionnaires involve only vegetable oil and cornflakes. The only difference between the two is the order in which vegetable oil and cornflakes are presented. The third one involves vegetable oil and salmon, and the last one involves cornflakes and salmon. All contingent valuations are about a paired choice between GM and non-GM alternatives. For salmon, there are two cases: (1) non-GM and GM-fed salmon and (2) non-GM and GM salmon. The number of each questionnaire was pre-specified and each version was distributed randomly among the respondents. The purpose of the above treatment is to cope with order effect as well as to shorten the questionnaire length. Each version contains two of the three products, and salmon is always preceded by the other product. This is because the salmon section is more complicated than the others in that there are two choices involved. In the contingent valuation literature, evidence is found that willingness to pay

is sensitive to the order of valuation in a sequence of CV questions; namely, respondents' willingness to pay for the same good decreases if the valuation is made later in the sequence of valuation questions (Carson). Although it does not have a significant effect on coefficient estimates whether salmon is preceded by vegetable oil or cornflakes, it is conceivable that willingness to pay to avoid the salmon of GM variety is underestimated because of the order of presentation. Moreover, as the GM salmon is more involved than the GM-fed salmon in terms of biotechnology, the GM salmon is always preceded by the GM-fed salmon.[4]

Model

The data contain information on respondents' knowledge, attitudes, perception, preference on labeling, and outcomes of contingent valuations. The main question is how price, demographic variables as well as knowledge/perception/attitude variables affect the choice between GM and non-GM alternatives. The basic framework of analysis is provided by the random utility model (see Ben-Akiva and Lerman, chap. 4 and 5). In this model, consumers are hypothesized to choose an alternative so as to maximize their utility. Let U_{ij} denote consumer i's utility from choosing alternative j. Then, consumer i chooses alternative j if

$$U_{ij} > U_{ik} \text{ for all } k \neq j.$$

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 mainly represents the researcher's ignorance about the consumer's utility function.

Note that for soybeans and corn, the choice is merely between the GM and non-GM alternatives. Hence, the appropriate model is the binary logit model. However, for salmon, the choice is among GM, GM-fed, and non-GM salmon, which is better handled by a multinomial model even though respondents make one binary choice at a time. For the illustration of analytical method, we use the multinomial logit model because the binary logit model is a special case of multinomial logit model.

To make the model operational, we make the assumption that the random components ε_{ij} are independently and identically distributed as type I extreme value distribution. Then, as shown by McFadden (1974), the probability that individual i chooses alternative j is written as

$$\text{Prob}(i \text{ chooses } j) = \frac{e^{V_{ij}}}{\sum_{k=1}^{J} e^{V_{ik}}},$$

where J is the number of alternative products and in the case of salmon, $J = 3$. Let $d_{ij} = 1$ if individual i chooses alternative j and $d_{ij} = 0$ otherwise. Then the log-likelihood function for the multinomial logit model is given by

$$\ln L = \sum_{i=1}^{n} \sum_{j=1}^{J} d_{ij} \ln \frac{e^{V_{ij}}}{\sum_{k=1}^{J} e^{V_{ik}}}. \tag{1}$$

We now assume that the deterministic component is linear in parameter:

$$V_{ij} = \alpha_j + \beta P_{ij} + \gamma_j z_i,$$

where P_{ij} is the price of jth alternative and z_i is a vector of consumer i's demographic characteristics and subjective components. Then, the log-likelihood in equation 1 will be maximized with respect to the parameters to obtain the maximum likelihood estimates of the parameters. Note, however, that not all of the α_j's and γ_j's are identifiable (see Greene, p.860). We normalize so that $\alpha_j = 0$ and $\gamma_j = 0$. For example, in the salmon model, we have the following utility functions.

$$U_{i1} = \beta P_{i1} + \varepsilon_{i1} \qquad \text{(Non-GM salmon)} \tag{2}$$

$$U_{i2} = \alpha_2 + \beta P_{i2} + \gamma_2 z_i + \varepsilon_{i2} \qquad \text{(GM-fed salmon)} \tag{3}$$

$$U_{i3} = \alpha_3 + \beta P_{i3} + \gamma_3 z_i + \varepsilon_{i3} \qquad \text{(GM salmon)} \tag{4}$$

The utility function for the non-GM alternative consists of the price variable and the random component; that is, the constant term as well as the respondent-specific variables all drop out. The above normalization rule is also used for vegetable oil and cornflake cereal.

Once the parameters are estimated, we can compute the mean willingness to pay. Consider the case for salmon. The utility function for non-GM salmon is given by equation 3 and that for GM-fed salmon by equation 4. Let WTP_{i2} denote consumer i's willingness to pay to avoid the GM-fed salmon (and choose the non-GM salmon). Then the following equation must hold:

$$\beta(P_{i2} + WTP_{i2}) + \varepsilon_{i1} = \alpha_2 + \beta P_{i2} + \gamma_2 z_i + \varepsilon_{i2}.$$

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

$$E[WTP_{i2}|\alpha_2, \beta, \gamma_2] = \frac{\alpha_2 + \gamma_2 z_i}{\beta},$$

where we used the assumption that ε_{ij} have zero means. Likewise, consumer i's willingness to pay to *avoid* the GM salmon (and choose the non-GM salmon) is

$$E[WTP_{i3}|\alpha_3, \beta, \gamma_3] = \frac{\alpha_3 + \gamma_3 z_i}{\beta}.$$

Note that there are only two alternatives (i.e., GM or non-GM) for vegetable oil and cornflakes. Consumers' willingness to *avoid* the GM alternative can be computed in a similar fashion for the cases of vegetable oil and cornflakes.

Empirical Results

A pilot 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 cooperation rate of 80.6%.[5] These respondents were drawn from 48 states (excluding Alaska and Hawaii). On average, it took 18 minutes to complete the telephone interview.

Table 2 lists the definition of the variables used for econometric analysis, and table 3 presents

the means and standard deviations of the respondent-specific variables. Because of the split sample design, the sample size and hence descriptive statistics differ from product to product. For the sake of comparison, data from census 2000 are also provided. Since the targeted population (food shoppers of age 18 or older) is only a subset of population of interest in the census, there need not be an exact correspondence between the census and our sample. For example, the percentage of male respondents is in the twenties in our sample while close to 50% is male in the census. This is because grocery shopping is mainly done by a female member in most households. About 50–60% of the respondents are at least somewhat informed about GMOs or GM foods. The self-reported knowledge is on average consistent with the results of two true or false questions (TF1 and TF2). About 50% or fewer respondents say GM foods are risky to human health. Religious or ethical concerns seem to be low in importance (about 40% or lower) in deciding whether or not to consume GM foods. Added together, these results may indicate that the U.S. consumers do not hold particularly negative views on GM foods. This may be attributable to the relatively high level of confidence in the government (about 46–62%). Nevertheless, most respondents (more than 80%) think that labeling of food with regard to GM content is important.

Tables 4 and 5 exhibit maximum likelihood estimates of parameters for vegetable oil, cornflakes, and salmon. As was mentioned earlier, all coefficients except the price coefficient are normalized to zero for the utility function of the non-GM alternative. Consequently, the reported parameter estimates are for the utility functions of the GM vegetable oil or cornflakes and for those of the GM-fed and GM salmon. As a result, a positive sign of a coefficient means that an increase in the variable leads to an increase in the probability of the GM alternative getting chosen, ceteris paribus.

The most obvious result is that price coefficient is negative and quite significant. The negative sign indicates that the higher the price, the lower the utility. The significance of the price coefficient implies that the choice between non-GM and GM is affected by the price difference between them. Some consumers may not choose a GM alternative no matter what, but most others are likely to switch products as they observe a price difference. A lower price will increase the acceptance of GM foods for many consumers. Also notable is that risk perception (RP) is negative

and significant. A negative sign implies that consumers are more likely to choose the non-GM alternative if they perceive GM foods as risky to human health. Except for the GM salmon, RP attains 5% level of significance. The insignificance for the GM salmon may be explained by the fact that the GM salmon is always presented after the GM-fed salmon. Another notable result is that the dummy variable for the West region is negative and significant (except for GM salmon, once again). This means that respondents in the West are more likely to choose non-GM, ceteris paribus. It is interesting to observe the sign of the Midwest variable, however. Although significance is not attained, the sign is consistently positive. The fact that Midwest is the largest producers of GM soybeans and GM corn may have influenced the Midwest respondents' stated behavior. It is more subtle to interpret the coefficient estimates of the other variables. Their coefficients are not consistently significant across products. In terms of sign, the confidence in the government and age are consistent. The more confidence in the government, the more likely it is that the GM alternative is chosen. The variable is significant only for vegetable oil and GM salmon. Age is not significant but consistently signed negative. A negative sign means that younger consumers are more likely to accept the GM alternative. The difference between male and female is not significant, unlike previous surveys (for instance, Hossain et al., 2002). Education has inconsistent signs and is insignificant except for GM salmon. The evidence on education in the literature is mixed; in some surveys, education will increase the acceptance, but in others, education is insignificant as a determinant. It is important to note, however, years of schooling do not measure the content of education. The presence of children in the household has a negative sign for vegetable oil and cornflakes and achieves significance only for cornflakes. For both salmon, the sign is (contrary to the expectation) positive, meaning that the respondent is more likely to choose the GM alternative if living with children. It is not clear how this result is obtained. The differences between whites and nonwhites and between Protestants and non-Protestants are only significant for vegetable oil. For other products, signs are not consistent. Income is not significant as in Hossain et al., contrary to Boccaletti and Moro. VER1 is significant and positive for vegetable oil only. This means that respondents are more likely to choose GM vegetable oil if the vegetable oil section comes before the cornflakes section. Coefficients on version dummies are not necessarily consistently signed or

significant.

Table 6 shows the respondents' willingness to pay (WTP) to avoid GM alternatives. Expected WTP is computed for each respondent, which may be positive or negative. Mean and median WTPs are presented in the table, but they are sample means and sample medians of expected (mean) WTPs for the respondents. It was hypothesized that the WTP for vegetable oil is lower than that for cornflakes, which is lower than that for salmon, with the WTP to avoid GM salmon being the highest. The reason behind this hypothesis is that the modified sequence of genes cannot be detected in vegetable oil and that consumers may be more willing to accept GM foods involving the alteration of plant genes only. However, the WTP is the lowest for cornflakes. It is doubtful that respondents know that modified sequences of DNAs are not detectable in vegetable oil, so the result is not surprising. The WTP for GM salmon is the highest of all WTPs, which supports the second hypothesis. In other words, respondents apparently have higher aversion toward products involving gene-modification of animal as in Burton et al. A simple t-test of difference rejects the null hypothesis of equality of WTPs between GM-fed and GM salmon. The WTPs for vegetable oil and GM-fed salmon are very close, the latter being slightly smaller than the former. This result is not robust; different econometric specifications have yielded a smaller WTP for vegetable oil (not reported here). Nevertheless, the two WTPs are not very far apart from each other under different specifications, and they are both lower than that for GM salmon. A simple t-test cannot reject the null hypothesis of equality of WTPs between vegetable oil and GM-fed salmon at the 5% level. The WTP for cornflakes is the lowest, and much lower than those for oil and GM-fed salmon. A simple t-test rejects the equality of WTPs for vegetable oil and cornflakes at the 5% level. This may be explained by the worst fitness of the model for cornflakes: McFadden's R-squared is lowest for cornflakes. Moreover, there is a reason for questioning the quality of cornflakes data. Unlike vegetable oil, cereal is a highly differentiated product. Some consumers may not eat corn-derived cereal altogether, and even if they do consume it, they may choose some highly value-added corn cereal instead of plain cornflakes. In short, there are so many uncontrollable elements about cornflakes, and they may have affected respondents' answers. Tortilla chips may have been more serviceable, but their usefulness vis-à-vis that of cornflakes is unknown.

Table 7 tabulates WTPs by selected variables. Double asterisks (**) indicate 5% level of significance of the relevant variable, and single asterisks (*) indicate 10% level of significance. We include insignificant variables for the sake of comparison. Sometimes the difference in WTP between groups is quite large. For instance, those who perceive GM foods as risky have much larger willingness to pay to avoid the GM alternative, especially where the coefficient is more significant. In other words, if the policy maker can lower the level of risk perception, then the acceptance of GM foods will be heightened even further in that a relatively small price difference is needed for a group of consumers to accept GM foods. Large differences in WTPs are also found for WEST and GOV as part of general tendency that significant coefficients yield large differences in WTPs.

Concluding Remarks

This paper reports results from the pilot U.S. national telephone survey on genetically modified foods. The survey questionnaire involves contingent valuation questions on vegetable oil, cornflake cereal, and salmon. Despite its small size, the sample seems to be fairly dispersed among 4 regions of the United States and not out of range as compared to the census data. However, the split sample design has led to even smaller sample size for each of the three food products.

The survey data are analyzed with the binary and multinomial logit models. Even with the sample size limitations, we see that consumers do care about the price even when the choice involves as controversial products as genetically modified foods. American consumers are generally accepting GM foods if sufficient price discounts are made on them. Among the determinants of choice, risk perception stands out. Consumers are less likely to accept GM foods if they rate them risky to human health. There still remains a question of what determines risk perception of consumers from the standpoint of policy makers and marketers. Demographic variables are not necessarily significant determinants of choice as argued by Senauer. We need further examine whether this is a phenomenon arising from the smallness of the sample or a phenomenon essential to the choice between non-GM and GM foods.

The willingness to pay to avoid the GM alternative is estimated for each food product. The mean WTPs to avoid are, respectively, 41.2%, 31.4%, 40.9%, and 52.5% of the base price for GM

vegetable oil, GM cornflake cereal, GM-fed salmon, and GM salmon. The WTP for GM salmon is the highest and significantly different from that of GM-fed salmon. It appears that respondents feel weaker aversion to GM foods involving only modification of plant genes. Although all of the estimated WTPs seem reasonable in terms of magnitude, the WTP for cornflake cereal was lower than expected, probably due to poor data quality. The problem may or may not persist as the sample size gets bigger. Substituting cornflakes with another corn product may or may not be the risk worth taking in the full-fledged survey. A focus group may be useful in determining the product choice.

The reported results are based on a pilot survey, so they must be treated as such even though the sample was taken from the entire continental United States. We have obtained reasonable estimates of willingness to pay. To feel more comfortable with the results, we need to investigate respondents' formation of perception and attitudes.

Before concluding the paper, we should note the limitation of our econometric analysis. Although follow-up questions have increased the number of observed choices and hence econometric efficiency, our econometric models are not fully efficient in that they do not use all of the existing information. The contingent valuation takes a so-called double-bounded form, but the econometric model employed above does not use the sequential nature of the CV data. The valuable insights obtained from the pilot survey will be used for revising the questionnaire, and more appropriate econometric models will be used for analyzing the data collected in a larger scale survey to be conducted in the near future.

Footnotes

[1]Gene-altered fish attract much attention these days as they are the most likely candidates of genetically modified animals that first hit the open market (Pew Initiative on Food and Biotechnology).

[2]Telephone or in-person interviews can easily handle the follow-ups, as pointed out by Hanemann et al.. Mail survey must include all contingent questions, not all of which are relevant for any single respondent, making the questionnaire appear discouragingly lengthy.

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

[4]Although the mean willingness to pay to avoid the GM salmon is greater than that for the GM-fed salmon, which is precisely as we hypothesized, it may be better to randomize the order of presenting two salmon in the future survey.

[5]This response rate is the most conservative measure of disposition of the survey according to the standard definition of the American Association of Public Opinion Research. Basically, any 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.

References

Alberini, A. "Efficiency vs. Bias of Willingness-to-Pay Estimates: Bivariate and Interval-Data Models." *Journal of Environmental Economics and Management* 29(1995): 169–180.

Alberini, A., B. Kanninen, and R. Carson. "Modeling Response Incentive Effects in Dichotomous Choice Contingent Valuation Data." *Land Economics* 73(1997): 309–324.

An, Y., and R. Ayala. "A Mixture Model of Willingness to Pay Distributions." Working Paper, Department of Economics, Duke University, 1996.

Ben-Akiva, M., and S. Lerman. *Discrete Choice Analysis: Theory and Application to Travel Demand*. Cambridge, Massachusetts: MIT Press, 1985.

Boccaletti, S., and D. Moro. "Consumer Willingness-to-Pay for GM Food Products in Italy." *AgBioForum* 3(2000): 259–267. URL: http://www.agbioforum.org/vol3no4/vol3no4arl4boccaletti.pdf

Burton, M., D. Rigby, T. Young, and S. James. "Consumer Attitudes to Genetically Modified Organisms in Food in the UK." *European Review of Agricultural Economics* 28(2001): 479–498.

Cameron, T., and J. Quiggin. "Estimation Using Contingent Valuation Data from a 'Dichotomous Choice with Follow-Up' Questionnaire." *Journal of Environmental Economics and Management* 27(1994): 218–234.

Carson, R. "Contingent Valuation: A User's Guide." *Environmental Science and Technology* 34(2000): 1413–1418.

Carson, R., W. Hanemann, and R. Mitchell. "Determining the Demand for Public Goods by Simulating Referendums at Different Tax Prices." Working Paper, Department of Economics, University of California, San Diego, 1986.

Greene, W. *Econometric Analysis,* 4th edn. Upper Saddle River, New Jersey: Prentice Hall, 2000.

Haab, T. "Nonparticipation or Misspecification? The Impacts of Nonparticipation on Dichotomous Choice Contingent Valuation." *Environmental and Resource Economics* 14(1999): 443–461.

Haab, T., and K. McConnell. *Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation.* Cheltenham, UK and Northampton, MA, USA: Edward Elgar, 2002.

Hanemann, W., J. Loomis, and B. Kanninen. "Statistical Efficiency of Double-Bounded Dichotomous Choice Contingent Valuation." *American Journal of Agricultural Economics* 73(1991): 1255–1263.

Hanemann, W., and B. Kriström. "Preference Uncertainty, Optimal Designs, and Spikes." *Current Issues in Environmental Economics.* P.-O. Johansson, B. Kriström, and K.-G. Mäler, eds., pp. 58–77. Manchester and New York: Manchester University Press, 1995.

Hoban, T. "Trends in Consumer Attitudes about Agricultural Biotechnology." *AgBioForum* 1(1998): 3–7. URL: http://www.agbioforum.org

Hossain, F., B. Onyango, A. Adelaja, B. Schilling, and W. Hallman. "Public Perceptions of Biotechnology and Acceptance of Genetically Modified Food." Working Paper, Food Policy Institute, Rutgers University, 2002.

Kriström, B. "Spike Models in Contingent Valuation." Substantially revised version of an invited paper to 1st Toulouse conference on Environmental and Resource Economics, Toulouse, France, March 30-31, 1995. URL: http://www.sekon.slu.se/ bkr/spike.pdf

McFadden, D. "Conditional Logit Analysis of Qualitative Choice Behavior." *Frontiers in Econometrics.* P. Zarembka, ed., pp. 105–142. New York and London: Academic Press, 1974.

__ . "Contingent Valuation and Social Choice." *American Journal of Agricultural Economics* 76(1994): 689–708.

Mendenhall, C., and R. Evenson. "Estimates of Willingness to Pay a Premium for Non-GM Foods: A Survey." *Market Development for Genetically Modified Foods.* V. Santaniello, R. Evenson and D. Zilberman, eds., pp. 55–61. CAB International, 2002. URL: http://www.cabi-publishing.org/bookshop/ReadingRoom/085199573x/085199573xCh5.pdf

Mitchell, R., and R. Carson. *Using Surveys to Value Public Goods: The Contingent Valuation Method.* Washington, D.C.: Resources for the Future, 1989.

Moon, W., and S. Balasubramanian. "Public Perceptions and Willingness-to-Pay a Premium for Non-GM Foods in the US and UK." *AgBioForum* 4(2001): 221–231. URL: http://www.agbioforum.org

Pew Initiative on Food and Biotechnology. *Public Sentiment about Genetically Modified Food*(Special Report). Washington D.C.: The Mellman Group and Public Opinion Strategies, 2001.

__ . *Future Fish: Issues in Science and Regulation of Transgenic Fish.* Washington D.C., 2003. URL: http://pewagbiotech.org/research/fish/fish.pdf

Priest, S. "US Public Opinion Divided over Biotechnology?" *Nature Biotechnology* 18(2000): 939–942.

Senauer, B. "The Food Consumer in the 21st Century." Working Paper, Retail Food Industry Center, University of Minnesota, 2001.

Table 1. Survey Design and Sample Distribution of Price Discounts

	Base	5% off	10% off	20% off	30% off	50% off
Vegetable Oil	$ 1.90	$ 1.80	$ 1.70	$ 1.50	$ 1.30	$ 1.00
Corn Flakes	$ 4.00	$ 3.80	$ 3.60	$ 3.20	$ 2.80	$ 2.00
Salmon	$ 6.00	$ 5.70	$ 5.40	$ 4.80	$ 4.20	$ 3.00
% of sample	100%	10%	25%	30%	25%	10%

Table 2. Variable Definition and Coding

Variable Name	Definition and Coding
Knowledge and Awareness	
KNOW	1 if very well/somewhat informed about GMOs or GM foods; 0 otherwise.
TF1	1 if one answers correctly to the first true or false question; 0 otherwise.
TF2	1 if one answers correctly to the second true or false question; 0 otherwise.
OIL	1 if one thinks that GM soybeans are already used in vegetable oil; 0 otherwise (For vegetable oil only).
CF	1 if one thinks that GM corn is already used in cornflakes; 0 otherwise. (For cornflakes only)
CF2	1 if one purchases cornflakes more often than at least once per month; 0 otherwise (For cornflakes only).
SAL2	1 if one eats salmon more often than at least once per month; 0 otherwise (For salmon only).
PANEL	1 if one often looks at the panel of nutritional information on the food package; 0 otherwise.
Attitude and Perception	
REL	1 if religious or ethical concerns are extremely or somewhat important; 0 otherwise.
GOV	1 if the government's regulatory performance is excellent or good; 0 otherwise.
TAS	1 if taste is the most important food attribute; 0 otherwise.
NUT	1 if nutrition is the most important food attribute; 0 otherwise.
SAF	1 if safety is the most important food attribute; 0 otherwise.
RP	1 if one thinks GM food is extremely or somewhat risky to human health; 0 otherwise.
LABEL	1 if labeling of GM foods is extremely or somewhat important; 0 otherwise.
Demographic	
AGE	One's age as of 2002.
GENDER	1 if male; 0 otherwise
EDU	Year of school completed.
MARITAL	1 if one is married; 0 otherwise.
LNINC	The natural logarithm of income cohorts ranging from 1 to 10.
WHITE	1 if white; 0 otherwise.
PROTEST	1 if protestant;0 otherwise.
WEST	1 if West; 0 otherwise.
MIDWEST	1 if Midwest; 0 otherwise.
NORTHEAST	1 if Northeast; 0 otherwise.
SOUTH (dropped)	1 if South; 0 otherwise.
KIDS	1 if with children of age 17 or younger; 0 otherwise.
Price	
PRICE	Price of alternative product
Survey Versions	
VER1	1 if vegetable oil precedes cornflakes; 0 otherwise.
VER2	1 if cornflakes precede vegetable oil; 0 otherwise.
VER3	1 if vegetable oil precedes salmon; 0 otherwise.
VER4 (dropped)	1 if cornflakes precede salmon; 0 otherwise.

Table 3. Descriptive Statistics

	Census 2000	Vegetable Oil		Cornflakes		Salmon	
	Mean (Med)	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
KNOW	···	0.525	0.5003	0.5213	0.5007	0.5882	0.4926
TF1	···	0.4333	0.4965	0.5319	0.5001	0.4412	0.4969
TF2	···	0.6333	0.4828	0.6383	0.4816	0.6618	0.4735
RP	···	0.5167	0.5007	0.4681	0.5001	0.4301	0.4955
REL	···	0.4083	0.4924	0.3191	0.4672	0.3676	0.4826
PANEL	···	0.55	0.4984	0.5957	0.4919	0.614	0.4872
TAS	···	0.275	0.4473	0.266	0.4429	0.3015	0.4593
NUT	···	0.325	0.4692	0.2766	0.4483	0.3493	0.4771
SAF	···	0.2083	0.4069	0.2553	0.437	0.1912	0.3936
LABEL	···	0.85	0.3577	0.8404	0.3671	0.8603	0.347
GOV	···	0.5	0.5009	0.617	0.4872	0.4632	0.4991
OIL	···	0.5667	0.4965	···	···	···	···
CF	···	···	···	0.5319	0.5001	···	···
CF2	···	···	···	0.2234	0.4175	···	···
SAL	···	···	···	···	···	0.3934	0.4889
AGE	35.3 (Med)	45.6807	14.9829	47.9247	15.7983	47.3195	14.9353
GENDER	0.491	0.2583	0.4385	0.2128	0.4102	0.2353	0.4245
EDU	···	13.8144	2.0166	13.6824	2.176	13.9207	1.9558
Less than 9th grade	0.075	0.2	0.4007	0.117	0.3222	0.1654	0.3719
High School (9–12)	0.407	0.275	0.4473	0.3404	0.4749	0.2426	0.429
Some College (13)	0.21	0.125	0.3313	0.1064	0.309	0.1801	0.3846
Assoc. Degree (14)	0.063	0.0833	0.2769	0.0638	0.245	0.0662	0.2488
Bachelorfs (15)	0.155	0.175	0.3807	0.2128	0.4102	0.1765	0.3815
More (>15)	0.089	0.1417	0.3494	0.1596	0.367	0.1691	0.3752
WEST	0.225	0.1417	0.3494	0.1489	0.3568	0.136	0.3431
MIDWEST	0.229	0.1583	0.3657	0.1702	0.3767	0.1838	0.3877
NORTHEAS	0.19	0.125	0.3313	0.1702	0.3767	0.1213	0.3268
KIDS	0.328	0.375	0.485	0.3298	0.4712	0.3824	0.4864
MARITAL	0.544	0.5833	0.4939	0.6064	0.4897	0.6324	0.4826
WHITE	0.751	0.8167	0.3877	0.8404	0.3671	0.8199	0.3846
PROTEST	0.560*	0.325	0.4692	0.3936	0.4897	0.3493	0.4771
LNINC	0.699 (Med)	1.5924	0.6137	1.6499	0.6048	1.6467	0.5744
VER1	···	0.2833	0.4515	0.3298	0.4712	···	···
VER2	···	0.25	0.4338	0.2234	0.4175	···	···
VER3	···	···	···	···	···	0.5184	0.5001
Sample Size	···	121	···	94	···	139	···

Sources: The U.S. Census Bureau, except the PROTEST variable, which is from The Gallup Organization, Princeton, NJ, "Gallup Poll Releases-Easter Season Finds a Religious Nation"; published 13 April 2001;
http://www.gallup.com/poll/releases/pr010413.asp

Table 4. Parameter Estimates – Vegetable Oil and Cornflakes

	GM Vegetable Oil		GM Cornflakes	
	Coeff.	Std. Err.	Coeff.	Std. Err.
PRICE	−2.2939 ∗ ∗	0.7434	−0.8508 ∗ ∗	0.2981
CONSTANT	−0.7032	2.6544	1.9384	2.6799
KNOW	1.0375	0.7499	0.8045∗	0.4830
TF1	−0.8580	0.5666	−0.9981∗	0.5734
TF2	0.1072	0.5799	−0.4225	0.5647
RP	−1.9704 ∗ ∗	0.6091	−2.5943 ∗ ∗	0.6134
REL	−0.7745	0.5991	0.4061	0.5378
PANEL	−0.3589	0.4704	−0.0964	0.4744
TAS	−1.9893 ∗ ∗	0.8252	1.2082	0.7397
NUT	−2.9205 ∗ ∗	0.9643	1.1593	0.7510
SAF	−2.3998 ∗ ∗	0.9051	0.3078	0.7342
LABEL	0.6050	0.6410	0.3753	0.6508
GOV	1.3967 ∗ ∗	0.5141	0.4391	0.5161
OIL	−0.0909	0.5604		
CF			0.7956	0.5496
CF2			0.9653	0.6471
AGE	−0.0041	0.0185	−0.0261	0.0190
GENDER	−0.1623	0.6045	−0.3027	0.5603
EDU	0.1817	0.1605	−0.0612	0.1419
WEST	−1.7330∗	0.8963	−1.2939∗	0.6935
MIDWEST	0.9054	0.7203	0.0662	0.7176
NORTH	−0.1732	0.6973	−1.8316 ∗ ∗	0.8032
KIDS	−0.2906	0.5940	−1.4687 ∗ ∗	0.6153
MARITAL	−0.1965	0.5347	−0.8219	0.6030
WHITE	−1.8042 ∗ ∗	0.7962	−0.9124	0.7226
PROTEST	−0.8833∗	0.5347	−0.1965	0.4536
LNINC	0.3258	0.4592	0.8296	0.5233
VER1	1.1664∗	0.6005	−0.2445	0.5536
VER2	0.7206	0.7066	−1.0400	0.6367
McFadden's R^2		0.4447		0.3645

Note: The symbols ** and * indicate that the coefficient is significant at the 5% and 10% levels, respectively.

Table 5. Parameter Estimates – Salmon

	Coeff.	Std. Err.	Coeff.	Std. Err.
PRICE	−0.8607 ∗ ∗	0.1901		
	GM-fed Salmon		*GM Salmon*	
CONSTANT	1.9238	2.4107	0.9912	3.0362
KNOW	0.1100	0.4798	0.1218	0.5334
TF1	−0.2467∗	0.5278	−0.7410 ∗ ∗	0.607
TF2	1.0642 ∗ ∗	0.5687	1.5436∗	0.6339
RP	−1.3163 ∗ ∗	0.5467	−1.0668	0.6227
REL	−1.2953	0.5709	−0.9215	0.6642
PANEL	0.1384	0.4505	−0.354	0.5063
TAS	0.1398	0.8237	−0.1082	0.9561
NUT	−0.3628	0.8144	−0.2944	0.9243
SAF	−0.0309	0.9173	−0.678	1.0528
LABEL	−0.6255	0.6148	−0.7292 ∗ ∗	0.6693
GOV	0.5874	0.494	1.8336∗	0.5869
SAL	−0.3722∗	0.5062	−1.1721	0.6735
AGE	−0.0348	0.0201	−0.0001	0.0214
GENDER	−0.6133	0.5811	0.4548	0.5871
EDU	−0.1173	0.1382	−0.2515 ∗ ∗	0.1663
WEST	−0.5454 ∗ ∗	0.658	−2.3419	0.9323
MIDWEST	−1.5357	0.6636	−0.8672	0.6464
NORTHEAST	−0.3459	0.6922	−1.2341	0.8143
KIDS	0.0715	0.5199	0.4303	0.5902
MARITAL	0.3459	0.5476	0.0029	0.6217
WHITE	0.2602	0.6302	0.7809	0.8572
PROTEST	0.2389	0.5009	−0.4741	0.5419
LNINC	0.0829	0.4403	0.5402	0.5231
VER3	−0.0386	0.4895	−0.7610 ∗ ∗	0.5692
McFadden's R2	0.4258			

Note: The symbols ** and * indicate that the coefficient is significant at the 5% and 10% levels, respectively.

Table 6. WTP to Avoid GM Alternatives

	GM Vegetable Oil		GM Cornflakes		GM-fed Salmon		GM Salmon	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
WTP (dollars)	$0.78	$0.63	$1.26	$0.96	$2.45	$2.39	$3.15	$2.94
WTP (% of Base)	41.2%	33.3%	31.4%	23.9%	40.9%	39.8%	52.5%	48.9%
Base Price	$1.90		$4.00		$6.00		$6.00	

Table 7. WTP by Selected Variables

		Vegetable Oil		Cornflakes		GM-fed Salmon		GM Salmon	
		Mean	Median	Mean	Median	Mean	Median	Mean	Median
GENDER	0	45.10%	39.30%	34.40%	30.20%	40.30%	39.10%	53.30%	47.80%
	1	30.70%	18.90%	19.80%	16.30%	42.60%	45.80%	50.20%	54.10%
KIDS	0	44.30%	33.70%	22.9%**	21.2%**	43.50%	41.80%	55.70%	52.80%
	1	35.70%	33.30%	48.7%**	40.5%**	36.60%	39.40%	47.30%	43.30%
MARITAL	0	42.80%	25.20%	34.00%	25.50%	44.70%	39.80%	55.20%	52.80%
	1	39.90%	36.80%	29.70%	23.90%	38.60%	39.70%	50.90%	46.60%
WHITE	0	32.2%**	33.3%**	28.30%	25.50%	48.60%	42.40%	69.10%	67.30%
	1	42.9%**	33.7%**	31.90%	23.90%	39.40%	39.40%	49.30%	46.10%
PROTEST	0	41.3%*	32.2%*	30.40%	23.90%	44.80%	45.10%	53.60%	47.80%
	1	41.0%*	36.8%*	32.70%	26.00%	35.10%	32.50%	50.90%	52.10%
WEST	0	35.3%*	25.9%*	26.9%*	23.4%*	40.6%**	39.8%**	48.40%	45.70%
	1	72.6%*	63.2%*	55.2%*	36.6%*	42.7%**	52.0%**	77.10%	77.10%
MIDWEST	0	44.30%	38.40%	34.90%	23.90%	36.50%	35.60%	51.00%	49.80%
	1	23.20%	21.80%	10.80%	21.40%	60.10%	60.10%	59.20%	47.80%
NORTHEAST	0	40.10%	30.40%	24.7%**	21.9%**	39.80%	39.10%	50.80%	46.10%
	1	47.20%	47.70%	63.7%**	40.8%**	48.40%	54.50%	64.00%	57.90%
RP1	0	16.0%**	10.1%**	1.8%**	4.7%**	25.4%**	18.1%**	41.60%	42.00%
	1	65.8%**	61.4%**	65.7%**	67.6%**	59.7%**	59.8%**	65.80%	63.70%
REL1	0	38.40%	21.80%	35.20%	30.70%	30.80%	26.40%	43.30%	43.70%
	1	45.60%	44.00%	23.10%	16.40%	57.80%	59.80%	68.00%	63.70%
GOV	0	60.1%**	60.2%**	40.20%	23.90%	45.70%	47.10%	66.4%*	65.4%*
	1	22.7%**	12.7%**	26.00%	25.50%	35.60%	32.10%	37.2%*	40.1%*