IOWA STATE UNIVERSITY

The Value of Verifiable Information in a Controversial Market: Evidence from Lab Auctions of Genetically Modified Food

Matthew Rousu, Wallace Huffman, Jason F. Shogren, Abebayehu Tegene

September 2002

Working Paper # 02003

Department of Economics Working Papers Series

Ames, Iowa 50011

The Value of Verifiable Information in a Controversial Market: Evidence from Lab Auctions of Genetically Modified Food

Matthew Rousu, Wallace E. Huffman, Jason F. Shogren, and Abebayehu Tegene

February 25, 2002

The authors are graduate student, Department of Economics, Iowa State University; professor, Department of Economics, Iowa State University; Stroock distinguished professor of natural resource conservation and management, Department of Economics and Finance, University of Wyoming; and Senior Economist, Food and Rural Economics Division, ERS, U.S. Department of Agriculture, respectively.

The authors gratefully acknowledge financial assistance from the USDA under Cooperative Agreement No. 43-3AEL-8-80125, the Cooperative State Research, Education, and Extension Service, USDA, under Grant No. 00-52100-9617, and the Iowa Agriculture and Home Economics Experiment Station. Also, we thank Wayne Fuller and Phil Dixon in the Department of Statistics for assistance with the statistical experimental design, Walt Fehr and John Miranowski for helpful suggestions and comments, and Monsanto for providing food products. The views expressed are the authors' and do not represent the views or policies of the USDA.

Abstract

Two interested parties dominate the current debate on genetically modified (GM) foods: environmental groups and agribusiness companies. For the average consumer to arrive at an informed decision on these new foods, they must rely on information from interested parties. Unfortunately, information from interested parties does not provide an accurate picture of the benefits and risks of new products. This paper examines the effects of information on consumers' demand for new food products, GM-foods, in an environment where information from one or more interested parties is provided. We design and conduct laboratory auction experiments using randomly chosen adult consumers from two large metropolitan areas who are grouped into twelve experimental units and subjected to six randomly assigned information treatments. We find that in this environment, verifiable information has a small but positive value to sample consumers, and the projected annual social value to all processed foods consumed is relatively large for this public good. Such a large potential value may make it worthwhile for the United States to establish a new third party institution that would produce and distribute verifiable information on GM food.

1. Introduction

R&D frequently leads to the development of new inputs and consumer goods, and the introduction of new products, e.g., foods, can lead to information wars as interested parties try to influence market outcomes. Two groups dominate the debate over genetically modified (GM) foods. These groups have very different ideas or beliefs about the benefits and risks of agricultural biotechnology. Agribusiness companies like Monsanto and Syngenta support agricultural biotechnology and say that GM foods will help protect the environment, increase nutrition, and help end world hunger (Council for Biotechnology Information, 2001). Environmental groups like Greenpeace and Friends of the Earth oppose agricultural biotechnology and say that GM foods could cause allergic reactions, will hurt the environment, and could increase the power of multinational companies (Greenpeace, 2001). One could characterize the on-going GM-food controversy as an information war between the pro- and anti-biotech interest groups. The average U.S. consumer and farmer has available to him (her) diverse information from these interested parties as they makes decisions on the use of GM products. Socially good or bad decisions may result. Huffman and Tegene (2002) have hypothesized that independent, third-party information, or *verifiable information*, might improve social welfare in this environment. Decision-makers can profit from access to impartial information about the likely risks and benefits of genetic modification.

This paper examines the effects of information on consumers' demand for new food products, GM-foods, in an environment where information from one or more interested parties is provided. Four issues are examined. First, how does diverse information from interested parties affect consumers' willingness to pay for genetically modified foods? Second, does third-party or verifiable information on genetic modification, in an environment where pro- or (and) anti-biotech information is provided, change consumers' purchasing behavior? Third, if behavior changes, what is the value of verifiable information to consumers? Fourth, if we generalize our results to the aggregate U.S. demand for processed foods, what is the approximate annual social value?

To address these issues, we design and conduct a set of laboratory auction experiments on randomly chosen adult consumers from two large metropolitan areas who are grouped into twelve experimental unit and subjected to six randomly assigned information treatments. In designing the experiments, we combine the best attributes of statistical experimental design and experimental economics to obtain a superior overall experimental design. Our empirical analysis of the experimental data shows that the release of pro- and anti-biotech information affects bid prices in the expected direction; the release of pro- and anti-biotech information together leads to intermediate bid prices, i.e., anti-biotech information does not dominate pro-biotech information when it is present; and when pro- or anti-biotech information is present, the release of third-party or verifiable information is a moderating force on willingness to pay. Finally, we show that the value of verifiable information to sample consumers is small, but positive, and when we venture to extend our results to cover annual sales of U.S. processed foods, verifiable information on genetic modification, treated as a public good, has a large annual social value. Hence, we conclude that the U.S. should explore in much greater detail the design of a new independent institution to produce and distribute verifiable information on genetic modification of foods.

2. Experimental Design

With two interested parties injecting diverse information into in a controversial market, what are rational consumers likely to do? Ideally, these buyers will make informed decisions provided they are (a) sophisticated enough to understand the technical processes at work and to recognize that interested parties' supply information tainted by a political agenda, and (b) they can verify all the information provided (Milgrom and Roberts, 1986). Unfortunately, this full and verifiable information environment does not define the market for genetically modified products. Genetic modification is a complex process, which involves taking genes from one organism and placing them into another. Most consumers do not know the intricate details of this process. In addition, not all GM information is currently verifiable. Also, the search costs for most consumers to find neutral information is very high, as there are contradictory messages about GM as "food to feed the planet" versus GM as "frankenfood" (see for example Gates, 2001). Because of these high search costs, a verifiable information source – defined as a source that has no financial ties to genetic modification and produces information that is verifiable – could have tremendous consumer value (Huffman and Tegene, 2002).

Limited evidence from earlier surveys and the lab suggests that consumers only hear the bad news in a controversial market with diverse information and without verifiable information. Individuals amplify the risks of a neoteric product and discount its benefits. Viscusi (1997), for instance, showed using a survey that when consumers received divergent information on environmental risks, they put greater weight on the expert who provided a high-risk assessment. They did so regardless of whether the low-risk assessment came from a government or an industry source. A similar "alarmist" reaction to a new product was also observed in Fox, Hayes, and Shogren's (2001) lab auction experiment on the value of food irradiation. Their initial results follow intuition: a favorable description of irradiation increased demand and an unfavorable description decreased demand. But when presented with both a favorable and unfavorable description, demand fell to zero, suggesting the negative portrayal dominated the positive. Bidders bid as if they had only heard the anti-irradiation argument, despite the fact that the negative information was presented by a consumer advocacy group and was presented in a non-scientific manner.

Consistent with several models of choice under risk (e.g., loss aversion, status quo bias, Bayesian updating), this result illustrates the incentive for partisan groups to promote unscientific claims for their personal gain and for loss in welfare of others. The open question that neither the Viscusi nor Fox, Hayes, and Shogren studies address is the potential social value of introducing third party verifiable information about the risks and benefits of the controversial products for sale in the market. One attempt to estimate the value of such information was Foster and Just's (1989) study on how news of insecticide contamination (heptachlor) affected milk consumption in Hawaii. Foster and Just calculated the value of third party information as the difference in rational consumers' choices under incomplete and more complete information. They estimated the value of information as about $10.00 per person per month. Foster and Just did not, however, control for the type of information as a treatment variable. This will distinguish our experimental design from theirs.

We design our experiment to incorporate the private-information-revealing feature of experimental auction markets like Fox et al. (2001) and the rigorous randomized treatment effects of statistical experimental design. The experimental design consisted of six biotech information-labeling treatments with two replications. The treatments are randomly assigned to twelve experimental units, each consisting of 13 to 16 consumers drawn from the households of two major urban areas and who are paid to participate. Each participant participated in two trials.[1] Using randomly chosen consumers from the population of an urban area, rather than undergraduate college students at a university, is a advantage when it comes to drawing inferences from the experiments or generalizing to the Midwest or whole U.S. population.

Consumers might react differently to GM content in different types of food or they may have no demand for some food products. Using only one food item seemed unlikely to reveal enough information, given the sizeable fixed cost of conducting the experiment. Three food items were chosen: vegetable oil (made from soybeans), tortilla chips (made from yellow corn), and Russet potatoes. In the distilling and refining process for vegetable oils, essentially all of the proteins (which are the components of DNA and the source of genetic modification) are removed leaving pure lipids. Minimal human health concerns should arise from GM oil, but consumers may either worry that GM soybeans affect the environment or lack adequate information on the distilling process. Tortilla chips are highly processed foods that may be made from GM or non-GM corn, and consumers might have human health and environmental concerns. Russet potatoes are purchased as a fresh product and are generally baked or fried before eating. Similar to tortilla chips, consumers might see both human health and environmental risks from eating GM-Russet potatoes.

Auctions were conducted at two Midwestern U.S. cities: Des Moines, IA, and St. Paul, MN. Participants in the auctions were consumers in these two areas who were contacted by the Iowa State University Statistics Laboratory and agreed to participate in the study. The Statistics Laboratory obtained 1,200 to 1,500 randomly selected residence telephone numbers from each of the metropolitan areas. Employees of the ISU Statistics Laboratory called these numbers to make sure that the phone number was for a residence. The employees then asked to speak to an adult in the household (individual who was 18 years of age or older). They were told that Iowa State University was looking for people who were willing to participate in a group session in Des Moines (St. Paul) that relates to how people select food and household products. The sessions were held on Saturday, April 7th (April 21st) and participants were informed that the session would last about 90 minutes. Each participant was told that they would receive $40 in cash for their time. The sessions were held at the Iowa State University Learning Connection, 7th and Locust, Des Moines (lower level of the Classroom Office Building, University of Minnesota, St. Paul). Three different times were available each auction day, 9 a.m., 11:30 p.m., and 2 p.m., and willing participants were asked to choose a time that best fit their schedule. Participation per household was limited to two adult individuals, and they were assigned to different groups.[2] To willing participants, the Statistics Laboratory followed up by sending a letter containing more information, including a map and instructions on when and where the meeting would be held, how to get there, and a telephone number to contact for more information.

There were twelve experimental units, six in Des Moines, and six in Minneapolis. Twelve hundred people in Des Moines were called and 99 of them agreed to participate. Of those 99 people who agreed to participate, 77 did indeed attend. For the Minneapolis experiments, 1,500 people were called and 118 people agreed to participate. Of those 118, we had 95 participants in the Minneapolis experiments. The total sample size is 172, which is large compared to most experimental auctions.

Each auction had ten steps, which are summarized in figure 1.[3] When participants arrived at the lab, they signed a consent form to agree to participate in the auction. After they signed this form, they were given $40 for participating and an ID number to preserve their anonymity. The participants then read a brief set of instructions and filled out a questionnaire.

Step 2 introduced the auction. We used a random *n*th price auction in this experiment (Shogren et al., 2001). The advantages of the random *n*th price auction are that it is demand revealing in theory and the auction attempts to engage bidders at all locations along the demand curve.[4] The random *n*th-price works as follows: Each of k bidders submits a bid for one unit of a good; then each of the bids is rank-ordered from highest to lowest. The auction monitor then selects a random number which is drawn from a uniform distribution between 2 and k; and the monitor sells one unit of the good to each of the (*n*-1) highest bidders at the *n*th-price. For instance, if the monitor randomly selects n = 5, the four highest bidders each purchase one unit of the good priced at the fifth-highest bid. Ex ante, bidders who have low or moderate valuations now have a nontrivial chance to buy the good because the price is determined randomly. This auction increases the odds that insincere bidding will lead to a loss. Participants were given detailed instructions on the random *n*th-price auction, including an example written on the board. After the participants learned about the auction, a short quiz was given to ensure that everyone understood how the auction worked.

Step 3 was the first practice round of bidding, where participants bid on a brand-name candy bar. The participants were asked to examine the product and then place a (sealed) bid on the candy bar. The bids were collected and the first round of practice bidding was over. Throughout the auction, when the participants were bidding on items in a particular round, they had no indication of what other items they may be bidding on in future rounds or if additional rounds would occur.

Step 4 was the second practice round of bidding. In this round the participants bid separately on three different items. The three products were the same brand-name candy bar, a deck of playing cards and a box of pens. The consumers were asked to examine the three products in practice round two and make bids on the products. Then the bids were collected. Only one of the two rounds was chosen as binding (valid), so that participants would not take home more than one of any product. The reason was to eliminate price reduction due to the consumer buying a larger quantity because of diminishing marginal utility of these products (i.e., lower prices due to a consumer's negatively sloped demand curve).[5] Participants were informed that only one of the two rounds would bind before step 3 and were reminded of this again before step 4.

After the two practice auction rounds were completed, the binding round and the binding *n*th-prices were revealed in step 5. All of the bids were written on the blackboard, and the *n*th-prices were circled for each of the three products. Participants could see what items they won immediately, and the market-clearing price. The participants were notified that all purchases of goods would take place after the experiment was over, so that all exchanges of money for goods would take place at the end of the session.

In step 6, information about biotechnology was released to the participants. The possible types of information a participant could receive were: (1) *the industry perspective*—a collection of statements and information on genetic modification provided by a group of leading biotechnology companies, including Monsanto and Syngenta; (2) *the environmental group perspective*—a collection of statements and information on genetic modification from Greenpeace, a leading environmental group; and (3) the *third-party, verifiable perspective*—a statement on genetic modification approved by a third-party group, consisting of a variety of individuals knowledgeable about genetically modified goods, including scientists, professionals, religious leaders, and academics, none of whom have a financial stake in genetically modified foods. To assist the participants process these different sources of information, the volume of information released of each type was limited to one 8 1/2" x 11" page, and it was organized into five categories: general information, scientific impact, human impact, financial impact, and environmental impact, to ease the information processing load on participants. Figures 3, 4, and 5 show the exact wording of the three types of information about genetically modified food.

The information was randomized to create six treatments of information combinations: pro-biotechnology information; anti-biotechnology information; both pro and anti-biotechnology information;[6] pro-biotechnology and third party, verifiable information; anti-biotechnology and third-party,[7] verifiable information; and pro-biotechnology, anti-biotechnology, and third-party, verifiable information. These six combinations were randomized among all twelve experimental units, with each information combination going to two experimental units.

Two auction rounds followed the distribution of information. One of the two rounds had the participants bid on food products with just a standard food label. The other round had participants bid on the same food products with the same label, except there was a sentence added indicating that the food had been genetically engineered. These labels were made as plain as possible to avoid any influence on the bids from the label design (see Figure 2). The sequencing of GM labels was randomized across experimental units. Each combination of information was given to two experimental units. One of these experimental units bid on food with the standard label in round one, and the food with the label indicating genetic modification in round two. The other experimental unit bid on food with the label indicating genetic modification in round one, and the standard label in round two. For each experimental unit, only one of the two food rounds was chosen as the binding (valid) round. This avoided the problem of bid prices being reduced as consumers moved along their demand curve.

In step 7, participants bid on three different food products: a bag of potatoes, a bottle of vegetable oil, and a bag of tortilla chips. The participants were instructed to examine the three products and then write down their (sealed) bid for each of the three goods. Participants bid on each good separately. Then the bids were collected from the individuals, and the participants were informed that they were about to look at another group of food items.

Step 8 had participants come examine the same three food products, but with the different labels (the second trial). After the participants examined the products, they were instructed to bid on the three products. Each good was bid on separately. The bids were then collected from all of the participants. Once again, consumers were informed that only one of the two trials or bidding rounds would bind before step 7, and they were told this again before step 8.[8]

Step 9 consisted of the selection of which of the two trials would be chosen as binding, along with the binding *n*th-prices. After the binding round and binding *n*th prices were revealed, the winners were notified and the participants were asked to complete a brief post-auction questionnaire. In step 10, the participants who did not win any products were informed that they were free to leave, and the participants who won products exchanged money for their goods, and then they were free to leave.

3. Empirical specification I: Consumer demand under diverse information

Following Viscusi and Evans (1990), we begin our empirical specification by first developing a state-dependent utility model of GM food consumption given diverse information. A person compares his perceived expected utility (henceforth, utility) from consuming GM-labeled foods and plain-labeled foods. These two goods are nearly perfect substitutes, in which consumption can result in either a good or bad outcome, with distinct probabilities[9]. Equation (1) shows the state-dependent utility function for a consumer who purchases GM-labeled food, called *labeled*; equation (2) is his utility for a purchase of plain-labeled foods, called *non-labeled*:

(1) $$EU^{j}_{labeled}(w) = p^{j}_{labeled}(I)U^{j}(w) + \left(1 - p^{j}_{labeled}(I)\right)V^{j}(w)$$

(2) $$EU^{j}_{non-labeled}(w - M) = p^{j}_{non-labeled}U^{j}(w - M) + \left(1 - p^{j}_{non-labeled}\right)V^{j}(w - M).$$

where consumer *j*'s income is *w*, and M is the monetary premium he pays for the non-labeled food (the premium can be positive, negative or zero). Consumer *j* obtains utility U^j if the good state occurs, and V^j if the bad state occurs, where $U^j > V^j > 0$.

Assume the bad state occurs when either consumer *j* becomes ill or a bad environmental outcome occurs (e.g., genetic cross-breeding). Let $p^j_{labeled}(I)$ and $p^j_{non-labeled}(I)$ be consumer *j*'s perceived probability that the GM-labeled food and plain-labeled food will yield the good state. Assume the information the consumer has on genetic modification, $I \sim (-\infty, \infty)$ affects the perceived probability that GM-labeled foods will result in a good state. Large positive I represents positive or favorable information on GM foods; large negative I represents negative or less favorable information on GM foods. When a consumer gets positive information on GM foods, I increases and the consumer perceives greater utility from GM-labeled foods and greater marginal utility from GM-labeled foods. The information a consumer receives in our experiments is randomly assigned, and can differ among participants. The consumer's perceived probability of a good outcome from plain-labeled food *does not depend on information about GM foods*.

When equation (3) holds, the consumer is indifferent between purchasing GM-labeled and plain-labeled foods

(3) $$EU^j_{labeled}(w) = EU^j_{non-labeled}(w-M).$$

or:

(3a) $$p^j_{labeled}(I)U^j(w) + \left(1 - p^j_{labeled}(I)\right)V^j(w) =$$

$$p^j_{non-labeled}U^j(w-M) + \left(1 - p^j_{non-labeled}\right)V^j(w-M).$$

The consumer prefers GM-labeled foods when the left-hand side of (3a) exceeds the right-hand side, otherwise he prefers the plain-labeled foods. In addition, standard comparative statics show that an increase in positive GM information increases the consumer's likelihood of consuming GM-labeled foods by increasing the expected utility of GM-labeled foods:

$$\frac{\partial EU^{j}_{labeled}(w)}{\partial I} = \frac{\partial p^{j}_{labeled}(I)U^{j}(w) + \left(1 - \partial p^{j}_{labeled}(I)\right)V^{j}(w)}{\partial I}$$

$$= \frac{\overbrace{\partial p^{j}_{labeled}(I)}^{+}U^{j}(w) + \left(1 - \overbrace{\partial p^{j}_{labeled}(I)}^{+}\right)V^{j}(w)}{\partial I} > 0 .$$

We now define the aggregate demand for GM foods. Let $X^{j}_{labeled}$ represent the quantity of GM-labeled foods demanded by consumer *j*. Assume $X^{j}_{labeled}$ is positive for consumers who prefer GM-labeled foods, and zero otherwise. We sum the quantity demanded over all consumers to obtain the aggregate demand for GM-labeled foods:[10]

(4) $$AGDEMAND_{labeled} = \sum_{j} X^{j}_{labeled}(I) .$$

Assume the population of consumers is heterogeneous in tastes and income such that they can be grouped as: (i) consumers of GM-labeled products, (ii) consumers who initially consume plain-labeled foods but switch to GM-labeled product with more positive GM information; and (iii) consumers of plain-label foods who never switch with positive information. Now split aggregate demand for GM-labeled foods into those consumers who initially buy GM-labeled foods and those who do not:

(4a) $$AGDEMAND_{labeled} = \sum X^{buyGM}_{labeled}(I) + \sum X^{zeroGM}_{labeled}(I) .$$

Taking the derivative of (4a) with respect to information *I* yields:

(5) $$\frac{\partial AGDEMAND_{labeled}}{\partial I} = \overbrace{\sum \frac{\partial X_{labeled}^{buyGM}(I)}{\partial I}}^{\geq 0} + \overbrace{\sum \frac{\partial X_{labeled}^{zeroGM}(I)}{\partial I}}^{>0} > 0,$$

which says that an increase in positive information I increases the aggregate demand for GM-labeled foods. The first term on the right-hand side of (5) is the derivative for those who initially consumed the GM-labeled product, and it can be greater than or equal to zero. The second term is the derivative for consumers who do not initially consume GM-labeled foods. For some individuals this derivative is zero, and for others, this derivative is positive because they switch. The second summation term is positive, and the aggregate demand for GM-labeled foods is increasing in information I. The opposite result holds for negative information.

We now consider the specific regression analysis used to examine consumer behavior under diverse information. The regressions hold consumers' tastes constant for each of the three products by making the dependent variable the difference in bid prices for plain-labeled and GM-labeled products for each participant. This price difference is derived by taking the difference of the demand equations for each product in the two trials. Let the inverse demand equation for the GM-labeled and plain-labeled food be:

(6) $$P_j^{non-labeled} = \beta_1^{non-labeled} + \beta_2^{non-labeled} X_{j2} + \mu_j^{non-labeled}$$

and

(7) $$P_j^{labeled} = \beta_1^{labeled} + \beta_2^{labeled} X_{j2} + \mu_j^{labeled}.$$

where P_j represents the price bid for a good by participant j; β_1 is an intercept term; X_{j2} is a vector of exogenous variables, and β_2 is the associated vector of coefficients. μ_j is a zero mean disturbance term.

Subtracting equation (7) from equation (6), we obtain an equation in which the dependent variable is the difference in bid prices for the two trials:

(8) $$P_j^{non-labeled} - P_j^{labeled} = \beta_1^{non-labeled} - \beta_1^{labeled} + \left(\beta_2^{non-labeled} - \beta_2^{labeled}\right)X_{j2} + \mu_j^{non-labeled} - \mu_j^{labeled}$$

The coefficients and error terms can be condensed and rewritten as:

(8a) $$P_j^{non-labeled} - P_j^{labeled} = \beta_1^* + \beta_2^* X_{j2} + \mu_j^*.$$

The difference in bid prices is explained by an intercept term β_1^*, a slope term β_2^* that is multiplied by a vector of exogenous characteristics X_{j2}, and a random error term μ_j^*.[11]

Equation (8a) is likely to be censored because a zero bid for the GM-labeled product or the plain-labeled product or both may occur. This censoring has four cases (see Figure 7). Case (1): consumer *j* bids a positive amount for both the GM-labeled and the plain-labeled product; the measured difference in bid prices is the difference between the two bid prices. Case (2): consumer *j* bids zero for the GM-labeled product and a positive amount for the plain-labeled product. The "true difference" in bid prices with the censored regression will be greater than the difference between the two observed bid prices. This arises because the bids on the GM-labeled product are censored at zero. Case (3): consumer *j* bids a positive amount for the GM-labeled product and zero for the plain-labeled product. This is the same as Case (2), the true difference in bid prices for the censored regression is absolutely larger than the measured difference between the two bid prices. Case (4): consumer *j* bids zero for both products. This does not give any information about their true demand for GM products.

A positive aspect of using the censored regression model is that zero bid prices are correctly accounted for, and effects of bias from the zero bids are minimized. The disadvantage is that we must assume a bid price distribution. Assume the zero bid prices would have followed a normal distribution, had they not been censored. Statistical tests are conducted using the likelihood ratio test statistic (Greene, 2000).[12] The large sample distribution of $-2\ln\lambda$ is chi-squared, with degrees of freedom equal to the number of restrictions imposed.

4. Empirical specification II: The value of verifiable information

We now define the empirical specification to obtain the value of verifiable information. We compare the utility gained using the *ex post* probabilities of harm from GM labeled foods for those bidders who switched their purchasing behavior with new information. This approach is similar to the approach used by Foster and Just (1989) and Teisl *et al*. (2001). Because the goods are nearly perfect substitutes, consumers who receive third-party information on GM foods could change their relative preferences, but their preferences might not change enough to cause them to switch to the other good. As an example, assume a consumer is initially willing to pay $1.00 for a GM-labeled food product and $2.00 for a plain-labeled food product, and the plain-labeled food costs $2.00. Suppose the market-clearing price for the GM-labeled food is $1.60. The consumer would initially buy the plain-labeled food. If third-party information increases the consumer's willingness to pay for the GM-labeled product from $1.00 to $1.50, the information changes the consumer's relative preference toward GM-labeled food but not enough to make him switch. Since the GM-labeled food costs $1.60, he is still better off purchasing the plain-labeled version of the product.

We evaluate two types of individuals who gain from third-party information. The first type is one who purchases GM-labeled foods before he received third-party, verifiable information, but switches to plain-labeled foods after he receives the third-party information. The second type purchased plain-labeled foods before the third-party information is introduced, and then switches to GM-labeled foods after he receives the third-party information.

What is the welfare gain for consumers who switch after verifiable information is released/provided? First, let's look at the welfare gains for a consumer who switches from the plain-labeled food to the GM-labeled food. The consumer originally purchases the plain-labeled food, and the surplus the consumer receives from that purchase is the difference between his/her willingness to pay and the price for the plain-labeled food. Consumer *j*'s surplus from purchasing plain-labeled food or GM-labeled food is shown in (9) and (10):

(9) $$surplus^{j}_{non-labeled} = WTP^{j}_{non-labeled} - P^{j}_{non-labeled}$$

(10) $$surplus^{j}_{labeled} = WTP^{j}_{labeled} - P^{j}_{labeled}\,.$$

Because we are looking at the case in which a consumer originally purchases plain-labeled foods, the consumer perceives a greater surplus from consuming the plain-labeled food than from consuming the GM-labeled food. For consumers who switch after receiving third-party information, the surplus from purchasing the GM-labeled food is now greater than the surplus from purchasing the plain-labeled food. The welfare gain to the consumers who switch is the surplus they receive from purchasing the GM-labeled food minus the surplus they would receive if they purchased the plain-labeled food. A consumer *j's* increase in welfare from third-party information due to switching from the plain-labeled product to the GM-labeled product:

(11) $$PREMGAIN^{j}_{labeled} = surplus^{j}_{labeled} - surplus^{j}_{non-labeled}\,.$$

Those consumers who initially purchased the GM-labeled food and then switched to the plain-labeled food after they received third-party information will also gain. Their gain will be the welfare gain from purchasing the plain-labeled foods minus the gain they would have received if they had purchased GM-labeled foods. The welfare gain of an individual *j* who switches from the GM-labeled product to the plain-labeled product is:

(12) $$PREMGAIN^{j}_{non-labeled} = surplus^{j}_{non-labeled} - surplus^{j}_{labeled}\,.$$

Note all consumers enjoy the premium gained by consuming one product instead of another, as shown in expressions (11) and (12), but the premium gained represents increased welfare (i.e., the value of information) for those *who switch products*. The total welfare gained for each product from a third-party source can be computed by summing the welfare gains over all individuals. The total value of information is obtained by summing the value of information for all individuals who switched to GM-labeled foods and all individuals who switched to plain-labeled foods:

$$(13) \qquad SUMVAL = \sum_{j \in switched} PREMGAIN^{j}_{non-labeled} + \sum_{j \in switched} PREMGAIN^{j}_{labeled} \ .$$

There are three combinations of information a person could have received when no third-party information is available. A consumer could have access to only positive information on GM foods, have access to only negative information on GM foods, or could have access to both positive and negative information on GM foods. The gains from third-party information are computed for each of the three situations.

Three magnitudes are needed to value verifiable information: (1) the difference in the marginal percentage who purchase GM-labeled foods after third-party information is introduced; (2) the value of third-party information to each person who switches; and (3) the average value of third-party information per person. These three values will be obtained for individuals in each of the three information settings (receiving positive information, receiving negative information, or receiving both positive and negative information).

First, we determine the net change in the percentage of consumers who purchase GM-labeled foods. The experimental auction provides data on how much a consumer values the plain-labeled product and the GM-labeled product, but no information on these prices. To compute the value of information, we need an estimate of the prices a consumer would face in the market. To do this, we assume that the price for a GM-labeled food *is the mean bid price for that food product across all auction participants*, and the price for the plain-labeled food is the mean bid price for that food product. Because we are trying to assess the average value of information for each product, we will assume that all participants purchase either the GM-labeled version or the plain-labeled version of a product. Individuals purchase the product that gives him/her the greater surplus, as shown in equations (9) and (10). The net change in the percentage who purchase the GM-labeled product is the (absolute) difference between the "percentage who purchase GM-labeled foods when treated to third-party information" and the "percentage who purchase GM-labeled foods but do not receive third-party information;" given the other information they have received:

$$(14) \qquad Percentswitch = \left| percentbuyGM^{thirdparty} - percentbuyGM^{no-thirdparty} \right|.$$

For participants who receive only negative information, third-party information should cause some to switch to GM-labeled foods. For participants who only receive positive information, one would expect some to switch to plain-labeled foods. For consumers who receive both positive and negative information, it is difficult to predict whether consumers would buy more or less GM-labeled food when third-party information is given. The net percentage change is the absolute value of the difference in the percentage who consume the GM-labeled food with and without third-party information.

Who switches once third-party information is introduced? We do not know the particular individuals who switch, but we do know the percentage of the sample who switched after the introduction of third-party information. We assume that the individuals who switched have relative preferences for GM-labeled foods that are evenly distributed throughout the population who consume the good that has been switched to. For example, if third-party information causes a number of consumers to switch their purchasing habits to consume GM-labeled foods, we will assume that these consumers who switched have relative valuations of GM-labeled foods that are evenly distributed throughout the population of consumers who purchase the GM-labeled foods.

Second, we estimate the value of third-party information to a person who switches either to or from the GM-labeled food. To determine the value of third-party information to a consumer who switches, we divide the total value of verifiable information, as computed in equation (13), by the number of consumers who switched products:

$$(16)\qquad switchervalue_l = \frac{SUMVAL}{N^{buy-switchedproduct}}.$$

In equation (16), $switchervalue_l$ is the average value of third-party information to a consumer that switches his/her purchase of product l either to or from the GM-labeled food after they receive the third-party information. This works because we are assuming the consumers who switched are evenly distributed throughout the population of consumers. The total value of third-party information for product l can be obtained by multiplying the average value of third-party information per switcher by the number of switchers:

$$(17)\qquad totalvalue_l = switchervalue_l \times N^{switched}.$$

Then the average value of third-party information for product l can be computed by dividing the total value of third-party information by the total number of consumers in the population:

$$(18)\qquad avevalueperson_l = \frac{totalvalue_l}{N^{pop}}.$$

In sum, our experimental auction data and econometric design allows us to calculate the percentage of consumers who switch in each of the information settings: receiving positive information, receiving negative information, or receiving both positive and negative information. The average value of third-party information per person who switches will be computed for each product. We then estimate an average value of third-party information per consumer in the population for each product, and then translate this into a total value to the United States.

5. Results and Discussion

Table 1 summarizes the demographic characteristics of the 172 auction participants. Sixty-two percent of the participants in the auctions were female. The mean age of a participant was 49.5 years (a person had to be at least 18 years old to participate). Two-thirds of the auction participants were married. On average, the participants were well educated, with the mean education level being more than two years in college. The participants had a mean total household income (before taxes) of $57,000. Most of the participants in the experiments were white (ninety percent), and most people indicated that they read labels before they buy a new food product. The demographic characteristics of our participants indicate that our experiments had a representative sample of the Midwest region of the United States.[13]

Some participants chose to bid zero in both trials, i. e., for both the GM-labeled and the plain-labeled variety of a particular food product. These participants provide no information about their taste for genetic modification; they were willing to pay zero for one unit, indicating they had no demand for the particular food product. Table 2 presents the mean bids for participants, segregated by information treatment, but does not include bids for consumers who bid zero for both the GM-labeled and plain-labeled varieties of a product.[14] In Table 2, the number of participants who bid a positive amount for a product is different for each of the three goods. This arises because more consumers chose to bid zero for the GM-labeled and plain-labeled vegetable oils than for the GM-labeled and plain-labeled bags of tortilla chips, and the fewest number of consumers chose to bid zero for the GM-labeled and plain-labeled bags of potatoes. Many consumers who bid zero for both varieties of one product, bid a positive amount for the other products.[15]

The Effect of Diverse Information

Part A of table 2 shows the mean bid prices for all participants. Consumers, on average, discounted GM-labeled foods by fourteen percent. Part B shows that participants who received only positive information actually put a premium on the GM-labeled food for two of the three products. This was despite the fact that the genetic modification was only used to enhance the production process, and did not give the foods any enhanced attributes. Part C shows that when consumers received only negative information, they discount the GM-labeled foods by an average of approximately thirty-five percent. Part D shows that consumers who received both positive and negative information discount the GM-labeled foods by an average of seventeen to twenty-nine percent, depending on the food product.

Third-party information has an impact on the willingness to pay for GM-labeled foods. Part E shows that consumers who received positive and third-party information discounted GM-labeled foods slightly. This is in contrast to the consumers who received only positive information who valued the GM-labeled foods more than their plain-labeled counterpart on average. Part F shows that participants who received negative and third-party information still discounted the GM-labeled foods, but by a smaller amount than the participants who received only negative information. Part G shows that participants who received negative and third-party information discounted the GM-labeled foods by an average of seventeen to twenty-two percent, depending on the product. Participants who received positive, negative and third-party information were more accepting of the GM-labeled foods than those who received only positive and negative information. The participants who received positive, negative and third-party information discounted the GM-labeled food by an average of zero to eleven percent, depending on the product.

Our results are consistent with Viscusi (1997) who found that individuals placed a slightly greater weight on negative information than positive information. In our auction, participants who received only positive information did not discount the GM-labeled food, while those who received only negative information discounted the GM-labeled food by an average of 35 percent. Those who received both positive and negative information put slightly more weight on the negative information, discounting the GM-labeled foods by 20 percent. The results here are in contrast to Fox *et al*.'s (2001) who obtained the result that negative information dominated positive information. They argued that one reason could be due to a "status quo bias," (or endowment effect) where participants were originally endowed with a regular pork sandwich and could bid to upgrade to an irradiated pork sandwich. Participants may have their bids biased due to being endowed with one type of sandwich.[16] Our auction had participants bid on items in separate rounds (trials), thus our results are not influenced by a "status quo bias."

Tables 3, 4, and 5 display the censored regression results.[17] For all three goods, models were fitted using five dummy variables to test for impacts of different information types. Dummy variables are defined for negative information; negative and positive information; positive and third party information; negative and third party information; and positive, negative, and third-party information. *Positive information is the omitted information type from the reported regression results*. Other regressors include gender, income, a dummy variable indicating if a person saw the food with GM labels in trial one, and a dummy variable indicating if the participant perceived themselves to be informed about GM foods.[18] These variables allow us to control for selective demographic characteristics and examine how prior knowledge about genetically modified foods affects willingness to pay or demand.

The intercept term is statistically insignificant for all three products. The coefficients for the dummy variables indicating that participants received only negative information are large, positive, and statistically significant. The coefficients for the dummy variable indicating that an individual who received positive and negative information is positive and these coefficients are statistically significant for some of the food products. These results show individuals who received only negative or both positive and negative information behaved differently than individuals who received only positive information when making purchasing decisions.

The coefficients for the dummy variables where an individual received positive and third-party information are small, positive, and not statistically significant. Hence, third-party information does not have a large impact on the difference in bids between the plain-labeled and GM-labeled foods for participants who received only positive information.

The coefficients for the dummy variables indicating that a participant received negative and third-party information are generally statistically significant. The coefficients for the dummy variables indicating that a participant received all three types of information are not statistically different from zero for any of the food products. The impact is not significantly different from the outcome when consumers received only positive information.

Few demographic variables were found to contribute significantly in explaining bid price difference for the two trials. Females discounted GM-labeled foods by less than men for all of three products in the auctions. The fact that female consumers discounted GM-labeled foods by less than men seems contrary to much of the risk perception literature that states that women are more risk averse. One explanation is that females on average have more experience shopping for food than do males. However, none of the coefficients was statistically significant from zero.

Those consumers who had higher incomes discounted all three GM-labeled food products more than those who have lower incomes. The coefficient is statistically significant for one of the three products – vegetable oil. It is not surprising that higher income consumers discounted GM-labeled foods more heavily. This is consistent with “food quality” being a luxury good.

Those consumers who considered themselves at least “somewhat informed about GM foods” (as recorded in the pre-auction survey) discounted GM-labeled foods by more than other participants. This coefficient is statistically significant (10% level) for one of the three food products – Russet potatoes. Those who perceived themselves to be informed bid far less for the GM-labeled foods than others. This result suggests they had heard negative information on GM foods prior to the experiment. In all of the censored regression equations, we rejected the null hypothesis that the explanatory variables included in the regression had no explanatory power (or all non-intercept coefficients were jointly zero).

The Value of Verifiable Information

We present the value of third-party information for each of the three cases a consumer could find themselves in: only receiving positive information, only receiving negative information, and receiving both positive and negative information. Table 6 presents the value of information results for the three food products: the marginal percentage of people who switch, the value to a person who switches, and the average value to a person in society.

When an individual received only positive information, one would expect third-party information to cause some individuals to switch to plain-labeled foods. Our results show that this is not necessarily the case. Those consumers who received both positive and third-party information were more likely to purchase GM-labeled potatoes, but they were less likely to purchase the GM-labeled tortilla chips than individuals who received only positive information.

The share of consumers who switched to either of these goods is very small. The average value per person from the introduction of third-party information was approximately one-half cent per product.

While third-party information brought about virtually no change in consumption behavior for tortilla chips and potatoes, consumers who received positive and third-party information were much more likely to purchase GM-labeled vegetable oil than consumers who receive only positive information. Approximately fifteen percent of the population that received positive information switched from plain-labeled vegetable oil to GM-labeled vegetable oil after the introduction of third-party information. This is consistent with third-party information revealing that when vegetable oils are refined, there is virtually no genetically modified material left in vegetable oil even when they are made from genetically engineered soybeans. For consumers who are worried about their own health, they now become more likely to purchase GM-labeled vegetable oil, even if they do not change their attitude towards other GM-labeled products. The value per person who switches to the GM-labeled vegetable oil is almost twenty-one cents per switcher, and the average value per person is just over three cents per bottle. This is interesting because consumers who receive third-party information would get virtually no gain from this information except when purchasing the vegetable oil. While these are interesting results, very few participants have heard only positive information about GM foods prior to the experiment. Therefore, the other two groups; those who received only negative information and those who received both positive and negative information were probably more representative of the general population.

We expect that consumers who initially received only negative information on GM foods but later were given third-party information to be more likely to consume GM-labeled foods.

The results from the experiments validate this expectation. For all three products, a significant portion of the population switched from plain-labeled to the GM-labeled food: 18.6 percent to 28.2 percent of people switch to the GM-labeled food, depending on the product. The value of the third-party information for each person who switches ranges from seventeen to twenty-five cents per item, depending on the product.

Combining information together, the average consumer gains 4.7 cents per bag of tortilla chips, 6.7 cents per bottle of vegetable oil, and 4.3 cents per bag of potatoes when they initially received only negative information and then third-party information is introduced. Participants who received positive, negative and third-party information are more likely to purchase GM-labeled foods than individuals who received only positive and negative information. The share of participants who switched from plain-labeled foods to GM-labeled foods is smaller for each of the three goods in this auction when compared to the participants who received negative information, but greater for each food than for individuals who receive only positive information.

Only 8.7 percent of participants switched to the GM-labeled tortilla chips, while 15.9 percent and 21.5 percent switched to the GM-labeled vegetable oil and GM-labeled potatoes. The value per person who switched from the plain-labeled to GM-labeled food ranged from twenty-three to twenty-nine cents per product. This leads to an average value per person of 2 cents per bag of tortilla chips, 4.3 cents per bottle of vegetable oil, and 6.3 cents for each bag of potatoes.

Generalizing the per person value of information in an experiment to the aggregate value of the U.S. population is risky but instructive, even if only to understand the upper limit on the value that verifiable information on GM might provide. On average, the value of verifiable information is about 4 cents per product for those individuals who have heard either negative information or both positive and negative information on GM foods. Because the prices for these three food products typically range between $1.50 - $2.50, verifiable information has a value of approximately 2 percent of the purchase price for products that could be genetically modified.

Estimates vary for the amount of foods on grocers' shelves that are GM. On the lower end, some observers predict that two thirds of *all processed foods* in the U.S. contain some GM material (Davis, 2001); on the upper end, some advocates argue that two thirds of *all products* in a grocery store contain GM material (Friends of the Earth, 2001). We approximate the aggregate value of verifiable information using the lower estimate, assuming one third of all products on a grocer's shelf might be GM. In 1997, U.S. citizens spent $390 billion for food at home (USDA – Putnam and Allshouse). Thus, if one third of all products are GM, Americans spent roughly $130 billion on foods that could be GM. If verifiable information has a value of approximately 2 percent of the product's price, and if one could generalize these results our best estimate is that verifiable information would be worth about 2.6 billion dollars annually to U.S. consumers.

While large, the aggregate value does not seem totally unrealistic.[19] The value of $2.6 billion divided by the number of people in the US gives an average value of approximately $9.00 per year for every man, woman, and child. Foster and Just found a value of information of approximately $10.00 per person, per month ($120.00 per year), using the same techniques. Their study only focused on milk, while our study is examining all consumer foods that might be genetically modified.

6. Concluding Comments

While new food products developed using genetic modification remain controversial, our results showed that pro-, anti-, and verifiable biotech information have significant impacts on consumers' demand for GM-labeled foods.. Our experimental design revealed three key results. First, information about GM foods from interested parties impacts consumer demand. This helps explain why groups such as Greenpeace and Friends of the Earth have been disseminating massive amounts of negative information on GM foods. Although these groups are interested parties and provide biased information, their information has an impact. Likewise, it explains why biotechnology companies have invested heavily to advertise the positive aspects of biotechnology (Thrane, 2001). Although these companies are interested parties and provide biased information, their information has increased the demand for GM-foods-- even in the presence of negative information. This is important because previous literature dealing with other new food products, e.g., irradiated pork, showed that negative information tends to dominate positive information when both are presented to consumers.

Second, an independent, third-party source that provides verifiable information on GM foods has a significant impact on consumers' demand for GM foods. Third-party information had its greatest impact on consumers who received negative information, prompting them to view GM foods more favorably and to increase their demand.

Finally, through a new method developed to determine the value of information, it was shown that third-party information on GM foods could have a value of $2.6 billion per year to U.S consumers. Although this number may seem large to some readers, we believe that it is a lower bound estimates because the anti-biotechnology lobby have in some cases been successful in getting such large reductions in the demand for GM products that they have been removed from the shelves of grocery stores. This type of holdup outcome would have much greater welfare costs than the marginal effects of information that we have estimated. A second reason why $2.5 billion is an underestimate of social value of verifiable information is that this information has international public good attributes (Huffman and Tegene 2002). Therefore, the total social value of verifiable information is potentially much larger than our estimate. Because of the large social value of verifiable information on GM food and the unlikelyhood that another country will provide it, i.e., free-rider problem among affected countries (Huffman and Tegene 2002), the United States should develop a new third-party institution, separate from the federal government, to oversee the provision of this information. Resources to support this activity, however, seem most likely to come from federal tax collections because of the free-rider problem within the United States.

Much research remains to be done on this topic. New research is currently testing the impact of information on the willingness to pay for foods with “negative GM-labels,” labels that say “this product is not made using genetic engineering.” Additional research is needed to determine how a regulatory body that supplies third-party, verifiable information on GM foods could be established, and how much this type of regulatory process would cost.

References

Australia New Zealand Food Authority. "Genetically Modified Foods" (May 2001) http://www.anzfa.gov.au/GMO/

Becker, G., M. DeGroot and J. Marschak. "Measuring Utility by a Single Response Sequential Method." *Behavioral Science* 9 (1964), 226-236

Caswell, Julie A. "Should Use of Genetically Modified Organisms Be Labeled?" *AgBioForum*, 1 (1998): 22-24. http://www.agbioforum.missouri.edu

Caswell, Julie A. "Labeling Policy for GMOs: To Each His Own?" *AgBioForum*, 3 (2000): 53-57. http://www.agbioforum.missouri.edu

Caswell, Julie A. and Daniel I. Padberg. "Toward a More Comprehensive Theory of Food Labels." *American Journal of Agricultural Economics* 74 (May 1992) 460-467

Cherry, T., T. Crooker, and J. Shogren. "Rationality Spillovers." Working paper, University of Wyoming (2000)

CNN. "Europe Approves Tough GM Food Rules" (Feb. 14, 2001) http://www.cnn.com/2001/WORLD/europe/02/14/eu.gm/index.html

Council for Biotechnology Information. "Frequently Asked Questions." http://www.whybiotech.com/en/faq/default.asp?MID=10. Retrieved October 2001.

Coursey, D., J. Hovis and W. Schulze, 1987, The Disparity Between Willingness to Accept and Willingness to Pay Measures of Value." *Quarterly Journal of Economics*, 102, (1987) 679-690

Davis, Jeanie. "'Frankenfoods' – Friend of Foe?". WebMD, May 22, 2001 http://my.webmd.com/content/article/1728.80187

Economic Research Service, U.S. Department of Agriculture. "Economics of Food

Labeling." *Agricultural Economic Report* No. 793. (December 2000)

FDA. "Voluntary Labeling Indicating Whether Foods Have or Have not been Developed Using Bioengineering." (January 2001) http://vm.cfsab.fda.gov/~dms/biolabgu.html

Foster, William and Richard E. Just. "Measuring Welfare Effects of Product Contamination with Consumer Uncertainty." *Journal of Environmental Economics and Management* 17 (1989) 266-283

Fox, John A., Dermot J. Hayes and Jason F. Shogren. "Consumer Preferences for Food Irradiation: How Favorable and Unfavorable Descriptions Affect Preferences for Irradiated Pork in Experimental Auctions." *Journal of Risk and Uncertainty*, forthcoming.

Fox, John A. Jason F. Shogren, Dermot J. Hayes and James Kliebenstein. "CVM-X: Calibrating contingent values with experimental auction markets." *American Journal of Agricultural Economics* 80 (1998) 455-465

Franciosi, R., R. M. Isaac, D. Pingry, and S. Reynolds. "An Experimental Investigation of the Hahn-Noll Revenue Neutral Auction for Emissions Licenses." *Journal of Environmental Economics and Management*, 24 (1993) 1-24

Friends of the Earth. "The Need for Labeling Genetically Engineered Foods." (March 2001) http://www.foe.org/safefood/factshtgelabel.htm

Galang Jr., Jose M. "Market Forces, Rise and Shine." (March 2001) http://www.monsantoindia.com/news/archives/march2001/050301.html

Gates, B. (2001). "Will Frankenfood Feed the World?" Time. Visions of the 21st Century. http://www.time.com/time/reports/v21/tech/mag_food.html

Greene, William H. *Econometric Analysis: Fourth Edition*. 2000. pp. 150-153, 614-335

Greenpeace International. "We Want Natural Food!" (March 2001) http://www.greenpeace.org/~geneng/

Greenpeace International. “7. Public Concern” (March 2001) http://www.greenpeace.org/%7Egeneng/reports/food/intrfo07.htm

Greenpeace International. “11. The Potential For Allergic Reactions” (March 2001) http://www.greenpeace.org/%7Egeneng/reports/food/intrfo11.htm

Griffiths, William E., R. Carter Hill, and George G. Judge. *Learning and Practicing Econometrics*. 1993. pp. 570-571

Herrmann, Robert O., Rex H. Warland and Arthur Sterngold. “Who Reacts to Food Safety Scares? Examining the Alar Crisis.” *Agribusiness* 13 (1997) 511-520

Hoffman, E., D. Menkhaus, D. Chakravarti, R. Field and G. Whipple. “Using Laboratory Experimental Auctions in Marketing Research: a Case Study of New Packaging for Fresh Beef.” *Marketing Science*, 12 (1993) 318-338

Huffman, Wallace E. and Abebayehu Tegene. “Public Acceptance of and Benefits from Agricultural Biotechnology: A Key Role for Verifiable Information,” in V. Santaniello, R. E. Evenson, and D. Zilberman, eds. *Market Development for Genetically Modified Foo*d. CAB International, forthcoming 2002.

Huffman, Wallace E., Jason F. Shogren, Matthew Rousu, and Abe Tegene. “The Value to Consumers of GM Food Labels in a Market with Diverse Information: Evidence from Experimental Auctions.” Iowa State University, Department of Economics, Staff Paper Number 345, December 2001.

Knetsch, J., F.F. Tang, and R. Thaler. “The Endowment Effect and Repeated Market Trials: Is the Vickrey Auction Demand Revealing?” Working paper, Simon Frazier University (1998)

Lusk, Jayson L., John A. Fox, Ted C. Schroeder, James Mintert, and Mohammad Koohmaraie. "In Store Valuation of Steak Tenderness." *American Journal of Agricultural Economics* 83 (3) August 2001 pp. 539-550.

McClusky, Jill J. "A Game Theoretic Approach to Organic Foods: An Analysis of Asymmetric Information and Policy." *Agricultural and Resource Economics Review* 29 (April 2000): 1-9

Melton, Bryan E., Wallace E. Huffman, Jason F. Shogren and John Fox. "Consumer Preferences for Fresh Food Items with Multiple Quality Attributes: Evidence from an Experimental Auction of Pork Chops." *American Journal of Agricultural Economics* 78 (November 1996): 916-23

Midwest Profiles. Department of Economics, Iowa State University. http://www.profiles.iastate.edu/. August 2001.

Milgrom, Paul and John Roberts. "Relying on the Information of Interested Parties." *Rand Journal of Economics* 17 (Spring 1986):18-32

Miller, G. and C. Plott. "Revenue Generating Properties of Sealed-bid Auctions" An Experimental Analysis of One-price and Discriminative Actions." In V. Smith, ed., *Research in Experimental Economics*, vol. 3 (JAI press, Inc., Greenwich, CT), (1985) 159-182

Phillips, Peter W.B. and Heather Foster. "Labeling for GM foods: Theory and Practice." Paper presented to the International Consortium on Agricultural Biotechnology Research (ICABR) on "The Economics of Agricultural Biotechnology" Ravello, (Italy) August 24-28, 2000.

Phillips, Peter W.B. and Stuart Smyth. "Competitors Co-Operating: Establishing a supply chain to manage genetically modified canola." Presentation to the Economics of Quality Control in Agriculture Conference (1999).

Putnum, Judith Jones and Jane E. Allshouse. "Food Consumption, Prices, and Expenditures, 1970-1997." Economic Research Service, U.S. Department of Agriculture, Statistical Bulletin No. 965

Rousu, Matthew and Wallace E. Huffman. "GM Food Labeling Policies of the U.S. and Its Trading Partners." Iowa State Department of Economics Staff Paper, Number 344.

Runge, C. Ford and Lee Ann Jackson. "Negative Labeling of Genetically Modified Organisms (GMOs): The Experience of rBST." *AgBioForum* 3 (2000) 310-314. http://www.agbioforum.missouri.edu

Shogren, Jason F., "Experimental Methods and Valuation," in K. G. Maler and J. Vincent, eds. *Handbook of Environmental Economics*. Amsterdam, the Netherlands, forthcoming.

Shogren, Jason F., John A. List and Dermot J. Hayes. "Preference Learning in Consecutive Experimental Auctions." *American Journal of Agricultural Economics* 82 (November 2000): 1016-21

Shogren, Jason F., M Margolis, C Koo, John A. List, "A Random *n*th-Price Auction." *Journal of Economic Behavior and Organization* 46 (December 2001).

Shogren, Jason F., Seung Y. Shin, Dermot J. Hayes and James B. Kliebenstein. "Resolving Differences in Willingness to Pay and Willingness to Accept." *The American Economic Review* 84, No. 1 (March 1994), pp. 255-270.

Smyth, Stuart and Peter W.B. Phillips. "Science and Regulation: Assessing the impacts of incomplete information and information in the global agricultural biotechnology industry." Paper presented to the International Consortium on Agricultural Biotechnology Research

(ICABR) on “The Economics of Agricultural Biotechnology” Ravello, (Italy) August 24-28, 2000.

Stigler, George J. “The Economics of Information.” Journal of Political Economy 69 (June 1961): 213-225.

Tambling, Grant. “Labelling of Genetically Modified Food.” (Retrieved May 2001) http://www.anzfa.gov.au/documents/mr24_99.asp

Thrane, Linda. “About Us.” Council for Biotechnology Information. (Retrieved September 2001) http://www.whybiotech.com/en/whoarewe/con35.asp?MID=2

Teisl, Mario F., Nancy E. Bockstael and Alan Levy. “Measuring the Welfare Effects of Nutrition Information.” *American Journal of Agricultural Economics* 83 (February 2001): 133-149.

U.S. Food and Drug Administration. “Guidance for Industry: Voluntary Labeling Indicating Whether Foods Have or Have Not Been Developed Using Bioengineering.” (January 2001) http://vm.cfsan.fda.gov/~dms/biolabgu.html

Vickrey, William. “Counterspeculation, Auctions, and Competitive Sealed Tenders.” *Journal of Finance* 16 (March 1961): 8-37

Viscusi, Kip W. “Alarmist Decisions with Divergent Risk Information.” *The Economic Journal* 107 (November 1997): 1657-1670

Viscusi, Kip W. and William N. Evans. “Utility Functions that Depend on Health Status: Estimates and Economic Implications.” *American Economic Review* 80, No. 3 (June 1990) pp. 353-374.

Figure 1: Steps in the experiment

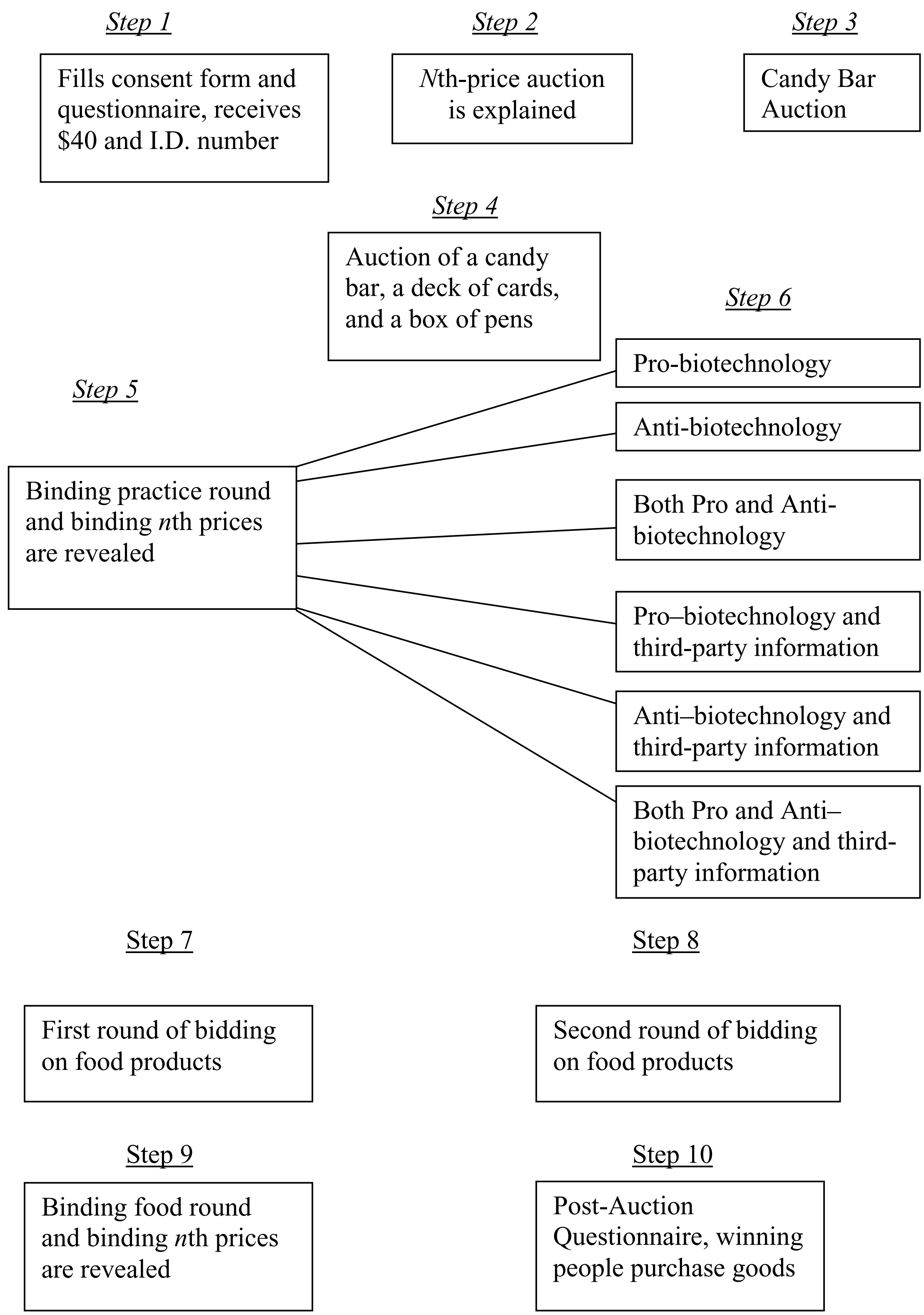

Figure 2: Labels used for the three food items

Russet Potatoes

Net weight 5 lb.

This product is made using
genetic modification (GM)

Russet Potatoes

Net weight 5 lb.

Tortilla Chips

Net weight 16 oz.
Fresh made Thursday April 5th

This product is made using
genetic modification (GM)

Tortilla Chips

Net weight 16 oz.
Fresh made Thursday April 5th

Vegetable Oil

Net weight 32 fl. oz.

This product is made using
genetically modified (GM) soybeans

Vegetable Oil

Net weight 32 fl. oz.

Figure 3: Information given to participants. Anti-biotechnology shock

The following is a collection of statements and information on genetic modification from Greenpeace, a leading environmental group.

General Information

Genetic modification is one of the most dangerous things being done to your food sources today. There are many reasons that genetically modified foods should be banned, mainly because unknown adverse effects could be catastrophic! Inadequate safety testing of GM plants, animals, and food products has occurred, so humans are the ones testing whether or not GM foods are safe. Consumers should not have to test new food products to ensure that they are safe.

Scientific Impact

The process of genetic modification takes genes from one organism and puts them into another. This process is very risky. The biggest potential hazard of genetically modified (GM) foods is the unknown. This is a relatively new technique, and no one can guarantee that consumers will not be harmed. Recently, many governments in Europe assured consumers that there would be no harm to consumers over mad-cow disease, but unfortunately, their claims were wrong. We do not want consumers to be harmed by GM food.

Human Impact

Genetically modified foods could pose major health problems. The potential exists for allergens to be transferred to a GM food product that no one would suspect. For example, if genes from a peanut were transferred into a tomato, and someone who is allergic to peanuts eats this new tomato, they could display a peanut allergy.

Another problem with genetically modified foods is a moral issue. These foods are taking genes from one living organism and transplanting them into another. Many people think it is morally wrong to mess around with life forms on such a fundamental level.

Financial Impact

GM foods are being pushed onto consumers by big businesses, which care only about their own profits and ignore possible negative side effects. These groups are actually patenting different life forms that they genetically modify, with plans to sell them in the future. Studies have also shown that GM crops may get lower yields than conventional crops.

Environmental Impact

Genetically modified foods could pose major environmental hazards. Sparse testing of GM plants for environmental impacts has occurred. One potential hazard could be the impact of GM crops on wildlife. One study showed that one type of GM plant killed Monarch butterflies.

Another potential environmental hazard could come from pests that begin to resist GM plants that were engineered to reduce chemical pesticide application. The harmful insects and other pests that get exposed to these crops could quickly develop tolerance and wipe out many of the potential advantages of GM pest resistance.

Figure 4: Information given to participants, pro-biotechnology shock

The following is collection of statements and information on genetic modification provided by a group of leading biotechnology companies, including Monsanto and Syngenta.

General Information

Genetically modified plants and animals have the potential to be one of the greatest discoveries in the history of farming. Improvements in crops so far relate to improved insect and disease resistance and weed control. These improvements using bioengineering/GM technology lead to reduced cost of food production. Future GM food products may have health benefits.

Scientific Impact

Genetic modification is a technique that has been used to produce food products that are approved by the Food and Drug Administration (FDA). Genetic engineering has brought new opportunities to farmers for pest control and in the future will provide consumers with nutrient enhanced foods. GM plants and animals have the potential to be the single greatest discovery in the history of agriculture. We have just seen the tip of the iceberg of future potential.

Human Impact

The health benefits from genetic modification can be enormous. A special type of rice called "golden rice" has already been created which has higher levels of vitamin A. This could be very helpful because the disease Vitamin A Deficiency (VAD) is devastating in third-world countries. VAD causes irreversible blindness in over 500,000 children, and is also responsible for over one million deaths annually. Since rice is the staple food in the diets of millions of people in the third world, Golden Rice has the potential of improving millions of lives a year by reducing the cases of VAD.

The FDA has approved GM food for human consumption, and Americans have been consuming GM foods for years. While every food product may pose risks, there has never been a documented case of a person getting sick from GM food.

Financial Impact

Genetically modified plants have reduced the cost of food production, which means lower food prices, and that can help feed the world. In America, lower food prices help decrease the number of hungry people and also lets consumers save a little more money on food. Worldwide the number of hungry people has been declining, but increased crop production using GM technology can also help further reduce world hunger.

Environmental Impact

GM technology has produced new methods of insect control that reduce chemical insecticide application by 50 percent or more. This means less environmental damage. GM weed control is providing new methods to control weeds, which are a special problem in no-till farming. Genetic modification of plants has the potential to be one of the most environmentally helpful discoveries ever.

Figure 5: Information given to participants, independent, verifiable information

The following is a statement on genetic modification approved by a third-party group, consisting of a variety of individuals knowledgeable about genetically modified foods, including scientists, professionals, religious leaders, and academics. These parties have no financial stake in genetically modified foods.

General Information

Bioengineering is a type of genetic modification where genes are transferred across plants or animals, a process that would not otherwise occur (In common usage, genetic modification means bioengineering). With bioengineered pest resistance in plants, the process is somewhat similar to the process of how a flu shot works in the human body. Flu shots work by injecting a virus into the body to help make a human body more resistant to the flu. Bioengineered plant-pest resistance causes a plant to enhance its own pest resistance.

Scientific Impact

The Food and Drug Administration standards for GM food products (chips, cereals, potatoes, etc.) is based on the principle that they have essentially the same ingredients, although they have been modified slightly from the original plant materials.

Oils made from bioengineered oil crops have been refined, and this process removed essentially all the GM proteins, making them like non-GM oils. So even if GM crops were deemed to be harmful for human consumption, it is doubtful that vegetable oils would cause harm.

Human Impact

While many genetically modified foods are in the process of being put on your grocers' shelf, there are currently no foods available in the U.S. where genetic modification has increased nutrient content.

All foods present a small risk of an allergic reaction to some people. No FDA approved GM food poses any known unique human health risks.

Financial Impact

Genetically modified seeds and other organisms are produced by businesses that seek profits. For farmers to switch to GM crops, they must see benefits from the switch. However, genetic modification technology may lead to changes in the organization of the agri-business industry and farming. The introduction of GM foods has the potential to decrease the prices to consumers for groceries.

Environmental Impact

The effects of genetic modification on the environment are largely unknown. Bioengineered insect resistance has reduced farmers' applications of environmentally hazardous insecticides. More studies are occurring to help assess the impact of bioengineered plants and organisms on the environment. A couple of studies reported harm to Monarch butterflies from GM crops, but other scientists were not able to recreate the results. The possibility of insects growing resistant to GM crops is a legitimate concern.

Figure 6: Information and labeling given to experimental units one through twelve

Exp. unit	Positive/negative	Third-party	Round with GM labels
1.	Pro-biotech	Yes	1
2.	Anti-biotech	Yes	1
3.	Pro-biotech, anti-biotech	Yes	1
4.	Pro-biotech	Yes	2
5.	Anti-biotech	Yes	2
6	Pro-biotech, anti-biotech	Yes	2
7	Pro-biotech	No	1
8	Anti-biotech	No	1
9.	Pro-biotech, anti-biotech	No	1
10.	Pro-biotech	No	2
11.	Anti-biotech	No	2
12.	Pro-biotech, anti-biotech	No	2

Figure 7: The four cases of the censored regression

Case	Plain-labeled bid	GM-labeled bid	Censored Regression Difference
1.	$P^{non-labeled}$	$P^{labeled}$	$P^{non-labeled} - P^{labeled}$
2.	$P^{non-labeled}$	0	$> P^{non-labeled}$
3.	0	$P^{labeled}$	$< -P^{labeled}$ or $> \left\|-P^{labeled}\right\|$
4.	0	0	.

. represents a missing value, due to the zero bids.

Table 1. Characteristics of the Auction Participants

Variable	Definition	Mean	St. Dev
Gender	1 if female	0.62	0.49
Age	The participant's age	49.5	17.5
Married	1 if the individual is married	0.67	0.47
Education	Years of schooling	14.54	2.25
Household	Number of people in participant's household	2.78	1.65
Income	The households income level (in thousands)	57.0	32.6
White	1 if participant is white	0.90	0.30
Read_L	1 if never reads labels before a new food purchase	0.01	0.11
	1 if rarely reads labels before a new food purchase	0.11	0.31
	1 if sometimes reads labels before a new food purchase	0.31	0.46
	1 if often reads labels before a new food purchase	0.37	0.48
	1 if always reads labels before a new food purchase	0.20	0.40
Informed	1 if an individual considered themselves at least somewhat informed regarding genetically modified foods	0.42	0.49
Labels1	1 if the treatment bid on foods with GM labels in round 1	0.52	0.50

Table 2. Mean bids for people, excludes double-zero bids

A. Mean bids – all participants

	n	mean bid	std. dev.	Median	Minimum	Maximum
GM OIL	146	1.07	0.81	0.99	0	3.99
OIL	146	1.24	0.78	1.00	0	3.79
GM CHIPS	155	1.03	0.85	0.99	0	3.99
CHIPS	155	1.20	0.81	1.00	0.05	4.99
GM POTATOES	159	0.84	0.66	0.75	0	3
POTATOES	159	0.98	0.65	0.89	0	3.89

B. Mean bids when participants only received positive information.

	n	mean bid	std dev	Median	Minimum	Maximum
GM OIL	26	1.56	0.73	1.50	0	2.99
OIL	26	1.54	0.79	1.55	0	3.50
GM CHIPS	30	1.31	0.72	1.13	0	2.99
CHIPS	30	1.36	0.72	1.18	0.05	2.99
GM POTATOES	27	1.30	0.71	1.25	0	2.50
POTATOES	27	1.26	0.67	1.25	0	2.00

C. Mean bids when participants only received negative information.

	n	mean bid	std dev	Median	Minimum	Maximum
GM OIL	26	0.79	0.82	0.50	0	3.25
OIL	26	1.22	0.65	1.00	0.25	2.49
GM CHIPS	29	0.81	0.94	0.50	0	3.99
CHIPS	29	1.25	1.02	1.00	0.05	4.99
GM POTATOES	29	0.61	0.68	0.50	0	2.75
POTATOES	29	0.98	0.88	0.75	0.05	3.89

D. Mean bids when participants received both positive and negative information.

	n	mean bid	std dev	Median	Minimum	Maximum
GM OIL	24	0.68	0.55	0.50	0	1.79
OIL	24	0.90	0.72	0.85	0	3.00
GM CHIPS	23	0.68	0.74	0.35	0	2.25
CHIPS	23	0.81	0.79	0.49	0.05	2.75
GM POTATOES	26	0.50	0.39	0.50	0	1.50
POTATOES	26	0.70	0.43	0.50	0.05	1.60

E. Mean bids when participants received both positive and third-party information.

	n	mean bid	std dev	Median	Minimum	Maximum
GM OIL	26	1.12	0.62	1.00	0	2.39
OIL	26	1.14	0.57	1.00	0.10	2.39
GM CHIPS	25	1.24	0.77	1.19	0	2.79
CHIPS	25	1.33	0.73	1.16	0.20	2.89
GM POTATOES	26	0.92	0.45	0.99	0	1.85
POTATOES	26	0.93	0.39	0.99	0.25	1.90

F. Mean bids when participants received both negative and third-party information.

	n	mean bid	std dev	Median	Minimum	Maximum
GM OIL	21	1.33	1.05	1.25	0	3.99
OIL	21	1.60	0.97	1.50	0.49	3.79
GM CHIPS	25	1.12	0.97	0.99	0	3.50
CHIPS	25	1.38	0.77	1.01	0.49	3.00
GM POTATOES	27	0.89	0.77	0.89	0	3.00
POTATOES	27	1.14	0.67	0.99	0.50	3.00

G. Mean bids when participants received positive, negative and third party information.

	n	mean bid	std dev	Median	Minimum	Maximum
GM OIL	23	0.94	0.77	0.95	0	2.75
OIL	23	1.06	0.82	1.00	0.05	3.29
GM CHIPS	23	0.95	0.81	0.85	0	3.25
CHIPS	23	0.95	0.66	0.99	0.1	2.89
GM POTATOES	24	0.82	0.61	1.00	0	1.99
POTATOES	24	0.84	0.55	0.84	0.01	2.00

Table 3. Censored Regression Estimates explaining difference in bid prices between GM-labeled and plain-labeled tortilla chips
(n=172, standard errors are in parentheses)

Dependent variable: Bid price non-labeled food – bid price GM-labeled food

Regressors	(1)	(2)	(3)	(4)	(5)	(6)
Pro	0.060	0.093	0.106	0.008	0.039	-0.034
	(0.099)	(0.110)	(0.119)	(0.137)	(0.119)	(0.151)
Anti	0.481 **	0.473 **	0.474 **	0.481 **	0.489 **	0.494 **
	(0.145)	(0.145)	(0.145)	(0.144)	(0.145)	(0.144)
Pro and Anti	0.132	0.124	0.128	0.138	0.136	0.147
	(0.152)	(0.153)	(0.153)	(0.152)	(0.152)	(0.153)
Pro and Third-party	0.035	0.031	0.035	0.003	0.023	0.001
	(0.147)	(0.147)	(0.147)	(0.148)	(0.146)	(0.148)
Anti and Third-party	0.245 *	0.241	0.246 **	0.244 *	0.241	0.256 *
	(0.148)	(0.148)	(0.149)	(0.147)	(0.147)	(0.148)
All information	-0.027	-0.023	-0.019	0.003	-0.028	-0.009
	(0.151)	(0.151)	(0.151)	(0.151)	(0.151)	(0.151)
Labels-Round 1		-0.063	-0.063	-0.064	-0.045	-0.050
		(0.089)	(0.089)	(0.089)	(0.090)	(0.090)
Gender			-0.025			-0.011
			(0.091)			(0.091)
Income				0.0017		0.0015
				(0.0014)		(0.0014)
Informed					0.104	0.087
					(0.092)	(0.093)
Likelihood ratio test	15.92 **	16.28 **	16.49 **	17.93 **	17.70 **	18.83 **

** indicates that a variable is significant at 5%
* indicates that a variable is significant at 10%

Table 4. Censored Regression Estimates explaining difference in bid prices between GM-labeled and plain-labeled vegetable oil.
(n=172, standard errors are in parentheses)

Dependent variable: Bid price non-labeled food – bid price GM-labeled food

Regressors	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.032	0.053	0.117	-0.128	-0.015	-0.104
	(0.126)	(0.142)	(0.150)	(0.169)	(0.152)	(0.180)
Anti	0.530 **	0.496 **	0.504 **	0.505 **	0.516 **	0.529 **
	(0.180)	(0.181)	(0.180)	(0.179)	(0.181)	(0.178)
Pro and Anti	0.259	0.231	0.262	0.255	0.250	0.295
	(0.183)	(0.183)	(0.183)	(0.181)	(0.182)	(0.181)
Pro and Third-party	0.061	0.046	0.079	-0.012	0.032	0.014
	(0.179)	(0.178)	(0.179)	(0.178)	(0.177)	(0.179)
Anti and Third-party	0.335 *	0.301	0.338 *	0.288	0.312 *	0.333 *
	(0.190)	(0.191)	(0.192)	(0.188)	(0.190)	(0.189)
All information	0.186	0.181	0.204	0.208	0.170	0.218
	(0.185)	(0.184)	(0.184)	(0.182)	(0.184)	(0.182)
Labels-Round 1		-0.139	-0.136	-0.149	-0.115	-0.127
		(0.109)	(0.108)	(0.107)	(0.110)	(0.108)
Gender			-0.140			-0.131
			(0.111)			(0.109)
Income				0.0032 *		0.0029 *
				(0.0017)		(0.0017)
Informed					0.142	0.112
					(0.113)	(0.112)
Likelihood ratio test	10.90 *	12.52 *	14.11 **	16.21 **	14.09 **	18.63 **

** indicates that a variable is significant at 5%
* indicates that a variable is significant at 10%

Table 5. Censored Regression Estimates explaining difference in bid prices between GM-labeled and plain-labeled potatoes.
(n=172, standard errors are in parentheses)

Dependent variable: Bid price non-labeled food – bid price GM-labeled food

Regressors	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.039	0.064	0.076	-0.019	-0.029	-0.069
	(0.088)	(0.096)	(0.103)	(0.117)	(0.101)	(0.124)
Anti	0.504 **	0.470 **	0.472 **	0.478 **	0.501 **	0.507 **
	(0.125)	(0.122)	(0.122)	(0.122)	(0.120)	(0.120)
Pro and Anti	0.262 **	0.233 *	0.239 *	0.248 **	0.258 **	0.271 **
	(0.126)	(0.124)	(0.125)	(0.124)	(0.122)	(0.123)
Pro and Third-party	0.057	0.041	0.046	0.018	0.026	0.015
	(0.125)	(0.123)	(0.123)	(0.124)	(0.120)	(0.122)
Anti and Third-party	0.339 **	0.323 **	0.329 **	0.322 **	0.332 **	0.337 **
	(0.125)	(0.123)	(0.124)	(0.122)	(0.120)	(0.122)
All information	0.088	0.095	0.099	0.110	0.078	0.092
	(0.128)	(0.126)	(0.126)	(0.126)	(0.124)	(0.124)
Labels-Round 1		-0.174 **	-0.174 **	-0.177 **	-0.146 **	-0.150**
		(0.073)	(0.073)	(0.072)	(0.072)	(0.072)
Gender			-0.026			-0.022
			(0.075)			(0.074)
Income				0.0014		0.0009
				(0.0014)		(0.0011)
Informed					0.190 **	0.179 **
					(0.074)	(0.075)
Likelihood ratio test	22.54 **	28.17 **	28.29 **	29.69 **	34.56 **	35.36 **

** indicates that a variable is significant at 5%
* indicates that a variable is significant at 10%

Table 6. Value of third-party, independent information on genetically modified foods.

A. Value to participants who receive positive information*

	Percent who switch to GM	Value per switcher	Average value per person
Tortilla Chips	- 3.3%	$0.108/bag	$0.004/bag
Vegetable Oil	15.4%	$0.209/bottle	$0.032/bottle
Potatoes	3.3%	$0.183/bag	$0.006/bag

B. Value to participants who receive negative information**

	Percent who switch to GM	Value per switcher	Average value per person
Tortilla Chips	18.6%	$0.250/bag	$0.047/bag
Vegetable Oil	28.2%	$0.236/bottle	$0.067/bottle
Potatoes	25.0%	$0.172/bag	$0.043/bag

C. Value to participants who receive both positive and negative information***

	Percent who switch to GM	Value per switcher	Average value per person
Tortilla Chips	8.7%	$0.233/bag	$0.020/bag
Vegetable Oil	15.9%	$0.276/bottle	$0.043/bottle
Potatoes	21.5%	$0.293/bag	$0.063/bag

* On average, more individuals purchased the GM-labeled potatoes and GM-labeled vegetable oil when they received positive and verifiable information as opposed to just getting positive information, but fewer individuals purchased the GM-labeled tortilla chips than their plain-labeled counterpart when they received positive and verifiable information.

** Consumers who received negative and verifiable information were more accepting of GM foods than individuals who only received negative information

*** Consumers who received positive, negative, and verifiable information were more accepting of GM foods than individuals who only received positive and negative information

[1] This is in contrast to the tradition in experimental economics of having an individual participate in multiple trials. See Shogren (forthcoming).

[2] When two adults in a household participated, the Iowa State Statistics Laboratory talked to both of them separately to obtain a commitment to participate and they were told that they would be assigned to different groups.

[3] The complete set of information given to participants is available upon request from the author.

[4] For a more detailed description of the benefits of the random *n*th price auction, see Shogren *et al*. (2001) or Huffman *et al*. (2001).

[5] If one assumes that there is little or no income effect from the deck of cards and box of pens, the two bids on the candy bar should be the same. The reason is that since the deck of cards and box of pens are neither complements nor substitutes to the candy bar, they should not impact the bids on the candy bar. A Wilcoxon signed-rank test confirmed that the bids for the candy bars are not significantly different in the two rounds, with a test statistic of 0.03. This result does not contradict the notion that the subjects' bidding behavior was reasonable.

[6] When a participant received both pro-biotechnology and anti-biotechnology information, the order was randomized, so that some participants received the pro-biotechnology information first, and others received the anti-biotechnology information first.

[7] When third-party information was distributed, it always was distributed after the other information sources.

[8] These experiments were set up to minimize endowment effects. i. e., participants were endowed at the beginning of the experiment with $40 but not GM-food. See Shogren (forthcoming) for evidence on endowment effects.

[9] Each individual consumer chooses between GM-labeled and plain-labeled foods, which are technically described as having a linear indifference curve. Assuming away the possibility that the budget constraint line lies exactly on the consumer's linear indifference curve, if the consumer purchases multiple quantities of the same product, all of the purchases will be the GM-food or all of the product will be the non-GM food.

[10] Assume no non-pecuniary external effect across consumers occurs.

[11] Because no bid prices are revealed until all bids are placed and participants in a trial were restricted from talking with each other, there is no contemporaneous correlation of random disturbance terms across participants in a trial.

[12] The likelihood ratio takes the maximum of the likelihood function of a regression that only has an intercept term (the restricted equation) divided by the maximum of the likelihood function of the regression that includes some explanatory variables (the unrestricted equation). This is shown in the following equation:

$$\lambda = \frac{\hat{L}_R}{\hat{L}_U}.$$

In this equation, $\hat{L}_R$ represents the maximum of the likelihood function for the regression with only the intercept term, and $\hat{L}_U$ represents the maximum of the likelihood function for the unrestricted equation.

[13]Demographic information for both the St. Paul area (Ramsey County) and the city of Des Moines can be found at Midwest Profiles, at http://www.profiles.iastate.edu/.

[14]The percentage discount of foods is similar to the percentage when all bids are included.

[15]Only 7 out of the 172 participants bid zero for all six products.

---

[16] Recall that our participants are only given money and no physical commodity, and this minimizes the endowment effects.

[17]OLS regressions were also filled to 172 observations and with the observations remaining after "double-zero" bids sere excluded. The results for these regressions are similar, and are available from the authors upon request.

[18]Several other models were fitted which included as regressors, the participant's age, marital status, religious upbringing, and educational attainment. None of these variables, however, impacted the difference in bid prices in a statistically significant way (at the ten-percent level).

[19]One could argue that this estimated might underestimate value for two reasons. First, we presume people who did not change their consumption habits of genetic modification get no value from new information. This is a restrictive assumption, as some people may feel better about their consumption if verifiable information confirms that they were making the correct choices, relative to their preferences. Second, we are considering the aggregate value to U.S. consumers only. But this information would also be freely available to people in foreign countries who make up 19/20th of the world population, which implies more aggregate value for the GM information.