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

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Abstract: Food products containing genetically modified (GM) ingredients have entered the market over the past decade. The biotech industry and environmental groups have disseminating conflicting private information about GM foods. This paper develops a unique methodology for valuing independent third-party information in such a setting and applies this method to consumers' willingness to pay for food products that might be GM. Data are collected from real consumers in an auction market setting with randomized information and labeling treatments. The average value of third-party information per lab participant is small, but the public good value across U.S. consumers is shown to be quite large.

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I. INTRODUCTION

If all information regarding new products is public, consumers can search out this information and make informed decisions (Stigler 1961; Hirshleifer and Riley 1992), but the available information is typically incomplete and asymmetric. That is, some effects of the new commodities/technologies on consumers and the environment are either unknown or only privately known (private information) by non-consumers. With private information, the informed and interested parties frequently have an incentive to use their private information strategically (Akerlof 1970; Mohol 1997), for example, to beneficially affect market conditions.

Foods made using bioengineering, often referred to as genetically modified (GM) foods, are examples of new goods with largely the same set of attributes as conventional foods, but that are produced using new agricultural technologies about which consumers might have positive or negative preferences. These new raw materials have been produced with crop varieties that contain one or more transgenic genes—genes that have been moved across species using the gene-splicing technology of Cohen and Boyer and that could not be moved using conventional sexual reproduction (Cohen et al. 1973; Huffman and Evenson 2006, p. 167-175). The transgenic traits of these innovations relate to the insertion of herbicide tolerant and insect resistant genes from soil bacteria into crop varieties, which can be expected to reduce farmers' production costs for raw food, and thereby, possibly to reduce food prices to consumers. However, this technology has not created *commercially available* foods that consumers' value directly, e.g., reduced bruising or enhanced protein or vitamin content. Genetically engineered crop varieties for enhanced input traits burst upon the frontier of agricultural technologies in the mid-1990s with herbicide tolerant soybeans and insect resistant cotton varieties.[1] Since then, herbicide tolerant cotton, corn and canola varieties and insect resistant corn varieties have been successfully developed and marketed to American farmers (Fernandez-Cornejo and Caswell 2006). Soybeans and corn and canola seeds are important U.S. sources of vegetable oil, corn is a principal source of sweetener, and corn and soybeans are significant sources of other ingredients for processed foods. Tomatoes bioengineered for extended shelf life (Flavr-Savr) and potatoes for insect resistance were also approved by the Food and Drug Administration in the early 1990s, but these products failed commercially after a few years on the market and were withdrawn.

The GM crop varieties currently available to U.S. farmers have been developed and marketed principally by two large chemical companies; Monsanto and Syngenta. As has been the case in U.S. agriculture for at least six decades, these companies have extensively advertised their perceived positive benefits of these new crop varieties, sharing a type of private information. Given that financial interests in biotechnology, these pro-biotech parties have used their private information selectively or strategically to expand the size of the market for GM crops by emphasizing that GM crops would enhance environmental quality, increase food availability, and reduce world hunger (Council for Biotechnology Information, 2001). In contrast, environmental NGOs, including Greenpeace and Friends-of-the-Earth, have countered by asserting that foods made from GM plant materials might harm human health by introducing new allergens (e.g., see " Frankenfoods," Greenpeace, 2003), harm the environment by possibly out-crossing with native species, reducing genetic diversity, prevent farmers from saving their own seed for future plantings, or give excessive market power to multinational companies (Greenpeace, 2001a, b, c, Friends-of-the-Earth, 2003). Such diverse and conflicting information leads to potential confusion among consumers (and possibly agricultural producers). Similarly public officials are also faced with a situation of information asymmetry and may not be able to discern socially optimal policies for GM crop varieties and GM foods, or their short- and long-run social welfare effects (Hausman 2003).

In principle, society can avoid losses due to strategic behaviors of interested parties toward new technologies and products if decision makers can access independent, third-party or *verifiable information* (Milgrom and Roberts, 1986; Huffman and Tegene, 2002). Verifiable information provides an objective assessment of the benefits and costs, including environmental and health risks of genetically modified crop varieties and foods made from these raw materials.

This overall objective of this paper is to develop a unique methodology for valuing independent third-party information in such a setting, and then apply this method to consumers' willingness to pay for food products that might be GM. Data are collected from real consumers participating in an auction market setting with randomized information and labeling treatments. Our methodology improves upon the standard protocol of experimental economics where undergraduate students are the auction participants, and they are put through a long set of non-randomized treatments (e.g., Shogren et al. 1994, Fox et al. 2002.).[2] Applying our method for valuing third-party information, we show that verifiable information in the GM food market has potentially large and statistically significant social value. Our new methods are generally applicable to new goods.

II. BACKGROUND

For millennia, individuals involved in cultivation of land have engaged in a rudimentary form of genetic modification in an attempt to augment the desirable attributes of their crops. They have selected the most productive and hardiest seeds from each year's harvest for use in subsequent plantings. However, since the early 1990s, genetic modification has been associated with a much narrower set of techniques that use recombinant DNA or gene splicing technology to facilitate the transfer of genes across species.[3] Foods made using this type of genetically modified material are known commonly as GM foods.

The growing controversy over GM food products and the perceived importance of facilitating informed food purchases has stimulated interest in food labeling, identity preservation, and new sources of information (Caswell, 2000). For example, Greenpeace and Friends-of-the-Earth advocate mandatory labeling asserting that labeling would benefit consumers by enabling them to easily chose whether or not to consumer products containing GM content (Friends-of-the-Earth, 2001; Greenpeace, 2006). Some international NGOs have made GM foods their number one issue (Nestle, 2003).

Before 1990, food labels were largely unregulated. But, the 1990 Nutrition Labeling and Education Act dramatically changed nutrition labels on packages of food sold in U.S. supermarkets (Balasubramanian and Cole 2002; Caswell, 2000). This law requires packaged foods to display nutritional information prominently in a new label format, namely the Nutrition Facts panel. It also regulates health claims and descriptor terms on food packages. If the proposal by environmental groups' for GM-food labels were adopted, the label would be a *negative* label denoting the "use of GM ingredients." However, GM content has not been proven scientifically to have human health consequences, except for the transport of some known allergens to new locations. Hence, today, GM food labels would not meet the nutrition labeling requirement of nutrient intake leading to proven health outcomes.

GM products used for food do have to pass a food safety test. In 1992, the U.S. Department of Health and Human Services issued a regulation that GM food did not have to be labeled if the food product had the same food characteristics as its non-GM counterparts, i.e., contained the same basic attributes. In January 2001, the FDA issued a "Guidance for Industry" statement reaffirming this policy, stating that the only GM foods requiring labels are foods with different characteristics than their non-GM counterpart. Currently, labeling food for GM content is not required for any other food. Under the current rules and regulations governing the food industry, a GM-labeling initiative could be implemented either by manufacturers voluntarily, or the FDA would need to change its policy. However, if a voluntary label is affixed to a food product, the FDA has mandated that it cannot use the phrase “genetically modified”. The FDA preferred the phrase “genetically engineered” or “made through biotechnology.” In contrast, the European Union and most other Western European countries have strong labeling and tracking requirements for GM content.

In Europe, international environmental groups were effective in lobbying governments with their platform that “consumers have the right to know whether their food is GM or not” (Greenpeace, 2001). In 1997, the European Commission enacted a mandatory GM food labeling policy. The Commission required each member country to enact a law requiring labeling of all new products containing substances derived from GM organisms. In October 2003, the European Parliament passed more stringent labeling legislation requiring that food and feed that contains at least 0.9 of one percent of GM content must be labeled as GM, and that traceability of the product from the farm to the consumer must be maintained.

In the European Union (EU), mandatory labeling has led to the curious result that no (or very little) GM foods are being sold in grocery stores and supermarkets. Once the label requirement went into effect, the environmental groups mounted a major negative information campaign against GM products. The result was reduced demand by EU consumers, and then the gradual disappearance of GM products from store shelves. In effect, the implementation of mandatory labeling of GM food resulted in a reduction in the variety of foods available for consumers

(Carter and Gruere 2003).

Japan, Australia, New Zealand, Norway, Switzerland and at least nine other countries have also passed mandatory GM-labeling requirements (Carter and Gruere 2003). However, labeling involves additional real costs, such as testing for the presence of GM, segregating crops, monitoring for truthfulness in labeling, enforcement of existing regulations, and risk premiums for being out of contract (Wilson and Dahl 2005).

An effective labeling policy requires the use of scarce resources to maintain an effective "segregation" system or an "identity preservation system."[4] To the extent that there is a market for non-GM crops, buyers would be expected to specify in their purchase contracts some limit on GM content and/or precise prescriptions regarding production/marketing/handling processes (Wilson and Dahl 2005). One can envision a marketplace of buyers who have differentiated demand according to their risk tolerance for GM content. To make this differentiation meaningful, new costs and risks are incurred. Additional testing for GM content involves the costs of deciding which test to use, among those with varying accuracy, and then conducting the test. If non-GM is the "superior commodity," then there is the risk that GM and non-GM varieties will be commingled, and then with some positive probability, the GM content will be detected in shipments to customers and will be out of contract and rejected. This is a serious economic problem as agents seek to determine the optimal strategy for testing and mitigating risk.

Limited evidence from related consumer acceptance studies suggests that consumers behave as if they have an asymmetric value function, in that they seem to act on "bad" news in a controversial market while heavily discounting "good" news. Viscusi (1997) and Fox et al. (2002) concluded that individuals amplify the risks of a neoteric product and discount benefits.

Using a survey in which consumers received divergent information on environmental risks, Viscusi showed that consumers place greater weight on information from the expert who provided a high-risk assessment. They did so regardless of whether the low-risk assessment came from a government or industry source. A similar "alarmist" reaction to a new product was observed by Fox, Hayes, and Shogren's (2002) in laboratory auctions of irradiated meat. In agreement with intuition, they found that a favorable description of irradiation increased demand and an unfavorable description decreased demand. However, when consumers were presented with both favorable and unfavorable descriptions, they bid as if they had used only the negative information resulting in a dramatic decline in demand for irradiated meat, despite the fact that the negative information was presented in a non-scientific manner by a consumer advocacy group.

Consistent with 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 private gain. The important question that Viscusi and the Fox, Hayes, and Shogren studies do not address is the social value of introducing verifiable information into a market where a controversial product is for sale. From this, we might hypothesize that verifiable information is most valuable under a voluntary-labeling policy, as in the U.S., Canada and Argentina, but not a mandatory policy, as in the EU and Japan.

Stigler (1961), Hirshleifer and Riley (1992), Molho (1997), and Morris and Shin (2002) provide general frameworks for placing an economic value on information. Foster and Just (1989) devised an applied methodology for assessing the value of government information about insecticide contamination (heptachlor) of milk for human consumption in Hawaii. They used market level data to calculate the value of government information as the difference between rational consumers' choices under incomplete and more complete information. In our study, we use information obtained from experimental auctions where participants/consumers are provided with randomly assigned information and labeling treatments. By using an experimental market, we are able to obtain precise information on consumers' reactions to the injection of verifiable information when information from interested parties is already available. Further, our methodology can be applied to assess consumer responses to other new goods when interested parties might have propagated scientifically unfounded conflicting information.

III. EXPERIMENTAL DESIGN

With two interested parties disseminating conflicting information into a market for a new good, what are rational consumers likely to do? Consumers should be able to make informed decisions provided they are (a) sophisticated enough to understand the technical processes at work and to recognize that interested parties' provide information reflecting their own private interests, and (b) they can verify all of the information provided (Milgrom and Roberts, 1986). Unfortunately, a full and verifiable information environment does not characterize the market for GM food products (also see Mendenhall and Evenson, 2002). Genetic modification through bioengineering is a complex process, and not all GM information is currently verifiable. Additionally, the search costs for most consumers to find neutral information is very high, as there are contradictory messages describing GM food as "food to feed the planet," as well as "Frankenfood" (see, for example, Bill Gates, 2001). Because of these high search costs, an independent, third-party source providing verifiable information about genetic modification has potentially large public good value (Huffman and Tegene, 2002).

We design a set of experiments to incorporate the private-information-revealing feature of experimental auction markets similar to the experiments described in Smith (1976) and Fox, Hayes, and Shogren (2002), and then introduce rigorous randomized treatment effects from the field of statistical experimental design. Although we conduct two practice rounds of bidding on common goods to learn our auction process, our main results follow from information collected from two rounds of bidding on the experimental food products where the experimental design consists of six biotech information-labeling treatments randomly assigned to sessions or trials with two replications. Each session consists of 13 to 16 adult consumers drawn randomly from the households of two major Midwestern cities.[5] Iowa State University's Center for Survey Statistics and Methods (CSSM) contacted prospective participants and offered them the opportunity to participate in an Iowa State University project dealing with consumers' decisions on food and household products. Individuals were told that they would need to come to a common location, a lab or classroom, that the project would take about 90 minutes of their time, and that they would be paid $40 for participating.

We anticipated that consumers would have heterogeneous tastes for food ingredients and methods of production. Given the sizeable fixed cost of conducting a laboratory experiment even with one commodity, we conjectured that using three somewhat different experimental food items in an auction would be only marginally more expensive. We chose to use in our auctions: vegetable oil (made from soybeans), tortilla chips (made from yellow corn), and Russet potatoes. At the time of the planned experiments, these food products could have been made using GM ingredients or technology. Furthermore, in the distilling and refining processes 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. Hence, for GM oils, minimal human health concerns should arise, but consumers might be concerned about GM soybeans having adverse affects on the environment. 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. As with tortilla chips, consumers might perceive human health and environmental risks from eating GM Russet potatoes.

The CSSM obtained randomly selected residence telephone numbers from each of the metropolitan areas, and contacted these numbers to find eligible participants. Participants were asked to come on a particular Saturday in April, and to choose one of three different starting times: 9 a.m., 11:30 a.m. or 2 p.m. Participation per household was limited to two adults, and they were assigned to different sessions. The CSSM followed up by sending willing participants a letter containing more information, including the date and location, a map and a telephone number to contact for more information. The response rate was about 19 percent, and the total number of participants or sample size for this paper is 172, which is large compared to most experimental auctions.

The protocol for an auction day and sessions is critical to the success of the experiments. Each auction session is conducted by one of two session monitors, and it consists of the same exact 10 steps, which are summarized in Figure 1. In Step 1, when participants arrive, the host assigns them to a particular session and monitor. The monitor asks them to sign a consent form agreeing to participate in the session. After participants sign this form, the monitor gives them $40 for participating and an ID number to preserve their anonymity. The participants then are asked to read a brief set of instructions and to complete a short questionnaire asking for socio-demo-economic information and attitudes toward several types of biological technologies.

In Step 2, participants learn the auction mechanism of a random *n*th price auction. In the random *n*th price auction (Shogren et al. 2001), an object is auctioned to n bidders, for example n = 13, and auction rules require each player to submit a private bid (a nonnegative number). The envelopes are then collected by the auctioneer or session monitor, and the n bids are ranked from highest to lowest. Next, the session monitor draws a single number from a discrete uniform distribution over one to the subset of positive integers from one to n, for example, five. In this case, the four highest bidders are the winners, and they each pay the fifth highest price.[6] This auction mechanism is incentive compatible, as it gives every bidder an incentive to bid his or her own true value. However, unlike the Vickrey or 2nd price auction, n-1 of the bidders have a chance to be winners. Thus, the random *n*th price auction does a better job of keeping all bidders engaged in the auction relative to other demand revealing auctions like the Vickery auction and the BDM (Shogren et al. 2001, Lusk and Rousu). We do not conduct a repeated-round auction with posted prices, where bidders place bids on identical items across a number of rounds and adjust their bids based on information revealed in other bidders' prices. For a summary of how repeated rounds in auctions affect bidding behavior, see Corrigan and Rousu (2006).[7]

The session monitor then writes an example of the *n*th price auction on the blackboard. After participants learn the general attributes of the auction, a short quiz is administered to the participants to test their understanding of the auction mechanism. Note that throughout the auction, when a participant is bidding on an item in a particular round, he or she does not know if additional rounds will occur. Participants are assured, however, that at most they will purchase only one unit of any auctioned item. This has two advantages. First, it eliminates price reduction because a bidder has a negatively sloped demand curve for any commodity. Second, it significantly reduces concerns that participants might have about liquidity, given that they were not told in advance that they would be participating in a real auction.

Step 3 is the first "practice round of bidding" in which participants bid on a brand-name candy bar. The participants are asked to examine the product and then place a (sealed) bid. The bids are collected by the session monitor and ordered from 1 to n. The first round of practice bidding is then completed.

Step 4 is a second round of practice bidding. In this round, each participant in a session bids separately on a set of three items. This is to provide experience in bidding on more than one item at a time. The items are a brand-name candy bar, a deck of playing cards, and a box of pens. The participants are asked to examine the three items and place bids on each product separately. Then the bids are collected by the session monitor and ordered from highest to lowest. Of the two practice rounds, only one is chosen as binding (valid).

In Step 5, the binding round (randomly chosen between practice sessions one or two) and the binding *n*th-prices are revealed to bidders. All of the bids from the two practice rounds are written on the blackboard, and the *n*th-price is circled for each of the products. Bidders are then told whether they are a "winner" and the market-clearing price that they are to pay on binding bids. The bidders are told by the session monitor that all payment of money for goods will take place after the experimental session.

Step 6 is the first round of bidding on the experimental food products—vegetable oil, tortilla chips, and potatoes—that might be genetically modified. A randomly assigned information treatment is injected into each session at this point for these food items. The information treatments consist of packages of one or more of the following perspectives on agricultural biotechnology: (1) *the industry (pro-biotech) perspective*—a collection of mainly positive or optimistic statements and information on genetic modification provided by a group of leading biotechnology companies, including Monsanto and Syngenta; (2) *the environmental group (anti-biotech) perspective*—a collection of mainly negative statements and information on genetic modification from Greenpeace, a leading environmental group; and (3) the *third-party (verifiable* *information) perspective*—an objective statement on genetic modification, as of the date of the experiments, approved by a third-party group consisting of a variety of individuals knowledgeable about GM goods, including scientists, professionals, religious leaders, and academics, none of whom have a financial stake in GM foods. To assist the participants in processing these different perspectives, the volume of information is limited to one 8 1/2" x 11" page that is organized into five categories—general information, scientific impact, human impact, financial impact, and environmental impact—in order to ease the information processing load on participants. Figures 2, 3, and 4 display the exact layout and wording of the three perspectives on genetic modification.

The three types of information are organized into six information treatments: (i) pro-biotechnology information; (ii) anti-biotechnology information; (iii) pro- and anti-biotechnology information; (iv) pro-biotechnology and third-party, verifiable information; (v) anti-biotechnology and third-party, verifiable information; and (vi) pro-biotechnology, anti-biotechnology, and third-party, verifiable information. These six combinations are randomly assigned to 12 experimental sessions with two replications (see figure 5).[8] The sequence of information in treatments containing more than one type of information is as follows. If the treatment contained both pro-biotech and anti-biotech information, the sequencing of this information to bidders in a session is randomized. If the treatment contains verifiable information, this information is always distributed last. This was done to most closely simulate the environment that exists in the U.S. and to be the one from which the value of verifiable information should be assessed.

We also use two types of food labels, a "plain label" identifying only the contents of a food package and a "GM label" that indicates both the content of the package and whether the product is produced using GM ingredients or GM technology. These labels are plainly designed and clearly displayed on the front of the food containers (see figure 6). For each session or trial, the sequencing of food labels is also randomized; some sessions receive the plain label first and the GM label second and the others receive the GM labels first and vice versa. The participants in each auction session then bid in two rounds on vegetable oil, tortilla chips and potatoes that are identical except for food labels. Hence, each bidder in a session places bids on a total of six experimental food items: GM-labeled vegetable oil, plain-labeled vegetable oil, GM-labeled tortilla chips, plain-labeled tortilla chips, GM-labeled Russet potatoes, and plain-labeled Russet potatoes.[9]

In Step 7, bidders are told that only one round of bidding on vegetable oil, tortilla chips, and potatoes will be binding and then instructed to examine the three food products and write down their (sealed) bid for each of them separately. The bids are then collected by the session monitor and ordered from high to low. The bidders are now told by the monitor that they are about to look at another group of food items.

In Step 8, bidders are informed by the session monitor again that only one round of bidding on food products will be binding, and then they are asked to examine another set of experimental commodities—vegetable oil, tortilla chips, and potatoes. These food products now have a different label. After the participants examine these products, they are instructed by the monitor to place bids on each of them separately. The bids are then collected from all of the bidders or participants and ordered from high to low by the session monitor.

In Step 9, the session monitor randomly selects among the two rounds of bidding on vegetable oil, tortilla chips and potatoes for the binding round, and selects the random *n*. After both the binding round and the binding *n*th prices are revealed to bidders by the session monitor, the participants who are winners are notified and all participants/bidders are asked to complete a brief post-auction questionnaire.

In Step 10, the participants/bidders who are winners, either in one of the two practice rounds or one of two rounds of bidding on experimental food items, are told to go to the stockroom next door to exchange money for their winning goods, and then they are free to leave. Bidders who did not win any product are informed that they are free to leave immediately.

IV. EFFECTS OF VERIFIABLE INFORMATION ON WILLINGNESS TO PAY

With the information obtained from the experimental auction sessions, it is possible to assess the impact of diverse information and the social value of verifiable information on consumers' willingness to pay for food products that might be genetically modified at the time of the experiments. We first examine bidding behavior for GM-labeled food items with and without verifiable information on genetic modification. Following Viscusi and Evans (1990), we expect that bidders will react rationally to biotech industry and environmental group perspectives. Without verifiable information, we expect bidder's demand for GM-foods to shift rightward when the biotech industry perspective is injected into the experiment and leftward when the environmental group perspective is provided. We perform both unconditional and conditional analysis of the bid prices submitted by the auction participants, denoted "bidders".

We first present summary statistics for our sample and then an unconditional analysis of our data on bidders' behavior. The attributes of the auction participants or bidders are summarized in table 1, and they are representative of the populations from which they are drawn. In table 2, participants' bids in the laboratory auction experiments are summarized. In Part A, mean bid prices across all information and labeling treatments are displayed. On average, bidders discounted GM-labeled food items by 14 percent relative to exactly the same food items having a plain food label. Part B shows that bidders who received only the biotech industry perspective are willing, on average, to pay a small premium for GM-labeled food items for two of the three products. This occurred despite the fact that genetic modification is only used to enhance attributes that might be expected to lower farmers' production costs and not otherwise to directly benefit consumers, e.g., by enhancing nutrient content or improving shelf life. Part C shows that when bidders receive only the environmental group perspective, they discount the GM-labeled food items by an average of 35 percent relative to the plain-labeled food item. Part D shows that bidders who receive both the biotech industry and environmental group perspectives discount GM-labeled foods by an average of 17 to 29 percent across the three experimental food products.

An important issue is the size of the impact of verifiable information. Table 2, Part E, shows that bidders who receive both the biotech industry and environmental group perspectives discount GM-labeled food items only slightly relative to the plain-labeled food items. These differences, however, are not statistically significant relative to the bids from those who only receive the pro-bio-tech (biotech industry) perspective. In contrast, bidders who receive only the biotech industry perspective value GM-labeled foods higher than the plain-labeled counterpart.

Table 2, Part F, shows that bidders who receive both anti-biotech and verifiable information discount the GM-labeled foods by an average of 17 to 22 percent across the three experimental food items. Bidders who receive anti-biotech, pro-biotech, and verifiable information are more accepting of the GM-labeled foods than those who receive pro-biotech (biotech industry) and anti-biotech (environmental group) perspectives. The bidders who receive the sixth information treatment—pro-biotech, anti-biotech and verifiable information—discount the GM-labeled food by an average of 0 to 11 percent across the three food items.

Given the interest in the effects of verifiable information on bidders' behavior, we perform a test of a null hypothesis of no effect versus significant effects using a Wilcoxon Rank-Sum test. This testing is conducted as part of a more extensive analysis of the unconditional analysis of bidders' behavior. The effects of verifiable information on bidders who receive the anti-biotech perspective are reported in table 3, and they show a statistically significant effect of verifiable information on bidding behavior at the 5 percent level for vegetable oil, 10 percent level for tortilla chips, and 5 percent level for potatoes. The differences in bids when verifiable information is introduced for those who previously received both the biotech industry and environmental group perspectives are statistically significant at the 10 percent level using the Wilcoxon Rank-Sum test for potatoes, but are not significantly different from zero for tortilla chips or vegetable oil (see table 3).

While information from unconditional analysis of the bid prices is suggestive, multiple regression analysis of bid prices allows us to control for possible confounding factors, e.g., a bidder's gender, age and income, and for the censoring of bids. The regression model holds bidders' tastes constant for each of the experimental food products by defining the dependent variable to be the difference in a bidder's bid prices for plain-labeled (non-labeled) and GM-labeled (labeled) food items. The bidder's inverse demand equation for the plain-labeled food item is

$$(1)\quad P_j^{non-labeled} = \beta_1^{non-labeled} + \beta_2^{non-labeled} X_{j2} + \mu_j^{non-labeled}$$

and for the GM-labeled food item is

$$(2)\quad P_j^{labeled} = \beta_1^{labeled} + \beta_2^{labeled} X_{j2} + \mu_j^{labeled},$$

where P_j represents the price bid for a food item by bidder j; β_1 is an intercept term; X_{j2} is a vector of exogenous variables associated with the bidder and other information; and β_2 is the associated vector of regression coefficients. μ_j is a random disturbance representing other unmeasured effects. It is assumed to have a zero mean and to be normally distributed.

Subtracting equation (2) from equation (1), we obtain an equation in which the dependent variable is the bidder's difference in bid prices for the two products:

$$(3)\ \ P_j^{non-labeled} - P_j^{labeled} = \beta_1^{non-labeled} - \beta_1^{labeled} + \left(\beta_2^{non-labeled} - \beta_2^{labeled}\right) X_{j2} + \mu_j^{non-labeled} - \mu_j^{labeled}.$$

The coefficients and error terms can be condensed and rewritten as

$$(4)\ \ P_j^{non-labeled} - P_j^{labeled} = \beta_1^* + \beta_2^* X_{j2} + \mu_j^*.$$

Hence, the difference in bid prices is then explained by an intercept term β_1^*, a vector of slope terms β_2^* that is multiplied by a vector of exogenous characteristics X_{j2}, and a random disturbance term $\mu_j^* = \mu_j^{non\text{-}labeled} - \mu_j^{labeled}$.[10]

If a bidder submits a zero bid for non-labeled food product or for a labeled food product, disturbance term μ_j^* in equation (4) is censored (Greene 2003, 761-766). The censoring scenarios are as follows. Case (1): bidder *j* bids a positive amount for both the GM-labeled and the plain-labeled food item; the measured difference in bid prices for bidders is the difference between the two bid prices. Case (2): bidder *j* bids zero for the GM-labeled product and a positive amount for the plain-labeled product. The "true difference" in a bidder's bid price 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 food items are censored at zero, and this outcome is transmitted directly to the disturbance in equation (4). Case (3): bidder *j* bids a positive amount for the GM-labeled product and zero for the plain-labeled product. As in Case (2), the true difference in a bidder's bid prices for the censored regression is absolutely larger than the measured difference between his or her two bid prices. Case (4): bidder *j* bids zero for both the plain- and GM-labeled food items. This latter outcome does not give any information about a bidder's true demand for GM products.

A positive aspect of using the censored regression model for a bidder's bid price differences[11] and associated random disturbances is that zero bid prices are accounted for correctly, and bias effects from zero bids are minimized. The disadvantage is that the model in not linear in its unknown parameters and compound disturbance. Least squares estimation is no longer feasible, but maximum likelihood estimation of equation (4), including censoring, is feasible and reasonable (Greene 2003). Tests of joint null hypotheses on the regression coefficients in equation (4) against an alternative of negation can be performed using the likelihood ratio test statistic, $\lambda = L_r/L_u$. L_u and L_r are the values of the maximum of the "unrestricted" likelihood function (equation (4), including censoring, and the maximum of the likelihood function after restrictions contained in the null hypothesis are imposed on the unrestricted model (Greene 2003, 484-486). λ is the sample value of the likelihood ratio for a particular unrestricted model and null hypothesis. In large samples, $-2 \ln (L_r/L_u)$ is distributed approximately as chi-squared, with degrees of freedom equal to the number of restrictions imposed by the null hypothesis on the parameters of the unrestricted model (Greene 2003, p. 484-486).

Now we turn to maximum likelihood estimates of the regression coefficients in equation (4), including censoring. To increase the power of the statistical tests with the econometric model, we pool the observations on bid price differences across the three commodities. Hence, the sample size for this fitted model is 516 (= 172x3). Dummy variables are defined for each of the three types of information (pro-biotech, anti-biotech, and verifiable) and indicators for pro-biotech and anti-biotech separately are included, plus interactions between pro-biotech and anti-biotech, pro-biotech and verifiable, anti-biotech and verifiable, and all three information types.

Other regressors include a bidder's gender and household income, a dummy variable taking a value of one if a bidder saw the GM label in the first trail (and zero otherwise), and a dummy variable indicating a value of one if the bidder perceives herself/himself to be informed about GM foods before the auction (and zero otherwise).[12] These latter regressors allow us to control for selective demographic attributes of bidders and to examine how a bidder's prior knowledge about GM foods or GM technologies affects willingness to pay and demand.

Table 4 displays the basic maximum likelihood regression results and associated standard errors.[13] Commodity fixed effects are included, but no intercept term is included. The estimated coefficients for information treatment effects show that in auction sessions where bidders receive only anti-biotech information the bid price differences are larger (between GM and plain--labeled) and statistically significant at the 5 percent level. When bidders receive only pro-biotech information bid price differences are reduced, but the difference is not significantly different from zero at the 5 percent (or 10 percent) level. When bidders receive both pro-biotech and anti-biotech information, the bid price difference is reduced but it also is not statistically significant. From these results, we conclude that in those sessions where bidders receive only anti-biotech or both pro-biotech and anti-biotech information they bid differently than where they receive only pro-biotech information.

When bidders are in sessions that receive pro-biotech and verifiable information, the impact of this combination is not statistically significant. When bidders are in sessions that receive anti-biotech and verifiable information bid price differences are reduced, and the difference is significantly different from zero. Hence, those who receive anti-biotech information along with verifiable information discount GM foods less than those who receive only anti-biotech information. When bidders are in sessions that receive all three types of information (pro-biotech, anti-biotech, and verifiable), the impact of this treatment on bid price differences is small and not statistically significant. Hence, in this complex setting, verifiable information does not have a distinguishable effect.

To focus more specifically on the potential significance of verifiable information on bidders' behavior, we perform a joint test that verifiable information has no effect on bidder behavior. We do this by deleting the three information treatments from equation (4) that include verifiable information as a component of a treatment. The sample value of the chi-squared statistic for this test is 7.17 with 3 degrees of freedom, and at a 10 percent significance level, the tabled chi-squared is 6.97. Hence, verifiable information has a statistically significant effect on bidders' willingness to pay for commodities that might be genetically modified.

Other results include the following: Bidders who have larger household incomes discount GM by a larger amount that those with less household income. This result is statistically significant at the 5 percent level and is consistent with non-GM products being viewed on average by bidders as a superior product. Those bidders who consider themselves to be at least "somewhat informed about GM foods" (as recorded in the pre-auction survey) discount GM-labeled foods by more than other bidders. This effect is statistically significant (at the 10 percent level). Moreover, this result suggests that bidders in our experiments who are "GM-informed" have on average acquired/received negative information about GM-foods prior to the experiment.[14] Bids also are affected by the labeling sequence. Bidders who are in sessions that bid on the GM-labeled food products in round one (and the plain-labeled food products in round two) discount GM-labeled foods by less than those who are in sessions that bid on the products in the opposite order. The regression coefficient for this regressor is statistically significant at the 5 percent level, and the result reinforces the importance of randomized assignment of treatments to sessions in experimental auctions, which is an innovation in our methodology. Finally, we perform a joint test of no explanatory power of equation (4) when fitted to the pooled data with commodity fixed effects and censoring. The sample value of the chi-squared statistic is 18.6 with 10 degrees of freedom. The tabled value of the chi-squared statistic at the 5 percent significance level is 18.3. Hence, this null hypothesis of no explanatory power of equation (4) is rejected.

V. METHODOLOGY FOR VALUING VERIFIABLE INFORMATION

In the previous section, we showed that independent, verifiable information affects bidders' bids on food products that may be GM, given the presence of information from interested parties. We now summarize the methodology used to estimate the public-good value of verifiable information. First, consider the empirical specification of the model leading to the public-good value of verifiable information. Our approach is similar to the approach taken by Foster and Just (1989) and Teisl et al. (2001). Information has value if an agent's observable behavior changes. For our case, information has social value if a participant/consumer changes his/her behavior as a result of receiving the information, i.e., *they "switched products that they purchased" — from GM-labeled to plain-labeled foods, or vice versa*.[15]

Consider the two types of bidders that benefit from verifiable information. One type purchases GM-labeled food before receiving verifiable information, and then switches to plain-labeled food after receiving verifiable information. The second type purchases plain-labeled food before receiving verifiable information, and switches to GM-labeled food after receiving the same information.

The economist's task is to approximate the net welfare change for bidders who change their observed behavior after receiving verifiable information. Because we are trying to assess the average value of information for each product, we assume all bidders purchase either the GM-labeled version or the plain-labeled version of a product. The bidder's surplus is approximated by the difference between his/her willingness to pay (WTP) and the "market price" (i.e., the price consumers would pay for a product in a store) for the product he/she purchases. Bidder *j*'s consumer surplus from purchasing plain-labeled food or GM-labeled food is defined to be:

(5) $surplus_{PL}^{j} = WTP_{PL}^{j} - MP_{PL}^{j}$

(6) $surplus_{GML}^{j} = WTP_{GML}^{j} - MP_{GML}^{j}$.

In equations (5) and (6), the bidder's WTP is revealed in the experimental auctions, MP is the price the bidder faces for the product in the marketplace, the superscript j refers to bidder j, and the subscripts PL and GML refer to the plain-labeled and GM-labeled products in this section.[16]

A consumer or bidder purchases either the GM-labeled or plain labeled food product. The product that bidder j purchases is assumed to be the one that gives him/her the higher surplus. Formally, if $surplus_{PL}^{j} > surplus_{GML}^{j}$ then $buy\_PL_{I}^{j} = 1$ and $buy\_GML_{I}^{j} = 0$, and if $surplus_{PL}^{j} < surplus_{GML}^{j}$ then $buy\_PL_{I}^{j} = 0$ and $buy\_GML_{I}^{j} = 1$, where the subscript *I* refers to the information setting (whether or not the consumer has received verifiable information). Those who purchase the plain-labeled product after receiving verifiable information obtain

(7) $PREMGAIN_{PL}^{j} = surplus_{PL}^{j} - surplus_{GML}^{j}$.

Similarly, those who purchase the GM-labeled product after receiving verifiable information gain:

(8) $PREMGAIN_{GML}^{j} = surplus_{GML}^{j} - surplus_{PL}^{j}$.

Although all bidders enjoy the premium gained by consuming one product instead of another, as shown in expressions (7) and (8), the premium gained represents the increase in welfare (i.e., the value of information) only for those *who switch products*.

We next discuss the method used to estimate the percentage of bidders who change purchases when verifiable information is introduced. First, the percentage of bidders who purchase GM-labeled products is denoted:

$$(9) \quad percentbuy\,GM_I = \left(\sum_j buy\_GML_K^j \right) \Big/ N \,.$$

Equation (9) shows that this number can be represented as the summation across bidders that purchase the GM-labeled version of the commodity divided by the total number of bidders. Therefore, the percentage of bidders who purchase the plain-labeled version is 1-$percentbuyGM_I$.

Verifiable information causes a bidder to switch purchases if his or her surplus for one version (e.g., the plain-labeled product) prior to receiving verifiable information, but higher consumer surplus for the other version (e.g., the GM-labeled product) after receiving verifiable information. The net change in the percentage who purchase the GM-labeled product due to the introduction of verifiable information is the (absolute) difference between the "percentage who purchase GM-labeled foods when treated to verifiable information" and the "percentage who purchase GM-labeled foods but do not receive the verifiable information" given the other information they have received:

$$(10) \quad Percentswitch^K = \left| percentbuyGM_{verifiable} - percentbuyGM_{no-verifiable} \right|.$$

In equation (10), the percentage of bidders who switched purchases is estimated as the absolute value of the difference in the percentage that purchase the GM-labeled food with and without verifiable information. The superscript K represents either GM-labeled or plain-labeled foods, depending on which product bidders are switching to.

Who switches purchases once verifiable information is introduced? Because bidders who receive given information treatments are in distinct experimental sessions, we do not know the specific persons who switch, but we can compute the percentage of the sample that switched after the introduction of verifiable information. To do this, we assume that the bidders who switch have relative preferences for the food products that are uniformly distributed across the population that consumes the good that was abandoned. For example, we assume that bidders who switched to GM-labeled foods after receiving verifiable information had relative valuations of plain-labeled foods that were evenly distributed throughout the population of consumers who purchased the plain-labeled foods before information was introduced. Thus, without verifiable information, treated and untreated participants have the same behavior.

We now compute the probability of a participant being a "switcher"—one who changes his or her behavior after verifiable information is introduced:

(11) $$prob\_switch_{GML} = Percentswitch^{GML} \big/ percent\,buy\,GM_{verifiable} \ .$$

(12) $$prob\_switch_{PL} = Percentswitch^{PL} \big/ percent\,buy\,non-GM_{verifiable} \ .$$

To determine the expected value of verifiable information to a participant, we multiply his or her premium surplus (PREMGAIN) by the probability that he or she switched products:

(13) $$\begin{aligned} EVperson^{j} &= PREMGAIN^{j}_{GML} * prob\_switch^{j}_{GML} \\ &+ PREMGAIN^{j}_{PL} * prob\_switch^{j}_{PL} \end{aligned} \ .$$

In equation (13), $EVperson^{j}$ is the expected value of information to bidder j.[17] One can also think of this as the average value of verifiable information across all bidders or participants. What is important is that we can compute this value for each of the three products and over different initial information treatments.

Next we need the expected value of information to a bidder who switches purchases. This is computed by dividing the expected value of verifiable information per person by the percentage of bidders who switched purchases:

$$(14) \quad EVswitcher = EVperson^{j} \big/ percentswitch \ .$$

In equation (14), *EVswitcher* is the average value of verifiable information *to a bidder who switches* his or her purchase of a food product, either to GM-labeled food from plain-labeled, or vice versa.[18]

In summary, the experimental auction data collected for this study allow us to calculate the percentage of bidders who switch in each of the information settings: receiving the pro-biotech perspective, the anti-biotech perspective, and both pro- and anti-biotech perspectives. We then estimate an expected value of verifiable information per experiment participant or bidder, and suggest that it might be appropriate to apply this number to the whole U.S. population.

Now consider the estimated value of verifiable information. For each commodity, table 5 presents the marginal percentage of bidders who switch, the value of verifiable information to a person who switches, and the expected value of verifiable information to a person in society. When a bidder receives only the biotech industry perspective, one might expect the introduction of verifiable information to cause some individuals to switch to plain-labeled foods. For example, among those bidders who receive both biotech industry and verifiable information, some are more likely to purchase GM-labeled potatoes, but are less likely to purchase the GM-labeled tortilla chips than bidders who received only the biotech industry perspective. The share of bidders who switched to either of these goods, however, is small. Among those bidders who first received biotech industry information, *the expected value of the verifiable information per person was about one-half cent per product, but was only statistically significant for the potatoes.*

While verifiable information brought about virtually no change in bidding behavior for tortilla chips and potatoes, bidders who received biotech industry and verifiable information were much more likely to purchase GM-labeled vegetable oil than bidders who receive only the industry perspective. Approximately 15 percent of the bidders who received the biotech industry perspective switched from plain-labeled vegetable oil to GM-labeled vegetable oil after the introduction of the verifiable information. This outcome is consistent with verifiable information revealing that vegetable oils do not contain DNA because all the protein carrying DNA is boiled out in refining vegetable oils for human consumption. Vegetable oils made from GM- and non-GM soybeans are chemically and nutritionally indistinguishable. Bidders worried about their own health now become more likely to purchase GM-labeled vegetable oil, even if they do not change their attitude toward other GM-labeled products. Among those bidders who receive biotech industry information, *the average value per person of verifiable information to those who switch to the GM-labeled vegetable oil is almost 21 cents per switcher, and the expected value per person is just over 3 cents per bottle.* These value estimates are statistically significant at the 1% level using a t-test (table 5).[19] This is interesting because among bidders who received biotech industry information, virtually all of the surplus gain arose from vegetable oil and little from the other two products.

In another scenario, some bidders received either the environmental group perspective only or both the biotech industry and environmental group perspectives. We now consider the value of verifiable information in these cases. We expect that bidders who initially received only the environmental group perspective on GM foods and later were given the verifiable information will be more likely to purchase GM-labeled foods. Our results confirm this hypothesis. For all three experimental food products, a significant share of the sample switched from plain-labeled to the GM-labeled food under these circumstances: between 18.6 and 28.2 percent of bidders switch to the GM-labeled food, across the three commodities. The value of verifiable information for each bidder who switches ranges from 18 to 25 cents per food item, and *the expected value of information per person in the experiments is 5.1 cents per bag of tortilla chips, 5.4 cents per bottle of vegetable oil, and 4.5 cents per bag of potatoes.* These values of information estimates are all statistically significant at either the 1 percent or 5 percent level (table 5).

Bidders who receive biotech industry and environmental group perspectives first and then receive verifiable information are more likely to purchase GM-labeled foods than bidders who did not receive verifiable information. The share of bidders who switch from plain-labeled foods to GM-labeled foods is smaller for each of the three goods in this auction when compared to the bidders who receive the environmental group perspective, but larger for each food item than for bidders who receive only the biotech industry perspective. Only 8.7 percent of bidders 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. Moreover, the average value of verifiable information per person who switched from the plain-labeled to GM-labeled food ranged from 23 to 30 cents across the three food products. In this scenario, the *implied expected value of verifiable information was 2 cents per bag of tortilla chips, 4.4 cents per bottle of vegetable oil, and 6.4 cents for each bag of potatoes* (table 5).[20]

Suppose we take a bold step and prepare a "ballpark" estimate of the value of verifiable information on genetic modification for the whole U.S. population. Generalizing is not without some risks, but the generalization is also illustrative. Our estimate is that the value of verifiable information is about 4 cents per food product for participants who have heard either the environmental group perspective or both environmental group and biotech industry perspectives on GM foods. Because the prices for these three food products in units that we used in our experiment were typically 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 of the share of grocery store foods that are genetically modified vary. Some observers suggest that two-thirds of *all processed foods* in the United States contain some GM material (Jeanie Davis 2001). Others argue that one-third of *all products* in a grocery store contain GM material (Friends-of-the-Earth 2001). To provide a conservative estimate, we approximate the aggregate value of verifiable information by assuming that only one-third of all products on a grocer's shelf were genetically modified at the time of our experiments in April, 2001.

In 1997, U.S. citizens spent $390 billion for food at home (Putnum and Allshouse 1999). Appling the one-third rule, we suggest that Americans spent roughly $130 billion on foods that might be genetically modified. If verifiable information has a value of about 2 percent of the price for these foods, and if one generalizes these results, our estimate of the potential public good value to U.S. consumers of verifiable information is about $2.6 billion annually. While large, the aggregate value does not seem totally unrealistic. Two and six-tenths billion dollars is only an average value of approximately $9.00 per year for every U.S. man, woman, and child. As a reference point, Foster and Just (1989) reported a value of government information about pesticide contaminated milk in Hawaii of approximately $10.00 per person per month ($120.00 per year), using similar techniques.

VI. CONCLUDING COMMENTS

We have presented a new methodology for testing and valuing the effects of objective third-party or verifiable information in a market with conflicting information. Our results show that the perspectives of interested parties are consequential in an auction market setting; pro-biotech information distributed by the biotech industry and has significantly negative effects on bid-price differences between plain and GM-labeled product, and anti-biotech information distributed by environmental NGOs has significantly positive effects on bid price differences for food that might be genetically modified. However, no single type of information is dominant, although the empirical impacts of pro-biotech and verifiable information have similarities. In an environment that is roughly similar to the situation that exists in the United States today, which is one of voluntary GM-labeling, we show that verifiable information has a significant effect on bid price differences when participants have not received pro-biotech information, and more generally, when our data on bidding behavior are pooled across all three commodities. We expect similar results in other developed countries that have voluntary labeling policies. Furthermore, we argue that verifiable information has its greatest impact, and hence greatest potential social value, when interested parties are disseminating information that is quite negative about the new technologies. However, if the resistance were to disappear, the value of verifiable information would be greatly reduced.

Verifiable information has value when it changes the behavior of consumers. We make several simplifying assumptions and produce a calculation suggesting that verifiable information on genetic modification might have an annual social value to U.S. consumers through food purchases of $2.6 billion annually. This might seem high, but it is expected to decrease over time if reputable sources of verifiable information for GM foods and technologies were established in the United States. The exact details of how such a system might function or be financed are summarized in Huffman and Tegene (2002).

Our new methodology for assessing the impacts and value of conflicting and third-party information on consumers' willingness to pay for new goods items can be adapted to a range of new consumer goods, e.g., fresh fruit with reduced bruising, food fortified with protein and vitamins, and new drugs. In particular, policy makers could use our methodology to assess the public good benefit of new information for controversial commodities and compare these benefits to their expected social cost.

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TABLE 1
Variables for Auction Participants-Bidders and Sample Summary Statistics (N = 172)

Variable	Defintions	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 (GM) foods	0.42	0.49
Labels1	1 if the treatment bid on foods with GM labels in round 1	0.52	0.50

* Pre-experiment information.

TABLE 2
Mean Bids for Participants-Bidders, Excluding Double-Zero Bids

Mean bids—all bidders and treatments

Commodity/Type	N	Mean Bid	Standard Deviation	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

A. Mean bids when bidders received only pro-biotech information

Commodity/Type	N	Mean Bid	Standard Deviation	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

B. Mean bids when bidders received only anti-biotech information

Commodity/Type	N	Mean Bid	Standard Deviation	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

C. Mean bids when bidders received both pro-biotech and anti-biotech information

Commodity/type	N	Mean Bid	Standard Deviation	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

D. Mean bids when bidders received pro-biotech and verifiable information

Commodity/type	N	Mean Bid	Standard Deviation	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

E. Mean bids when bidders received anti-biotech and verifiable information

Commodity/type	N	Mean Bid	Standard Deviation	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

F. Mean bids when bidders received pro-biotech, anti-biotech, and verifiable information

Commodity/type	N	Mean Bid	Standard Deviation	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
Results from Test of Null Hypothesis of No Significant Difference in Bid Prices between Pairs of Information Treatments

Commodity/Information Type	Reduction in the Premium for Plain-Labeled Version of Food Products when Third-Party, Verifiable Information Is Introduced	One-Sided P-Value from Wilcoxon Rank-Sum Test Statistic
Potatoes – pro-GM info	$ - 0.05	0.34
Vegetable oil – pro-GM info	$ 0.00	0.30
Tortilla chips – pro-GM info	$ -0.04	0.38
Potatoes – anti-GM info	$ 0.14	0.07
Vegetable oil – anti-GM info	$ 0.16*	0.05
Tortilla chips – anti-GM info	$ 0.18	0.13
Potatoes – Both pro- and anti-GM info	$ 0.18*	0.03
Vegetable oil – Both pro- and anti-GM info	$ 0.06	0.28
Tortilla chips – Both pro- and anti-GM info	$ 0.13	0.28

TABLE 4
Estimates of pooled censored regressions explaining bid price differences in GM-labeled and plain-labeled foods using a commodity fixed effects model (n=516, standard errors are in parentheses)[a]

Dependent variable: Bid price plain-labeled food less bid price GM-labeled food

Regressors	Coefficients.
Pro-biotech	–0.073
	(0.097)
Anti-biotech	0.432**
	(0.093)
Pro-biotech x anti-biotech	-0.199
	(0.131)
Pro-biotech x verifiable	0.007
	(0.088)
Anti-biotech x verifiable	-0.205**
	(0.090)
Pro-biotech x anti-biotech x verifiable	0.065
	(0.157)
Other variables:	
Labels-Round 1	-0.115**
	(0.053)
Gender	-0.045
	(0.054)
Income	0.00001**
	(0.0000)
Informed	0.093*
	(0.054)
Chi-squared-excluding 3 regressors containing verifiable information	7.177*
Chi-squared for no explanatory power of regressors	76.44**

[a] The estimated coefficients for the commodity fixed effects are not reported.
* indicates statistical significance at the10 percent level.
** indicates statistical significance at the 5 percent level.

TABLE 5
Value of verifiable information about genetic modification and GM-foods to participants-bidders

A. Value to bidders who originally received pro-biotech information[+]

	Participants Switching to GM		
	Percentage	Value per person	Average overall value
Tortilla Chips (N=25)	3.3 percent[+]	$0.112/bag	$0.004/bag t value = 1.54
Vegetable Oil (N=26)	15.4 percent	$0.209/bottle	$0.032/bottle ** t value = 4.25
Potatoes (N=26)	3.3 percent	$0.184/bag	$0.006/bag ** t value = 6.01

B. Value to bidders who originally received only anti-biotech information[++]

	Participants Switching to GM		
	Percentage	Value per person	Average overall value
Tortilla Chips (N=25)	18.6 percent	$0.250/bag	$0.051/bag ** t value = 2.91
Vegetable Oil (N=21)	28.2 percent	$0.190/bottle	$0.054/bottle * t value = 2.75
Potatoes (N=27)	25.0 percent	$0.179/bag	$0.045/bag ** t value = 5.89

C. Value to bidders who originally received both pro-biotech and anti-biotech information [+++]

	Participants Switching to GM		
	Percentage	Value per person	Average overall value
Tortilla Chips (N=23)	8.7 percent	$0.233/bag	$0.020/bag ** t value = 3.77
Vegetable Oil (N=23)	15.9 percent	$0.280/bottle	$0.044/bottle ** t value = 3.29
Potatoes (N=24)	21.5 percent	$0.298/bag	$0.064/bag ** t value = 3.48

* Statistically significant at the 5% level using a t-test.
** Statistically significant at the 1% level using a t-test.
[+] On average, more individuals purchased the GM-labeled potatoes and GM-labeled vegetable oil when they received pro-biotech and verifiable information as opposed to just getting pro-biotech information, but fewer individuals purchased the GM-labeled tortilla chips than their plain-labeled counterpart when they received pro-biotech and verifiable information.
[++] Consumers who received anti-biotech and verifiable information were more accepting of GM foods than individuals who only received anti-biotech information.
[+++] Consumers who received pro-biotech, anti-biotech, and verifiable information were more accepting of GM foods than individuals who only received pro-biotech and anti-biotech information.

FIGURE 1

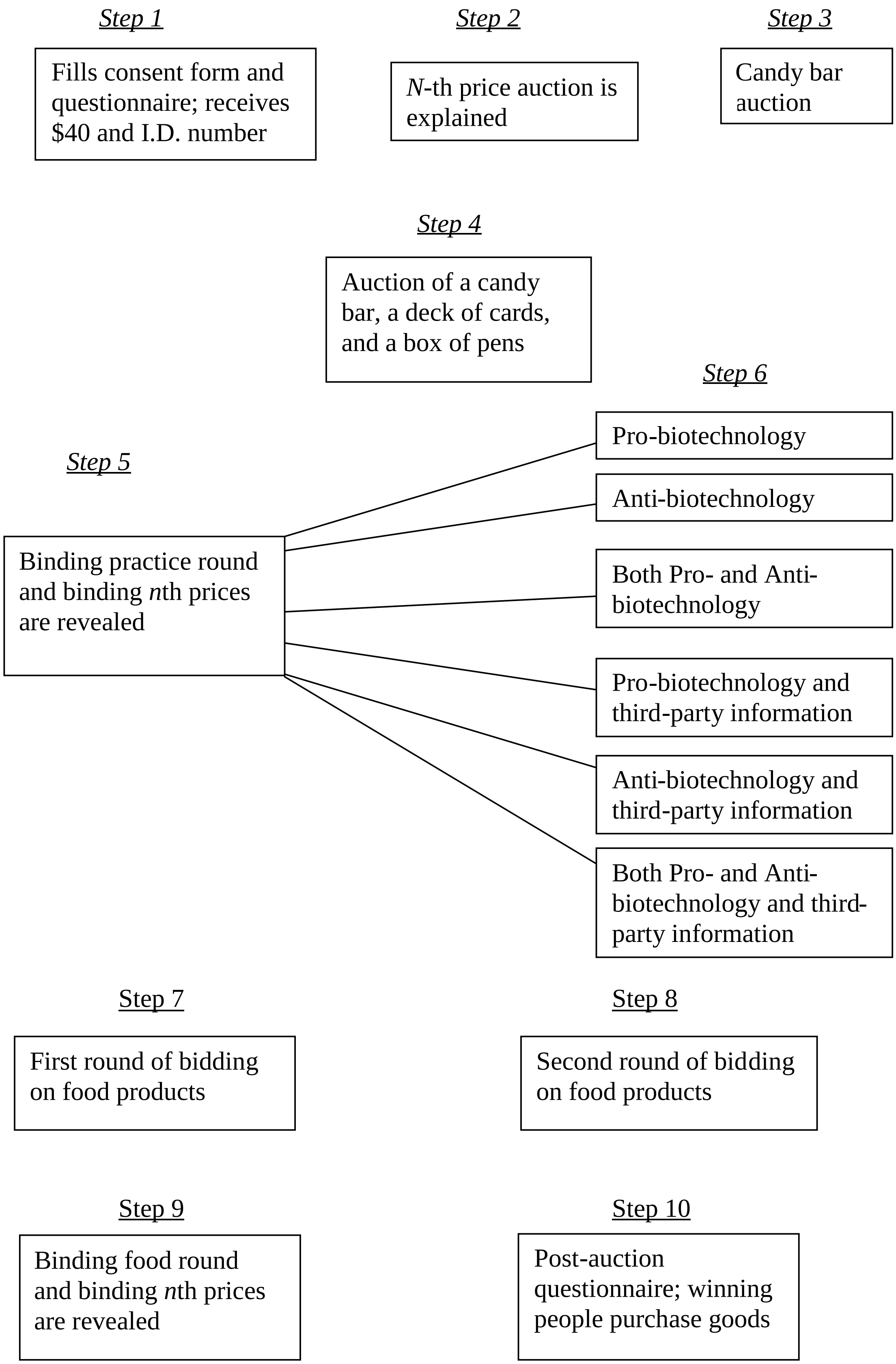
Step 1
Fills consent form and questionnaire; receives $40 and I.D. number
Step 2
N-th price auction is explained
Step 3
Candy bar auction
Step 4
Auction of a candy bar, a deck of cards, and a box of pens
Step 5
Binding practice round and binding nth prices are revealed
Step 6
Pro-biotechnology
Anti-biotechnology
Both Pro- and Anti-biotechnology
Pro-biotechnology and third-party information
Anti-biotechnology and third-party information
Both Pro- and Anti-biotechnology and third-party information
Step 7
First round of bidding on food products
Step 8
Second round of bidding on food products
Step 9
Binding food round and binding nth prices are revealed
Step 10
Post-auction questionnaire; winning people purchase goods

FIGURE 2

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 3

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 let 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 4

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.) are 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 removes 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' shelves, 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 5

Session	Pro-biotech and Anti-biotech Information Treatments Disseminated	Third-party Information Disseminated	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 6

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 genetic modification (GM).

Vegetable Oil

Net weight 32 fl. oz.

ENDNOTES

1. A herbicide tolerant crop variety is created by transferring a soil bacteria into the plant that is resistant to a chemical herbicide, e.g., Round-Up, and then when this variety is planted, farmers can apply Round-Up and kill all the plants in the field except for the Round-Up tolerant crop variety. An insect resistant crop variety is created by transferring soil bacteria into the crop that is toxic to common plant insects, e.g., the cotton boll and bud worm, European Corn borer. In this case, biological control rather than a toxic chemical pesticide is used to control the target insect.

2. In designing the experiments, we combine the best attributes of survey design, statistical experimental design, and experimental economics to obtain a superior overall experimental design. Our methodology differs significantly from the telephone survey employed by Mendenhall and Evenson (2002) to solicit information about consumers' risk perceptions of GM-foods and hypothetical willingness to pay a premium for non-GM foods.

3. In 1973, Cohen and Boyer discovered the basic technique for recombinant DNA, which launched a new field of genetic engineering. The Cohen-Boyer patent on gene-splicing technology was awarded in 1980 to Stanford University and the University of California (Office of Technology Assessment 1989). They built on the 1953 discovery by Watson and Crick of the structure of DNA and of the suggestion about how it replicates.

4. Wilson and Dahl, 2005, estimate that the cost of segregation with a varietal-declaration system is much less expensive than for an identity preservation system.

5. A "session" in experimental economics is equivalent to an "experimental unit" in statistical experimental design literature.

6. If there are ties, this can increase the number of winners to greater than n-1.

7. The view of our advisors from the Iowa State University, Department of Statistics, was that putting an individual through many rounds of bidding would change their behavior because of the experience, and so we were encouraged to keep the total number of bidding rounds per participant to a very small number—two. This is in contrast to most economics experiments where individuals are put through a long nonrandomized sequence of rounds of bidding.

8. When participants in a session received both pro-biotech and anti-biotech information, the order was randomized, so that some participants received the pro-biotech information first, and others received the anti-biotech information first. When third-party information was distributed in as session, it always was distributed after the other information types.

9. Because all consumers bid on GM-labeled and plain-labeled food products, our experimental market emulates a market where mandatory GM-labeling is required (similar to markets in Europe, Japan, and many other parts of the world). However, Huffman et al. (2004) showed that consumers interpreted labeling in a market with mandatory GM-labeling the same as they interpreted labeling in a market with voluntary labeling, so our results should not be constrained to markets that require mandatory labeling of GM-foods.

10. Because no bid price is revealed until all bids are placed and participants in a session were restricted from talking with each other, we anticipate no contemporaneous correlation of random disturbance terms across bidders in a session.

11. Our censored regression model is a more general form of the common tobit model (Greene 2003). While a tobit model, the dependent variable or associated disturbance is censored, but given equations (1) and (2) and zero bids, we have a disturbance term $\mu_j^* = \mu_j^{non\text{-}labeled} - \mu_j^{labeled}$ which can have censoring on one or both of its components—the bid for the plain and (or) GM-labeled products.

12. Several other models were fitted which included as regressors, the bidder'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 10-percent level).

13. OLS regressions were also fitted to 172 observations and to the observations remaining after "double-zero" bids were excluded. The results for these regressions are similar, and are available from the authors upon request.

14. See Huffman et al. (2006) for an analysis of the impact of bidders' prior beliefs about GM technology on their willingness to pay for food items that might be GM.

15. Note that our model does not assume an auction market, but a conventional market. But, auctions are essential for this analysis because our auction market elicits the non-hypothetical WTP under different information treatments that is not obtainable in a conventional market.

16. In computing this value of verifiable information, we used "market" prices that we paid for plain-labeled vegetable oil, yellow tortilla chips and Russet potatoes as the market price for plain-labeled product: $1.65 for the 32 ounce bottle of vegetable oil, $2.99 for the 16 ounce bag of tortilla chips, and $1.79 for the 5 pound bag of potatoes as the prices for the plain-labeled products. For market price of GM-labeled product, we adjusted the market price of plain-labeled price for the average GM-discount in our experiment. Therefore the estimated market prices for the GM-labeled products were $1.48 for the oil, $2.82 for the tortilla chips, and $1.65 for the potatoes.

17. Note that because it is assumed that auction participants consume either GM or plain-labeled food products, that only one of the two PREMGAIN coefficients will be positive while the other is zero. The PREMGAIN coefficients will also differ across participants.

18. The SAS code used to estimate the value of information is available from the authors upon request.

19. For all value of information test-statistics, we also ran a non-parametric Wilcoxon signed-rank test, and found similar results.

20. Recall that we had to use estimated prices for the GM-labeled products to compute the value of information, and we used the mean discount for GM-labeled foods to estimate these prices. We consider the impact of used alternative prices. One alternative set of prices yielded a greater premium for plain-labeled foods (prices for GM-labeled products estimated to be $1.38 for the oil, $2.72 for the tortilla chips, and $1.58 for the potatoes), and one that yielded a smaller premium for plain-labeled foods (prices for GM-labeled products estimated to be $1.57 for the oil, $2.91 for the tortilla chips, and $1.72 for the potatoes). The average value of information for the three food products was 5 cents and 3 cents per product for the greater and smaller plain-labeled premiums, respectively. Thus, our results are relatively robust to the estimated prices.