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The Effects of Information on Consumer Demand for Biotech Foods

Evidence from Experimental Auctions

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

Abstract

Consumers' willingness to pay for food products decreases when the food label indicates that a food product is produced with the aid of modern biotechnology. This bulletin presents empirical evidence on consumers' willingness to pay for biotech foods based on the presence or absence of labels advising that the food was prepared with the aid of biotechnology. The authors designed and conducted an experimental auction to elicit consumers' willingness to pay for "genetically modified" (GM)-labeled and standard-labeled foods under different information regimes. The evidence gathered for vegetable oil, tortilla chips, and potatoes shows that labels matter. In particular, under all information treatments, consumers discounted food items labeled "GM" by an average of 14 percent. While gender, income, and other demographic characteristics appeared to have only a slight impact on consumers' willingness to pay for biotech foods, information from interested parties and third-party (independent) sources was found to have a strong impact.

Keywords: Biotech, bioengineering, biotechnology, food labels, auctions, experimental economics, random *n*th price, willingness to pay.

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Summary

This bulletin presents empirical evidence on consumers' willingness to pay for foods with and without biotech labels. The findings were derived from laboratory auction experiments for three food items: vegetable oil, tortilla chips, and potatoes, about which consumers were given pro-biotechnology, anti-biotechnology, and independent, third-party information. The results indicated that consumers' willingness to pay for food products decreases when the food label indicates that a food product is produced with the aid of modern biotechnology (biotech foods). (*According to the Food and Drug Administration (FDA) and U.S. Department of Agriculture (USDA), "bioengineered" or "biotech" are preferable terms to describe foods produced with the aid of modern biotechnology. However, "genetically modified (GM)" and "genetically engineered" are also commonly used to describe biotech foods in academic publications. Since we used the terms GM and "non-GM" in our experimental auctions, we continue to use these terms in this bulletin whenever we refer to the labels in the experimental auctions.*) Under all information treatments, consumers discounted food items labeled "GM" by an average of 14 percent. In addition, gender, income, and other demographic characteristics appear to have only a slight impact on consumers' willingness to pay for biotech foods. However, information from interested parties and third-party information do influence consumers' willingness to pay for biotech and (perceived) non-biotech foods. It was found that consumers who received only negative information about agricultural biotechnology paid 35-38 percent less for food products labeled "GM," depending on the product. When the negative information was coupled with independent, third-party information, consumers were willing to pay 17-22 percent less for "GM"-labeled food. Likewise, when given only positive information about agricultural biotechnology, consumers bid higher for "GM" than for plain-labeled food in two of the three food items. However, when they are provided with both positive information about biotechnology and the independent, third-party information, consumers bid higher for plain-labeled food in all three cases. An independent, third-party source that provides verifiable information on biotechnology has a significant impact on consumers' demand for biotech foods. Third-party information had its greatest impact on consumers who received negative information, prompting them to view biotech foods more favorably. Also, the use of the term "GM" (rather than biotech or bioengineered) might have influenced the results.

Consumers' desires to make informed decisions about their food purchases have made the biotech food labeling issue an important public policy debate. The debate revolves around the benefits and risks of agricultural biotechnology. Agribusiness companies like Monsanto support agricultural biotechnology and say that biotech foods will help protect the environment, increase nutrition, and end world hunger. Environmental groups like Greenpeace oppose agricultural biotechnology and say that biotech foods cause allergic reaction, hurt the environment, and increase the power of multinational companies. The average consumer (and farmer) may rely on the information from these interested parties to make their decisions on biotech products. Currently the United States does not have a mandatory labeling policy for biotech foods, but several other countries do. Implementing a mandatory labeling policy in the United States might have benefits, but also involves costs, both variable and fixed. Moreover, further analysis of the data collected for this study shows that the current U.S. voluntary labeling policy is more efficient than mandatory labeling policy (Huffman et al., 2002).

The bulletin examines several issues. First, do biotech food labels have any significant effect on consumers' willingness to pay for biotech and non-biotech foods? Second, is consumers' willingness to pay for biotech foods affected when they receive information from interested parties? Third, would an independent, third-party group providing information (e.g., verifiable information) about biotechnology change consumers' purchasing behavior? Finally, do socioeconomic factors (e.g., gender, income, education) affect consumers' willingness to pay for biotech food items?

The bulletin combines tools of survey design, statistical experimental design, and the laboratory experimental auction mechanism to answer these questions. The experiments used a randomly selected sample of 172 consumers from two Midwestern cities: Des Moines, IA, and St. Paul, MN. The 172 auction participants were assigned to 1 of 12 experimental units, each consisting of 13-16 participants. Six information packets: (1) pro-biotechnology; (2) anti-biotechnology; (3) both pro- and anti-biotechnology; (4) pro-biotechnology and third-party, verifiable information; (5) anti-biotechnology and third-party, verifiable information; and (6) pro-biotechnology, anti-biotechnology, and third-party, verifiable information were randomized among all 12 experimental units, with each information packet going to two experimental units. 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. Participants then bid (sealed) on the three products separately, each product with and without a "GM" label.

Much future research on this topic remains. The food products in these auctions, although bioengineered, were deemed substantially equivalent to the conventional commodity. In some biotech foods, however, biotechnology may be used to enhance the quality (e.g., protein, fat, sugar content, shelf life) of the product, although not all of these products are in the market. Future research could examine how consumers react to biotech foods that have specific benefits. Future research could also examine if the language on the labels (e.g., "GM," biotech, bioengineered, genetically engineered, etc.) would have significant impact on consumers' willingness to pay for biotech foods.

The Effects of Information on Consumer Demand for Biotech Foods

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Introduction

Consumers' desires to make informed decisions about their food purchases have made the biotech food labeling issue an important public policy debate. The debate revolves around the benefits and risks of agricultural biotechnology. Agribusiness companies like Monsanto support agricultural biotechnology and say that biotech foods will help protect the environment, increase nutrition, and end world hunger (Council for Biotechnology Information, 2001). Environmental groups like Greenpeace oppose agricultural biotechnology and say that biotech foods cause allergic reaction, hurt the environment, and increase the power of multinational companies (Greenpeace, 2001). Consumer advocates and a wide range of environmental and food safety groups have mounted an active campaign against biotech foods. The average consumer (and farmer) may rely on the information from these interested parties, both pro and con, to make their decisions on biotech products. Huffman and Tegene (2002) have hypothesized that independent, third-party information improves social welfare in this environment. According to qualitative and quantitative research conducted in the United States by the International Food Information Council (IFIC), consumers accept food biotechnology when the benefits are effectively communicated (Schmidt, 2002).

In a recent study, Lin, Chambers, and Harwood (2000) concluded that "lack of information about the magnitude of premiums that consumers may be willing to pay for non-biotech crops makes near-term decisions difficult for elevators and farmers" (p. 54). This bulletin presents empirical evidence on U.S. consumers' willingness to pay for foods with and without biotech labels using laboratory auction experiments for three food items. In an experimental auction with divergent information about risks and benefits, we examined whether consumers value information provided in biotech labels. Following Fox, Hayes, and Shogren (2002), we created the divergent information design by providing six combinations of pro-biotechnology, anti-biotechnology, and third-party perspectives, which provided their corresponding views on the scientific impact, human impact, financial impact, and environmental impact of biotech foods. Iowa State University (ISU) Statistics Department randomly chose actual consumers in two major Midwestern U.S. cities. The consumers were paid to participate in experiments on food and household products.

This bulletin examines several issues. First, do biotech labels have any significant effect on consumers' willingness to pay for biotech and non-biotech foods? Second, is consumers' willingness to pay for biotech foods affected when they receive information from interested parties? Third, would an independent, third-party group providing information (e.g., verifiable information) on biotech foods change consumers' purchasing behavior? Finally, do socioeconomic factors (e.g., gender, income, education) impact the effect of biotech food labels on consumers' willingness to pay for food items?

We applied laboratory experimental auction markets, along with a statistical design, to answer these questions. Combining the positive features of statistical experimental design and auction markets yields a strong experimental design. Experimental auctions have been used to evaluate consumers' willingness to pay for food quality attributes (see, for example, Melton et al., 1996; and Fox, Hayes, and Shogren, 2002) and food safety (e.g., Hayes et al., 1995). Fisher, Wheeler, and Zwick (1993) surveyed the use of experimental economics in agricultural and resource economics.

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Issues Related to Labeling

Labeling is often used to deliver information to consumers on product characteristics that consumers are not able to evaluate by looking at the product. Whether a product is produced with the use of biotechnology is difficult or impossible for the consumer to determine by looking at the product. However, labeling of biotech has become one of the most controversial issues in agriculture today. Currently, the United States does not require biotech foods to be labeled, unless the new food product is substantially different from the original product (the U.S. Food and Drug Administration, FDA, 2001). If the product is substantially different from the traditional product, the label must identify the difference, perhaps through a new common name, but the label does not have to identify the new trait or characteristic as being derived through bioengineering. FDA requires labeling when the use of biotechnology introduces a known allergen or when it substantially changes the food's nutritional content or its composition (Schmidt, 2002).

In January 2001, the FDA issued proposed guidance, not yet finalized, regarding the voluntary labeling of food containing or not containing bioengineered ingredients. The guidance also clarifies the position of FDA with regard to the required labeling of products with new or unique traits, as explained above. However this proposed guideline does not mention a standard for what percentage of an ingredient in a food product can be bioengineered for the product still to be labeled as non-biotech (FDA, 2001). Two things are of note: first, the guidance states that FDA considers the term "genetically modified" and its variants inaccurate, since all modern foods have been genetically modified through traditional breeding techniques. *According to FDA and USDA, "bioengineered" or "biotech" are preferable terms to describe foods produced with the aid of modern biotechnology. However, the terms "genetically modified (GM)" and "genetically engineered" are also commonly used to describe biotech foods in academic publications (see, for example, AgBio Forum)*. Since we used the terms "GM" and "non-GM" in our experimental auctions, we continue to use them in this bulletin whenever we refer to the labels in the experimental auctions. Second, FDA considers misleading a voluntary statement such as "bioengineered free" on a label, since it may imply that the labeled food is superior to foods that are not so labeled. FDA also considers "bioengineered free" labels to be inaccurate because it implies that a product is 100 percent free of biotech components, which is nearly impossible to guarantee or verify. Examples of voluntary labels acceptable to the guidance are: "Genetically engineered," "This product contains cornmeal that was produced using biotechnology," or "This oil is made from soybeans that were not genetically engineered" (FDA, 2001).

The U.S. policy contrasts with the policies of many other countries, including Australia, China, Japan, and the countries in the European Union (EU), which all have mandatory labeling requirements for biotech foods (Rousu and Huffman, 2001). These countries often have different levels of bioengineering that they will tolerate before a product must be labeled as biotech. For example, the EU and Australia allow up to 1 percent of any ingredient in a food product to be bioengineered before the product must be labeled as biotech. Japan allows 5 percent of any ingredient to be bioengineered before the product must be labeled as such.

Caswell (1998 and 2000) has shown that there are many possible policies that could be implemented, including mandatory labeling of biotech foods, voluntary labeling of biotech and non-biotech foods, bans on all labeling to indicate whether or not a food is bioengineered, or voluntary labeling of non-biotech foods with an accompanying disclaimer noting the government's judgment about any difference between biotech and non-biotech foods. Runge and Jackson (2000) propose the last option as a solution to the current controversy over labeling of biotech foods. The policies that each country chooses are likely to be determined by the information demanded by consumers of each country.

An informed decision on whether or not to implement a labeling policy on bioengineered foods can only be done after a benefit/cost analysis. The balance of the benefit and cost depends on the type of program adopted (e.g., voluntary, mandatory) and market conditions. A related issue in the ultimate benefits and costs is how effectively labels convey information, the certainty of the labeling (e.g., "does contain" versus "may contain"), and the ability of the supply chain to provide high levels of integrity in the segregation process (Caswell, 2000).

Using the auction results presented in this bulletin, Huffman et al. (2002) have provided evidence that a voluntary biotech labeling policy results in greater societal welfare than regulated mandatory labeling policy of biotech foods. They argue that United States has been prudent in fending off calls for a mandatory biotech labeling policy.

Benefits of Labeling

Consumer groups and environmental groups have argued that there are benefits for consumers from mandatory labeling of biotech foods. Some groups (e.g., Greenpeace, Friends of the Earth) advocate that labels on biotech foods give consumers the right to choose whether or not to consume biotech foods.

Golan, Kuchler, and Mitchell (2000) have analyzed the potential benefits of general labels on foods. One benefit is making it easy to find information, e.g., on nutritional content of foods. Thus, labeling of foods can lead to more informed food choices by consumers.

Caswell and Padberg (1992) recommend a more comprehensive view of the benefits of any labels on food products. The benefits can be above and beyond what are normally considered the typical benefits from labels. The benefits from food labels include increased consumer information and more consumer confidence in product quality. Also, labels can provide an option value, even for consumers who do not currently read food labels. This option value exists because if a food is labeled, consumers always have the option to view the label, either now or in the future.

Runge and Jackson (2000) argue that negative labeling (e.g., "This product was not genetically engineered") has advantages for both consumers and producers. Drawing lessons from the Recombinant Bovine Somatotropin (rBST) experience, they argue that adoption of negative labeling can create significant niche markets for producers and that a carefully designed negative label would avoid the potential information biases of the positive label system.

Costs of Labeling

While there might be benefits to labeling, implementing a labeling policy involves some costs. The cost of labeling involves far more than the paper and ink to print the actual labels. Biotechnology firms oppose mandatory labeling for all biotech foods because they do not think foods should be specially labeled unless the food is different from the conventional product (Council of Biotechnology Information, 2001). The labels on a biotech food could be taken as a warning about health, whereas no significant health-related differences between biotech and non-biotech foods have been detected.

Golan, Kuchler, and Mitchell (2000) listed many costs associated with implementing a general food labeling policy. Some of the costs if a mandatory labeling policy is enacted include:

(1) Cost of identity preservation: Accurate labeling requires an extensive identity preservation system from farmer to elevator to grain processors to food manufacturers to retailers. When separating biotech from non-biotech foods, mistakes in delivery of the product are always a possibility, as is accidental mingling of non-biotech crops with their biotech counterparts. For example, in the United States, biotech corn, known as Starlink, was not approved for human consumption, but got into U.S. food system. Under identity preservation, farmers must ensure that non-biotech crops are not mingled with biotech variety. Farmers need to develop buffer zones to ensure no cross-pollination of biotech and non-biotech crops. Farmers also need to make sure planting and harvesting equipment are cleaned between biotech and non-biotech varieties. All of these items imply real costs if a labeling policy is implemented.

(2) Higher consumer prices: These added labeling and segregation costs would lead to higher prices for consumers (and possibly lower prices to producers). Higher prices could cause a regressive tax for lower income households, because low-income households spend a larger share of their income for food than do high-income households. In addition to low-income persons' having to pay for labeled food, the poor and less educated are less likely to benefit from food labels. This might lead to a "reverse Robin Hood effect" of taking money from the poor to benefit the rich (Golan, Kuchler, and Mitchell, 2000). Furthermore, the costs would be borne by all consumers regardless of the level of their own concerns.

(3) Costs to the agricultural industry: Some argue that labels could impose costs on the food and agricultural industry without providing compensating benefits to consumers. Labels could steer

consumers away from biotech products, which would lead to reduced consumption and trade, and investment in research and marketing in biotechnology and their products may be significantly diminished (Runge and Jackson, 2000). Also, Golan, Kuchler, and Mitchell (2000) suggest that labeling could change industry structure. With some fixed costs associated with labeling, small firms may have higher per-unit labeling costs than large firms. This would mean increasing returns to scale, and an incentive for firms to grow, or close down. A labeling policy that decreases the number of firms could decrease competition and might increase prices for consumers. Firms could also face reformulation costs.

(4) Adverse effect on information: Adding more information to food labels may dilute consumer awareness of other information on the label (Golan, Kuchler, and Mitchell, 2000). This concern seems most important when the labeling policy being considered would inform consumers of an attribute that may not impact human health, e.g., bioengineering.

(5) Cost of verification: Labeling without independent verification is not likely to be useful. Hence, a new labeling policy would require resources for government or third-party verification.

There are relatively few cost estimates due to labeling of biotech foods. An ERS study, based on a survey of 84 elevators, estimates that segregation of non-biotech crops could add about $0.22 per bushel and $0.54 per bushel to marketing costs for corn and soybeans, respectively (Lin, Chambers, and Harwood, 2000). These estimates do not include the premium to producers. These cost estimates reflect average costs to the elevators only and do not take into account additional costs associated with segregation at the farm level.

A study commissioned by the Canadian government estimates that mandatory labeling of bioengineered foods would increase food prices a minimum of 9 to 10 percent (Byrne, 2002). This means, for example, that a tortilla costing $1.50 would increase to about $1.65.

Australia and New Zealand commissioned KPMG, an accounting and consulting firm, to examine the costs of complying with a new labeling law. KPMG estimated that the costs of the labeling laws could mean an increase in consumer prices from 0.5 to 15 percent, and that firms could also face lower profits (Phillips and Foster, 2000). Even though they commissioned the study, the Australian and New Zealand Food Standard Council did not accept these estimates because the study assumed a much more elaborate system of private certification/testing and government oversight than the Council envisioned (Caswell, 2000). Updated estimates are being prepared. Phillips and Smyth (2000) estimated that, in 1995-96, a voluntary identity-preserved production and marketing system in Canada cost from 13 to 15 percent. One thing seems apparent; implementing a labeling policy on biotech foods would not be cost free, even if the exact magnitude of the cost is unknown.

Divergent Information

When the first biotech food product, a tomato engineered for longer shelf life, was released in the United States, it was accompanied by information in the media and at the markets, which increased familiarity of this new technology. However, commodity crops, such as corn and soybeans with altered agronomic traits, have subsequently been released without much media coverage (Shoemaker, 2001), although they received the same amount of public notification as all other regulations related to food safety. While there may not be any cause for concern about the safety of biotech foods, some consumers object to consuming food produced with any technology that lacks a long, established history of use. In addition, food labeling has become an issue of consumers' "right to know" (Shoemaker, 2001). At the same time, consumer and environmental groups on one side and agribusiness and biotech firms on the other side provide consumers with conflicting information about the benefits and risks of agricultural biotechnology. Also, bioengineering is a complex process and most people do not know the intricate details of this process (see, for example, FDA's report on focus groups, FDA, 2000). With different sources giving information to consumers, what are consumers likely to do? Studies by the International Food Information Council (IFIC) have shown the importance of the source of biotechnology information to consumers. "Who is educating consumers, not just the education itself, has emerged as a crucial factor to acceptance [of biotech foods]" (Schmidt, 2002).

Viscusi (1997) studied consumer reaction to environmental risks from air pollution emissions from chemical factories. He showed that when consumers receive divergent information on environmental risks, they tend to put a greater weight on the high-risk assessment. The individual's reaction was similar for information from both government and industry sources of information.

Fox, Hayes, and Shogren (2002) examined the effects of positive and negative information on consumers' willingness to pay for irradiated pork sandwiches. They found that when consumers were presented with both positive and negative information on food irradiation, the negative information dominated the consumers' decision-making. This was despite the fact that the negative information source was identified as a consumer advocacy group, and the information was written in a non-scientific manner.

Recent research shows that there may be a need for third-party, verifiable information on biotech foods, so consumers do not have to rely on the information from biotechnology companies and environmental groups (Huffman and Tegene, 2000). Research on organic foods reached a similar conclusion, in that there may be benefits from an independent, third-party monitor to help reduce false claims by interested parties (McClusky, 2000).

An experiment was designed to incorporate the private-information-revealing feature of experimental auction markets and the rigorous randomized treatment effects of statistical experimental design.[2] The experimental design consisted of six biotech information-labeling treatments with two replications. The treatments were randomly assigned to 12 experimental units, each consisting of 13-16 consumers drawn from the households of two major urban areas. Consumers were paid to participate. At the suggestion of the statisticians, each participant participated in only two trials.[3] Using randomly chosen consumers from the population of an urban area, rather than undergraduate college students at a university, is a major advantage when drawing inferences from the experiments or generalizing to the Midwest or whole U.S. population. Conducting experiments in two urban areas rather than one enhances credibility of generalizations and shows that the experiments can be replicated across urban areas.

Consumers might react differently to biotech content in different types of food, or they may have no demand for some food products. Hence, using only one food item seemed unlikely to reveal enough information, given the sizeable fixed cost of conducting the experiments. 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 bioengineering) are removed, leaving pure lipids. Hence, minimal human health concerns should arise from biotech oil, but consumers may worry that biotech soybeans affect the environment or that they lack adequate information on the distilling process. Tortilla chips are highly processed foods that may be made from biotech or non-biotech 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. Consumers might see both human health and environmental risks from eating biotech Russet potatoes.

[2] Phil Dixon and Wayne Fuller, Department of Statistics, Iowa State University, provided assistance with the statistical design part of the project.

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

Random *n*th-price auction

Auctions have been a popular mechanism in laboratory valuation experiments by economists. In particular, Vickrey's (1961) second-price auction has been used frequently. The second-price auction induces individuals to reveal private information contained in their preferences for new goods and services (Shogren et al., 1994; Fox et al., 1998; and Shogren, List, and Hayes, 2000). The popularity of the second-price auction is largely due to the mechanism's being demand revealing in theory and relatively simple to explain, and it has an endogenous market-clearing price. In the second-price auction, bids (sealed) for a good are ranked from highest to lowest, and the winner pays the second highest price. Participants have an incentive to tell the truth about their valuation for a good because the auction separates what they say from what they pay. Sincere bidding is the weakly dominant strategy (Shogren, List, and Hayes, 2000). Further, evidence from induced value experiments suggests the auction mechanism can produce efficient outcomes in the aggregate (Kagel, 1995).

The second-price auction, however, has a problem: it does not accurately reveal the complete demand curve for a good by all participants. Individuals whose value for a good is far below or above the market-clearing price frequently bid insincerely. Bidders whose values are far below or above the market-clearing price are called off-the-margin bidders (Shogren et al., 2001). These bidders have a low opportunity cost from an insincere bid, making it difficult to accurately measure the entire demand curve. A second-price auction might not engage low-value bidders who think they will never lose by insincere bidding (see Miller and Plott, 1985, and Franciosi et al., 1993). Insincere bidding can be sustained if the behavior is undetected and unpunished by the institutional structure of the auction mechanism (see Cherry et al., 2000).

We chose the random *n*th price auction for our biotech-food experiment because it is designed to engage both the on- and off-the-margin bidders (see Shogren et al., 2001). The auction combines elements of two classic demand-revealing mechanisms: the second-price auction and the Becker-DeGroot-Marschak (1964) random pricing mechanism. The key characteristic of the random *n*th price auction is that it is a random but endogenously determined market-clearing price. Randomness is used to give all participants a positive probability of being a purchaser of the auctioned good; the endogenous price guarantees that the market-clearing price is related to the bidder's private values.

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—the n in the *n*th-price auction—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 = 4, the three highest bidders each purchase one unit of the good priced at the fourth-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 (Shogren et al., 2001).

The Experiments

Auctions were planned and conducted at two Midwestern U.S. cities: Des Moines, IA, and St. Paul, MN. The Iowa State University (ISU) Statistics Laboratory obtained 1,200-1,500 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 (18 years or older) in the household. 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 ISU Statistics Laboratory contacted consumers in these two areas who agreed to participate in the study. The sessions were held on two different Saturdays (April 7 and 21) in 2001, and participants were informed that the session would last about 90 minutes. Each participant was told that he or she would receive $40 in cash for his or her time. The sessions were held at the Iowa State University Learning Connection, 7th and Locust Street, 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 a.m., and 2 p.m. Willing participants chose a time that best fit their schedule. Participation per household was limited to two adults, and they were assigned to different groups.[4] The Statistics Laboratory sent participants a letter containing more information, including a map, a meeting time and location, and a telephone number to contact for more information.

There were 12 experimental units—six in Des Moines and six in Minneapolis. Ninety-nine people in Des Moines agreed to participate out of 1,200 called. Of the 99 who agreed to participate, 77 actually attended. For the Minneapolis experiments, 118 people, out of 1,500 called, agreed to participate. Of those 118, 95 participated. The sample size totaled 172, which is large compared to most experimental auctions.

Each auction had 10 steps, which are summarized in figure 1.[5] Upon arrival at the experiment, participants signed a consent form agreeing to participate in the auction. After they signed this form, the participants 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.

In step 2, 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.

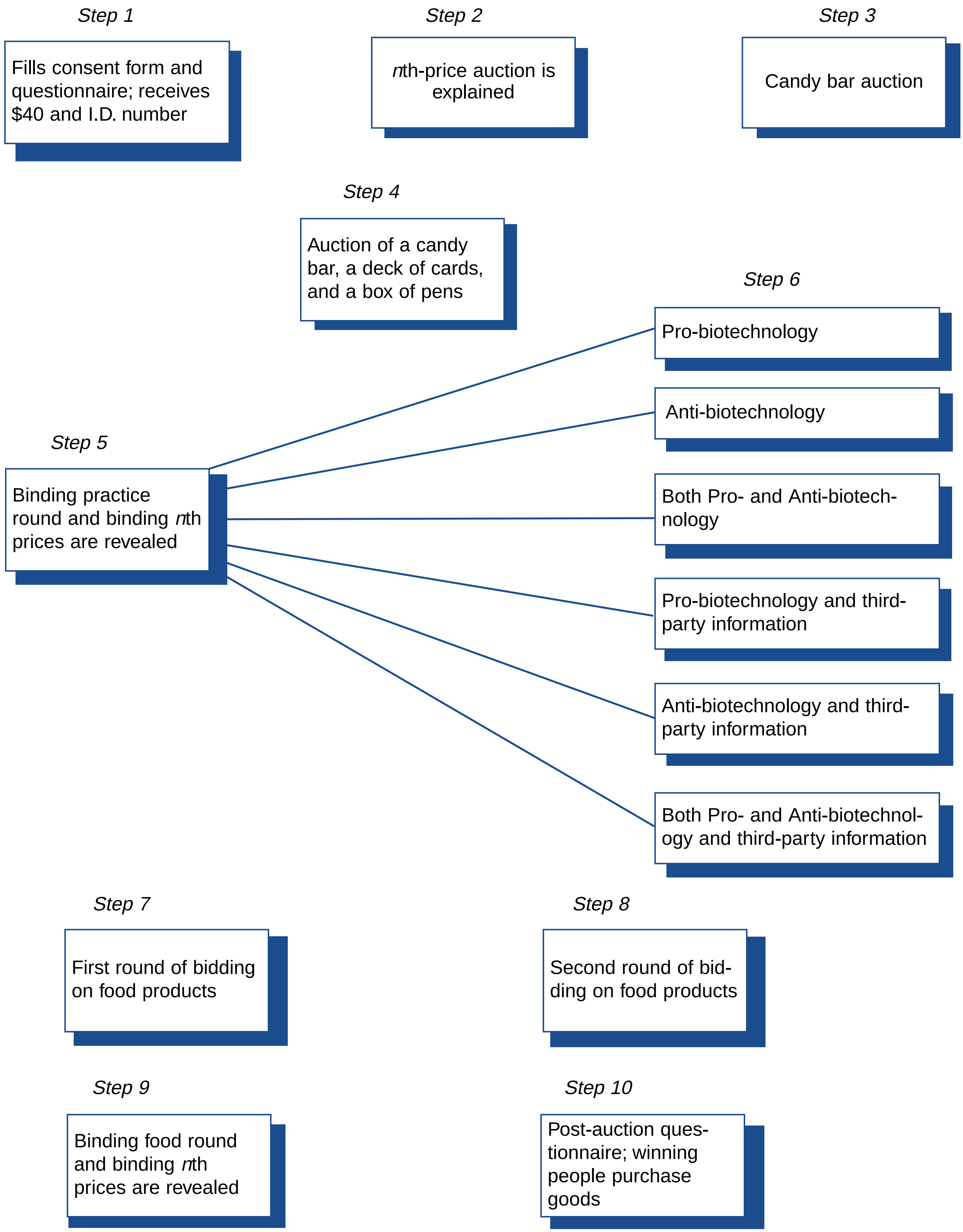
Step 3 was the first practice round of bidding, during which participants bid on a brand-name candy bar. The participants were asked to examine the product and then place a bid (sealed) on the candy bar. The bids were collected and the first round of practice bidding ended. Throughout the auctions, as the participants bid on items in a particular round, they had no indication of what other items they might be bidding on in future rounds.

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

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

[5] The complete set of information given to participants may be requested from the authors.

Figure 1
Steps in the experiment



any product. The reason was to eliminate price reduction due to the consumer's 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).[6] 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 board, and the *n*th prices were circled for each of the three products. This way, participants could see what items they had won (bought) immediately, and what price they had to pay for the items. 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, participants received one of six potential information packets about biotechnology. The information packets were produced as follows. Three packets of information contained:

(1) *the industry perspective*—a collection of statements and information on biotechnology provided by a group of leading biotechnology companies, including Monsanto and Syngenta;

(2) *the environmental group perspective*—a collection of statements and information on biotechnology from Greenpeace, a leading environmental group;

(3) *the independent, third-party group perspective*—a statement on biotechnology approved by a third-party group, consisting of a variety of individuals knowledgeable about biotech foods, including scientists, professionals, religious leaders, and academics, none of whom have a financial stake in genetically modified foods.

To assist the participants' processing of these different sources of information, the volume of information released of each type was limited to one page. To ease the information-processing load on participants, the information was organized into five categories: *general information, scientific impact, human impact, financial impact, and environmental impact*. Figures 2-4 show the exact format and wording of the three information sources.

The information was randomized to create the six information packets: (1) pro-biotechnology; (2) anti-biotechnology; (3) both pro- and anti-biotechnology; (4) pro-biotechnology and third-party verifiable information; (5) anti-biotechnology and third-party[7] verifiable information; and (6) pro-biotechnology, anti-biotechnology, and third-party verifiable information. The 6 information packets were then randomized among all 12 experimental units, with each information packet going to 2 experimental units. 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.

Two auction rounds followed the distribution of information. The rounds were differentiated by the food label—the food had either a standard label or a biotech label. In one of the rounds, participants bid on the three food products each with just a standard food label. In the other round, participants would be bidding on the same three food products with a biotech label, which differed from the standard label by inclusion of only one extra sentence: "This product is made using genetic modification (GM)." (As noted earlier, USDA and FDA prefer the terms "biotech" or "bio-engineered" to "GM," although "GM" and non-"GM" are commonly used in academic publications, e.g., *AgBio Forum*.) These labels were made as plain as possible to avoid any influence on the bids from the label design. The labels are presented in figure 5. The sequencing of biotech labels was randomized across experimental units. Each information packet was given to two experimental units (fig. 6). One of these experimental units bid on food with the standard label in round one, and the food with the label indicating bioengineering in round two. The other experimental unit bid on food with the label indicating bioengineering in round one, and the standard label in round two (fig. 6). For each experimental unit, participants knew that

[6] 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 bars should be the same. If the deck of cards and box of pens are neither complements nor substitutes for the candy bar, they should not impact the bids on the candy bar.

[7] Third-party information was always distributed after the other information sources.

Figure 2

Information given to participants, industry perspective (pro-biotechnology)

The following is a 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 3

Information given to participants, environmental group perspective (anti-biotechnology)

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, third-party perspective (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 5
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 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 and anti-biotech	No	1
10.	Pro-biotech	No	2
11.	Anti-biotech	No	2
12.	Pro-biotech and anti-biotech	No	2

only one of the two food rounds would be chosen as the binding (valid) round.

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 examine the same three food products, but each with a different label from round 1. Again the participants examined the products and bid on the three products separately. The bids were then collected from all of the participants. Once again, consumers were informed that only one of the two food rounds would be binding.[8]

Step 9 selected the binding round and the binding *n*th prices for the three goods. After the binding round and binding *n*th prices were chosen, the winners were notified and all participants were asked to fill out a brief post-auction questionnaire. In step 10, the participants who did not win any products were informed that they could leave; the participants who had won products exchanged their goods for money, and were then free to leave.

The Data

A summary of the demographic characteristics of the 172 auction participants is presented in table 1. Sixty-two percent of the participants in the auctions were female. The mean age of the participants 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 2 years in college. The participants had a mean total household income (before taxes) of $57,000, with an average household size of three. Ninety percent of the participants in the experiments were white, and most people indicated that they read labels before they buy a new food product.

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 biotech foods; they were willing to pay zero for one unit, a small demand. 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.[9] In table 2, the number of participants who bid a positive amount for a product is different for each of the three goods. This occurs because more consumers bid zero for the "GM"-labeled and plain-labeled vegetable oils than for the "GM"-labeled and plain-labeled bags of tortilla chips. "GM"-labeled and plain-labeled bags of potatoes had the largest number of non-zero bids. Many consumers who bid zero for both the biotech and non-biotech varieties of one product bid a positive amount for the other products.[10]

The Effect of Information

Part A of table 2 addresses the question, "Do labels have any significant effect on consumers' willingness to pay for biotech and non-biotech foods?" Part A of table 2 shows the mean bid prices for all participants for each of the three products: the 5-pound bag of potatoes, the 32-ounce bottle of vegetable oil, and the 1-pound bag of tortilla chips. Under all information treatments and all auctions, consumers, on average, discounted food items labeled "GM" by 14 percent.[11] Thus, "GM" labels affect consumers' willingness to pay for "GM" and plain-labeled food products. It is possible that participants might have perceived the

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

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

[11] In another similar experiment (Huffman et al., 2002), 142 consumers in Des Moines and Minnesota participated in auctions for the same 3 food products. There were 2 labeling regimes: (1) 86 consumers participated in plain-labeled and "GM"-labeled products; and (2) 56 consumers participated in plain-labeled and non-"GM"-labeled products. We examined the difference in bids for the "perceived" GM product to the "perceived" non-GM product. In (1), the GM-labeled was the perceived GM product while the plain-labeled was assumed to be the perceived non-GM product. In (2), the plain-labeled food was assumed the perceived GM product while the non-GM product was the perceived non-GM product. Statistical tests showed that consumers' bid for the perceived non-GM products in the auctions (labeling regimes 1 and 2) are not different. That is, consumers discounted perceived GM foods similarly in the two auctions. In this experiment, all participants received positive and negative information while some participants received third-party information.

Table 1—Characteristics of the auction participants

Variable	Definition	Mean	Standard deviation
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 household's income level (in thousands)	57.0	32.6
White	1 if participant is white	0.90	0.30
Read	1 if never read labels before a new food purchase	0.01	0.11
	1 if rarely read labels before a new food purchase	0.11	0.31
	1 if sometimes read labels before a new food purchase	0.31	0.46
	1 if often read labels before a new food purchase	0.37	0.48
	1 if always read 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
Labels 1	1 if the participant bid on foods with GM labels in round 1	0.52	0.50

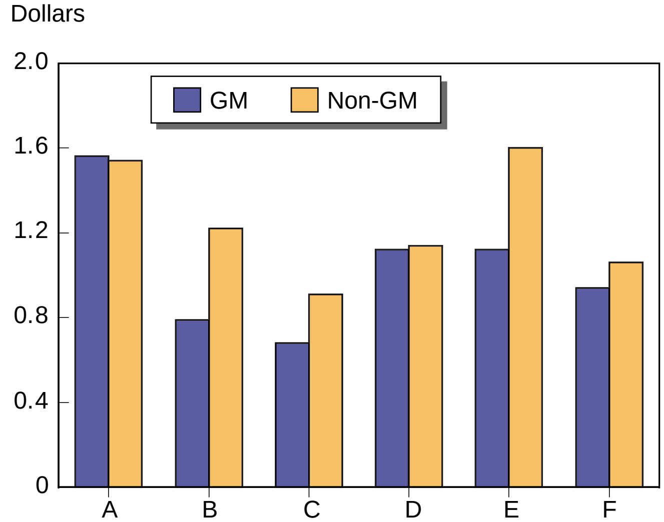
plain-labeled products as non-biotech when comparing the "GM"-labeled and plain-labeled food products.

Table 2, parts B-G, shows how consumers' willingness to pay for "GM"-labeled and plain-labeled foods is affected by divergent information about the benefits and risk associated with biotechnology. 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 biotechnology was only used to enhance the agronomic traits and did not give the foods any enhanced attributes. Part C shows that when consumers received only negative information, they discounted the "GM"-labeled foods by an average of 35 percent. Part D shows that consumers who received both positive and negative information discounted the "GM"-labeled foods by an average of 16-29 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 and 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. Participants who received negative and third-party information discounted the "GM"-labeled foods by an average of 17-22 percent, depending on the product. Part G shows that 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 0-11 percent, depending on the product. Figures 7-9 show the average bids for

Figure 7

Oil: Mean bids for GM-labeled and standard-labeled foods



Note: **A** = only positive information; **B** = only negative information; **C** = both positive and negative information; **D** = both positive and third-party information; **E** = both negative and third-party information; and **F** = positive, negative, and third-party information.

Table 2—Mean bids for participants receiving positive, negative, and third-party information excluding double-zero bids

A. Mean bids – all participants

	n	mean bid	std dev	Median	Minimum	Maximum
Biotech oil	146	1.07	0.81	0.99	0	3.99
Oil	146	1.24	0.78	1.00	0	3.79
Biotech chips	155	1.03	0.85	0.99	0	3.99
Chips	155	1.20	0.81	1.00	0.05	4.99
Biotech 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 received only positive information

	n	mean bid	std dev	Median	Minimum	Maximum
Biotech oil	26	1.56	0.73	1.50	0	2.99
Oil	26	1.54	0.79	1.55	0	3.50
Biotech chips	30	1.31	0.72	1.13	0	2.99
Chips	30	1.36	0.72	1.18	0.05	2.99
Biotech 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 received only negative information

	n	mean bid	std dev	Median	Minimum	Maximum
Biotech oil	26	0.79	0.82	0.50	0	3.25
Oil	26	1.22	0.65	1.00	0.25	2.49
Biotech chips	29	0.81	0.94	0.50	0	3.99
Chips	29	1.25	1.02	1.00	0.05	4.99
Biotech 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
Biotech oil	24	0.68	0.55	0.50	0	1.79
Oil	24	0.90	0.72	0.85	0	3.00
Biotech chips	23	0.68	0.74	0.35	0	2.25
Chips	23	0.81	0.79	0.49	0.05	2.75
Biotech potatoes	26	0.50	0.39	0.50	0	1.50
Potatoes	26	0.70	0.43	0.50	0.05	1.60

Continued--

Table 2—Mean bids for participants receiving positive, negative, and third-party information excluding double-zero bids--Continued

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

	n	mean bid	std dev	Median	Minimum	Maximum
Biotech oil	26	1.12	0.62	1.00	0	2.39
Oil	26	1.14	0.57	1.00	0.10	2.39
Biotech chips	25	1.24	0.77	1.19	0	2.79
Chips	25	1.33	0.73	1.16	0.20	2.89
Biotech potatoes	26	0.92	0.45	0.99	0	1.85
Potatoes	26	0.93	0.39	0.99	0.25	1.90

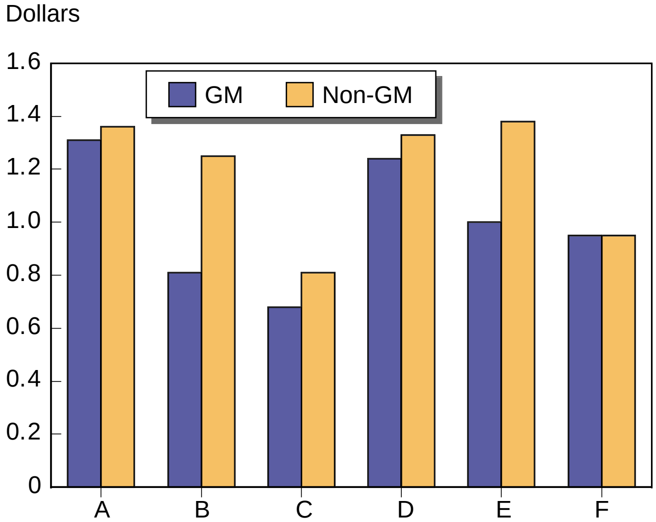
F. Mean bids when participants received both negative and third-party information

	n	mean bid	std dev	Median	Minimum	Maximum
Biotech oil	21	1.33	1.05	1.25	0	3.99
Oil	21	1.60	0.97	1.50	0.49	3.79
Biotech chips	25	1.12	0.97	0.99	0	3.50
Chips	25	1.38	0.77	1.01	0.49	3.00
Biotech 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

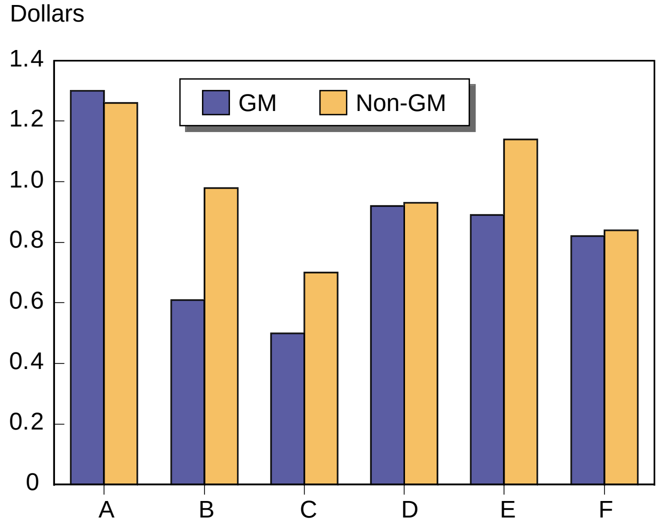
	n	mean bid	std dev	Median	Minimum	Maximum
Biotech oil	23	0.94	0.77	0.95	0	2.75
Oil	23	1.06	0.82	1.00	0.05	3.29
Biotech chips	23	0.95	0.81	0.85	0	3.25
Chips	23	0.95	0.66	0.99	0.1	2.89
Biotech potatoes	24	0.82	0.61	1.00	0	1.99
Potatoes	24	0.84	0.55	0.84	0.01	2.00

Figure 8
Chips: Mean bids for GM-labeled and standard-labeled foods



Note: **A** = only positive information; **B** = only negative information; **C** = both positive and negative information; **D** = both positive and third-party information; **E** = both negative and third-party information; and **F** = positive, negative, and third-party information.

Figure 9
Potatoes: Mean bids for GM-labeled and standard-labeled foods



Note: **A** = only positive information; **B** = only negative information; **C** = both positive and negative information; **D** = both positive and third-party information; **E** = both negative and third-party information; and **F** = positive, negative, and third-party information.

"GM"-labeled and plain-labeled foods when participants are given divergent information.

Our results as well as Viscusi's (1997) indicated that individuals placed a slightly greater weight on negative information than on positive information. In our auction, those 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 35 percent (oil and chips) and 38 percent (potatoes). Those who received both positive and negative information put slightly more weight on the negative information, discounting the "GM"-labeled foods by 16-29 percent, depending on the product. In their experiments, Fox, Hayes, and Shogren (2002) found that negative information dominated positive information. They argued that one reason could be due to a "status quo bias" (or endowment effect). They argued that losses associated with switching to an alternative are given greater weight than corresponding gains; that is, there is a bias in favor of status quo. In their experiment, participants were originally endowed with a regular pork sandwich (the product under investigation) and could bid to upgrade to an irradiated pork sandwich, where irradiation reduces the risk of parasitic illness. Our auction had participants bid on items in separate rounds (trials), thereby eliminating the possibility of a "status quo bias."

Econometric Model

Regression analysis provides the statistical framework for examining consumer behavior and answering the questions raised earlier in the bulletin. The dependent variable in all of the regressions is the difference in bid prices for a plain-labeled and "GM"-labeled product for each participant. Thus, consumers' tastes are held constant for each of the three products. We can express bid difference as the difference between inverse demand functions for the two products. Let the inverse demand equation for the "GM"-labeled food (called labeled), and the plain or standard-labeled food (called non-labeled) be:

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

and

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

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 the random error term for participant j.

Subtracting equation (2) from equation (1), we obtain an equation where the dependent variable is the difference in bid prices for the two trials, as shown in equation (3):

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

The coefficients and error terms can be condensed and rewritten as shown in equation (3a):

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

The difference in bid prices is explained by an intercept term β_2^*, a slope β_1^* term that is multiplied by a vector of exogenous characteristics X_{j2}, and a random error term μ_j^*. Equation (3a) can now be estimated.

Equation (3a), however, is likely to be censored since consumers were restricted to a minimum bid of zero for a product. The censored bid prices are the zero bids for the "GM"-labeled and/or the plain-labeled product. This censored regression model has four cases. In 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 just the difference between the two bid prices. Case (2) occurs when 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 from the fact that the bids on the "GM"-labeled product were censored at zero. Case (3) occurs when consumer j bids a positive amount for the "GM"-labeled product and zero for the plain-labeled product. Like case (2), the true difference in bid prices for the censored regression is (absolutely) larger than the measured difference between the two bid prices, because the participant's bid for the plain-labeled product is censored. Case (4) occurs when consumer j bids zero for both products. This does not give any information about their true demand for biotech products. A summary of the four cases is given in figure 10.

By using the censored regression model, the zero bid prices are correctly accounted for, and effects of bias from the zero bids are minimized. Hence, we expect the coefficient estimates for this regression method to have better statistical properties than if we had ignored the censoring. 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.

[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.

Figure 10
The four cases of the censored regression

Case	Plain-labeled bid	"GM"-labeled bid	Censored regression difference
1.	$P^{\text{non-labeled}}$	P^{labeled}	$P^{\text{non-labeled}} - P^{\text{labeled}}$
2.	$P^{\text{non-labeled}}$	0	$> P^{\text{non-labeled}}_{1}$
3.	0	P^{labeled}	$< -P^{\text{labeled}}$ or $> \lvert -P^{\text{labeled}} \rvert$
4.	0	0	•

Note: "• " represents a missing value, due to the zero bid.

Regression Results

The censored regression results are presented in tables 3-5.[13] 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. Other regressors include gender (dummy variable taking a value of 1 if a person is female), income, "labels Round 1" (a dummy variable taking a value of 1 if a participant bid on foods with "GM" labels in round 1 and plain labels in round 2), and "informed" (a dummy variable taking a value of 1 if the participant perceived himself (herself) to be well informed about biotech foods).[14]

Regression (1) in tables 3-5 reports on the test of the difference in bid prices due to "GM" labels. The intercept term in regression (1) of tables 3-5 is positive and statistically significant, implying that, on average, participants were willing to pay 19 cents less for a 32-ounce bottle of vegetable oil labeled as "GM," 21 cents less for a 1-pound bag of tortilla chips labeled as "GM," and 17 cents less for a 5-pound bag of Russet potatoes labeled "GM." Hence, "GM" labels have a statistically significant effect on consumers' willingness to pay for each food item.

Regression (2) is used for testing the effect of information types on the willingness to pay for "GM"-labeled and plain-labeled food products. The coefficients for "Anti," a dummy variable taking a value of 1 if a participant received only negative information, are large, positive, and statistically significant in all cases. The coefficients for "Pro and Anti," a dummy variable taking a value of 1 if an individual received positive and negative information, are positive, and these coefficients are statistically significant for some of the products. These results show that 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 "Pro- and Third-party," a dummy variable taking a value of 1 if 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 "Anti- and Third-party," a dummy variable indicating that a participant received negative and third-party information, are generally statistically significant. The coefficients for "All information," a dummy variable indicating that a participant received all three types of information, are not statistically different from zero for any of the food products. Hence, the impact is similar to the outcome when consumers received only positive information. The coefficient for the dummy variable "labels Round 1" is negative in all cases, indicating that participants who bid on the "GM"-labeled food in the first round paid a smaller premium for plain-labeled food than the other participants. However, the coefficient is statistically significant for only one of the food items (potatoes).

In regression (3), the difference in bid prices is regressed on an intercept term, information types, and the variable "labels round 1." The coefficient of this dummy variable is negative for all three products, indicating that participants who bid first on the "GM"-labeled food in the first round discounted the "GM"-labeled food less than the other participants. However, the coefficient of the "labels round 1" was not statistically significant.

13 Ordinary least square 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 may be requested from the authors.

14 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 10-percent level).

Table 3—Censored regression estimates explaining difference in bid prices between "GM"-labeled and plain-labeled tortilla chips

	Dependent variable: Bid price non-labeled food–bid price GM-labeled food						
Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intercept	0.209**	0.060	0.093	0.106	0.008	0.039	-0.034
	(.046)	(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	-	0.035	0.031	0.035	0.003	0.023	0.001
Third-party		(0.147)	(0.147)	(0.147)	(0.148)	(0.146)	(0.148)
Anti and	-	0.245 *	0.241	0.246 **	0.244 *	0.241	0.256 *
Third-party		(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	-	15.92 **	16.28 **	16.49 **	17.93 **	17.70 **	18.83 **

** indicates that a variable is significant at 5 percent.
* indicates that a variable is significant at 10 percent.
(n=172, standard errors are in parentheses).

Table 4—Censored regression estimates explaining difference in bid prices between “GM”-labeled and plain-labeled vegetable oil

	Dependent variable: Bid price non-labeled food–bid price GM-labeled food						
Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intercept	.193**	-0.032	0.053	0.117	-0.128	-0.015	-0.104
	(.056)	(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	-	10.90 *	12.52 *	14.11 **	16.21 **	14.09 **	18.63 **

** indicates that a variable is significant at 5 percent
* indicates that a variable is significant at 10 percent.
(n=172, standard errors are in parentheses).

Table 5—Censored regression estimates explaining difference in bid prices between "GM"-labeled and plain-labeled potatoes

	Dependent variable: Bid price non-labeled food–bid price GM-labeled food						
Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intercept	0.175** (.039	-0.039 (0.088)	0.064 (0.096)	0.076 (0.103)	-0.019 (0.117)	-0.029 (0.101)	-0.069 (0.124)
Anti	-	0.504 ** (0.125)	0.470 ** (0.122)	0.472 ** (0.122)	0.478 ** (0.122)	0.501 ** (0.120)	0.507 ** (0.120)
Pro and Anti	-	0.262 ** (0.126)	0.233 * (0.124)	0.239 * (0.125)	0.248 ** (0.124)	0.258 ** (0.122	0.271 ** (0.123)
Pro and Third-Party	-	0.057 (0.125)	0.041 (0.123)	0.046 (0.123)	0.018 (0.124)	0.026 (0.120)	0.015 (0.122)
Anti and Third-Party	-	0.339 ** (0.125)	0.323 ** (0.123)	0.329 ** (0.124)	0.322 ** (0.122)	0.332 ** (0.120)	0.337 ** (0.122)
All information	-	0.088 (0.128)	0.095 (0.126)	0.099 (0.126)	0.110 (0.126)	0.078 (0.124)	0.092 (0.124)
Labels-Round 1	-	-	-0.174 ** (0.073)	-0.174 ** (0.073)	-0.177 ** (0.072)	-0.146 ** (0.072)	-0.150 ** (0.072)
Gender	-	-	-	-0.026 (0.075)	-	-	-0.022 (0.074)
Income	-	-	-	-	0.0014 (0.0014)	-	0.0009 (0.0011)
Informed	-	-	-	-	-	0.190 ** (0.074)	0.179 ** (0.075)
Likelihood ratio	-	22.54 **	28.17 **	28.29 **	29.69 **	34.56 **	35.36 **

** indicates that a variable is significant at 5 percent.
* indicates that a variable is significant at 10 percent.
(n=172, standard errors are in parentheses).

Regressions (4)-(6) are used to test the effect of gender, income, and being "well informed about 'GM' foods" on the willingness to pay. Few demographic variables had an impact on the difference in bid prices. Women discounted "GM"-labeled foods less than men for all three products in the auctions. 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 had 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.

Consumers who considered themselves "well informed about 'GM' foods" (as recorded in the pre-auction survey) discounted "GM"-labeled foods more than other participants. This coefficient is statistically significant (10-percent 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 other bidders. This result suggests they had heard negative information on "GM" foods. This result contrasts with the survey results obtained by Boccaleti and Moro (2000) which indicates, among people who rated their degree of awareness about "GM" as good, over 60 percent were positive toward "GM" foods. Regression (7) includes all the variables in regressions (1)-(6). The results are similar to the regressions (1)-(6). 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 results from our experiments are noteworthy. Consumers discounted food products labeled "GM" by 14 percent, based on information they received. In comparing "GM"-labeled with standard- or plain-labeled products, consumers might have perceived the plain-labeled products as non-"GM." The discounting was similar across the three products, suggesting that most consumers perceive net biotech effects similarly for the three goods. If the term "GM" "taps anxieties that precondition consumers to be wary of biotechnology" (Schmidt, 2002), then the 14-percent discount for biotech foods could be considered as an upper bound.

The result that consumers discount "GM"-labeled foods has notable implications given the ongoing global controversy over the issue of labels on biotech foods. This debate has forced many countries around the world to consider or to implement new food labeling policies. This trend has strong implications for grain handlers, food manufacturers, and others in the supply chain. For example, in January 2000, Best Foods Inc. decided to end its use of biotech ingredients in manufactured foods destined for the EU, in order to avoid the biotech labeling requirements; and Frito-Lay Inc. announced that it would cease using biotech corn in its snack foods manufacturing (Lin, Chambers, and Harwood, 2000).

Given that the participants in the study did reveal a significant discount for foods labeled "GM," a mandatory biotech labeling policy seems likely to reduce demand for biotech products. Assuming that the participants in the experiment are representative of the U.S. population, there appears to be a strong preference for non-biotech. However, the demand for these non-biotech (and biotech) products is influenced by the type of information about biotechnology that consumers receive. FDA focus groups and IFIC studies also indicate that consumers may react differently to terms such as "GM," "biotech," "genetically engineered," "bioengineered," etc. According to IFIC, if the benefits of biotechnology are effectively communicated, U.S. consumers will accept biotech foods (Schmidt, 2002).

Conclusion

This study has shown that consumers' willingness to pay for food products decreases when the food label indicates that a food product is produced using biotechnology. Consumers discounted food items labeled "GM" by 14 percent. In addition, gender, income, and other demographic characteristics appear to have only a slight impact on consumers' willingness to pay for biotech foods. However, information from interested parties and third-party information do influence consumers' willingness to pay for biotech and (perceived) non-biotech foods. The use of "GM" rather than "biotech" or "bioengineered" on the labels could also have influenced the results.

The data presented in table 2 show that consumers who received only negative information about biotechnology paid 35-38 percent less for food products labeled "GM," depending on the product. When the negative information is coupled with independent third-party information, they were willing to pay only 17-22 percent less for "GM"-labeled food. Likewise, when consumers were given only positive information about biotechnology, consumers bid higher for "GM"-labeled than plain-labeled food for two of the three food items. However, when consumers were provided with positive information from the industry perspective and the independent third-party perspective, they bid higher for plain-labeled food in all three cases.

The econometric results presented in tables 3-5 also showed that consumers who received only positive information behaved differently from those who received only negative information and both negative and third-party information. The third-party information does not appear to change the behavior of those who receive positive information. Demographic variables such as gender and income have little impact on the willingness to pay for "GM"-labeled and plain-labeled food products.

With bioengineering remaining controversial, information on biotech foods will have a major impact on consumer acceptance of foods with biotech labels. This experimental auction has produced the following results. First, people, on average, were willing to pay 17-21 cents per unit more to purchase plain-labeled food than "GM"-labeled food. Consumers might have perceived the plain-labeled products as non-biotech. Nonetheless, the observation that such a large "premium" exists for food items that are perceived to be non-biotech has strong implications for grain handlers, food manufacturers, and others in the marketing system. Second, information about biotechnology from interested parties has an impact on consumer demand. This helps explain why groups such as Greenpeace and Friends of the Earth have been disseminating massive amounts of negative information on biotech foods. Likewise, it explains why biotechnology companies have invested heavily to advertise the positive aspects of biotechnology (Thrane, 2001).

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

Much future research on this topic remains. New research is currently testing the impact of information on the willingness to pay for foods with negative biotech labels, that is, labels that say, "This product is not made using biotechnology." The food products in these auctions were bioengineered and deemed substantially equivalent to the conventional commodity. However, there are biotech foods being developed to enhance the quality (e.g., protein, fat, sugar content, and shelf life) of the product. None of these products are currently on the market. Future research could examine how consumers react to biotech foods that have specific benefits. Finally, future research could also examine if language on the label (e.g., "GM," biotech, bioengineered, genetically engineered, etc.) would have an impact on consumers' willingness to pay for these biotech foods.

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