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by

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Abstract

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This paper addressed the puzzling resistance of Presidents of southern African countries to food aid in 2002, given near certain starvation and long-term negative health effects of malnutrition of their constituents. First, I show that NGOs led by Greenpeace and Friends of the Earth are disseminating information claiming that GM foods are dangerous to human health and are "Frankenfoods." Second, people in European Union countries, who are not in any danger of starvation, have strong preferences for non-GM foods, which they can easily afford. Over the long term, however, the tastes of EU consumers matter to southern African countries because some of these countries hope to export agricultural products in the future. GM-food aid, which most likely would contain GM-maize, is seen as a potential contaminant to native African maize varieties, and over the long term to be a threat to south African exports to the EU. Hence, understanding resistance to GM-food in developed countries is crucial to formulation of better food policies in Africa and to sustainable development.

New and important results are reported from a statistical analysis of the market characteristics that push consumers in a high-income country to resist GM foods, with an emphasis on negative information from environmental groups and third-party, verifiable information, which could neutralize misinformation. For this study, a unique sample of adult consumers participated in laboratory (random *n*th price) auctions of three food products where labeling and information treatments were randomly assigned to experimental units. A key finding is that negative GM-information supplied by environmental groups pushes some high income consumers out of the market for GM products and increases the probability that all consumers are out of the market. However, verifiable information dampens the effectiveness of negative GM-product information. Hence, a vocal interested source can stymie technology adoption in both rich and poor countries and increase the probability of general malnutrition and micro-nutrient deficiencies and starvation and unsustainable development in poor countries because of the failure to accept food aid and adopt new GM technology.

Better Dead Than GM-Fed? Information and the Effects of Consumers' Resistance to GM-Foods in High-Income Countries

Southern Africa's food crisis during 2001-2003 is set to be the worst in a decade. More than 15 million people have been dangerously hungry in Zambia, Mozambique, Malawi, Zimbabwe, Swaziland and Lesotho. In this region maize is the staple, and the recent drought and some bad public policies have reduced hungry people to eating wild leaves, berries, and scavenger foods (*Economist's* Editors 2002). The recent drought, however, has been far less severe than in the earlier 1991-92 drought which was the worst that southern African has seen in modern times (Parlberg 2002).

One might expect that food aid would be welcome in these countries, but during the summer of 2002, the six above nations, which were most affected by the recent drought, rejected U.S. food aid because the corn earmarked for distribution contains genetic modification to resist insects. However, at the beginning of September 2002, the World Health Organization convinced the leaders of Lesotho, Malawi, and Swaziland to accept GM grains, but Zimbabwe and Mozambique have required that GM-containing grain can be imported only if it is sent from the port of entry to be milled. Milling, however, is costly and time consuming (Editor, *Nature Biotechnology*).

In Zambia, President Mwanawasa called American donations of maize "poison" and refused to import it, despite a warning from the UN World Food Program that relief supplies in his country would be exhausted by early October (Parlberg 2002; *BBC News* 2002). Up to three million people in Zambia face starvation.

Why are southern Africans wary of GM-food aid? These African governments refused GM corn because they feared that Europe will ban their agricultural exports if they become "contaminated" with transgenetic materials from bt corn. Although the EU has not found any evidence that GM corn is unsafe, it has imposed a moratorium on the marketing approvals for GM crops based on the precautionary principle. This concept has encouraged regulators to ban new products or technologies on the suspicion that they could pose a treat to human health or the environment.

Although the main southern African agricultural exports to the EU have been animal products, not grains, and livestock products from GM fed materials are not affected by EU trade restrictions (Parlberg 2002), this fact has seemingly gone unnoticed by the leaders. The WHO and FAO have reaffirmed that it is "unlikely that GM food pose a risk to human health (Editor, *Nature Biotechnology* 2002)." Compared with the clear and immediate danger posed by the short and long-term effects of malnutrition and starvation (Fogel 1994), the possibilities of being poisoned by Frankenfood seem rather remote. Hence, short-term benefits to food aid certainly exceed the costs.

Consumers in the European Union countries, who are not in any danger of starvation, have strong preferences for non-GM foods or have displayed strong resistance to GM foods (Parlberg 2001, 2002; Johnson 2002). "Non-GM" is a quality attribute that high income consumers can easily afford. EU farmers will continue to prosper, thanks to lavish subsidies, and their consumers will remain well fed.[1] In contrast, in southern Africa, roughly two-thirds of the population are farmers. An unusually large share are women, and they are poor and malnourished in part because they lack improved crop technologies to battle against drought, poor soil fertility, crop diseases, and insect problems.[2] They are not only short of food in general but also micronutrient deficiencies and face technical and economic constraints.[3] New biotechnology products, e.g., see Johnson 2002, Qaim and Zilberman 2003, Binenbaum et al. 2003, could remedy this situation. However, the precautionary EU policies toward the environment are also slowing technology transfer to Africa (Parlberg 2001).[4] The EU has been insisting that governments in Africa treat GM crops as a potential serious threat to "biodiversity." Over the long run, the tastes of EU consumers matter to southern African countries because historically Zambia, Zimbabwe, and some other countries have earned significant foreign exchange from agricultural exports to Europe. Any plausible threat to their exports has to be taken seriously.

GM-food aid is seen as such a threat because if some southern African farmers were to plant GM seeds from an aid shipment, e.g., even ones not crushed in the milling process, local maize varieties could be contaminated by pollen drift or physical mixing (*BBC News* 2002; *Economist's Editors* 2002). Over time these farmers might not be able to convince European buyers that their maize is GM-free or livestock and poultry are fed non-GM feed. Although imports of GM foods are not barred from the European Union by law, NGOs, led by Greenpeace and Friends of the Earth, have lobbied and demonstrated effectively, creating fear, rage and skepticism about biotechnology, and thereby, making EU consumers wary of GM foods (Nestle 2002). They have also lobbied for labeling of GM food products (Greenpeace International 1997; Friends of the Earth 2001), but have also demonstrated heavily against GM-labeled foods whenever they appear in food stores. In this environment, EU consumers' demand for GM foods has been insufficient for food stores and supermarkets to stock them (*Economist's* Editors 2002).

Although GM testing is possible, it is far from complete and somewhat expensive. It is, however, of sufficient scientific merit to present potential problems and risks for farmers in poor countries who want to export. *The fears of the high-income EU consumers are creating an obstacle to the acceptance of food aid by poor southern*

African countries and also to new agricultural technologies built on biotechnology (*Economist's* Editors 2002). These new technologies could reduce the cost of grain production in southern Africa and increase micronutrient content of farmer grown foods, which would make food more abundant and more nutritious over the long term, and reduce applications of commercial pesticides, improve environmental quality, and reduce the risks of pesticide contamination of agricultural workers (Johnson 2002; Qaim and Zilberman 2003).[5] However, opposition to importing GM products by certain developed countries governments presents a major barrier to a developing country. Even if opposition does not result in a ban, it may impose conditions that developing countries cannot met or could only met a very high costs, e.g., identity preservation and traceability of products from farm to market (Johnson 2002). Understanding GM-food resistance in developed countries is central to better food policies in southern Africa and sustainable development.

European consumers have been far more critical of GM foods than U.S. consumers. There are several potential explanations for the divergence. One potential reason is that Europeans have had to deal with the BSE crisis (Mad-Cow disease) and other food scares recently that U.S. consumers have not encountered and that could explain why Europeans are more hesitant to accept new GM technology in food products (Gaskill, 2000). Some claim that Europeans have a strong preference for "natural" which may cause their resistance to GM technology (Zechendorf, 1998). It is important to understand why Europeans and others in high-income countries are so critical of GM foods, because their resistance to GM-technology is, in part, why many African countries are not accepting food aid.

This paper examines the market characteristics that push consumers in high income countries to resist GM foods, with an emphasis on negative information from environmental groups and third-party, verifiable information (see Huffman and Tegene 2002). For this study, unique data were collected from adult consumers in the United States who participated in laboratory auctions of three food types with randomly assigned labeling and information treatments. Using U.S. consumers is important because U.S. consumers are generally supportive of GM foods and free from the BSE "food scare" fears and bias towards "natural" that are hypothesized to lead Europeans to reject GM foods. Key findings are that negative GM-product information supplied by environmental groups pushes some consumers out of the market for GM products and increases the probability that all consumers are out of the market for GM-foods. Verifiable information dampens the effectiveness of negative GM-product information. An important finding is that negative information on GM foods from environmental groups, an interested source, can stymie technology adoption in both rich and poor countries, and increase the probability of malnutrition and starvation in poor countries because of both the failure to accept food aid and new GM-technology.

EXPERIMENTAL DESIGN

We develop a model of consumer demand for food which includes a time-invariant linear individual- and country-specific unobserved effect. By randomly assigning information treatments to experimental units, we can compare the before and after treatment effects. By differencing the data before model estimation we remove any linear time-invariant individual- or country-specific unobserved effect, and this method leads to unbiased and consistent estimates of information treatment effects on the demand for GM-foods (Wooldridge 2002, pp. 299-314).

Consumers might react differently to GM content in different types of food or they might dislike some food products. Therefore using only one food item in a laboratory auction seemed unlikely to reveal enough information, given the sizeable fixed cost of conducting the experiment. Three food items were chosen for our willingness to pay (WTP) auctions: vegetable oil (made from soybeans), tortilla chips (made from yellow corn), and russet potatoes. In the distilling and refining process for vegetable oils, essentially all of the proteins (which are the components of DNA and the source of genetic modification) are removed leaving pure lipids. Minimal human health concerns should arise from GM oil, but consumers may either worry that GM soybeans affect the environment or lack adequate information on the distilling process. Tortilla chips are highly processed foods that may be made from GM or non-GM corn, and consumers might have human health and environmental concerns about this product. Russet potatoes are purchased as a fresh product and are generally fried or baked before eating. Similar to tortilla chips, consumers might see both human health and environmental risks from eating GM-russet potatoes.

We are interested in the effects of GM-food labels and information about GM-technology and products on consumer demand for food products that might be genetically modified. In our experiments, the two labels—GM and plain---were clearly displayed on the fronts of each food package (see figure 1). A one-page summary organized under five different headings—general information, scientific information, human impact, financial impact, and environmental impact-- was prepared for pro-GM information from Monsanto and Syngenta, large agribusiness companies; anti-GM information from Greenpeace, a leading environmental group and NGO opposing genetic modification; and independent, third-party or verifiable information from informed but financially disinterested sources. See figure 2-4. This information was organized into six information treatments: pro-GM, anti-GM, pro-GM and anti-GM, pro-GM and verifiable, anti-GM and verifiable, and all three types. The six information treatments were randomly assigned to experimental units, which consisted of 12 to 16 individuals.

We follow standard experimental auction valuation procedures (Smith 1976; Shogren et al. 1994), but make refinements to the design to better reflect consumer purchases. A summary is presented here, and details are in Rousu et al. (2002). First, our subjects submitted only one bid per product. We have stepped back from the protocol of using multiple, repeated trials and posted market-clearing prices to avoid any question of creating affiliated values which can affect the demand-revealing nature of a Vickrey-style auction (List and Shogren 1999). Second, endowment effects are minimized. We do not endow our subjects with a food item and then ask them to "upgrade" to another food item because that methodology can cause distorted bid prices (see List and Schroeder 2002 or Corrigan and Rousu 2003). As is the trademark for economics experiments, subjects were paid a participation fee, $40. Instead of endowing participants with food and having them bid to "upgrade" to another food item, we asked participants to bid on food items in only two trials. This avoids the risk of an in-kind endowment effect and of any credit constraint. Third, consumers bid on three unrelated food items: vegetable oil, corn chips and russet potatoes. We can obtain useful information on their tastes for genetic modification even if a subject disliked one or two products. Fourth, treatments are randomly assigned to experimental units, and estimation of treatment effects is simply the difference in means across treatments (Wooldridge 2001). We also randomize within treatments (e.g., order of pro- and anti-biotech information when an experimental unit received both types). Verifiable information, however, was always presented last.

Fifth, adult consumers over 18 years of age from two large metropolitan areas in the U.S. were chosen as participants by a random digit-dialing method. Although it is of secondary importance to the results that we obtain, the demographics of our sample taken from two major cities do not match perfectly the Census demographic characteristics for these two regions, they are similar and provide a sufficient representation for our probe into labeling and information effect on the demand for GM-products. (See Appendix A for means of attributes of survey areas). We use common food items available to shoppers in grocery stores and supermarkets, and prefer adults who are not primarily college students. Although Lusk and Schroeder (2002) and Fox et al. (2002) used college undergraduates in laboratory auctions of food items, students are not typical grocery store shoppers. They are 8.5 percent of shoppers versus 12.8 percent in the Census of Population. Katsaras et al. (2001) showed that women make up a disproportionate share of grocery store shoppers. A sample primarily of grocery store shoppers also weakens the sometimes-stated need for having students participate in several rounds of bidding to stabilize bids for food items and minimizes the Hawthorne effect in bidding (Melton et al. 1996), i.e., the methodology minimizes the chance that participants change their behavior only because they participate in an experiment with specific objectives.

Sixth, a Vickrey *2*nd price auction is frequently used in WTP experiments, but it does not engage off the margin bidders. For new products, researchers are interested in the location of the completed demand curve—not just one segment. We use the random *n*th price auction which has the advantage that it is demand revealing in theory, and the auction attempts to engage bidders at all locations along the demand curve (Shogren et al.

2001). For example, each of k bidders submits a bid for one unit of a good; for instance, if the monitor randomly selects n = 5 <= k, the four highest bidders each purchase one unit of the good priced at the fifth-highest bid. This random *n*th price auction increases the odds that insincere bidding will lead to a loss.

Finally, information from our laboratory experiments is complemented by information obtained from pre- and post-experiment questionnaires administered to participants. The pre-auction survey allowed us to obtain socio-demographic information and information on participants' beliefs about GM and other technologies before treatment, which is useful to help explain bidder behavior. The post-auction questionnaire allowed us to obtain information from participants about sources they would trust to provide verifiable information, a concept introduced in the experiment.

The Model

The model is one of a consumer demand function for food containing an unobserved individual- and country-specific effect with information as one determinant of demand. The assumption is that negative information shifts a consumer's demand function to the left or downward and verifiable information shifts it to the right or upward. The key hypotheses are: 1) Negative GM-information from NGOs increases the frequency of consumers "being out of the market" for one unit of a GM-food item and increases the probability of consumers being out of the market for all GM-food items, and 2) third-party, verifiable information dampens the effects of negative information on consumers. We define a consumer being "out of the market" for a GM-food item as occurring when s/he bids zero for one unit of GM-product (a strong test) or less than or equal to two-thirds their bid for plain-labeled product (a weaker test).

If a consumer does not have a positive WTP for one unit of a GM food when he/she has a positive WTP for the non-GM counterpart, this suggests he/she would not consume the GM variety of the product at any price. Determining what affects the probability of being out of the market is important, because if the rate of consumers' purchase of food items is too low, the grocery store will discontinue carrying, stocking, or supplying the food item. The weaker test assumes that a consumer is out of the market if the price an individual bids for the GM-labeled food is less than or equal to two-thirds of the price he/she bids for the plain-labeled food item. This weaker test captures the reality that premiums for non-GM foods generally do not exceed 20 percent (Kiesel et al. 2002).

The empirical evidence that we are looking for is contained in actual frequencies of consumer bids and probit models explaining the probability of a consumer being out of the market for one or more GM-food items (Wooldridge 2002). Although we have estimated probit models for each of the three products separately, we report only the evidence from joint outcomes for vegetable oil, tortilla chips, and russet potatoes.[6]

Results

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

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

Our results are consistent with Viscusi (1997) who found that individuals placed a slightly greater weight on negative information than positive information. In our auction, participants who received only positive information did not discount the GM-labeled food, while those who received only negative information discounted the GM-labeled food by an average of 35 percent. Those who received both positive and negative information put slightly more weight on the negative information, discounting the GM-labeled foods by 20 percent. One explanation for the moderated effect (but not offset) of negative information when participants received both positive and negative GM-product information is that some individuals have an asymmetric value function, giving greater weight to marginal losses than to gains (Kahneman and Tversky 1979).

Also, our results are in contrast to Fox *et al*.'s (2002) who obtained the result that negative information dominated positive information. They argued that one reason could be due to a "status quo bias," (or endowment effect) where participants were originally endowed with a regular pork sandwich and could bid to upgrade to an irradiated pork sandwich. Participants may have their bids biased due to being endowed with one type of sandwich.[7,8] Our auction had participants bid on items in separate rounds (trials). Thus our results are not influenced by a "status quo bias."

Tables 3 and 4 display the percentages of participants who are out of the market for the GM-labeled commodities using both the strong and weak tests for being out of the market. The number of observations differs across products, because if an individual bids zero for both the GM-labeled and plain-labeled versions of a commodity, he/she is not included in the analysis (he/she did not demand the product, so we cannot determine his/her taste for genetic modification). Similarly, when reporting on who is out of the market for all GM-labeled foods, we do not include those who bid zero for all food products. Under both tests a significant share of participants—9 to 24 percent--are out of the market, but a lower share for vegetable oil than for tortilla chips and russet potatoes. This arises because verifiable information pointed out that distillation and refinement of oils leaves only lipids and no GM-containing proteins.

In Table 5 the dependent variable takes a one if a participant's bid for all three GM-labeled-food item is 2/3rds or less than for the equivalent plain labeled food item. The reported results are estimated coefficients from probit models explaining the probability that a participant is out of the market (weaker definition) for all GM-foods.[9] The results in table 5 show that anti-biotech information increases significantly the probability that a consumer is out of the market for GM-food items, i.e., *negative information pushes consumers out of the market*. This result has important implications. If an NGO wishes to slow scientific progress, it could disseminate large amounts of negative information, even if the information is highly biased. With asymmetric information, it could even disguise true intentions by telling consumers it wants to keep them "fully informed" of the consequences of a product or technology, or to be very cautious until all the negative claims are disproved—the "precautionary principle." Even if individuals do not fully believe the information, negative information will increase the uncertainty about a product or process, which has been shown to decrease the likelihood of adoption (Purvis et al. 1995). With a significant reduction in consumer demand, supermarket managers may discontinue carrying an item, which reduces consumers' choices, and with a collapse in the market for the food item, farmers would discontinue using GM-technology. Given that technological change is one of the driving forces behind rising standards of living, stalling adoption of new goods broadly could lead to a significant reduction in future social welfare.

Table 5 shows that third-party, verifiable information *decreases significantly* the probability that consumers are out of the market for GM-labeled foods. This provides evidence that a third-party source that provides neutral, verifiable information on genetic modification and GM-foods could prevent markets for GM-foods from collapsing. In addition to the value verifiable information has by providing consumers with objective information on the risks and benefits of genetic modification (estimated in Rousu et al.

(2002) at $2.6 billion), verifiable information can increase the number of real options that consumers have in supermarkets.

Other results are that pro-biotech information also reduces the probability of consumers' being out of the market for GM-food products. Although the ag biotech-industry perspective frequently gets bad press, our results imply that it can also reduce the probability of consumers being out of the market for GM-labeled foods. In addition, consumers' pre-experiment beliefs are important factors for understanding the demand for GM-labeled foods. When a participant reported in our pre-experiment questionnaire that s/he was informed about GM-technology and products, s/he had a significantly higher probability of being out of the market for GM-foods (see table 5, model 8).

CONCLUSION AND IMPLICATIONS

This paper has provided new insights into and empirical evidence on factors affecting resistance to new products by consumers in a high income country. Our evidence is derived from unique data. We applied a sound statistical experimental design which randomly assigned labeling and information treatments to experimental units of adult consumers who participated in laboratory auction experiments of three food items that might be genetically modified. These were U.S. consumers who were free from the confounding effects such as experiencing the BSE crisis, Dioxin scandal, or having a predisposition towards "natural foods" that are present in European consumers. We find several important results. First, when participants saw GM-labeled foods rather than plain-labeled foods, a significant share-- 9 to 24 percent-- were pushed out of the market for GM-food. Second, when participants received negative GM-information from environmental groups, they had a significantly higher probability of being out of the market for GM-labeled food items. Third, third-party verifiable information dissipates partially the effects of negative GM-information. Verifiable information can be an effective policy tool to moderate resistance to new products and to keep new food products as options in supermarkets, thereby increasing consumers' range of choices.

Our results present an alternative explanation for Europeans' negligible demand for GM foods. Many have hypothesized that European's dislike for GM-foods originated in food scares such as Bovine Spongiform Encephalopathy (BSE) and foot and mouth disease in the UK, and dioxin in Belgium. An alternative interpretation of Europeans' low demand for GM-products is that NGOs, largely Greenpeace and Friends of the Earth, have been more prevalent there than in the US, disseminating larger amounts of negative GM-information, creating skepticism and doubt about GM technology, and that no trusted source of verifiable information exists.

Human malnutrition and starvation and sustainable development in southern Africa are related to the resistance to GM-foods in the EU, and the resistance to GMOs in developed countries can be explained, at least in part, by the dissemination of negative GM-production information and demonstrating against these products by NGOs. Future research could actually conduct GM-auction experiments in the EU. But in the mean time, the plight of southern Africa rests to some extent on changing food and agricultural trade policies of the rich countries. One such policy would be to establish and fund a new institution having as its objective to produce and distribute verifiable information on GM technology. This information would dissipate impacts of unduly negative antibiotech information being distributed by NGOs.

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Figure 1: 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 genetic modification (GM)	**Vegetable Oil** *Net weight 32 fl. oz.*

Figure 2. Information given to participants. Anti-biotechnology Information

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. Information given to participants, pro-biotechnology information

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

General Information

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

Scientific Impact

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

Human Impact

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

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

Financial Impact

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

Environmental Impact

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

Figure 4. Information given to participants, independent, verifiable information

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

General Information

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

Scientific Impact

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

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

Human Impact

While many genetically modified foods are in the process of being put on your grocers' shelf, there are currently no foods available in the U.S. where genetic modification has increased nutrient content. All foods present a small risk of an allergic reaction to some people. No FDA approved GM food poses any known unique human health risks.

Financial Impact

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

Environmental Impact

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

Figure 5. Steps in the experiment

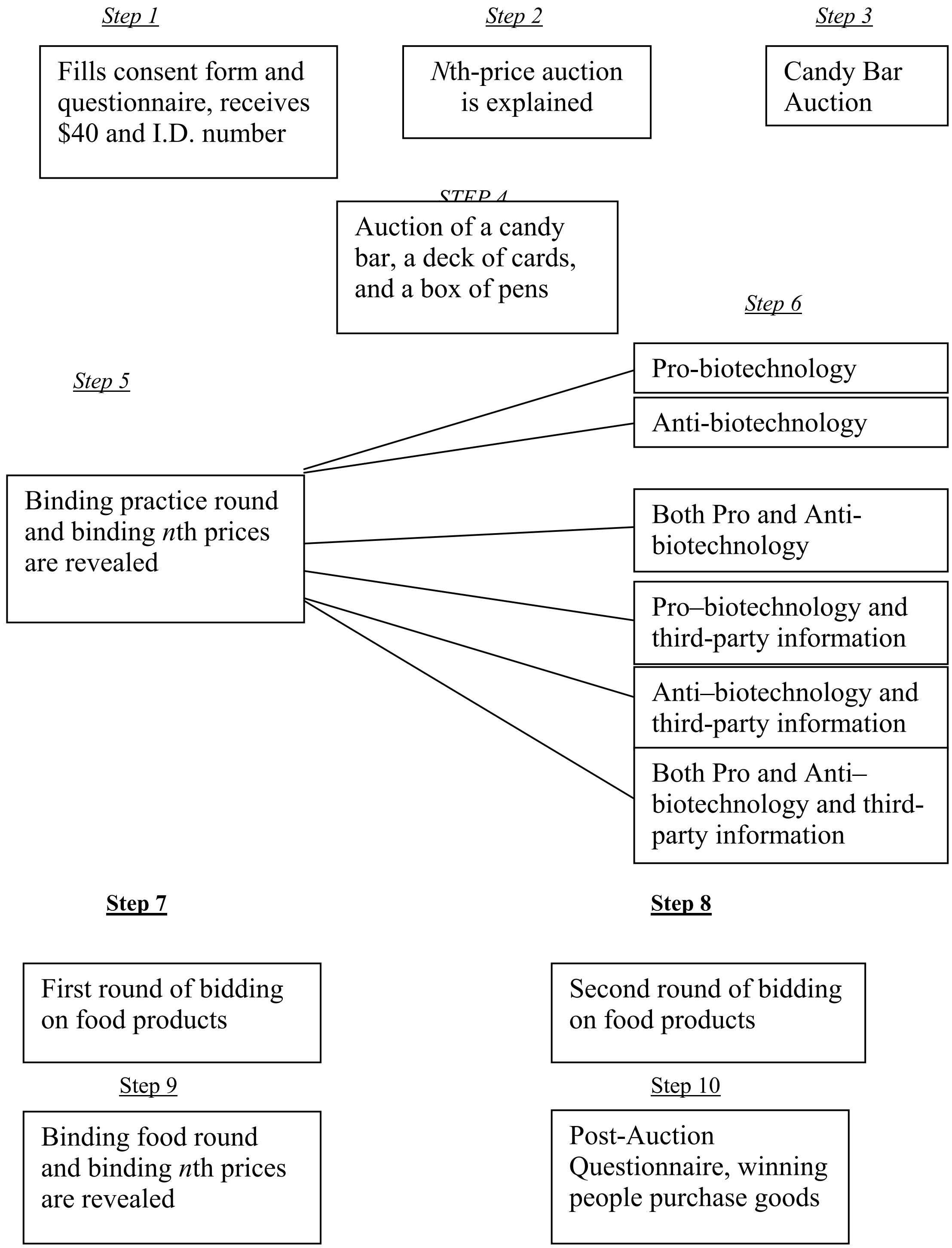

Table 1. Characteristics of the Auction Participants (N=172)

Variable	Definition	Mean	St. Dev
Gender	1 if female	0.62	0.49
Age	The participant's age	49.50	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)	57.00	32.60
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 him/herself at least somewhat informed regarding GM foods	0.42	0.49
Labels1	1 if the treatment bid on foods with GM labels in Round 1	0.52	0.50

* Information about participant's prior beliefs; information collected from participants in pre-auction questionnaire.

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

A. Mean bids – all participants

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

B. Mean bids when participants only received positive information

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

C. Mean bids when participants only received negative information

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

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

	n	mean bid	std dev	Median	Minimum	Maximum
GM OIL	24	.68	0.55	0.50	0	1.79
OIL	24	0.90	0.72	0.85	0	3.00
GM CHIPS	23	0.68	0.74	0.35	0	2.25
CHIPS	23	0.81	0.79	0.49	0.05	2.75
GM POTATOES	26	0.50	0.39	0.50	0	1.50
POTATOES	26	0.70	0.43	0.50	0.05	1.60

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

	n	mean bid	std dev	Median	Minimum	Maximum
GM OIL	6	1.12	0.62	1.00	0	2.39
OIL	26	1.14	0.57	1.00	0.10	2.39
GM CHIPS	25	1.24	0.77	1.19	0	2.79
CHIPS	25	1.33	0.73	1.16	0.20	2.89
GM POTATOES	26	0.92	0.45	0.99	0	1.85
POTATOES	26	0.93	0.39	0.99	0.25	1.90

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

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

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

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

Table 3. Percentage of Consumers who Bid Zero for a GM-Labeled Food Item[1]

	Observations	Out of Market	Percent Out of Market
All goods	165	17	10.3%
Vegetable oil only	146	13	8.9%
Tortilla chips only	155	20	12.9%
Potatoes only	159	20	12.6%

[1] When a consumer bids zero for the GM and non-GM version of a commodity their bids are not included.

Table 4. Percentage of Consumers Whose Bid for the GM-Labeled Food is Two-thirds the Amount They Bid for the Plain Labeled Food or Lower[1]

	Observations	Out of Market	Percent Out of Market
All goods	165	27	16.4%
Vegetable oil only	146	28	19.2%
Tortilla chips only	155	37	23.9%
Potatoes only	159	35	22.0%

[1] When a consumer bids zero for the GM and non-GM version of a commodity, their bids are not included.

Table 5. Probit Models: All Products – Dependent Variable = 1 if a Consumer is out of the Market for all three GM-Labeled Product Relative to the Plain Labeled One (bid is 2/3rds or less than bid for plain-labeled product) and 0 Otherwise [(Standard errors in parentheses, N=172)]

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	-2.045 **	-1.744 **	-1.198 **	-1.223 **	-1.174 **	-1.364 **	-1.258 **	-1.108 **
	(0.410)	(0.413)	(0.421)	(0.515)	(0.456)	(0.447)	(0.543)	(0.550)
Anti_info	1.204 **	1.156 **	0.718 *	0.724 *	0.714 *	0.751 *	0.735 *	0.786 *
	(0.437)	(0.429)	(0.384)	(0.391)	(0.384)	(0.394)	(0.400)	(0.408)
Pro_info			-0.613 **	-0.611 **	-0.619 **	-0.667 **	-0.687 **	-0.721 **
			(0.280)	(0.281)	(0.280)	(0.285)	(0.289)	(0.298)
Ver_info		-0.684 **						-0.666 **
		(0.309)						(0.274)
Income				0.0034			-0.0034	0.0029
				(0.0039)			(0.0040)	(0.0040)
Labels					-0.033		-0.147	-0.108
					(0.253)		(0.267)	(0.275)
Informed						0.372	0.418	0.530 *
						(0.259)	(0.273)	(0.285)

** Significant at the 5% level
* Significant at the 10% level

Appendix Table A. 2000 Census of Population Demographic Characteristics of the Two Survey Areas: Polk County, IA (including Des Moines area) and Ramsey County, MN (including St. Paul area)

Variables	Definition	Polk	Ramsey	Average
Gender	1 if female	0.52	0.52	0.52
Age	Median age	45.7	45.7	45.7
Married	1 if the individual is married *	59.5	51.4	55.5
Education	Years of schooling **	13.52	13.76	13.64
Income	The median households income level (in thousands)	46.1	45.7	45.9
White	1 if participant is white	0.9	0.8	0.85

All variables are for individuals of all ages, except for Married, which is for individuals 18 years or older, Education, which is for individuals 25 or older, and age, which is for individuals 20 or older.

* The estimate of the number of married people who are 18 or older was obtained by taking the number of people married over 15 and assuming that the number of people were married at ages 15, 16, and 17 were zero – this gives the percentage of people who are married who are 18 or older.

** The years of schooling was estimated by placing a value of 8 for those who have not completed 9th grade, 10.5 for those who have not completed high school, 12 for those who have completed high school but have had no college, 13.5 for those with some college but no degree, 14 for those with an associate's degree, 16 for those with a bachelor's degree, and 18 for those with a graduate or professional degree.

Appendix B. Table 1. Probit model: All products - Dependent variable = 1 if a Consumer is out of the Market for all Three Products (i.e. bids = 0 on all three products) and 0 Otherwise[1] (Standard errors in parentheses, N=172)

Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept	-2.045 **	-1.992 **	-1.262 **	-1.673 **	-1.818 **	-1.443 **	-2.190 **	-2.090 **
	(0.410)	(0.444)	(0.449)	(0.567)	(0.540)	(0.479)	(0.645)	(0.649)
Anti_info	0.764 *	0.753 *	0.395	0.493	0.461	0.410	0.537	0.543
	(0.448)	(0.447)	(0.406)	(0.420)	(0.525)	(0.421)	(0.445)	(0.446)
Pro_info			-0.549 *	-0.521	-0.525	-0.644 *	-0.580 *	-0.590 *
			(0.320)	(0.324)	(0.330)	(0.335)	(0.345)	(0.347)
Ver_info		-0.099						-0.307
		(0.334)						(0.297)
Income				0.0053			0.0043	0.0044
				(0.0042)			(0.0044)	(0.0042)
Labels					0.728 **		0.644 *	0.661 *
					(0.326)		(0.336)	(0.338)
Informed						0.456	0.282	0.336
						(0.290)	(0.307)	(0.313)

** Significant at the 5% level
* Significant at the 10% level
1 The dependent variable takes a one if a participant's bid for all three GM-labeled-food item is zero.

ENDNOTES

[1] Historically, some low risk technologies have been resisted with accompanying large death toll. In the United States, opposition to pasteurization of milk at the beginning of the twentieth century was widespread, with opponents saying, among other things, that pasteurization was not needed and that consumers had the "right to drink raw milk" (Hotchkiss 2002). Pirtle (1926) notes that the slow adoption of pasteurization resulted in thousands of deaths that could have been prevented. Also, over the past ten years an unusually large amount of consumer resistance has existed to irradiated meat and poultry, which essentially eliminates harmful bacteria like e-coli and salmonella (Nestle 2002; Fox 2002). This resistance has caused a significant number of annual deaths that were preventable at small marginal cost.

[2] Southern Africa, which has limited rainfall and irrigation water and medium to unfavorable soils, was largely bypassed by Green Revolution Technology (Johnson 2002).

[3] Micronutrient deficiencies are a serious problem when farm households depend on food that the family produces themselves (Johnson 2002). In developed countries, farm family purchase milk, flour, juices, and breakfast cereal from grocery stores that are fortified with micronutrients.

[4] Binenbaum et al. 2003 emphasize that international and national agricultural research centers have far greater freedom currently to operate in agricultural research oriented toward food crops for the developing world than is commonly perceived. They are generally able to operate in regions where most modern technologies are unprotected by IPRs. They emphasize that unlicensed production in developing countries of crops protected only in the developed countries is both legal and moral per se.

[5] The precautionary principle as applied by opponents to GMOs looks at only the potential harmful effects while ignoring real benefits that currently would occur to the producers/farmers (Parlberg 2001; Johnson 2002).

[6] All non-published results are available from the authors upon request.

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

[8] Another difference is that our anti-biotech information mentioned only minor human health hazards from consuming GM foods, e.g., allergies. In contrast in the irradiated meat experiment, the negative information included the possibility of getting cancer and dieing.

[9] See Appendix B, Table 1 for results for the strong test, i.e., equations explaining the probability that an individual bids zero on food items. The signs of the estimated coefficients in these equations support those in table 5.