# Consumer Acceptance of Genetically Modified Foods: Traits, Labels and Diverse Information

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# Consumer Acceptance of Genetically Modified Foods: Traits, Labels and Diverse Information

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**Abstract.** New experimental economic methods are described and used to assess consumers' willingness to pay for food products that might be made from new transgenic and intragenic genetically modified (GM) traits. Participants in auctions are randomly chosen adult consumers in major US metropolitan areas and not college students. Food labels are kept simple and focus on key attributes of experimental goods. Diverse private information from the agricultural biotech industry (largely Monsanto and Syngenta), environmental groups (largely Greenpeace and Friends of the Earth) and independent third-party information is used to construct the information treatments. Food labels and information treatments are randomized, which is a deviation from traditional lab methods. Auctions are best described as sealed bid random n-th price and not the standard Vickery 2nd price auctions. I show that participants in these experiments respond to both food labels and information treatments, but no single type of information is dominant.

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# Consumer Acceptance of Genetically Modified Food Crops: Traits, Labels and Diverse Information

The US has more than a decade of experience with commercially marketed, genetically modified (GM) horticultural and field crops, and is the dominant player in GM crops. The first GM commercial crops were the Flavr-Savr tomato and the Russet Burbank New Leaf potato, both deregulated in 1994 and marketed commercially shortly thereafter. At about the same time, field crop varieties possessing "input traits" were also developed and first marketed commercially. GM papaya was developed by the public sector and successfully marketed a little later. Some of the economic issues facing biotech horticultural crops have been summarized by Alston et al. (2006) and Bradford and Alston (2004).

In this paper, new experimental economic methods are described and used to assess consumer willingness to pay for food products that might be made with new transgenic and intragenic GM traits. Participants in my lab auctions are randomly chosen adult consumers in major US metropolitan areas. Food labels are kept simple and focus on key attributes of experimental goods. Diverse private information from the agricultural biotech industry (largely Monstanto and Syngenta), environmental groups (largely Greenpeace and Friends of the Earth) and independent third-party information (scientifically objective at the time of the experiments) is used to construct the information treatments. Willingness to pay is determined by experimental lab auctions under random food label and information treatments. Auctions are best described as sealed bid random n-th price and not the standard Vickery 2$^{nd}$ price auctions. I show that participants in these experiments respond both to food labels and information treatments, but no single type of information is dominant.
The first section of the chapter reviews early development of GM crops that were largely input traits of herbicide tolerance and insect resistance that have now spread unevenly across the world, and the second section describes some new methods for developing GM vegetable crops with enhanced

consumer attributes. The third section summarizes the development of US food-label policy and requirements. The fourth section describes new experiments designed to assess consumer willingness to pay for GM foods using lab auctions of experimental commodities, and reports results. In the final section, some conclusions and predictions about likely future developments in commercial horticultural crops are presented.

## I. Early Development of GM Crops

The first commercial GM crops were the Flavr-Savr tomato, developed for sale in the US by Calgene, and the Russet Burbank New Leaf potato developed by Monsanto. These two products were the first whole foods produced with biotechnology that were approved by the US Food and Drug Administration for retail sale.[1] The Flavr-Savr tomato, "a delayed-ripening tomato," was the product of more than a decade of research to develop a tomato that could be picked when ripe and transported without bruising (Alcamo 1999, pp. 256-257). The claim was that it would have a longer shelf-life than conventional tomatoes and would provide consumers and processors with tastier tomatoes because the fruit had been left to mature on the vine.[2] This was accomplished by gene-silencing, through a antisense RNA that interfered with translation and reduced the production of specific proteins that cause ripening (Alcamo 1999, pp. 63-65, 257).

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[1] A potential food safety concern was raised by the fact that in creating the genetically modified tomato, a marker gene for the antibiotic kanamycin was inserted. The marker gene is helpful for identifying which plants have been affected by a target gene (Alcamo 1999, p. 102-103, 244). When the marker is an antibiotic, technicians test for presence of successfully transferred genes of interest by applying the antibiotic. Only those cells that contain the antibiotic resistance will survive this treatment, and thereby, indicate that an accompanying target gene is present. The U.S. Food and Drug Administration (FDA), however, found no food safety concerns due to insertion of foreign antibiotics into plant cells.

[2] Because US winter fresh market tomato production is concentrated in Florida, which means shipping the fruit long distances to the US retail markets in the East, Midwest and South, it is important that the fruit does not perish on its journey to market because of its soft skin. (Winter tomatoes for the West are generally supplied by Mexico.) The conventional solution has been for tomato farmers to pick the fruits while they are green, i.e., "mature greens," transport them to the location of the retail market and then spray them with ethylene, a natural ripening agent, to artificially ripen and redden the fruit However, the artificially ripened tomatoes have an inferior flavor relative to vine-ripened tomatoes.

The first Flavr-Savr tomatoes were sold in US grocery stores in the summer of 1994 and were marketed as GM. They sold relatively well at first and were in about 2,500 stores by June 1995, but it became apparent that their performance did not match expectations. First, the genes for delayed ripening were inserted into a tomato variety that was best suited for processing, not direct eating, and that bruised relatively easily, contrary to its development objective. Second, contrary to expectations, it had a bland taste relative to conventional winter tomatoes. Third, the new tomato variety was suited to California's dry summer growing conditions, but not to the humid winter tomato growing regions of Florida and, as a result, was susceptible to Florida's tomato fungal diseases. Fourth, the retail price was more than two times higher than conventional fresh market tomatoes. Hence, a number of factors contributed to the failure of the Flavr-Savr tomato in the US market (Alcamo 1999, pp. 256-257, Soil Association 2005).

At the same time, Zeneca produced a related high-solids GM tomato for use in purees and soups, obtained approval for sale in the UK, and began marketing in 1996 under the brand names Safeway Double Concentrated Tomato Puree and Sainsbury's California Tomato Puree. These products were sold at a lower per unit price than purees from conventional tomatoes and were marketed in larger containers to make the product appear to consumers as a "better value." By 1999, the GM puree had captured up to 60 percent of the processed tomato market share in the UK. However, when unrelated food scares (e.g., BSE in sheep and cattle, dioxin in livestock feed) started to unfold in the UK in the late 1990s, Zeneca's GM high-solid tomato varieties were a casualty, and they were withdrawn from the market (Soil Association 2007).

Monsanto engineered the Russet Burbank New Leaf potato to be resistant to the Colorado potato beetle, a major potato pest, and this potato was deregulated in 1994. This new variety offered growers the advantage of significantly reducing the need for chemical pesticide applications, and initially gained favor in the fresh potato market. However, under pressure from consumer groups, the fast-food industry (e.g., McDonalds) and grocery store chains would not purchase it or halted early purchases, and this prompted Monsanto to withdraw the GM potato variety from the retail market in 1999 (Fernandes-Cornejo and Caswell 2006).

To date, the most commercially successful GM crops in the US have been those engineered with so-called "input traits," namely insect resistance (Bt) and herbicide tolerance (HT or RR/RoundUp Ready®). These GM traits were obtained by transferring genes largely from soil bacteria into selective species of commercial field crops to induce resistance or tolerance to target organisms, thereby creating a so-called transgenic crop variety (Alcamo 1999, pp. 250-256). The target of these traits has been canola, soybean, cotton, and corn, with commercial GM varieties of these four crops first introduced in the mid-1990s. As illustrated in Figure 1, these GM field crops, whose products are largely destined for oil, feed, and fiber, have had very rapid grower adoption. For instance, HT soybeans were first marketed to farmers in 1996 and now account for more than 90 percent of US soybean acreage. Canola with HT has also been successful, although it is a relatively small acreage crop in the US. Bt and HT cotton also got off to a fast start in 1996. By 2005, about 60 percent of US cotton carried HT or Bt genes, with the most recent varieties carrying both traits as a "stacked gene" variety. GM field corn got off to a slow start, and in 2005 about 30 percent of the corn acreage was planted to Bt and 15 percent to HT.[3] In corn, recent stacking of multiple Bt genes, imparting resistance against European corn borer and rootworm, often together with HT, has pushed GM corn acreage up the last two years and is anticipated to become the "gold standard" in the future.[4]

[3] Zilberman (2006) has argued that rational regulation of transgenic products should compare their risks and benefits with the risks and benefits of alternative technologies. Current regulations ignore the alternatives, and this is costly to society.
[4] Although herbicide tolerant wheat varieties have been developed for the US by Monsanto, they have not been marketed widely, nor are they currently available to farmers because of consumer resistance due to the use of wheat largely for food such as breads, pastas, etc.

Genetic improvement of papaya remains the one bright example of successful public sector bioengineering of a horticultural food crop. Starting in the 1940s, the Hawaiian papaya fruit industry was ravaged by a ringspot virus and, by the 1980s, Hawaii's papaya production had fallen significantly and was concentrated in the Puna district of the Big Island. However, by the early 90s, ringspot virus was invading that area, too. The University of Hawaii-Manoa, Cornell University and the USDA-ARS then initiated new research and developed a transgenic papaya variety that was resistant to ringspot, labeled Rainbow, and it was released freely to farmers in 1998 (Gonsalves and Ferreira 2003, Gonsalves 2004). Since its introduction, the Rainbow variety of papaya has been used strategically to create a virus-free ring as a buffer to slow the spread of papaya ringspot virus in the Puna area and to slow the development of resistance to the new technology (Gonsalves and Ferreira 2003, Zilberman 2004). Papaya is the only US crop in which public sector scientists have pioneered the development of a commercially successful GM crop variety.

Overall, the early commercial successes with GM crops were not with horticultural crops, but rather with a small set of field crops. The most likely reason is that consumers failed to personally see enhanced value from many of the new GM traits that were scientifically possible. In fiber crops and crops that are used heavily, but not exclusively, for livestock feed, consumer acceptance was less important. However, the image of GM crops with consumers has been damaged by the fact that new GM products with unique enhanced consumer attributes have been slow to develop.

## II. New Development of GM Vegetable Crops

As transgenic GM technology has been developed and marketed for a small set of field crops, a new line of research has recently emerged around intragenic GM horticultural crops (Rommens et al. 2004, 2005). Prompted by continued consumer resistant to transgenic food crops, these new methods introduce new traits into a crop variety by using only DNA from the same species, thereby yielding an "intragenic" genetic modification. This research was made possible by a small set of scientists recognizing that a huge range of genetic diversity exists within horticultural crops that have been grown for a long period of time under diverse environments and human needs, perhaps in relative isolation. For examples, major genetic diversity exists in potato and tomato, stretching from very old primitive or landrace varieties to the modern commercial varieties of today. However, in the case of the potato, in-breeding depression, tetraploid genetics and clonal propagation conspire to make traditional breeding difficult and slow. By taking a new intragenic bioengineering approach, genomic and metabolic pathway discoveries can be quickly introduced into established commercial varieties to fast-track the breeding process without introducing foreign DNA or antibiotic markers

Economists have shown recently that consumer acceptance of GM food crops is intimately linked to the type of traits engineered into the crops, the types of food labels on retail food products, and the information environment. For example, the GM food market has been subjected to diverse and conflicting information, and this makes informed decision-making by consumers and producers difficult (Rousu et al. 2007). Although the first commercial GM crop was a horticultural crop (the Flavr-Savr tomato) with "enhanced consumer attributes," all of the other commercially successful GM crops in the US have possessed input traits—traits that reduce either the cost of production or the variance in the cost of production to farmers and, hence, have only benefited consumers to the extent that they have lowered food prices or increased food availability. Although Falck-Zepeda et al. (2000) and Moschini et al. (2000) show that consumer surplus benefits from these technologies have been sizeable, these benefits have not registered effectively with consumers. With new intragenic potatoes and tomatoes that are engineered for dramatically enhanced antioxidants and vitamins (e.g., vitamin C, A, or E), improved starch content, and/or reduced bruising becoming scientifically possible, US consumers may, for the first time, see GM crops as having direct positive value to them over conventionally bred crops.[5]

**III. Food Labels and Information**

Economists have shown that food labels and information are important factors conditioning consumer response to GM foods (for example, see Huffman and Rousu 2006, Rousu et al. 2007, and Moschini and Lapan 2006.) Food products in the US can be labeled for nutritional claims and for safety. The 1990 Nutrition Labeling and Education Act dramatically changed nutrition labels on packaged foods sold in US supermarkets (Balasubramanian and Cole 2002).[6] This law requires packaged foods to display nutrition information prominently in a new label format, namely the Nutrition Facts panel. It also regulates serving size, health claims (that link a nutrient to a specific disease), and descriptor terms, e.g., “low fat”, on food packages. The goal of this legislation was to improve consumer welfare by providing nutrition information that would assist consumers in making healthy food choices.

As an indication of the costliness of effective food nutrient labeling, it is estimated that the US food industry spent $2 billion to comply with the 1990 Nutrient Labeling Act (Silverglade 1996). However, some attributes, such as enhanced calcium and vitamins A and C, are viewed positively by consumers, i.e., more is better in the case of positive consumer attributes. But other food attributes, such as salt, fat and pesticide residue, are negative, and then the consumer views less to be better. Food labels before the Nutriention Labeling Act had a seeming emphasis on negative labeling.

[5] Antioxidants are substances that may protect human cells from the damage otherwise caused by unstable molecules known as free radicals. Free radical damage over time is believed to cause some types of cancer. Antioxidants interact with and stabilize free radicals and may prevent some of the damage free radicals otherwise might cause. Antioxidants include beta-carotene, lycopene, vitamins C, E, and A, and other substances. These compounds are sometimes called phytonutrients and are naturally occurring in at least low levels in most fruits and vegetables.
[6] Unpackaged foods, for example fresh fruits and vegetables, are not affected.

Balasubramanian and Cole (2002) suggest that this tendency can be explained by consumers having an asymmetric value function, weighing a dollar of loss more heavily than a dollar of gain, which is Tversky and Kahneman's (1981) prospect theory.

The policies under the Nutrition Labeling and Education Act also tend to emphasize negative rather than positive labeling. First, permissible health claims are ones that associate specific nutrients with reduced risk of specific diseases. Of the seven health claims approved by the FDA at the onset of the new nutrient labeling act, three linked negative attributes exclusively with deadly diseases, i.e., dietary fat with cancer, sodium with hypertension, and dietary saturated fat with high cholesterol and heart disease, and only one claim featured a positive attribute, i.e., calcium and osteoporosis. Later claims have, however, been more balanced. Second, regulations on nutrient-content claims tend to focus more heavily on negative attributes (calories, sugar, sodium, fat, fatty acids and cholesterol) than on positive attributes such as fiber and vitamins.

Clearly, with foods made currently from crop varieties that contain GM input traits, adding a label for GM content would be an example of labeling a negative food attribute. However, GM content has not been proven scientifically to have human health consequences, except for the transport of some known allergens to new locations. Hence, GM food labels today would not meet the nutrition labeling law requirement of a proven nutrient intake leading to a better health outcome.

Genetically engineered products used for food, however, do have to pass a food safety test. In 1992, the US Food and Drug Administration (FDA) announced its landmark decision that food and food products will be regulated the same as those created by conventional means. This policy allows new GM foods to be treated as conventional foods as long as they meet three conditions: their nutritional value has not been lowered; they incorporate new substances that are already a part of the human diet; and they contain no new allergenic substances. In January 2001, the FDA issued a "Guidance for Industry" statement reaffirming this policy. In this statement, the FDA stated to the biotech industry that the only GM foods that need to be labeled are foods that have different characteristics from the non-GM version, e.g., elevated vitamin A levels. In the US, labeling food for GM content is not otherwise required. Firms, however, are to notify the FDA at least four months before putting a new GM food product on the market, and the scientific description of the product is posted on the Internet for review during this time (Just et al. 2006). Only minor changes have been made in these guidelines since 2001.

Hence, the GM-labeling policy in the US can be classified as being voluntary. If a voluntary label is affixed, the FDA has mandated that it cannot use the phrase "genetically modified." The FDA prefers the phrase "genetically engineered" or "made through biotechnology."[7] Effective GM-labeling, however, involves real costs, especially the costs of testing for the presence of GM content, segregating GM and non-GM products, variable costs of monitoring for truthfulness of labeling and enforcement of the regulations that exist, and risk premiums for being out of contract (Wilson and Dahl 2005, Roe and Sheldon 2007).

An effective GM-labeling policy includes effective segregation of GM from non-GM commodities. If one or the other of these products could be inexpensively color coded, segregation might not be very expensive. If, however, identity preservation through the production, marketing and processing chain was required, this system would be substantially more costly (Wilson and Dahl 2005). To the

[7] In contrast, the European Commission adopted GM food labels in 1997. The Commission requires each member country to enact a law requiring labeling of all new products containing substances derived from GM organisms. Japan, Australia and many other countries have also passed laws requiring GM labels for major foods. The international environmental lobby has frequently argued that "consumers have the right to know whether their food is GM or not" (Greenpeace 2001).

extent that there is a market for non-GM products, buyers would be expected to specify in their purchase contracts some limit on GM content and/or precise prescriptions regarding production/marketing/handling processes. One can envision a marketplace of buyers with differentiated demand according to their aversion to GM content. To make this differentiation effective, new costs and risks are incurred. Additional testing involves costs of conducting the tests, for which there are several technologies of varying accuracy. The risk is that GM products will be commingled with non-GM-products, so the detection system must test to see that customers' shipments are within contract limits for GM content. This is a serious economic problem, as agents seek to determine the optimal strategy for testing and other risk mitigation strategies.[8]

While private sector handlers routinely segregate and blend grains and beans as a primary function of their business, new risks arise when handling GM and non-GM-products, due to the added risk of adventitious commingling. When GM is the inferior product, growers and handlers of GM products have an incentive to mix GM with non-GM products. For US grains, Wilson and Dahl (2005) suggest that this risk may be about 4 percent at the grain elevator level. Farmer-processor contracting in horticultural or specialty crops, however, could reduce this margin by specializing in the product being delivered, such as non-GM or a positive GM trait. Another source of risk is testing, because no test is 100 percent accurate. Testing risk, however, varies with the technology, tolerance and variety of products handled, and seems likely to fall over time, as the technology of testing advances.

[8] "Tolerances" are an important issue in segregation and identity preservation. GM tolerance refers to the maximum impurity level for GM content that is tolerated in a product that still carries the non-GM label. There are two levels where tolerances apply: one is defined by regulatory agencies such as the FDA, and the other is commercial tolerance. Individual firms can and seem likely to adopt different tolerance levels, subject to any regulation. Moreover, different countries are likely to have different tolerance levels, and this increases the risks and costs of segregation or identity preservation.

In markets where there is imperfect information due to one or more parties having private information, private parties have an incentive to use their information to enhance their private goals (Akerlof 1970, Molho 1997). Highly conflicting information has been injected into the GM food market by interested parties. These vested parties are the agricultural biotech industry (see Huffman and Evenson 2006, pp. 153-183), including Monsanto, DuPont/Pioneer Hi-Bred, Dow, Syngenta and BASF that have disseminated information that is very favorable to GM technologies, crops and food products, and environmental groups, including Greenepeace, Friends of the Earth, Action Aid and Earth Watch, that have disseminated information that is very negative about GM crops, such as calling it "Frankenfood" (Rousu et al. 2004b). This diverse information has undoubtedly contributed to the GM food controversy and may be one factor explaining differences across Western countries in their acceptance of GM crops. Also, consistent with consumer education, independent third-party or verifiable information about agricultural biotechnology may have considerable value if available and disseminated to consumers (Huffman and Tegene 2002, Milgrom and Roberts 1986; Rousu et al. 2007). Verifiable information provides an objective assessment of the benefits and costs, including environmental risks, of GM crop varieties and the foods made from these raw materials. Hence, society can avoid losses due to strategic behavior of interested parties toward new technologies and products if decision makers have access to and use independent third-party or verifiable information.

## IV. Experiments Designed to Assess Consumer Willingness to Pay for GM Foods

Because GM foods are relatively new, my research team has chosen to use an auction market setting (Smith 1976) to collect information about consumer willingness to pay for (or demand) GM foods (Huffman et al. 2003, Rousu et al. 2007). This reflects the reality that GM food products are not generally labeled in the US, so grocery store purchases are not informative on this issue. Some scientists have used contingent value or stated preference surveys of consumer willingness to pay for new products. These surveys are known to contain hypothetical bias; participants in these surveys are not required to execute their stated preferences, i.e., "Participants don't have to pay what they say." For example, see Haneman 1984, Mendenhall and Evenson 2002, and Chern and Rickertsen 2004.

In contrast, in our auction market settings, consumers were expected to execute their winning bids by purchasing one unit of the auctioned commodity. Also, in contrast to most economics experiments that use university undergraduate students from the investigator's class as auction participants, we used *randomly chosen adult consumers in major metropolitan areas* that were identified by an independent survey agency. Individuals were told that an Iowa State University (or Iowa State University and University of Minnesota, or Iowa State University and Pennsylvania State University) project was being undertaken to obtain consumers' assessments of food and new household products. In particular, screened individuals were not told that they would be assessing GMOs or even would be participating in an experimental auction.

Economists frequently choose a Vickery 2$^{nd}$ price auction for valuing goods. However, it is well known that individuals who anticipate that they are far from placing the margin bid will bid randomly and insincerely. These participants have a real sense that their bid is not pivotal in determining the market price. We chose the random n-th price auction (Shogren et al. 2001). In this auction, the winning bidders are chosen from a uniform distribution over 1 to n, the total number of bidders in a session. For example, if there are 15 participants in a session, the bids are first ranked from 1 to 15, and the randomly drawn n is 5; then the four highest bidders pay the 5$^{th}$ highest price. With this type of auction mechanism all bidders are engaged because they sense that their bid will help determine the market price, or bidding their true willingness to pay is a weakly dominate strategy (McFadden 2007). Moreover, our auction is best described as being *a sealed-bid random nth price auction,* *because no information about willingness to pay for experimental products is released before all bids are placed.*

Individuals who agreed to participate came to a central location, signed a personal consent form, were paid $40 for their participation, and completed a short questionnaire on their social-demographic-economic characteristics and beliefs about a few technologies, including GMOs. Next they received instruction in the mechanics of a random n-th price auction. First, a candy bar was auctioned. Second, a candy bar, deck of playing cards, and box of ball point pins were auctioned to help participants become comfortable placing a bid on each of three unrelated commodities in a single round of bidding. Next, they took a short test on their understanding of the auction mechanism and any questions were answered. The auctioning of experimental commodities followed. After winning bids were determined, the participants completed another short survey, and then were told to execute winning binds by completing purchases of auctioned commodities in an adjacent stock room. Otherwise, they were told that they were free to leave.

In the first (2001) set of experiments, we chose participants who resided in the Des Moines, IA and St. Paul, MN areas, and they bid on a 32 oz bottle of vegetable oil (made from soybeans), a one pound bag of tortilla chips (made from yellow corn), and five pounds of fresh russet potatoes. In the second (2007) set of experiments, we chose participants who resided in the Des Moines and Harrisburg, PA areas, and they bid on one pound of fresh broccoli, one pound of tomatoes and five pounds of russet potatoes.

Simple food labels were constructed and placed on packages of all experimental foods (see Appendices A and C for the exact layout). These labels were designed by the researchers and contain only key facts.

In all of our experiments, we used three sets of diverse information about genetic modification and GM foods to construct information treatments: (1) the *industry (pro-biotech) perspective*—a collection of statements and information on genetic modification provided by a group of leading biotechnology companies, including Monsanto and Syngenta; (2) the *environmental group (anti-biotech) perspective*—a collection of statements and information on genetic modification from Greenpeace, a leading environmental group; and (3) the *independent, third-party (verifiable information) perspective*—a statement on genetic modification approved by a third-party group, consisting of a variety of people knowledgeable about GM goods, including scientists, professionals, religious leaders, and academics, who do not have a financial stake in GM foods. We limited the information statements about a particular party's perspective to one 8 1/2"x11" sheet of paper and organized the information under five different headings: General Information, Scientific Impact, Human Impact, Financial Impact and Environmental Impact, to reduce the information load on participants (See Appendices B and D, Figures 1, 2 and 3). Information treatments, consisting of one-to-three of the above information types, were injected into each of the sessions or experimental trials. For example, in the first set of experiments, the information treatments were: (1) only the industry perspective, (2) only the environmental group perspective, (3) industry and environmental perspectives, (4) environmental and third-party perspectives, (5) industry, environmental and third party perspectives. Information treatments were randomly assigned sessions without replacement. When a session received industry and environmental perspectives, the order was randomized. When a session received the third-party perspective it was always displayed last.

In the Des Moines and St. Paul experiments, each experimental unit (or session) of 13-16 individuals/consumers participated in only two rounds of bidding on experimental food items. The rounds were differentiated by the food label. In one round, which could be round 1 or 2 depending on the experimental unit, participants/consumers bid on three food products, each with a conventional food label that was made as plain as possible to avoid any influence on bids due to the label design. It stated only the *type of food* and *weight*. In the other round, participants bid on the same three food products with a GM label, which differed from the conventional food label by the inclusion of only one extra sentence: "This product is made using genetic modification (GM)." Each session or experimental unit received an information treatment chosen randomly from the six available treatments. Once the appropriate information treatment was distributed to participants in a given unit (session), two auction rounds were then conducted. A total of 172 individuals participated in this set of experiments.

In the Des Moines and Harrisburg experiments, each experimental unit (or session) of 13-16 individuals/consumers participated in four rounds of bidding on experimental food items. The rounds were differentiated by the composition of the food label, which had seven variants (with a maximum of four used in any session):

*Plain or conventional,*

*Plain plus the statement Intragenic GM Product,*

*Transgenic GM Product,*

*Enhanced Levels of Antioxidants and Vitamin C - Intragenic GM Product,*

*Enhanced Levels of Antioxidants and Vitamin C – Transgenic GM Product,*

*Enhanced Levels of Antioxidants and Vitamin C - GM Product,*

*GM Free Product,* or

*No Information.*

Although all bidders in a session or round of bidding saw the same food labels, they received different information treatments in the Des Moines and Harrisburg experiments. The Des Moines and Harrisburg experiments were unique in not only distinguishing the type of GMO, but also for injecting a treatment with "No Information." Also, the exact wording of the three types of information was modified to be appropriate to the emphasis of these experiments; for example, the industry perspective and third-party perspective described the key differences between "Transgenic" and "Intragenic GM Products" (Appendix D, Figures 2 and 3).

## V. Experimental Evidence on Key Bid-Price Differences

We first consider simple mean differences between genetically modified and conventional foods and then turn to a regression analysis of individual bidder price differences. In the latter analysis, the emphasis is on information treatments effects.

### A. Simple Differences in Mean Bid Prices.

We first examine simple bid-price differences for consumer willingness to pay for food items labeled as being genetically modified versus having a plain/conventional food label, specifying only the type and weight of the food (plus packaging date for tortilla chips). Using the 2001 Des Moines and St. Paul data, we examine overall bids for GM—vs. plain/conventionally-labeled food products. As shown in table 1 panel A, on average, bidders discounted the GM-labeled product by about 15% relative to its plain-labeled counterpart. The discount that bidders placed on the GM-labeled products did not vary significantly across the three products examined (also see Huffman et al. 2003b), but for tortilla chips the difference was different from zero at the 10% significance level.[9]

Turning to the 2007 Des Moines and Harrisburg samples, bidders were, on average, willing to pay a sizeable premium for food products containing the label "Enhanced Levels of Antioxidants and

[9] All three differences are significantly negative at better than the .07 significance level.

Vitamin C – Intragenic GM Product" relative to a plain/conventionally-labeled food product. The premium ranged from 39 cents to 45 cents per unit on the three food products, or 19% to 26% higher. The mean price for each of the three commodities—broccoli, tomatoes and potatoes—with enhanced attributes relative to products with a plain/conventional label, was different from zero at the 5% significance level.[10] Hence, when consumers bid on GM products containing input traits, the GM product was *weakly inferior* to the plain/conventionally labeled product. However, when consumers bid on fresh intragenic GM horticultural products containing enhanced levels of antioxidants and vitamin C, they were willing to pay a premium and, hence, the intragenic products were economically and statistically superior to a plain/conventionally-labeled product.[11] These results imply a dramatic difference in the incentives for private industry to label new genetically modified products with enhanced consumer attributes relative to those derived from raw materials that contain input traits (also see Roe and Sheldon 2007).

**B. Individual Bid-Price Differences and Diverse Information**.

We now provide econometric evidence relating individuals' bid-price differences to information treatments and food labels. In table 2, the results from fitting a model explaining the difference between a participant's bid on a product with a GM label and a plain/conventional label under one of six information treatments, are presented. The model of bid price differences is fitted with commodity fixed effects (but no intercept) to observations from the 2001 Des Moines-St. Paul sample. Recall that the mean bid-price difference is negative for this sample of bidders. The estimated coefficients for information treatment effects show that in auction sessions where bidders received only anti-biotech information the bid price differences were larger and negative (between

[10] The mean bid prices where the biotech method was switched from intragenic to transgenic, but otherwise containing enhanced consumer attributes, were larger than for the plain label but 14-22% lower than for the intragenic label.

[11] We have not undertaken sensory tests to determine whether consumers can perceive any differences in the conventional product relative to one with intragenic enhanced consumer attributes. Given that no "foreign" DNA nor antibiotic marker in present in the intragenic product, my hypothesis is that no perceived sensory differences exists. Moreover, Zhao et al. (2007) found no difference in a sensory analysis of conventional and organically grown fruits and vegetables, except that conventionally grown tomatoes scored slightly higher for ripeness, which is positively correlated with flavor intensity.

GM and plain-labeled, or the GM-labeled food was more heavily discounted) and statistically significant at the 5 percent level. When bidders received only pro-biotech information, bid price differences were reduced, but the difference was not significantly different from zero at the 5 percent (or 10 percent) level. When bidders received both pro-biotech and anti-biotech information, the bid price difference was reduced, reflecting the opposing forces of the two types of information in this information treatment. Moreover, this information treatment did not have a statistically significant affect on bid price differences. From these results, we conclude that in those sessions where bidders received only anti-biotech or both pro-biotech and anti-biotech information, they bid differently than when they received only pro-biotech information.

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

To focus more specifically on the potential significance of verifiable information types on bidders' behavior, we performed a joint test that verifiable information had no effect on bidder behavior (see table 2). We did this by deleting the three information treatments that included verifiable information as a component of a treatment. The sample value of the chi-squared statistic for this test is 7.17 with 3 degrees of freedom and, at a 10 percent significance level; the tabled chi-squared is 6.97. Hence, verifiable information had a statistically significant effect on bidders' willingness to pay for commodities that might be genetically modified.

Other results in table 2 include the following. Bidders who had larger household incomes discounted GM by a larger amount that those with less household income. This result is statistically significant at the 5 percent level and is consistent with non-GM products being viewed, on average, by bidders as a superior product. Participants coming into our experiments were asked about how well-informed they were about genetic modification. This subjective information was then coded into a dichotomous variable. Those bidders who considered themselves to be at least "somewhat informed about GM foods" discounted GM-labeled foods more than did other bidders. This effect is statistically significant (at the 10 percent level). Moreover, this result suggests that bidders in our experiments who were "GM-informed" had, on average, acquired/received negative information about GM foods prior to the experiment.[12] Bids also were affected by the labeling sequence. Bidders in sessions that bid on the GM-labeled food products in round one (and the plain-labeled food products in round two) discounted GM-labeled foods by less than those who were in sessions that bid on the products in the opposite order. The regression coefficient for this regressor is statistically significant at the 5 percent level, and *the result reinforces the importance of randomized assignments of treatments to sessions in experimental auctions*, which is an innovation in our methodology. Finally, we performed a joint test of no explanatory power for the regression model reported in table 2, conditional on pooled data with commodity fixed effects and censoring. The sample value of the chi-squared statistic is 18.6 with 10 degrees of freedom. The tabled value of the chi-squared statistic at the 5 percent significance level is 18.3. Hence, this null hypothesis of no explanatory power of the regression model fit to the 2001 samples is rejected.

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[12] See Huffman et al. (2006) for an analysis of the impact of bidders' prior beliefs about GM technology and food products on their willingness to pay for food items that are potentially GM.

Next, we turn to the 2007 sample of individuals from Des Moines and Harrisburg. Table 3 reports on a regression model explaining an individual's bid price difference between intragenic-labeled foods and plain/conventionally labeled foods, excluding bids for products that were labeled as having enhanced consumer attributes. In these results, the base case with no-information treatment gives a bid-price difference of intragenic GM- over plain-labeled food products by a statistically significant 52 cents per unit of product. When pro-biotech information treatment was injected into the experiments, the bid price difference is a statistically significant 73 cents per unit or 21 cents more than for the no-information treatment, suggesting a net positive influence of industry-provided biotech information on willingness to pay for intragenic GM products. The injection of the anti-biotech information treatment gives a bid price difference of only 25 cents per unit, which is 27 cents per unit lower than for the no-information treatment. However, this coefficient is not different from zero at the 5 or 10 percent significance levels, suggesting that environmental groups do not distinguish between intragenic and transgenic biotech methods for engineering new crops. The injection of a pro-biotech and anti-biotech treatment (where the order is random across participants in a session) increases the bid price difference by a statistically significant 56 cents per unit. The impact of this information treatment on bid price differences is slightly higher (4 cents per unit) than for the no-information treatment, which is a reflection of the opposing forces of pro-biotech and anti-biotech information, but with the edge going to the pro-biotech information. When the injected information treatment includes all three types of information (with verifiable information always last), the bid price difference is larger by a statistically significant 44 cents per unit, which is 8 cents less than for the no-information treatment. Comparing this result to the previous one, verifiable information seems to be a moderating force relative to the pro-biotech industry perspective. Finally, in a test that all of the regression coefficients in table 3 are jointly equal to zero, the null hypothesis is rejected at the 5 percent significance level. Hence, this econometric model has significant explanatory power of bid price differences.

Consumers have expressed some skepticism of transgenic GM food products, and our 2007 Des Moines and Harrisburg data set shows that consumers bid significantly higher prices for intragenic than transgenic food products that contain enhanced levels of antioxidants and vitamin C. However, the differences in these bid prices may be affected by the information environment in which consumers are bidding. To test this hypothesis, we examine the differences in bid prices for products with an intragenic GM label versus one with a transgenic GM label. Observations are pooled across all three commodity types and the estimation takes account of censoring of differences due to a single zero bid price in one of the two bid prices used to construct this difference. Observations with double zero bids are excluded because they were judged to contain no useful information relative to our hypothesis.

These new results are reported in table 4. Bid price differences for the base case of the no-information treatment is 18 cents per unit higher for intragenic than transgenic, but this number is not significantly different from zero at the 10 or 5 percent levels, suggesting that this information is truly uninformative about these biotech methods. In contrast, an injection of the pro-biotech information treatment gives a bid price difference by a statistically significant 67 cents per unit, suggesting that, on net, the industry perspective favors intragenic over transgenic. In contrast, an injection of anti-biotech information treatment gives a bid price difference of only 17 cents per unit, which is slightly lower than the point estimate for the no-information treatment and 50 cents per unit lower than for the pro-biotech information treatment. Injection of the pro-biotech and anti-biotech information treatment gives a bid price difference of a statistically significant 42 cents per unit, which is in the middle of the estimates for the pro-biotech and anti-biotech treatment estimates. The injection of the information treatment containing all three information types gives a bid price difference of 38 cents, which suggests that objective information moderates the positive impact of the pro-biotech information on bid-price differences.

In table 4, the estimated coefficient for the dummy variable denoting that the food product has enhanced antioxidants and vitamin C is a positive 12 cents per unit, and significant at the 10 percent level. This result suggests that the presence of enhanced consumer attributes increases the value to bidders of the intragenic over transgenic methods. The results in the table also show that significant "bidding round or order effects" exist in the data, which supports methodological advances using randomization. Household income has no impact on bid-price differences in these results. In conclusion, I can say that the information setting affects consumer discounting of transgenic relative to intragenic horticultural products.

**C. Individual Differences in Bid Prices and Prior Information**

New food products using genetically modified crops appeared in US supermarkets starting in 1996, and consumers perceived some risks. Because consumers are exposed to diverse and sometimes conflicting perspectives about GM technologies and foods, they form subjective beliefs. Huffman et al. (2007) examined the role of these prior beliefs on consumer willingness to pay for foods that might be genetically modified. The data are from the 2001 Des Moines and St. Paul experiments, where participants were asked before the experimental auction how well-informed they were about genetic modification—extremely, well, somewhat, not very well or not informed at all. Huffman et al. show that participants who had informed prior beliefs about genetic modification discounted GM-labeled food products by a larger amount than those who had uninformed prior beliefs. *Also, uninformed participants* were especially susceptible to information from interested and third parties.

In contrast, *informed participants* were generally not affected significantly by new information. These results contradict some earlier psychological studies that claimed that individuals tend to base rates (Tversky and Kahneman 1981). The results show how both skeptics and proponents of new technologies might try to manage information to achieve private or group-wide, but not social, objectives.

**D. Other Related Results**

1. Rousu et al. (2004a) examine the impact of tolerance levels, or the impact of the minimum level of GM contamination that will pass as GM-free. Using the 2001 Des Moines and St. Paul data, they examine bids on three food products that have different tolerance labels. In one trial, all consumers bid on foods with a non-GM label, certified to be completely free of genetically engineered material, and in the other trial, consumers bid on foods with a non-GM label indicating that a certain percentage of genetically modified material, either one or five percent, was tolerated. Consumers in these treatments did not receive any information on GM food products. This experiment contained three experimental units/sessions with a total of 44 participants.

Rousu et al. found evidence that consumers preferred foods that were 100% non-GM, relative to food products with small amounts of GM material (one or five percent). Consumers bid approximately 10 percent less for the GM-tolerant food products than they did for the certified GM-free products. However, they found that once GM content was present, no difference existed in bids between foods that contained 1 percent vs. 5 percent GM content (Rousu et al. 2004a). Thus, while these findings indicate that a significant percentage of consumers will pay more for GM-free labeled food products relative to conventionally labeled food products, it does not appear that one percent or higher tolerance levels for GM material matters.

## V. Discussion of GM Technology and Mixed Messages

Although consumers in the US are relatively tolerant of alternative production methods for their food, they do respond adversely to some risks. For example, when genetic modification refers to input traits, consumers in our experiments discounted GM food products by 15 percent, relative to a plain- or conventionally-labeled alternative. This seems to arise from environmental, biodiversity or health concerns from introducing foreign DNA into food crops. To circumvent these concerns, new methods have been developed for intragenic genetic modification, where no foreign DNA is introduced in the GM varietal development process. Our results from the 2007 data support the hypothesis that consumers have a more favorable perspective about these genetic modifications, and that they are, in fact, willing to pay a premium for enhanced levels of antioxidants and vitamin C by intragenic GM methods. However, when we were experimenting with food traits to consider including as enhanced food products, we experimented with "low pesticide residual" as a food quality attribute. Consumer reaction to this trait was complex, because the label raised a dormant issue that, yes, there is pesticide residue in our food. Mentioning that insect resistant (*Bt*) traits could be introduced so as to reduce the need for farmers to apply commercial pesticides, and thereby reduce chemical pesticide residual, was a hard sell.

Along a similar line of mixed messages, Markosyan et al. (2007) conducted surveys of consumers in grocery stores in October 2006 in the Pacific Northwest to test their willingness to pay for "naturally enriched antioxidant coatings" embedded in the *wax* on retail fresh apples. In general, consumers were willing to pay a little, four to eight percent more, for the antioxidant enhanced apples, but a number of consumers were quite negative about the technology, e.g., "I don't want to eat wax," "it is unnatural," "additives to fruit are not necessary," "washing apples removes the wax," "prefer foods without additives," and "it is better to get nutrients naturally." Hence, adding antioxidants to the wax of apples also raised the dormant issue that fresh commercial applies are waxed.

## VII. Conclusions and Predictions for the Future

More than a decade has passed since the first genetically modified foods appeared in US grocery stores. Early attempts to market fresh horticultural products, in particular, the Flavr-Savr tomato and the Russet Burbank Newleaf potato failed after very brief appearances in the market. Input traits developed by transgenetic methods applied to field crops have been much more successful, but consumers continue to express some resistance to them because of environmental, biodiversity or human health concerns. Recent developments of new intragenic GM methods are exciting because they permit scientists to use diverse genes and attributes identified in the genomes of particular horticultural plants to quickly enhance quality attributes of commercial varieties of crops like potato and tomato. This is very important in potato breeding, where it is impossible for scientists to dramatically enhance conventional levels of vitamin C and antioxidants using a range of conventional non-GM breeding methods. The new intragenic GM potato varieties enhanced with antioxidants and vitamin C promise to be the first successful commercial GM product with consumer traits on the market.

Economists' research has shown that US consumer acceptance and willingness to pay for GM food crops is not only conditioned by the nature of the new trait and the method of DNA transfer, but also by the content of food labels, prior beliefs of consumers, and content of diverse information injected into the food market about GM technologies and food products. During the era of input-trait dominated GM foods, consumers have revealed that GM food products are weakly inferior to conventional products, which means that marketers of GM food products will not label voluntarily.

With the commercialization of new intragenic GM products with enhanced consumer attributes, these new GM food products promise to command a premium relative to conventional food products. Hence, the private sector's incentive to voluntarily label GM products will change dramatically. This promises to be a positive development in the commercialization of GM food products.

During the era of input traits, consumers' informed prior beliefs were somewhat negative about agricultural biotechnology and GM foods. These prior beliefs, however, have the potential to become more favorable toward GM horticultural crops as new products with intragenic GM-enhanced consumer attributes become generally available in the food market. Also, strong evidence exists that consumers are positively influenced by biotech industry or pro-biotech information, and negatively affected by environmental group or anti-biotech information. Moreover, third-party verifiable information has been shown to be a moderating influence on consumer interpretation of anti-biotech and pro-biotech information and on willingness to pay for GM foods. Hence, a future role exists for public sector provision of third-party verifiable information about GM technologies and GM food products. This new information will affect prior beliefs of consumers about GM food products and be a useful input to objective assessments of new GM food products that enter the market, which could be important to the commercial successes of new GM horticultural crops.

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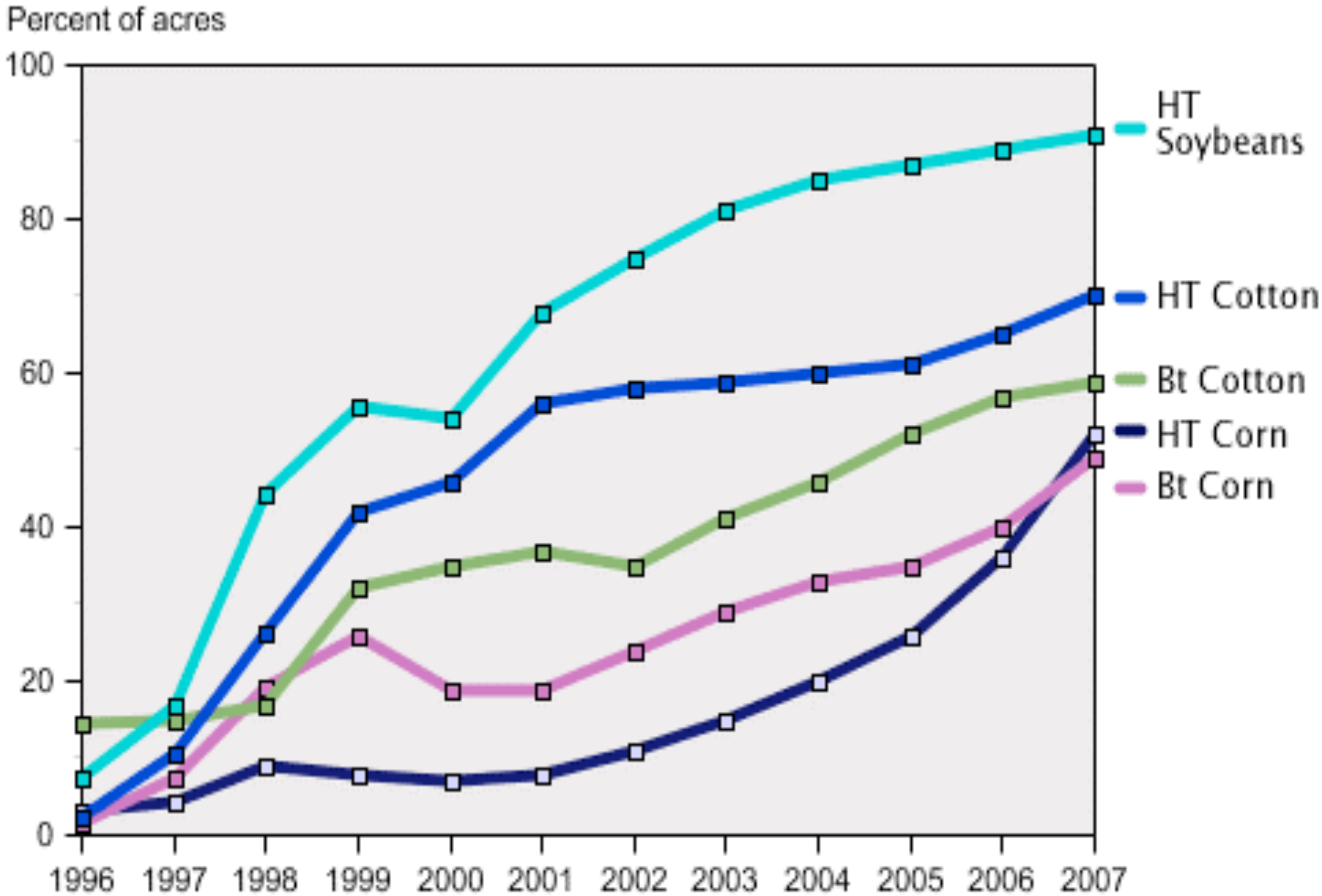
**Figure 1**
**Adoption of Genetically Engineered Crops: U.S., 1996-2007**




Note: Data for each crop category include varieties with both HT and Bt (stacked) traits.
Source: 1996-1999 data are from Fernandez-Cornejo and McBride (2002). Data for 2000-07 are avalable in the ERS data product, Adoption of Genetically Engineered Crops in the U.S., tables 1-3.

**Table 1. Mean Bids Reflecting Consumer Willingness to Pay for Specially Labeled Commodities Across All Information Treatments: Evidence from Two Sample Groups (standard deviation or error of the mean in parentheses)**

| Label | Commodities | | |
|---|---|---|---|
| Panel A: Des Moines and St. Paul samples (n = 172)[a/] | | | |
| | Vegetable Oil | Tortilla Chips | Potatoes |
| GM-input traits | $0.91 | $0.93 | $0.78 |
| | (0.0618) | (0.0651) | (0.0651) |
| Plain | 1.05 | 1.08 | 0.91 |
| | (0.0648) | (0.0648) | (0.0694) |
| Difference | $-0.14 | $-0.15* | $-0.13 |
| | (0.896) | (0.0919) | (0.0914) |
| Panel B: Des Moines and Harrisburg samples[b/] | | | |
| | Broccoli | Tomatoes | Potatoes |
| Intragenic GM with enhanced vitamin C and antioxidants (n = 98)[c/] | $1.675 | $1.764 | $2.610 |
| | ( 0.1146) | (0.1275 ) | (0.1861) |
| Plain (n = 92) | 1.284 | 1.376 | 2.157 |
| | ( 0.0791) | (0.1024 ) | (0.1205) |
| Difference | $0.391** | $0.388** | $0.454** |
| | (0.1410) | (0.1648) | (0.2248) |

[a/] One unit of each commodity equals a 32-oz. bottle of vegetable oil, a 1-pound bag of tortilla chips, and a 5-pound bag of russet potatoes.

[b/] One unit of each commodity equals 1-pound of loose broccoli, 1-pound of Beefeater tomatoes, and a 5-pound bag of russet potatoes.

[c/] Mean bid prices for transgenic GM commodities with enhanced attributes are: $1.448, $1.408 and $2.269, which are significantly less than the means for intragenic GM but more than the means for plain-labeled products.

* Denotes a difference that is different from zero at the 10% significance level.

* Denotes a difference that is different from zero at the 5% significance level.

**Table 2. Explaining Bid Price Differences Between GM- and Plain-Labeled Foods: Estimate of Censored Regression with Observations Pooled Across Commodities and Commodity Fixed Effects – Des Moines and St. Paul Samples (n=516, standard errors are in parentheses)[a]**

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

| Regressors | Coefficients | |
|---|---|---|
| Information Treatments: | | |
| Pro-biotech | 0.073 | (0.097) |
| Anti-biotech | -0.432** | (0.093) |
| Pro-biotech x anti-biotech | 0.199 | (0.131) |
| Pro-biotech x verifiable | -0.007 | (0.088) |
| Anti-biotech x verifiable | 0.205** | (0.090) |
| Pro-biotech x anti-biotech x verifiable | -0.065 | (0.157) |
| Other variables: | | |
| Labels-Round 1 dummy | - 0.115** | (0.053) |
| Gender dummy | 0.045 | (0.054) |
| Income of household | -0.00001** | (0.00) |
| Informed about GM per-experiment | -0.093* | (0.054) |
| Chi-squared for excluding 3 regressors containing verifiable information | 7.177* | |
| Chi-squared for no explanatory power of all above regressors jointly | 76.44** | |

[a] The estimated coefficients for the commodity fixed effects are not reported. Observations with double zeros were excluded.

* Denotes a coefficient or effect that is different from zero at the at the10% significance level.

** Denotes a coefficient or effect that is different from zero at the at the 5% significance level.

**Table 3. Explaining Bid Price Differences Between Intragenic GM-Labeled Foods and Plain-Labeled Foods (no enhanced consumer attributes): Estimate of Regression with Observations Pooled Across Commodities and Commodity Fixed Effects – Des Moines and Harrisburg Samples (n = 276, standard errors are in parentheses)[a]**

Dependent variable: Bid Intragenic GM-labeled less plain-labeled food

| Regressors | Coefficients. | |
|---|---|---|
| Information Treatments: | | |
| No Information | 0.52** | (0.21) |
| Pro-biotech | 0.73** | (0.21) |
| Anti-biotech | 0.25 | (0.20) |
| Pro-biotech x anti-biotech | 0.56** | (0.19) |
| Pro-biotech x anti-biotech x verifiable | 0.44** | (0.19) |
| Other Variables: | | |
| Round 2 dummy | -0.29** | (0.15) |
| Round 3 dummy | -0.37** | (0.15) |
| Round 4 dummy | -0.47** | (0.16) |
| Income of household ($K) | -0.01 | (0.01) |
| F value for no explanatory power of all above regressors jointly | 27.5** | |

[a] Sample considers all observation except for the commodities labels with enhanced vitamin C and antioxidants. Note: The estimated coefficients for the commodity fixed effects are not reported.

* Denotes a coefficient or effect that is different from zero at the at the10% significance level.

** Denotes a coefficient or effect that is different from zero at the at the 5% significance level..

**Table 4. Explaining Bid Price Differences Between Intragenic GM-Labeled and Transgenic GM-Labeled Food (over all labels): Estimate of Censored Regression with Pooling of Observations Across Commodities and Commodity Fixed Effects – Des Moines and Harrisburg Sample (n = 521 , standard errors are in parentheses)[a]**

Dependent variable: Bid price Intragenic GM label less bid price Transgenic GM-label

| Regressors | Coefficients. | |
|---|---|---|
| Information Treatments: | | |
| No Information | 0.180 | (0.13) |
| Pro-biotech | 0.667** | (0.14) |
| Anti-biotech | 0.168 ** | (0.13) |
| Pro-biotech x anti-biotech | 0.422** | (0.14) |
| Pro-biotech x anti-biotech x verifiable | 0.377** | (0.14) |
| Other Variables: | | |
| Dummy for enhanced antioxidants and vit C | 0.116* | (0.07) |
| Round 2 dummy | -0.407** | (0.09) |
| Round 3 dummy | -0.130** | (0.05) |
| Round 4 dummy | -0.218* | (0.05) |
| Income of household ($K) | -0.004 | (0.01) |

[a] The estimated coefficients for the commodity fixed effects are not reported. Observations with double zero excluded.

* Denotes coefficient or effect that is statistical significance at the10 percent level.

** Denotes coefficient or effect that is statistical significance at the 5 percent level.

## Appendix A. GM- and Plain Food Labels for 2001 Des Moines and St. Paul Experiments

**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.*

## Appendix B: Information Injected into the 2001 Des Moines and St. Paul Experiments

***Figure 1.*** *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 2.*** *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 let consumers save a little more money on food. Worldwide the number of hungry people has been declining, but increased crop production using GM technology can also help further reduce world hunger.

Environmental Impact

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

***Figure 3.*** *The following is a statement on genetic modification approved by a third-party group, consisting of a variety of individuals knowledgeable about genetically modified foods, including scientists, professionals, religious leaders, and academics. These parties have no financial stake in genetically modified foods.*

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

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

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

Human Impact
While many genetically modified foods are in the process of being put on your grocers' shelves, there are currently no foods available in the US 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.

**Appendix C. Examples of the Five Different Food Labels-Products in the 2007 Des Moines and Harrisburg Experiments (Note that these labels are smaller than the true label size)**

| | |
|---|---|
| Potato (5 lbs.) | Potato (5 lbs.)<br><br>GM Free Product |
| Potato (5 lbs.)<br><br>Intragenic GM Product | Potato (5 lbs.)<br><br>Transgenic GM Product |

| | | |
|---|---|---|
| Potato (5 lbs.)<br><br>Enhanced levels of<br>Antioxidants and Vitamin C<br><br>GM Product | Potato (5 lbs.)<br><br>Enhanced levels of<br>Antioxidants and Vitamin C<br><br>Intragenic GM Product | Potato (5 lbs.)<br><br>Enhanced levels of<br>Antioxidants and Vitamin C<br><br>Transgenic GM Product |

## Appendix D. Information Injected into the 2007 Des Moines and Harrisburg Experiments

**Figure 1.** *The following is a collection of statements and information on genetic modification from Greenpeace, a leading environmental group.*

**General Information**
Genetic modification (GM) takes genes from one organism and places then into another. The process lets scientists manipulate genes in an unnatural way. Inadequate safety testing of GM plants and food products has occurred. Humans and the Earth are being used as guinea pigs for testing whether "Frankenfoods" are safe. GM foods should be banned because their effect on consumers and the environment is unknown and potentially catastrophic! Genetic modification is one of the most risky things being done to your food sources today and should be stopped before more damage is done.

**Scientific Impact**
All genetic modifications of plants are risky. All GM techniques are relatively new and no one can guarantee that consumers or the environment will not be harmed. The biggest potential hazard of GM foods is the unknown.

**Human Impact**
Genetically modified foods could pose serious risks to human health. Some foods contain allergens, and the potential exists for allergens to be transferred into a GM food product that no one would suspect. For example, if the genes from a peanut were transferred into a tomato, and someone who is allergic to peanuts eats this GM tomato, he could display a peanut allergy.

Another problem with transgenic foods is a moral issue. Many GM techniques transfer genes across species. We believe it is morally wrong to alter life forms on such a fundamental level.

**Financial Impact**
GM foods are being pushed onto consumer by big businesses which only care about their own profits and ignore possible negative side effects. These groups are actually patenting new life forms they create with plans to sell for profits. Studies have shown that GM crops may even get lower yields than conventional crops.

**Environmental Impact**
GM foods could pose major environmental hazards. Little testing of GM plants for environmental impacts has occurred. One potential risk of GM crops is their impact on wildlife, including wild species of plants and insects. A study showed that one type of GM plant killed Monarch butterflies.

Another potential environmental hazard could come from pests that become resistant to new naturally occurring toxic substances engineered into plants to kill pests—insects and worms—or to make a plant resistant to a particular herbicide application. The target pests that get exposed to these new GM crops could quickly develop tolerances and wipe out many of the potential advantages of GM pest resistance.

***Figure 2.*** *The following is a collection of statements and information on genetic modification provided by a group of leading biotechnology companies, including Monsanto, Pioneer and Syngenta.*

**General Information**
Genetically modified (GM) plants have the potential to be one of the greatest discoveries in the history of farming. GM crops have lowered food production costs by improving insect and disease resistance and weed control in plants. New genetic engineering techniques could dramatically enhance consumer benefiting attributes of food such as vitamins, antioxidants, flavor, and shelf life. These improvements to plant quality can only be attained through GM, not conventional breeding.

The process of genetic modification takes genes from one organism and places them into another. There are two distinct types of GM used by biotechnology companies. *Transgenic* GM transfers genes between two *unrelated* organisms, for example from soil bacteria to corn. *Intragenic* GM involves transferring genes between two breeds of the *same* organism, for example, from wild species of corn to a commercial variety of corn.

**Scientific Impact**
Both *transgenic* and *intragenic* techniques are used to produce food products that are approved by the Food and Drug Administration (FDA). *Intragenic* modification is a genetic technique for significantly speeding up the conventional process of plant cross-breeding, which has been undertaken by farmers and plant breeders for thousands of years. Many industry groups believe *intragenics* should require minimal FDA testing because no foreign genes or proteins are added to the GM plant. We have only seen the tip of the iceberg of the future potential of GM for improving worldwide health and nutrition through enhanced plants.

**Human Impact**
The potential exists for GM to dramatically enhance traits that have direct value to consumers, such as increased vitamins and antioxidants, more flavor, longer shelf life, lower pesticide use, and reduced cost of production. Superior GM plants will help reduce worldwide malnutrition and improve the healthiness of foods. The FDA has approved GM food for human consumption, and Americans have been consuming GM foods for a decade. While every food (modified or not) poses some risks, there has never been a documented case of a person getting sick from GM food.

**Financial Impact**
With the introduction of enhanced nutrition, antioxidants, shelf life, flavors and other consumer-desired attributes using GM technology, consumers will for the first time enjoy the direct benefits of genetic engineering. GM plants have reduced farmers' costs, which mean lower food prices. Worldwide the number of hungry people is declining. GM technology is helping to feed the world and improve worldwide nutrition.

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

***Figure 3.*** *<u>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 GM foods.</u>*

**General Information**
The process of genetic modification (GM) takes genes from one organism and places them into another. There are two distinct types of GM used by biotechnology companies. *Transgenic* GM transfers genes between two *unrelated* organisms, for example from soil bacteria to corn. *Intragenic* GM involves transferring genes between two breeds of the *same* organism, for example from wild species of corn to a commercial variety of the crop. Hence, *intragenic* modification has much in common with conventional plant breeding.

**Scientific Impact**
The Food and Drug Administration (FDA) standard for GM food products is based on the principle that they have essentially the same ingredients, although modified from the original plant. Almost all GM crops meet the FDA's substantive equivalent requirement. Hence, they do not require special testing before commercial marketing can occur.

**Human Impact**
Many scientists see *intragenics* as having real potential for enhancing consumer attributes of plants such as dramatically increasing vitamin and antioxidant levels, extending shelf life, and reduced chemical pesticide application without concerns about gene transfer across species. These improvements to plants are only possible using genetic modification and not conventional breeding.

All foods present a risk of an allergic reaction to a small fraction of the population. No FDA approved GM food poses any known unique human health risks, but when genes are transferred across species, a new allergen is possible. This is more likely with *transgenics* than *intragenics*. While GM crops can result in higher yields and enhanced nutrition, there is no consensus whether GM foods have or will reduce worldwide hunger.

Many people have moral or religious objections to GM. Some groups see *intragenic*s as being more acceptable because genes are transferred between two breeds of the same species.

**Financial Impact**
GM seeds and other organisms are produced by businesses that seek profits. For farmers to switch to GM crops, they must see benefits from making a change. Consumers must also see benefits from consuming GM foods—lower price or enhanced consumer attributes. However GM technology may lead to changes in the organization of the agri-business industry and farming.

**Environmental Impact**
The long-term effects of GM on the environment are largely unknown. Bioengineered insect resistance has reduced farmers' applications of environmentally hazardous insecticides, but resistance to this bio-control system will increase over time. More studies are occurring to help assess the impact of bioengineered plants on the environment. Some studies reported harm to Monarch butterflies from GM crops, but other scientists were not able to recreate the results.

Enhanced consumer attributes, such as vitamins, antioxidants, and longer shelf life due to *intragenics* pose no known environmental hazards.