CONSUMER VALUATION OF GENETICALLY MODIFIED FOODS AND THE EFFECT OF INFORMATION BIAS

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ABSTRACT

Bid prices were elicited for standard-label cookies, muffins, and potato chips and those identified as not including genetically modified (GM) ingredients using an experimental auction. Including a statement that the product did not include GM ingredients increased bids over those offered for standard-label products. Providing negative-biased information about the impact of GM crops on the environment increased the risk participants associated with GM foods, and positive-biased information decreased perceived risk. Overall, providing impact information, whether positive- or negative-biased, increased bids for products presumed GM. The influence of information bias on bids varied among selected participant groups, supporting the presence of uniquely responsive market segments.

KEY WORDS: biotechnology, environment, experimental auction, genetically modified, information, willingness-to-pay

HIGHLIGHTS

INTRODUCTION

- Biotechnology includes the application of a wide range of scientific techniques to the modification and improvement of plants, animals, and microorganisms of economic importance. Genetic engineering (GE) refers more specifically to technologies involving recombinant deoxyribonucleic acid (DNA), wherein a single gene from one organism is placed into that of another with the resulting organism considered genetically modified (GM).

- As application of GE in crop varieties becomes more prevalent, participants from throughout the marketing channel face new opportunities, challenges, and risks associated with the development, use, and handling of the resultant products. Stakeholders will benefit from information about consumer acceptance of biotechnology and the resulting products and how it can be influenced. The objectives of this paper are to investigate consumer willingness-to-pay for food products containing GM ingredients and to assess the influence of biased information about the effect of biotechnology on the environment on willingness-to-pay.

METHODS

- An experimental auction was used to elicit and estimate the influence of information bias on consumer bids for food products (cookies, muffins, and potato chips) with a standard Nutrition Facts label and those also indicating they did not include GM ingredients.

- Products were selected which include ingredients commonly produced in North Dakota and for which GM varieties exist (*e.g.*, wheat, sugar) or already have been commercialized. Products were also selected so that consumers, regardless of demographic characteristics, universally purchase them. Individual serving, convenience-sized products were used to appeal to college students in the school environment.

- One hundred twelve students from North Dakota State University were randomly assigned one of three treatments defined by the information they would receive about the environmental impact of biotechnology (control, positive- or negative-biased information).

RESULTS

- Respondent Profiles

  ➢ Overall respondents expressed a general concern about the environment. There were differences based on socioeconomic characteristics.
  ➢ Participants were self-reportedly not well informed about GM foods. However, natural resource management and agriculture majors, students raised on a farm, and males considered themselves well informed.

➢ A strong majority of participants perceived only a moderate or low level of risk or no risk associated with consuming GM foods. In particular, participants majoring in agriculture, computer science, and, somewhat surprising, natural resource management, considered there to be a very low level of risk. Participants with children, who live with a spouse or partner, and who grew up in metropolitan areas, and females perceived a higher level of risk than others.

- Willingness-to-pay

  ➢ Tobit regressions estimated bid price as a function of dummy variables defining characteristics of participants and products, whether the product was GM versus non-GM, and bias of information provided.
  ➢ Bids for the presumed GM products were lower than those for the products labeled as non-GM.
  ➢ The effect of information bias regarding environmental impacts of GM crops on willingness-to-pay for GM food products was unexpected. Providing positive-biased information increased bids for GM products, as expected. However, bids also increased with negative-biased information. Possible explanations for this unexpected result include method of product labeling, participant characteristics, and the existence of unique market segments.
  ➢ As expected, the perceived level of risk associated with GM food products increased for participants who read negative-biased information and decreased for participants who read positive-biased information.

CONCLUSIONS

- Higher bids for non-GM products support the literature which, in general, shows that consumers will pay more for non-GM foods and that they do read labels.

- There clearly exist different market segments which may justify unique market promotion and advertising strategies. More specifically, firms should consider focusing promotional GM materials in markets including consumers who may know little about agricultural production technologies, especially biotechnology.

- The effect of biased-information (*e.g.*, in an advertising campaign) on acceptability and willingness-to-pay for non-GM products may differ by product type.

  "Because of the limitations of the existing literature, much of what is known about public reactions to specific genetically modified foods comes from responses to a few particularly controversial products….As a result, the biotechnology and food industries, consumers, and policy makers are often left making decisions about future products based on generalized, incomplete, contradictory, and all-too-often, anecdotal evidence."
  Hallman, et al., p. 2

Consumer Valuation of Genetically Modified Foods and
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INTRODUCTION

Biotechnology includes the application of a wide range of scientific techniques to the modification and improvement of plants, animals, and microorganisms of economic importance (Persley and Siedow). Genetic engineering (GE) refers more specifically to technologies involving recombinant deoxyribonucleic acid (DNA) wherein a single gene from one organism is placed into that of another with the resulting organism considered genetically modified (GM). Commercial GE applications in agriculture did not evolve until the second half of the 20th century (Franks; Uzogara). The first available food product with a GM ingredient, potato chips, entered the market in 1967. These chips were made with indoor-grown GM Lenape potatoes. It was another two decades before the first outdoor test of GM crops took place, and the Food and Drug Administration did not approve the first whole GM food product, the Flavr Savr tomato, until 1994. Thereafter, the scope and use of GE in agriculture evolved quickly. The three major GM crops grown today - corn, soybeans, and cotton - were first commercialized in 1995 (Kalaitzandonakes), and by the following year, 23 GM crops had been approved for production in the United States. By 2001, 69% of cotton, 68% of soybeans, 55% of canola, and 19% of corn grown in the United States were GM (Fernandez-Cornejo and McBride). The result is that a multitude of food products retailed today contain GM ingredients.

As application of GE in crop varieties becomes more prevalent, participants from throughout the marketing channel face new opportunities, challenges, and risks associated with the development, use, and handling of the resultant products. Growers face decisions about whether or not to grow GM crops. Food manufacturers must consider use of commodities produced with biotechnology and determine labeling and promotion strategies for GM or non-GM food products. Consumers have new choices associated with food and other products. The aforementioned and other stakeholders will benefit from information about consumer acceptance of biotechnology and the resulting products and how it can be influenced.

There is currently little information available about the willingness of consumers and other market participants to purchase GM food products (Lusk, et al., 2001b). In part, this is because consumers are not well informed (Rousu, et al.; Roper Starch Worldwide, Inc.), and in part because available market research is limited. The purpose of this paper is to add to the existing body of literature about consumer willingness-to-pay for food products with ingredients produced from GE and those without. This study also examines whether the value consumers place on these products can be influenced by the bias of information available to them about the environmental effects of the technology used in producing their ingredients. There has been

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little work examining consumer perceptions about the environmental impacts of biotechnology even though environmental influence of agricultural production technologies in general is a concern for a majority of Americans (Hallman, et al.).

Specific focus of this study is on willingness-to-pay for food products including ingredients produced in the Northern Plains. Information about consumer acceptance of food products containing GM ingredients that are under development or have not yet been commercialized is especially lacking. This applies to two crops important in the Northern Plains region, wheat and sugarbeets. GM varieties of each have been developed, but neither has been commercialized because of uncertainty associated with consumer acceptance of the resultant products and the risk their use poses for marketing channel participants.

The remainder of this paper is organized as follows. The following section includes a brief review of literature on consumer awareness and acceptance of biotechnology. Included is a discussion of the methods used by social scientists to estimate revealed preference. Next the methods used in the current study are presented. Results and conclusions, including implications for the strategic behavior of agribusiness firms, conclude the manuscript.

REVIEW OF LITERATURE

Awareness of and Attitudes about Biotechnology

Evidence about what consumers think about biotechnology and how this influences their purchasing behavior is far from conclusive (Hallman, et al.). First, many research studies elicited public perceptions of biotechnology in the abstract rather than looking at specific products or their characteristics, and the results of those that consider more specific products or situations are often proprietary. Second, *awareness* and *acceptance* of the use of biotechnology are not synonymous (Hoban and Katic, 1998). Nor does acceptance of, or preference for, food products with particular characteristics necessarily translate into willingness-to-pay a premium for such products (Lusk, et al. 2001a).

That said, although sometimes conflicting, there is evidence from the literature that identifies factors that may or do influence how consumers perceive, and whether they are willing to pay for, products produced using biotechnology. Hallman, et al. found that men and those more highly educated had heard more about biotechnology, and that these groups and younger Americans more strongly approve of biotechnology than their counterparts. Approval increased when specific products and benefits were mentioned. Hoban and Katic reported that older and higher income consumers have greater awareness of biotechnology and that men and more highly educated consumers are more accepting of the associated benefits. They found that men, younger consumers, and those who had read about or otherwise heard about biotechnology were more willing to buy GM foods. The latter contrasts with Rousu, et al. who found that consumers who perceived themselves to be at least somewhat informed about biotechnology were willing to pay far less for GM foods than those less informed.

In spite of evidence from the literature, Hoban and Katic report that demographic variables explain less than 4% of the variance in acceptance of biotechnology among consumers.

More important are indicators of awareness and attitudes about biotechnology, explaining 25%. Baker and Burnham also report few differences in socioeconomic characteristics between a market segment of consumers who want to avoid GM foods and others. They instead found that variables measuring respondents' risk preferences and opinions of biotechnology were good discriminators of this market segment.

Acceptance arises from the benefits and risks consumers associate with the production of GM crops and consumption of the resulting food products. Therefore, information about those perceptions and whether and how they can be influenced are important to market channel participants. Detailed discussion of potential benefits and risks is found in the literature (*e.g.*, see Uzogara; Kamaldeen and Powell; Franks; Persley and Siedow). Demonstrated or potential benefits include more efficient and productive crops (*e.g.*, those that use less water or pesticides have higher yields) and the resulting potential for conservation of natural habitat, crops with expanded geographic boundaries for production and expanded range of use (*e.g.*, as renewable energy sources), and improvements in the healthfulness of, and nutrition provided by, resulting food products. Biotechnology may also one day allow for bio-remediation, which clears heavy metals from the soil (Franks).

There also exist technology-inherent risks (risks associated with food safety and environmental effects) and technology-transcending risks (emanating from the political and social context in which the technology is used) (Persley and Siedow). Concerns specific to environmental impact include the potential for unintended gene transfer, especially from and to those plants which cross-pollinate; virus-, herbicide-, or insecticide-resistant crops that may be difficult to control and harmful to non-target birds or insects; creation of new viruses or toxins; and reduction in genetic diversity (Persley and Siedow; Ando and Khanna; Franks; Kamaldeen and Powell; Uzogara). Producers may also find themselves liable for crop damage to neighboring fields.

Any impact GM crops may have on the environment will depend on the characteristics of the crop itself, the environment where it is grown, management by the producer, and rules that regulate production and development (Ervin et al.). These variables will exhibit some degree of interdependency. It is, therefore, not surprising that we are far from a comprehensive understanding of the impact of even a single biotechnology product on the environment. Regardless, in the absence of legislation, it is the perception (versus the actuality) of this impact among marketing channel participants, including the consumer, that is relevant.

Awareness of biotechnology appears to have increased slightly among American consumers since one of the first formal assessments of such during the early-1990s (Hoban, 2000a). However, consumers remain not well informed about biotechnology and freely admit to such (Roper Starch Worldwide, Inc.; Hallman, et al.). In a 1997 survey, 37% of respondents believed that GM products could not be found in supermarkets (40% believed they could) (Hoban and Katic). A 2000 survey revealed that the percentage believing GM products could not be found in supermarkets had fallen only to 32%, and the percentage that believed they could be found had increased only to 41%. By this time, most supermarkets in the United States contained GM food products. A persistent level of consumer ignorance about biotechnology was reconfirmed by Hallman, et al. who reported similar findings. Thirty-two percent of respondents

to their 2001 survey did not believe GM products were in grocery stores, while, again, 41% believed they were.

Although they are not well informed, in general the literature reporting on query by survey supports that Americans accept or are undecided about biotechnology (Hallman, et al.; Hoban, 1999; Hallman and Metcalfe). Acceptance tends to be higher for products that have specifically defined improvements in quality (*e.g.*, more nutritious foods, foods that stay fresh longer) (Hoban, 2000b). Hoban and Miller (1998) found support among nearly two-thirds of American consumers for insect protected GM crops; but only 58% approved of additional uses of biotechnology that improve foods. Hoban (2000b) found less support for insect protected crops; only self-reported by 51% of respondents. When defined as a replacement for chemicals in food production, 73% of consumers accepted the use of biotechnology (Roper Starch Worldwide, Inc.). A majority reported that its use is always or sometimes acceptable, although 25%, 16%, and 12% responded that it was never acceptable to use biotechnology to improve taste, production, and nutrition of food, respectively. Hallman, et al. reported support among 58% of respondents for using GM to create hybrid plants (37% disapproved). Approval of GM plants appears relatively low until it is compared to the only 63% of respondents who approved of traditional cross-breeding technologies (nearly 19% believed them to be morally objectionable). These examples demonstrate that 'acceptance' has a number of definitions and there is good reason to believe it can be influenced by education.

Willingness-to-pay

In the absence of prohibiting or restrictive legislation, the underlying empirical question of importance to participants throughout the marketing channel is the willingness-to-pay among consumers for food products defined by their GM content. The majority of existing literature assesses acceptance of biotechnology using surveys (*e.g.*, Baker and Burnham; Lusk, et al., 2002; and Lusk and Fox). However, a growing number of researchers have begun to use methods to assess revealed preference for GM foods, especially experimental auctions. Experimental auctions have the potential to provide more reliable measures of willingness-to-pay than hypothetical surveys (Lusk, Fox, and McIlvain). Other benefits are described in Fox, et al. (1998). Experimental auctions have been used in a number of studies to estimate consumer demand for new food items such as those introduced in the current study (*e.g.*, see Buzby, et al.; Fox, et al., 1998; Fox; Hayes, et al.; Rousu, et al.; Huffman, et al., 2002b; Lusk, et al., 2001a,b).

An initial effort to assess revealed consumer willingness-to-pay for a product guaranteed to be produced without biotechnology is reported in Fox et al. (1994). A Vickrey sealed-bid, second price auction was used to estimate the premium assigned to milk from cows guaranteed to have not received bovine somatotropin (bST).[1] The average premium bid to exchange a glass of milk from a cow receiving bST for one from a cow not receiving bST was positive. However, most bids, particularly in two of three metropolitan areas, were either zero or exceeded $1. In these markets, relatively few were willing to pay to exchange for non-bST milk, but the bid for

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[1] Bovine somatotropin (bST) is produced with recombinant DNA technologies. It has the potential to increase both milk production per cow and feed efficiency.

those so willing was relatively high. Providing factual, non-biased information to participants about bST coincided with lower variance in average bid between rounds.

Lusk, et al. (2001b) assessed willingness-to-pay among students endowed with a bag of corn chips including GM ingredients to switch for non-GM chips using first and second price auctions. All students were from Midwestern towns and enrolled in an agriculture major and most came from the farm. Because of the homogeneity of the population, typical demographic variables were excluded from the analysis. Variables incorporated into the model included those representing consumption habits, health related information, attitudes including those about GM foods, and hometown population. Not surprising given the population, students had little objection to GM foods and expressed a strong willingness to consume them. Seventy percent were unwilling to pay to exchange for non-GM corn chips and the average bid was only $0.07 per ounce. As demonstrated elsewhere in the literature, there was evidence of a market segment that valued the non-GM guarantee. The amount students were willing to pay for the non-GM corn chips was influenced negatively by chip consumption and positively by regular exercise. Scale differential questions where participants indicated their degree of concern for GM foods were useful in predicting both the probability individual students would pay to exchange for non-GM corn chips and the amount they would pay.

Huffman, et al. (2002b) used a random nth price experimental auction to assess willingness-to-pay for products under both voluntary (standard label versus non-GM label) and mandatory (standard label versus GM label) labeling scenarios. Participants submitted bids, which were ranked from high to low. A random number (n) was selected, and the product was sold to each of [n – 1] bidders at the nth price. As with other auction variants described here, participants never paid more than their bid price and, more commonly, less. A criticism of the commonly used Vickrey second-price auction is that it fails to disclose the complete demand curve for the auctioned item among participants. This is because participants who believe their bid is likely to be much higher or lower than the market-clearing price may offer an insincere bid. The random nth-price auction corrects for this problem because it attracts sincere bids from participants who might be off the margin. The nth price auction is both random (all bidders have the same positive probability of purchasing the item) and endogenous (the market-clearing price has some relation to the participants' individual values of the product).

Participants in two Midwestern cities bid on three products. Products were selected to represent those considered highly processed (tortilla chips), refined and distilled (vegetable oil), and fresh (potatoes). Six groups bid on products with a label indicating only the name of the product and those also noting "This product is made *without* genetic engineering" (italics added). Four groups bid on products with the plain label and those with labels indicating "This product is made *with* genetic engineering" (italics added). Participants bid on either the GM (or implied GM) or non-GM products in each round (*i.e.*, bids by individuals for GM and non-GM labeled products did not occur simultaneously). Round sequence was randomized, and only one round was binding so as to prevent reduction of bid prices as participants moved along their individual demand curve. Prior to bidding, participants were provided one page information summaries. Information provided was biased-positive, biased-negative, or verifiable (unbiased). [Rousu, et al. used data from six of the ten treatments to evaluate the effect of asymmetric (biased) information on willingness-to-pay for products with GM ingredients.]

Participants bid more for products presumed non-GM. Females and consumers with lower incomes discounted GM-foods less, although the differences were not large and generally not statistically significant. Those who perceived themselves at least somewhat informed about GM bid far less for GM foods, suggesting their prior-received information was weighted by a negative bias.

Huffman, et al. (2002a) used data from six treatments tested under the mandatory labeling policy scenario to evaluate the influence of information and demographic characteristics on the probability a consumer would be 'out of the market' for GM food products. Defined as a zero bid, 10% of consumers were 'out of the market' over all products. The percentage was lower for oil than for less refined products of tortilla chips and potatoes. Providing negative (positive) information about biotechnology increased (decreased) the probability a consumer would be 'out of the market.' Consumers who reported always reading labels for an initial purchase of a food item and those reporting they were at least somewhat informed about GM foods were more likely to be 'out of the market.'

METHODS

Auction Design

A random nth-price experimental auction was used to elicit and estimate the influence of information bias on consumer bids for food products with a standard Nutrition Facts label and those also labeled as not including GM ingredients. Methods closely parallel those described in Huffman, et al. (2002b) and Rousu, et al. Key differences include the composition of the participant population, type and form of products, product labeling, scope of information provided to participants and the timing of its introduction, and simultaneous (versus sequential) bidding on non-GM and presumed GM products.

One hundred twelve students from North Dakota State University (NDSU) were recruited to participate in the auction. Students were recruited through large-section anthropology, sociology, and communication classes. The market segment of university students provided a population likely to be consistently familiar with products considered. While the demographic characteristics of participants were relatively homogeneous, the literature demonstrates that their influence is likely to be overshadowed by heterogeneity in their beliefs and attitudes. Monetary compensation of $15 was provided to encourage participation, but its distribution prior to required purchases also served to eliminate any budgetary constraint. Approximately 33 students participated at each of 3 different time periods over a period of 2 days. A fourth auction was conducted in a College of Agriculture service course with 17 students a week later to increase sample size.

At each time period, students were randomly assigned one of three treatments defined by the information they would receive about the environmental impact of biotechnology. Independent auctions were held by treatment group (*i.e.*, auctions were held in each of three separate rooms at each time period). Each participant received a packet including a pre-auction survey, detailed instructions, information about biotechnology or North Dakota agriculture (control), and a post-auction survey. Moderators reviewed step by step instructions orally

throughout the auction. Practice rounds were conducted to ensure participants understood the auction process. In the initial practice round, participants bid on two candy bars (one with and one without almonds). In the second practice round, participants bid on two versions of three unique products. The two versions of each product were offered side by side (*e.g.*, two pens: one black and one blue).

The auction consisted of two rounds. In the first round, participants bid on three food products: individually wrapped muffins and chocolate chip cookies, and bags of potato chips. These products were selected to meet two key criteria. First, they include ingredients which are commonly produced in North Dakota and for which GM varieties exist (*e.g.*, wheat, sugar) or already have been commercialized (*e.g.*, corn, oil seeds, potatoes). Second, consumers, regardless of demographic characteristics, universally purchase these items. Individual serving, convenience-sized products were used to appeal to college students in the school environment. Participants bid discretely on two variations of each of the three products. Both included a standard Nutrition Facts label.[2] One also had a statement indicating "This product does not contain genetically modified ingredients." The two versions of each product were offered simultaneously to each participant (Figure 1). As such it was possible that participants could submit a winning bid, and be required to purchase, both the non-GM and GM versions of an individual product.

Labeling products containing GM ingredients was rejected as a strategy for the current study. The current U.S. labeling policy for food products regarding biotechnology is voluntary (Ervin, et al.). Products are required to be labeled only if they are not "substantially equivalent" to non-GM products. Huffman, et al. (2002b) demonstrate that when consumers can accurately read market signals (*i.e.*, can interpret information identically whether from voluntary or mandatory labeling strategies), a voluntary labeling policy provides higher welfare. Furthermore, in light of public ignorance of biotechnology and the extent of adverse controversy, it is unlikely that firms would voluntarily adopt a strategy of labeling foods as containing GM ingredients.

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[2] Under regulations from the Food and Drug Administration and the United States Department of Agriculture, the Nutrition Facts label provides nutrition labeling for most foods (except meat and poultry). Manufacturers are required to provide total calories, calories from fat, total fat, saturated fat, cholesterol, sodium, total carbohydrate, dietary fiber, sugars, protein, vitamin A, vitamin C, calcium, and iron.

POTATO CHIPS

Nutrition Facts:
Serving Size: one ounce (28 g., approximately 17 chips)

Calories 150	% Daily Value
Total Fat 9g	14%
Cholesterol 0mg	0 %
Sodium 160mg	7%
Total Carbohydrate 15g	5%
Protein 2g	

INGREDIENTS: SELECTED POTATOES, CORN OIL, AND/OR SUNFLOWER OIL AND/OR CANOLA OIL AND SALT.
**This product does not contain GM ingredients.

POTATO CHIPS

Nutrition Facts:
Serving Size: one ounce (28 g., approximately 17 chips)

Calories 150	% Daily Value
Total Fat 9g	14%
Cholesterol 0mg	0 %
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Protein 2g	

INGREDIENTS: SELECTED POTATOES, CORN OIL, AND/OR SUNFLOWER OIL AND/OR CANOLA OIL AND SALT.

Figure 1. Product Labels

Subsequent to the first round of bidding, participants were provided and instructed to read biased information about the effects of biotechnology on the environment, or general information about North Dakota agriculture. Environmental impact information was not identified as biased. Participants were instructed to read one page informational sheets that highlighted either positive or negative environmental impacts. Under each impact statement there were from one to five supporting statements. Positive-biased impact statements included the following:

- Fewer, less toxic pesticides used by farmers who grow genetically modified crops,
- Yield gains,
- Soil and water conservation, and
- Potential for less energy and air emissions due to more efficiency in product transport.

Negative-biased impact statements included the following:

- Increased use of certain herbicides,
- Lower yields,
- Increased tolerance in certain insects,
- Genes could move to wild species, creating weeds, and
- Harming non-targeted species.

A second round of bidding followed.

One of the primary interests of this research was to determine how respondents' willingness-to-pay is influenced by the GM content of the product. Products' bid functions dependent on the respondents' socioeconomic characteristics, the attributes of the products, and bias of environmental information provided were estimated econometrically.[3] These bid functions could not be estimated using conventional least-squares procedures because respondents' bids were censored. Asking respondents to bid for individual food items carries the implicit assumption that all respondents would be willing to pay a zero or positive amount. This does not allow for consideration of respondents' bids if they would expect to be paid to accept a product. In these cases, the appropriate question is actually a willingness to accept value, which the current research could not capture. As a result, some respondents who bid zero assign the product an actual value of zero while some bid zero simply because they could not offer a negative value. This problem censors the data at zero, and use of conventional ordinary least squares procedures would bias the estimated coefficients (Judge, et al.).

To compensate for the censoring issue, the willingness-to-pay bid functions were estimated using a Tobit procedure. The Tobit procedure provides a more efficient estimator. Use of ordinary least squares would provide consistent, but not unbiased, estimates. Tobit

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[3] Other variables considered in the analysis, but rejected for the final estimation due to insignificance, included Likert scale responses indicating the respondent's level of awareness and acceptance of biotechnology, use of food product labels, recycling behavior, perceptions about society's impact on the environment, population of hometown, age, religious affiliation, and ethnic background.

regressions were calculated using a single-stage maximum likelihood estimation procedure programmed in SAS. A single-stage Tobit estimation is more efficient than a two-stage estimation (Greene). The Tobit regressions estimated bid price as a function of dummy variables, participant characteristics, products (cookies, muffins and chips), whether the product was GM versus non-GM, and bias of information provided.

Two goodness-of-fit measures were calculated for the estimate: McFadden's Psuedo R^2 and the Likelihood Ratio. McFadden's Psuedo R^2 is normally used for limited dependent variable models, but it can be applied to any situation where a traditional R^2 measure cannot be used. It is similar to a traditional R^2 when estimating a model using ordinary least squares, but diverges substantially when the model is non-linear or has a truncated distribution. The Likelihood Ratio tests the hypothesis that all parameters are equal to zero.

With ordinary least squares regression, the estimated beta coefficient can be interpreted as the marginal effect. When data is censored at zero, the beta coefficient represents the marginal effect only for non-zero observations. The primary interest was observing the impact of the dummy variable(s) on bid price. Dummy variables are non-continuous and variables representing interactions among two or more dummy variables are non-differentiable. The marginal product assigned by the estimator to variables was, therefore, calculated as the discrete difference in estimated bid price when relevant dummy variables were assigned a value of one and when they were assigned a value of zero.

<center>RESULTS</center>

Respondent Profiles

Majors reported by the 112 participants were concentrated in the social sciences including sociology (30%) and humanities (26%). Fourteen percent reported a major within the College of Agriculture. The population was nearly evenly split by gender with males comprising 50.9% and females 49.1%. Most were Caucasian (93.1%), single (82.1%), and did not have children (88.4%). Seventy-two percent reported being employed. A majority earned an annual income of less than $5,000 (25%) or between $5,000 and $10,000 (32%). Eighty-three percent grew up under the Lutheran or Catholic faith. Thirty percent grew up on a farm. Just over one-third of participants (37.5%) were originally from a larger town or city (between 10,000 and 100,000 inhabitants). Half were evenly split between rural towns (less than 1,000) and small towns (between 1,000 and 9,999), and the remainder were from Minneapolis/St. Paul and their surrounding suburbs.

Both pre- and post-auction surveys included questions regarding the knowledge, behavior, and attitudes of participants. Overall respondents expressed a general concern about the environment. Nearly 60% said they *used* recycled products always or frequently, although only 45% reported recycling always or frequently. Thirty percent reported never recycling, and nine percent reported never using recycled products. Participants reporting earnings of more than $20,000 annually indicated they recycled products more often than those in each of the three lower income brackets. Those living with a spouse or partner were more likely to use recycled

<center>10</center>

products and to recycle. Agriculture majors recycled and used recycled products the least often among respondents.

Over two-thirds of participants agreed that more action needs to be taken to preserve the environment. A much lower percentage agreed that man has upset nature's balance (28.6%) or that pesticides are poisonous and should be prohibited (17%). The former is in contrast to a less strongly worded statement by Hallman, et al. (p. 28) who reported that 90% of Americans surveyed felt that "the balance of nature can be easily disrupted by humans." Females more strongly agreed with each statement in the current study than males ($p < .05$). Agriculture majors disagreed with each statement more strongly than others, particularly that pesticides should be prohibited. Those raised on a farm also expressed a stronger level of disagreement, than those not raised on a farm, that pesticides should be prohibited, but their level of agreement with the two other statements was not different. Those with children, and those living with a spouse or partner more strongly agreed that pesticides should be prohibited. Those with children and natural resource management majors agreed more strongly that more action needs to be taken to preserve the environment.

Participants reported on their knowledge about and perceptions of GM foods. They were asked how well informed they were regarding GM foods. The average response was 5.73 where 1 = extremely well informed and 8 = not informed at all. This concurs with the results of Hallman, et al. who found that Americans believe they are relatively uninformed about biotechnology. In the current study, nearly two-thirds of participants said they were only somewhat informed or not informed at all. Only 11% considered themselves well informed or extremely well informed. As a group, natural resource management students considered themselves the most well informed (average of 3.5). Majors in the College of Agriculture also considered themselves relatively well informed (average of 4.5). Participants raised on a farm and males considered themselves more well informed than their counterparts.

When asked how much of the food they consume is GM, the average response was approximately half. Overall, respondents believed there are substitutes for GM food products (average = 3.80 where 1 = always and 8 = never). Three-quarters thought there were substitutes always or frequently. Only 5% reported there were never substitutes. The only demographic characteristic found to influence perceptions about the availability of substitutes was whether the participant had children. Those with children believed there to be substitutes less often than others ($p = .083$).

Most participants perceived there to be only a moderate (38.4%) or low (46.4%) level of risk or no risk (5.4%) associated with consuming GM foods. In particular, participants majoring in agriculture (average of 6.5 where 1 = high risk and 8 = no risk), computer science (6.4), and, somewhat surprising, natural resource management (6.0) considered there to be a very low level of risk. Participants majoring in business assigned a relatively high level of risk (3.7), consistent with their very low level of self-reported knowledge regarding GM foods. Participants with children or who live with a spouse or partner perceived a higher level of risk than others. Females perceived a higher risk than males. And, as expected, participants who grew up in large metropolitan areas perceived a greater risk than those who grew up in rural areas or small towns,

and participants who did not grow up on the farm perceived a higher risk than those who did. Surprisingly, the latter difference was neither large nor significant (p = .122).

Finally, participants were asked about their use of food product labels. Participants self reporting that they read nutritional labels "always," "frequently," "occasionally," and "never" were nearly evenly split over the range of responses. Women reported reading labels more often than men (p = .016). Somewhat surprisingly, there was no difference in the frequency with which those with children and those without reported reading labels.

Willingness-to-pay

Model parameters and marginal effects from the Tobit estimate of willingness-to-pay are reported in Table 1. On balance, the regression fit the data quite well and the majority of the estimated coefficients are statistically significant. The Likelihood Ratio value rejects the hypothesis that all parameters are equal to zero (p < .01). Bids for the presumed GM product were lower than those for the product labeled as non-GM. This supports existing literature that demonstrates the average consumer is willing to pay a premium for food products guaranteed to be GM-free. However, the effect of information bias regarding environmental impacts of GM crops on willingness-to-pay for GM food products was unexpected. Providing positive-biased information increased bids for GM products, as expected. However, providing negative-biased information increased bids even more. That is, providing information describing the negative environmental impacts of biotechnology increased bids for GM food products.[4]

There are a number of possible explanations for this unexpected result, including method of product labeling, participant characteristics, and the influence of unique market segments among the participating population. Use of a standard Nutrition Facts label versus one also containing the statement "This product does not contain genetically modified ingredients" differentiated the GM and non-GM products. The decrease in bid for the GM product supports that participants read and understood product labels. However, the non-GM label was different than what they would have previously encountered in retail stores (products not containing GM ingredients available in retail stores are not currently labeled as such). Participants who received information about biotechnology may have been more likely to recognize the non-GM statement on the label (as different) and, subsequently, increased their bid for the product with the familiar Nutrition Facts label (the GM product).

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[4] A Tobit model with fewer variables was specified to verify unexpected results from the analysis. The marginal effects were consistent with those of the initial regression, except for positive-biased information. In the expanded-variable estimation, positive-biased information had a positive effect on bids for GM products. In the reduced-variable model estimation, it decreased participants' bids for GM products.

Table 1. Tobit Regression Results, Bid Price Estimator[a,b]

Parameter	Estimate	Standard Error	t-statistic	p-value	Marginal Effect
C (constant)	0.1389	0.0288	4.8220	.000	0.1271
B_f (raised on a farm)	0.0538	0.0271	1.9851	.047	0.0538
B_m (married)	0.4273	0.0856	4.9929	.000	0.4273
B_c (have children)	-0.3520	0.0905	-3.8888	.000	-0.3520
B_g (male)	0.0468	0.0233	2.0123	.044	0.0468
B_{am} (agriculture major)	0.3889	0.0394	9.8585	.000	0.5935
B_{sm} (sociology major)	0.1234	0.0284	4.3391	.000	0.1843
B_{gm} (GM)	-0.0459	0.0253	-1.8131	.070	-0.0459
I_{spgm}	0.2136	0.0936	2.2829	.022	0.1122
I_{sngm}	-0.1527	0.0885	-1.7261	.084	-0.0344
I_{apgm}	-0.0469	0.1254	-0.3739	.709	-0.1482
I_{angm}	0.2515	0.1248	2.0160	.044	0.3699
B_{co} (cookie)	-0.0424	0.0277	-1.5335	.125	-0.0424
B_{pc} (potato chips)	0.1902	0.0277	6.8682	.000	0.1902
I_{pgm} (positive biased information*GM)	-0.1013	0.0607	-1.6707	.095	0.0653
I_{ngm} (negative biased information*GM)	0.1183	0.0566	2.0906	.037	0.2172
e (error)	0.4104				

a. Unidentified parameters are as follows: I_{spgm} (sociology major * positive-biased information*GM), I_{sngm} (sociology major * negative-biased information*GM), I_{angm} (agriculture major * positive-biased information*GM), I_{angm} (agriculture major * negative-biased information*GM).

b. McFadden's Pseudo R^2 = .156, Likelihood Ratio = 277.132.

There was a high level of familiarity with agriculture among the participating population. Those who grew up on farms (30%) and/or who are majoring in agriculture (14%) are expected to have more knowledge about agriculture and be more aware and perhaps more accepting of the role of biotechnology in agriculture. For example, agriculture majors perceived there to be little risk associated with consuming GM foods and considered themselves relatively well informed about biotechnology. Those already well educated about biotechnology may not have been as receptive to the bias of information presented. And, in fact this appeared to be the case. Bids on GM products by agriculture majors increased after reading negative-biased information and decreased after reading positive-biased information, contrary to expectations. Alternatively, the information bias had the expected result on bids by sociology majors. They bid less for GM products after reading negative-biased information, and more after reading positive-biased information. It is reasonable that a group less well educated about biotechnology would be more responsive to information bias. It may also be that those already well educated did not carefully read or consider the information provided as they have likely seen similar information presented previously (*e.g.*, in class, popular press articles). Finally, it is possible that providing biased information contrary to that previously believed may have further entrenched prior-held beliefs. That is, telling students what they have learned and believe is wrong, particularly about a controversial issue, may have resulted in reinforcement of their prior-held beliefs.

To further investigate unexpected results, the level of risk participants assigned to the consumption of GM foods in pre- and post- auction questionnaires was compared. Participants were instructed to indicate the level of risk they believe is associated with the consumption of GM foods on a Likert Scale (1 = high risk, 8 = no risk). The mean difference between the pre- and post- survey responses for those receiving negative-biased information was .8974. The mean difference for the positive-biased group was -.1852, and that for the control group was .2703. Mean difference was statistically significant between the negative-biased and both the positive-biased and control groups. As expected, the perceived level of risk associated with GM food products increased for participants who read negative-biased information and decreased for participants who read positive-biased information. This supports the hypothesis that information can change participant perceptions about GM products, but contradicts the results of the Tobit estimation.

The model was next estimated for each individual product (cookies, muffins, and chips) separately. Estimating separate models for cookies and muffins did not change the overall results. Participants, regardless of the product, still bid a premium for products that were labeled non-GM, and biased information increased bids for GM products. However, the chip-specific estimate did have dissimilar results. Providing negative-biased information decreased the bid for GM potato chips, even among students whose academic major was agriculture.

CONCLUSIONS

Higher bids for non-GM products support the literature which in general shows that consumers will pay more for non-GM foods and that they do read labels (Center for Rural Studies). In the current study, the product label alone differentiated the non-GM version of each product. Thus, only participants who actually read the labels could have differentiated between them. The price premium placed on those products with the non-GM label supports the hypothesis that participants read the label. Negative- (positive-) biased information about the impact of biotechnology on the environment increased (decreased) the risk participants associated with GM foods. This is evidence that participants received the intended message from the biased information (*e.g.*, those reading negative-biased information thereafter associate more risk with GM foods). While overall their bidding behavior was inconsistent with expectations, the influence of information bias was as expected for those less likely to have prior education about biotechnology.

There are clearly different market segments which may justify unique market promotion and advertising strategies. Certainly firms should consider more specifically focusing promotional GM materials on markets including consumers who may know little about agricultural production technologies, especially biotechnology. This is also true for organizations speaking out against or advocating the use of biotechnology for the same reason: some consumer groups will be more responsive to such campaigns. If subsequent research supports that those more aware/accepting of biotechnology and GM foods are less responsive to (negative) information campaigns, firms might consider making the GM label customary. Rather than using resources to ensure products are GM-free, firms could simply label products as possibly including GM ingredients. Awareness from regular exposure may increase acceptance of GM foods.

Finally, results consistent with expectations for potato chips when the model was estimated separately suggest that the effect of biased-information (*e.g.*, in an advertising campaign) on acceptability and willingness-to-pay for non-GM products may differ by product type. This also has important implications for firms looking to the relatively thin body of literature reporting on revealed preference for GM-food products.

Future Research

The experimental design employed in the current research imposes limitations on its application, including those associated with participant population, credibility and influence of information, products, and product labeling. The population of participants was relatively homogeneous (North Dakota State University students). And, although the results generally concur with existing literature, caution is advised in applying the results to a wider population (*e.g.*, consumers in general, consumers over a larger geographic area). If financially feasible, engaging a more diverse population to participate in a future study would be helpful and would expand applicability of the results.

Because of the nature of the participating population, the products used in the auction were limited to immediate consumables (chocolate chip cookies, blueberry muffins, and potato chips). There is no evidentiary support that willingness-to-pay for refreshments containing GM ingredients is representative of the willingness-to-pay for other food products also containing GM ingredients (*e.g.,* pasta, bread, spaghetti sauce). Using different products in future research could widen the scope of findings. For example, a food category including healthful foods may appeal to different market segments and considering such may provide information about consumer demand of non-GM products among those most likely to purchase them.

Environmental impact information used was both visually attractive and credible; yet it was limited to a one-page scientific summary. There are many other possibilities for promoting or demoting the use of biotechnology that may be (much) more persuasive. Research that considers the effects of various means of presenting information on consumer demand may be useful. For example, using a television or magazine advertisement as a means to convey information about biotechnology could be more influential and alluring to more participants.

Also, it is expected that firms offering a retail food product that does not contain GM ingredients would use creative means to promote this on the product packaging, including the label. In the current study, the label clearly identified the set of relevant products as not containing GM ingredients, but identification of the products as such did not approach the level one would anticipate from an agribusiness firm retailing a food product. Creative product labeling may add to the price premium people are willing to pay for products that are indicated as being GM-free.

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LITERATURE CITED

Ando, Amy W., and Madhu Khanna. "Environmental Costs and Benefits of GM Crops." *American Behavioral Scientist* 44, No.3 (2000):435-463.

Baker, Gregory A. and Thomas A. Burnham. "The Market for Genetically Modified Foods: Consumer Characteristics and Policy Implications." *International Food and Agribusiness Management Review* 4(2002):351-360.

Buzby, J.C., J.A. Fox, R.C. Ready, and S.R. Crutchfield. "Measuring Consumer Benefits of Food Saftey Risk Reductions." *Journal of Agricultural and Applied Economics* 30(July 1998):69-82.

Center for Rural Studies. "Executive Summary: Attitudes Towards GM Organisms." Available at http://crs.uvm.edu/vtrpoll/2000/GMO, Retrieved 19 January 2001.

Ervin, David E., Sandra S. Batie, Rick Welsh, Chantal L. Carpentier, Jacqueline I. Fern, Nessa J. Richman, and Mary A. Schulz. "Transgenic Crops: An Environmental Assessment." Henry A. Wallace for Agricultural & Environmental Policy at Winrock International (November 2000), 81 pages.

Fernandez-Cornejo, and William D. McBride. "Adoption of Bioengineered Crops." USDA/ERS Agricultural Economics Report No. AER810, 67 pp, May 2002.

Fox, John A. "Determinants of Consumer Acceptability of Bovine Somatotropin." *Review of Agricultural Economics* 17(January 1995):51-62.

Fox, John A., James B. Kliebenstein, Dermot J. Hayes, and Jason F. Shogren. "Consumer Acceptability of Milk from Cows Treated with Bovine Somatotropin." *Journal of Dairy Science* 77 (1994):703-707.

Fox, J.A., J.F. Shogren, D.J. Hayes, and J.B. Kliebenstein. "CVM-X: Calibrating Contingent Values with Experimental Auction Markets." *American Journal of Agricultural Economics* 80 (August 1998):455-465.

Franks, Jeremy R. "The Status and Prospects for Genetically Modified Crops in Europe." *Food Policy* 24 (1999):565-584.

Greene, William H. *Econometric Analysis* (4th Edition), Upper Saddle, New Jersey: Prentice Hall, Inc, 2000.

Hallman, William K., and Jennifer Metcalfe. "Public Perceptions of Agricultural Biotechnology: A Survey of New Jersey Residents." Available at http://www.nalusda.gov/bic/Pubpercep/, Retrieved 11 November 2002.

Hallman, William K., Adesoji O. Adelaja, Brian J. Schilling, and John T. Lang. "Public Perceptions of Genetically Modified Foods: Americans Know Not What They Eat." Food Policy Institute Publication Number RR-0302-001, Rutgers, The State University of New Jersey, New Brunswick, March 15, 2002.

Hayes, D.J., J.F. Shogren, S.U. Shin, and J.B. Kliebenstein "Valuing Food Safety in Experimental Auction Markets." *American Journal of Agricultural Economics* 77(February 1995):40-53.

Hoban, Thomas J. "Biotechnology: Addressing Today's Core Issues for Better Food & Industry Growth." *Forum* (4th Quarter 2000a):95-105.

Hoban, Thomas J. "Consumer Acceptance of Food Biotechnology." Unpublished presentation (2000b).

Hoban, Thomas J. "Public Perceptions and Understanding of Agricultural Biotechnology." *Economic* Perspectives (1999). Available at http://usinfo.state.gov/journals/ites/1099/ijee/bio-hoban.htm, Retrieved 15 September 2000.

Hoban, T. J. and J.D. Miller. "Consumer images and impressions." Paper presented at the Annual Meetings of the American Association for the Advancement of Science, Philadelphia, PA, 1998.

Hoban, T.J., and L.D. Katic. "American Consumer Views on Biotechnology." *Cereal Foods World* 43(1) (1998):20-22.

Huffman, Wallace E., Jason F. Shogren, Abe Tegene, and Matt Rousu. "Negative Information and Resistance to Adoption of New Technology: The Case of Genetically Modified Food." Manuscript, Department of Economics, Iowa State University, Ames (June 2002a).

Huffman, Wallace E., Jason F. Shogren, Abe Tegene, and Matt Rousu. "Should the United States Initiate a Mandatory Labeling Policy for Genetically Modified Foods?" Manuscript, Department of Economics, Iowa State University (May 2002b).

Judge, George G., R. Carter Hill, William E. Griffiths, Helmut Lutkepohl, and Tsoung-Chao Lee. Introduction *to the Theory and Practice of Econometrics* (2nd Edition), New York: John Wiley & Sons, 1982.

Kalaitzandonakes, Nicholas. "A Farm Level Perspective on Agrobiotechnology." *Agricultural Outlook Forum* (1999):525-528. Presented February 23, 1999.

Kamaldeen, Sophia, and Douglas A. Powell. "Public Perceptions of Biotechnology." Food Safety Network Technical Report #17. Department of Plant Agriculture, University of Guelph, 16 August 2000.

Lusk, Jayson L., and John A. Fox.. "Consumer Demand for Mandatory Labeling of Beef From Cattle Administered Growth Hormones or Fed Genetically Modified Corn." *Journal of Agricultural and Applied Economics* 34(1) (April 2002):27-38.

Lusk, J.L., J.A. Fox, and C.L. McIlvain. "Consumer Acceptance of Irradiated Meat." Food Technology 53(March 1999):56-59.

Lusk, J.L., J.A. Fox, T.C. Schroeder, J. Mintert, and M. Koohmaraie. "In-Store Valuation of Steak Tenderness. *American Journal of Agricultural Economics* 83(3) (August 2001a):539-550.

Lusk, J.L., M.S. Danield, D.R. Mark, and C.L. Lusk. "Alternative Calibration and Auction Institutions for Predicting Consumer Willingness to Pay for Nongenetically Modified Corn Chips." *Journal of Agricultural and Resource Economics* 26(1, 2001b):40-57.

Lusk, Jayson L., Melissa Moore, Lisa O. House, and Bert Morrow. "Influence of Brand Name and Type of Modification on Consumer Acceptance of Genetically Engineered Corn Chips: A Preliminary Analysis." *International Food and Agribusiness Management Review* 4(2002):373-383.

Persley, Gabrielle J., and James N. Siedow. "Applications of Biotechnology to Crops: Benefits and Risks." Council for Agricultural Science and Technology Issue Paper No. 12 (December 1999), 8 pages.

Roper Starch Worldwide Inc. "Consumer and Farmer Opinions about Food and Agriculture." Philip Morris Management Co. (11, Jan. 2000).

Rousu, Matthew, Wallace E. Huffman, Jason F. Shogren, and Abebayehu Tegene. "The Value of Verifiable Information in a Controversial Market: Evidence from Lab Auctions of Genetically Modified Foods." Staff Working Paper, Iowa State University, Department of Economics, Series Paper #3, (February 2002).

Uzogara, Stella G. "The Impact of Genetic Modification of Human Foods in the 21st Century: A Review." *Biotechnology Advances* 18 (2000):179-206.