EFFECTS OF ENVIRONMENTAL IMPACT INFORMATION ON WILLINGNESS TO PAY FOR GENETICALLY MODIFIED PRODUCTS

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ABSTRACT
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The use of genetically modified crops has increased in U.S. agriculture. There is limited information available about consumer willingness to pay for genetically modified food products. Firms throughout the marketing channel will benefit from this information and from that regarding consumer knowledge or perceptions about biotechnology. An experimental auction was conducted using muffins, cookies, and chips. Participants were provided positive, negative, or no information regarding the effects of genetically modified crops on the environment. A tobit regression was used to analyze whether this impact information, attitudes, or socioeconomic characteristics affect willingness to pay.

Results indicate that, overall, pro and con information had effects contrary to economic theory but influenced specific groups of people in a way consistent with expectations. Thus, promotional marketing efforts could be effective for specific groups of people.
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CHAPTER I. INTRODUCTION

History

Some experts argue that genetic modification has been used since the beginning of time because farmers have always bred animals and plants to emphasize specific attributes. Technically, biotechnology did not evolve until the 20th century. The first food to enter the market with genetically modified (GM) components was potato chips in 1967. They were made with indoor grown GM Lenape potatoes, a variety with high solids content. This characteristic improved their value for producing potato chips (Uzogara, 2000). In 1987, the first outdoor test of GM crops took place (Franks, 1999). The FDA approved the Flavr Savr Tomato in 1994. This was the first whole GM food, as opposed to foods with GM components, available to consumers in the market (Uzogara, 2000). By 1996, twenty-three crops were approved for production in the United States (Franks, 1999). During this year GM corn, soybeans, potatoes, tomatoes, and cotton were extensively produced (Hoban, 1997b).

Agricultural biotechnology continues to grow in use and scope of application. The three major GM crops grown today, corn, soybeans, and cotton, were commercialized in 1995 (Kalaitzandonakes, 1999). By 1999, 52% of soybeans, 30% of corn, 9% of cotton, and 9% of canola grown worldwide were GM (Uzogara, 2000). These crops were grown on approximately 100 million acres of which approximately 71% were in the United States (Ervin et al., 2000). By 2001, 69% of cotton, 68% of soybeans, 55% of canola, and 26% of corn grown in the United States were GM (USDA, 2001). As a result, numerous food
products retailed today contain GM ingredients. Some of these include milk, bread, honey, cereals, peanut butter, cookies, and chips (Uzogara, 2000).

The GM varieties currently used in the United States include, among others, Bt corn, Bt cotton, Bt potatoes, RR cotton, RR soybeans, BXN cotton, Liberty Link oil seed rape, and Liberty Link corn (Carpenter and Gianessi, 2001 and Franks, 1999). Bt stands for *Bacillus thuringiensis*, which makes the crop toxic to specific pests. RR stands for Round up Ready, which makes the plant resistant to Round Up, and Liberty Link crops are resistant to Liberty Link. These burn-down herbicides can be applied to kill most unwanted plant species. Cotton specified as BXN, is tolerant to bromoxynil, a post-emergence broadleaf herbicide (Carpenter and Gianessi, 2001).

**Need for the Study**

As application of GM in crop varieties grows and expands in scope, participants from throughout the marketing channel face new opportunities, challenges, and risks associated with the development, use, and handling of the resultant products. These individuals will be called on to make strategic decisions regarding the use of biotechnology and products produced with and containing inputs resulting from biotechnology. They must decide whether the long-term benefits associated with use of biotechnology will outweigh the long-term costs, and whether the associated risks are acceptable.

For example, growers are faced with decisions about whether or not to grow GM crops. Biotechnology companies must make investment decisions including research, commercialization, and marketing of GM technologies, organisms, and products resulting from their use. Food manufacturers must consider use of commodities produced with
biotechnology and determine labeling and promotion strategies for food products including, or not including, commodities of GM origin. In addition, consumers have new choices associated with food and other products produced with biotechnology. The aforementioned and other stakeholders will benefit from information about consumer acceptance of biotechnology and factors influencing such. This information will facilitate decision-making and reduce associated risks.

Many U.S. consumers have heard little about the benefits or risks associated with biotechnology and, in fact, are not well educated about today’s production agriculture in general (Roper Starch Worldwide, Inc., 1999). Acceptance by consumers and participants at each step in the marketing channel is paramount to the commercial success of products including GM ingredients or developed using biotechnology. However, despite several studies during the past decade about GM crops and resulting products, there is little information available about the willingness of consumers and other market participants to purchase GM food products. Another void in research is how individuals and firms decide if they will buy, and how much they will spend on, these products. Firms that must decide whether to use GM components in their products are not fully informed about what consumers think or how much they know about products that contain GM ingredients. In part, this is because consumers are not well informed about biotechnology, and in part because available market research is limited.

**Purpose**

The objective of this thesis is to determine the differential in willingness to pay for food products with ingredients produced from biotechnology as compared to those without.
One of the most predominant topics in the biotechnology debate is how its adoption will impact the environment. There are numerous special interest groups that are concerned about the impacts biotechnology has or may have on the environment. Many of these groups are entirely against the production of GM organisms because they believe only harm can be done to nature with the advance and use of biotechnology. However, there are also proponents who believe that environmental benefits associated with the use of biotechnology do exist. A review of the literature will show that willingness to pay by consumers can be motivated by the scope and nature of information available to them about the environmental effects of biotechnology.

Specifically considered in this study, will be the effects information about the influence of biotechnology on the environment has on consumers’ willingness to pay for food products produced with and without biotechnology. An experimental auction will be conducted to test willingness to pay for GM versus non-GM containing food products between groups exposed to no, negative, and positive information about the relationship between biotechnology and the environment.

The objectives are as follows:

1. Gauge the level of knowledge regarding biotechnology in agriculture within a selected group of consumers.
2. Determine if what consumers are willing to pay for GM versus non-GM-containing food products is influenced by the bias of the information they receive about the effects of biotechnology on the environment and their attitudes and socioeconomic characteristics.
The conclusions will be useful for firms in decision-making in two ways. First, they will provide information about how consumers respond in the marketplace to information about how a product and/or its ingredients were produced. Second, information differentiating consumers based on their response to specific information about GM products and the potential implications to them, society, and the environment will help firms make market segmentation and promotion decisions. Food manufacturers and other firms in the marketing channel armed with information identifying the attitudes of one or more market segments about environmental issues and their socioeconomic characteristics, will be better prepared to evaluate the costs and benefits associated with use of GM ingredients. Thus, they will be able to make better decisions about how to market these products. More promising promotion and advertising strategies and decisions regarding the use of biotechnology and its resultant food product inputs will be identified as results of this research.

**Organization**

Chapter 2 includes a review of the literature related to agricultural biotechnology. Methods used to assess demand for products produced with biotechnology are presented in Chapter 3. Included is a brief discussion of the methods used by social scientists to predict consumer behavior and justification for, and details of, the methods employed in this thesis. Results of this research are presented in Chapter 4. Conclusions and implications for the strategic behavior of agribusiness firms are discussed in Chapter 5.
CHAPTER II. LITERATURE REVIEW

Introduction

The literature review includes a discussion of terms and definitions related to genetically modified organisms (GMOs), a brief history of biotechnology, an overview of public perceptions with regard to GMOs, a discussion of various biotechnology issues, and the actual or perceived risks and benefits associated with the use of biotechnology.

Terms and Definitions

A discussion of the literature regarding biotechnology necessitates a review and clarification of associated terminology. There are a number of terms used throughout the literature and popular press to describe biotechnology. Technically, biotechnology is 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, 1999). Selective breeding, one form of agricultural biotechnology, includes exchanging genetic material between two plants to get a plant with desired traits (Persley and Siedow, 1999).

A more commonly accepted definition of biotechnology today is taking a fragment of deoxyribonucleic acid (DNA) that has a specific gene from one organism and placing it into another organism, usually a plant. This technique is referred to as recombinant DNA technology. Another term frequently used to describe this process is genetic engineering (Persley and Siedow, 1999). Genetically modified organisms, or GMOs, are organisms that have been modified using genetic engineering. Plants that have been tailored with
DNA technology are sometimes called transgenic plants (Persley and Siedow, 1999). Other terms used are genetic enhancement and cloning. Negative terms associated with this topic are Frankenfood and Farmageddon (Uzogara, 2000).

Terms used to describe biotechnology have an important affect on how people perceive associated products, and therefore may influence their acceptability. A 1998 survey tested the use of various terms (Hoban, 2000b). Consumers favored the following terms with regard to the biotechnology issue, animal/plant biotechnology and genetically enhanced animal/plant products. Consumers did not prefer the terms genetically engineered, cloning, transgenic animals/plants, or genetically modified organisms.

**Public Perceptions**

Identifying public perceptions of biotechnology has been the objective of a number of studies in recent years. Assessment of the level of awareness and understanding among consumers, as well as how biotechnology influences their purchasing behavior are important to participants from throughout the marketing channel, including farmers, agribusinesses, and food processors. Hoban and Katic (1998, p. 20.) say it well “Awareness and acceptance of food biotechnology do not go hand-in-hand, consumers must be educated to understand the technology before they will accept products derived from it.”

**Worldwide acceptance of biotechnology**

Acceptance of GM food varies greatly worldwide. Attitudes about agricultural biotechnology are most positive in the United States, Canada, Finland, Italy, Japan, Portugal, and the Netherlands. Countries with negative attitudes are Austria, Denmark, Germany, and Sweden (Hoban, 1999). England and France also have become unreceptive
to biotechnology during the past few years. On the other hand, 67-75% of American consumers are optimistic about biotechnology.

As of 1995, surveys showed awareness of biotechnology to be high in Germany, Austria, Denmark, Japan, Canada, and the United States. It was considerably lower in Spain, Greece, Italy, and Portugal (Hoban, 1997). The same surveys indicated willingness to buy foods produced by biotechnology was highest in Canada, the United States, Portugal, Japan, and the Netherlands. Countries where people were less willing to purchase such products included Austria, Germany, Luxembourg, Norway, Ireland and Sweden.

Acceptance of biotechnology in the United States

One study that considered biotechnology perceptions within an individual state took place in New Jersey. Hallman and Metcalfe surveyed 604 New Jersey residents by telephone in May of 1993. Sixty-one percent of residents reported approving of genetic modification of plants, while only twenty-eight percent approved of genetic modification of animals. Twenty-seven percent strongly agreed with the statement, “We have no business meddling with nature”. Thirty-one percent strongly disagreed. Regarding the application of biotechnology, most New Jersey residents strongly approved of using it for curing human diseases and growing more nutritious grain to feed poor countries. When asked about quality of life, more than two-thirds of residents thought genetic modification would improve life “much” or “somewhat”.

Other surveys have elicited more geographically broad perceptions of U. S. residents about agricultural biotechnology (Hoban and Katic, 1998). The U.S. Department of Agriculture funded the first biotechnology perception survey in 1992. Subsequent
surveys were conducted in 1994, 1995, and 1996. A national consumer survey by the International Food Information Council (IFIC) was conducted in 1997. Hoban and Katic concluded from surveys during the 1995 to 1997 period, that Americans were willing to buy vegetables and fruits that are end products of biotechnology (1998). Hoban and Katic divided biotechnology into two categories, 1) modified to be resistant to insects and use less pesticide and 2) modified to taste better or fresher. They found that approximately three-quarters of residents surveyed would purchase the first and about two-thirds would purchase the second.

Results from a 2000 survey by Angus-Reid show the majority of American consumers accept biotechnology in various applications (Hoban, 2000b). Fifty-one percent of Americans were found to be in favor of insect protected crops, which are a major type of GM crops grown in the United States presently. These results concur with those of Hoban and Miller (1998) who found that 66% of those American consumers surveyed supported encouraging insect protected crops and 58% approved of additional uses of biotechnology that improve foods. A 2000 survey by the Grocery Manufacturers Association (GMA) showed similar results. Seventy-five percent or more of American consumers surveyed indicated that they support applications of plant biotechnology that lead to more nutritious foods, foods that stay fresh longer, foods that contain vaccines, and crops that require less water. In the same survey, only 5% of respondents said they had taken action due to concerns associated with GM foods (Hoban 2000c).

In a nation-wide telephone survey in 2000 by Roper Starch Worldwide Inc., on behalf of The Philip Morris Management Co. and The American Farm Bureau Federation, 1,002 adult consumers and 704 farmers were questioned about the acceptability of
biotechnology in farming to improve the size, appearance, or quality of food. Seventy-three percent of consumers reported a willingness to accept the use of agricultural biotechnology as a tradeoff for not using chemicals in food production. A majority reported that its use is always or sometimes acceptable although a non-insignificant percent considered its use never acceptable.

### Table 2.1. Acceptance of biotechnology use

<table>
<thead>
<tr>
<th>Question</th>
<th>Always Acceptable</th>
<th>Never Acceptable</th>
<th>Sometimes Acceptable</th>
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<tr>
<td>improve taste is</td>
<td>10</td>
<td>25</td>
<td>47</td>
</tr>
<tr>
<td>improve production is</td>
<td>17</td>
<td>16</td>
<td>48</td>
</tr>
<tr>
<td>improve nutrition is</td>
<td>18</td>
<td>12</td>
<td>51</td>
</tr>
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</table>

**Consumer awareness**

Consumer awareness of biotechnology has increased since 1995, although there still remains some degree of ignorance about the existence of food products resulting in part from biotechnology (Roper Starch Worldwide, Inc., 2000). In the 1997 IFIC survey, 40% of respondents said they believed that GM products could be found in supermarkets while 37% said they could not, the remainder did not know (Hoban and Katic, 1998). At this time period there certainly were numerous GM foods available in supermarkets.

The 2000 Roper Starch Worldwide Inc. telephone survey questioned interviewees about biotechnology in food and agriculture. When asked about biotechnology in crops to improve resistance to pests, production, or other qualities, 41% of respondents stated that
they did not know anything about this topic. Thirty-seven percent said they had heard more about related benefits and 17% had heard more about associated drawbacks. When asked about the effects of biotechnology on the healthfulness of food, 18% of respondents said it is harmful, 41% said it is beneficial, and 38% percent said they don’t know.

Americans have also been surveyed about the risks and benefits they believe are linked to GM foods. An Angus-Ried (2000) survey reported the highest perceived benefits by American consumers to be better productivity and yields, better quality foods, less pesticide use, and health/nutrition improvements. Risks Americans saw associated with GM foods are concerns about the safety of the food and its impact on human health, fear of the unknown, and virus mutations (Hoban, 2000c).

The Roper Starch Worldwide Inc., telephone survey (2000) reported United States consumers and farmers agreed that the agricultural industry could improve communication about risks and benefits associated with various farming applications. Although 47% of consumers and 45% of farmers thought the agricultural industry is doing a fair job of communicating benefits and costs, 24% and 22% respectively, thought they were doing a poor job.

**Labeling perceptions**

Perceptions about labeling GM foods have been considered. Hansen (1999) reviewed the following studies with regard to GM product labeling and found interesting correlations. Hansen cited Hoban and Kendall who found that 85% of the American people polled in their 1992 effort thought it was very important for GM products to be labeled. A concurring survey by Maki (1995), who surveyed 36,000 consumers, found 92% wanted GM foods to be labeled. Hallman and Metcalfe (1993) found that 84% of
New Jersey residents polled thought GM fruits and vegetables should be labeled. A Novartis sponsored survey in 1997 also concluded that most Americans want clear labels on foods that are GM.

A 2000 survey of 697 Vermont residents by The Center for Rural Studies at the University of Vermont also underscored the importance of the labeling issue. A majority of respondents reported reading food labels always or most of the time, being concerned about GMOs in food and agricultural products, and being ready to stop buying products if they were labeled as containing GMOs. A large proportion of respondents stated they would be willing to pay more for products that were guaranteed to be GMO-free (Center for Rural Studies, 2000).

**Public perception conclusions**

There are several factors that influence consumer’s perceptions and awareness of biotechnology. Hoban and Katic (1998) found that men have greater awareness of biotechnology than do women and that education has a positive impact on both awareness and acceptance of the benefits associated with biotechnology. They also found that younger consumers and those who had read about or otherwise heard about biotechnology were more willing to buy GM foods.

From consumer surveys on biotechnology acceptance over the past ten years, Dr. Tom J. Hoban has concluded that support for biotechnology will result from 1) recognizable benefits, 2) low level of risk, 3) moral acceptance by society, and 4) a high degree of confidence in third party experts (Hoban, 1998e).
Biotechnology Issues

A discussion of the issues related to the development, adoption, and use of biotechnology is categorized into food safety and regulation, ethics, environmental impacts, and benefits.

Food safety and regulation

A major issue involved in the biotechnology controversy is whether appropriate regulation to ensure food and environmental safety exists and whether it can and is being enforced. A three-agency system regulates the biotechnology industry in the United States. The three agencies are the Animal and Plant Health Inspection Service (APHIS, an agency of the United States Department of Agriculture), the Food and Drug Administration (FDA), and the Environmental Protection Agency (EPA) (USDA, 2000). The APHIS regulates the field-testing of GM plants and some microorganisms. The FDA controls the labeling and safety of drugs and food, except for meat and poultry. The EPA controls the use of pesticides and herbicides to ensure environmental safety (USDA, 2000). The regulatory approach to the use of biotechnology has been complicated. The initial question was whether existing jurisdictions and regulations covered regulation of biotechnology processes or resulting GM products, or rather if it was a new kind of technology that did not fit under existing regulations. If genetic modification in fact were a new form of biotechnology, new legislation would need to be created.

A second question was whether to regulate the process of genetic modification or the products of genetic modification (Lynch and Vogel, 2000). The government’s decision to regulate products of genetic modification was based, in part, on a report from the National Research Council (Lynch and Vogel, 2000).
Currently the United States has a voluntary GM product labeling policy. Products are required to be labeled only if the products are not “substantially equivalent” to non-GM products (Ervin et al., 2000). Otherwise companies will label their products GM only if the benefits of doing so exceed the costs. Other countries such as Japan, the European Union, Australia, and New Zealand have adopted a mandatory labeling policy for GM products (Caswell, 2000). Mandatory labeling is controversial because it is a "right to know" issue for some consumers, rather than a safety issue (Franks, 1999).

Intellectual property rights are also a problem in the biotechnology arena. The United States permitted GM crops to be patented beginning in 1980 (Franks, 1999). Patents are important because they can promote or demote the development of GM crops. Patents influence market structure and competition. Franks (1999) noted that technological innovation and knowledge are non-rival and non-excludable, which means they can be used by anyone at any time and cannot be charged. This would make biotechnology development unprofitable for most firms. However, development in this area can be made rival and excludable with patent laws.

Ethics

Exponential growth of the world’s population will also require a corresponding increase of food. Biotechnology is a possible answer to the dilemma of how to feed an ever-increasing population. Dron and Weil (1997, p. 240) state, “there is no way that the required increase in productivity could be reached without a technological breakthrough”. It is an ethical issue whether to use biotechnology in order to help feed the poor countries of the world while sparing the limited land resource. In addition to increasing the quantity of food available, biotechnology has the potential to create crops with additional nutritional
characteristics which will help decrease problems of malnutrition and deficiency disorders (Persley and Siedow, 1999).

The basic idea of modifying genes in plants and animals has been utilized for centuries (Hoban and Katic, 1998). Farmers and ranchers and their supporting industries have continually attempted to breed the best crops and the most efficient livestock. This is the concept behind biotechnology. Agricultural biotechnology simply allows dominant, desired characteristics to be put into a plant or animal with accuracy, speeding the traditional process of plant and animal selective breeding. Yet, some people believe it is unethical to modify nature in any way, shape, or form. They think biotechnology induces people to “play god”, which could lead to irreversible travesties.

There are numerous negative biotechnology campaigns by various groups that are highly publicized. To facilitate societal debate, it is critical for scientists and other experts to be involved in discussions regarding the role of biotechnology and present the public with honest facts (Dron and Weil, 1997). Consumer and social education will improve the ability of participants to make value judgments based on objective facts. Education is particularly important in industries like agriculture where there is a demonstrated level of ignorance and misconception. Consumers should be educated about how biotechnology is used in agriculture and food production. Many consumers take food for granted unless they hear about an associated problem (Hoban and Katic, 1998).

Another ethical issue related to biotechnology is a gap increase between the rich and the poor (Persley and Siedow, 1999). This could occur if biotechnology companies or large agricultural producers receive all the benefits of biotechnology, while poorer
producers and consumers receive none. Care needs to be taken to ensure the greatest number possible benefit from this technology.

Finally, there are questions of the unknown. Uncertainty does exist with regards to GM plants. There is always a possibility of mutation, relocation, and damage to the environment. Some people believe this matter is of concern to society and the environment, and could lead to unforeseen externalities. Therefore, it is important to continue with research in this area.

**Environmental concerns**

Possible effects of biotechnology on the environment are a concern. Stakeholders have a variety of divergent opinions about what effects this advanced science has had or will have on nature. A great deal of public attention arose from the publication of laboratory test results about the effect of Bt corn pollen on the survival rate of monarch butterfly larvae. Research found that monarch larvae that come in contact with and ingest pollen from Bt corn have a 44% mortality rate opposed to a 0% mortality rate from feeding on leaves with non-Bt corn pollen (Losey et al., 1999). The results of this study, implying that Bt corn will harm the monarch butterfly, have been questioned by a number of scientists. Monarch butterflies and their larvae feed only on the milkweed plant. Therefore, in order for the Bt corn pollen to be harmful to them in nature, milkweed plants would have to be on the edge of the field or in the field where the Bt corn is being grown. The United States Department of Agriculture (2000) states that corn pollen is heavy and does not move far from the plant of origin. This pollen is produced only for a short time during the corn production cycle.
There are various public interest groups such as Friends of the Earth and Greenpeace that strongly oppose GM foods on environmental grounds (Huffman and Tegene, 2000). Certain environmental groups are actively engaged in actions to slow or stop the use of biotechnology in agriculture. For example, Greenpeace challenged the EPA's release of Bt crops in a lawsuit (Huffman and Tegene, 2000). Fifty organizations, including Greenpeace, signed a petition in March of 2000 asking the FDA to remove GM foods from the market (Huffman and Tegene, 2000).

Certainly, methods used for any food production may affect the environment. Organic foods are popular in Europe, and gaining popularity in the United States. People purchase and consume these organic foods because they are all natural. Many consumers therefore assume organic foods have certain unique characteristics like improved food safety, and that production of these organic crops has a positive environmental impact. It is widely believed that organic foods are grown without the use of pesticides. In reality, pesticides that are considered “natural” can be used in organic crop production (Hoban 2000a). Food products that are GM or have GM ingredients currently go through more testing and government regulation than organic foods (Hoban, 2000a). There are safety concerns associated with all foods, whether they are grown organically, traditionally, or with use of biotechnology.

Any impact that GM crops may have on the environment will depend on various factors including 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., 2000). These variables can exhibit interdependency in influencing environmental impact. Specialized scientists are relied on to study these variables and the resulting
impact on the environment. Currently there is $6.9 million in funding for research on biotechnology risk assessment. This monetary value is only about four percent of the money available for public agricultural biotechnology research (Ervin et al., 2000). Clearly money for assessing the risks associated with biotechnology is an obstacle in providing significant results.

Additional environmental risks have been identified in the literature. Production of GM crops could result in "genetic pollution" in non-GM crops (Franks, 1999). Corn is one such plant since it cross-pollinates, and GM varieties could pollute non-GM corn (Ando and Khanna, 2000). There is the potential for "Super-weeds" to result from GM crops that are virus or herbicide resistant (Ando and Khanna, 2000; Franks, 1999). Changes in the ecosystem network would result from elimination of specific species (Franks, 1999). Franks also mentions the problem of liability for crop damage to neighboring fields.

Consumers are also concerned about possible viruses and mutations to plant and animal species that could occur with biotechnology (Kamaldeen and Powell, 2000). The wide-use of Bt cotton and corn could lead to insects that are resistant to insecticides and harmful to non-target birds or insects (Persley and Siedow, 1999). Other risks identified in the literature not directly related to environmental effects include human consumption of toxins or poisons from GM foods and creation of new viruses (Uzogara, 2000).

**Benefits associated with biotechnology**

There are also existing and potential benefits associated with biotechnology. These benefits do or can accrue to various participants. Kamaldeen and Powell (2000) state there could be an increase in profits for potentially everyone involved in the agriculture market. Some benefits for producers include lower costs, easier management, and higher yields
(Carpenter and Gianessi, 2001). Carpenter and Gianessi argue that there is a reduction in pesticide use related to GM crops, which benefits not only farmers, but also the environment (2001). Franks (1999) notes that genetic modification could increase the quality of existing commercial crop varieties and could increase the geographical boundaries where these crops are able to grow and thrive. Biotechnology can improve the nutritional characteristics of crops for use in food (Kamaldeen and Powell, 2000). For example, biotechnology may improve shelf life or increase certain nutritional characteristics for resulting foods such as protein or carbohydrate content.

Agricultural biotechnology has other potential environmental benefits. Some include reduced use of irrigation water, fewer or less potent energy and air emissions, “environmentally friendly” weed and insect management, and value-added products. GM crops potentially could be raised for new markets, such as renewable energy sources to replace petroleum-based products (Franks, 1999). Biotechnology also has potential environmental advantages such as bioremediation, which clears heavy metals from the soil and allows for conservation of natural habitat based on increased crop yields or more productive land (Uzogara, 2000). While all of these things are positive, there is little evidence that supports these benefits significantly influence how agricultural production impacts the environment.

**Conclusion**

The benefits and risks associated with biotechnology are shared among the public and private sectors. Farmers, biotechnology companies, and firms that utilize GM products
or ingredients observe benefits of biotechnology. Most of the risks associated with genetic modification are unobservable, but potentially worrisome to consumers.

There are varying levels of knowledge about biotechnology and resulting GM products among consumers. Groups and individuals speak out to promote or demote the use of biotechnology in order to influence consumers or other market participants. One issue that is commonly debated and used to persuade the public is affects of biotechnology on the environment. Research that determines how environmental impact information affects consumer's willingness to pay for food products would be beneficial to companies that use GM ingredients and to special interest groups and individuals that enforce environmental impact information onto the public.
CHAPTER III. METHODS

Introduction

Decisions to buy GM products are based on the purchaser’s information. This chapter reviews previous research using experimental auctions to evaluate consumer decisions regarding food products. It also presents the methods used in the current research to assess willingness to pay for food products containing ingredients from GM commodities and how willingness to pay is influenced by environmental information provided to the decision-maker.

Literature

The current study will closely parallel that of Huffman et al. (2001). Huffman et al. focused on how labeling options and asymmetric information affect willingness to pay for food products that may contain GM ingredients. The literature on biotechnology issues including ethics, labeling, safety, regulation, use of GM crops in the United States and other countries, and public perceptions of GMOs discussed in Chapter 2 overshadows the much more limited body of literature on the use of experimental auctions or other methods to assess willingness to pay for food products made with or including GM components.

Fox et al. (1994) measured consumer willingness to pay for milk from cows that were not given bovine somatotropin (bST). This study used a Vickrey sealed-bid, second-price auction where the bidder secretly bids and the highest bidder purchases the product at the second highest price. The experiment had two stages. In the first stage, an auction of candy bars was used to teach participants the method used in the auction. There were five bidding rounds and each participant submitted a bid for each. The second stage utilized
milk. This stage consisted of twenty trials where the participants bid how much they would be willing to pay to trade their glass of milk produced by a cow given the bST hormone milk for a glass produced by a cow not given bST. After the tenth trial, participants were provided with factual information regarding bST. There was more variance in the bids prior to the providing of information on bST (Fox et al., 1994). Results of the experiment show positive average bids to trade bST milk for non-bST milk. After reading bST facts, the bids leveled out and became more similar.

Melton et al. (1996) conducted an experimental auction to determine consumer preferences for products that have multiple quality characteristics. This study was conducted to determine what attributes contribute to the value of pork chops. The multiple characteristics analyzed in pork chops were color, marbling, and size. Each of these characteristics is observable to the consumer. A second-price, ascending bid auction was utilized, where the highest bidder purchases the pork chop at the second highest price. After each round, the participants were told the highest bid and then could increase their bid. This continued until participants stopped increasing their bids. There were thirty-three participants, each of whom were primary shoppers of households that consumed meat. Each participant bid on and evaluated eight pork chops differing with respect to color, marbling, and size, and also evaluated the chops after tasting them.

This auction consisted of five phases where participants went through a practice round, evaluated pictures and fresh pork chops, bid on pictures and fresh pork chops, then tasted and bid on pork chops. Consumers were given $20 for participation in this study. Results showed differences in attributes of pork chops significantly explained differences in their value to consumers. The experimental auction method was effective in revealing
differences in the value of a product differentiated to consumers by only a small set of characteristics, such as the color, marbling, and size of pork chops. In addition, the matter in which products in the auction were presented affected prices. People placed a different value on pork chops depending on which attribute was examined first. For example, pork chop size had a positive marginal value on bids before participants tasted the meat, but when the meat was tasted first, size was found to be insignificant.

Umberger et al. (2000) conducted an experimental auction in June 2000. The purpose of this study was to identify whether or not consumers can recognize flavor differences in beefsteaks, and if consumers are willing to pay a premium for their preferred flavor in beefsteaks. This study utilized a fourth-price Vickrey auction to find true willingness to pay by consumers. Based on the commonly used second-price Vickrey auction, this method used the fourth highest bid to determine the market price where the top three bidders purchase the steak at that price. There were two auctions; each one had 124 participants who were given $25 or $35 for participating. Two practice auctions were used to teach participants how the auction worked. Participants first tasted six steaks, then rated the steaks based on various traits. The study concluded that consumers differentiate between steaks with different degrees of marbling and different flavors. Consumers were willing to pay a higher amount of money for steak with characteristics that they prefer. This information may be particularly beneficial for firms that produce branded beef products and wish to price their products at premium prices.

Huffman et al. (2001) conducted two experimental auctions in April of 2001 in order to assess the effects of biotechnology information (positive, negative, and verifiable) on consumer's willingness to pay for food that may contain GM components. The results
would determine the effect the three different types of information had on willingness to pay based on the absence or presence of GM labels. This study took place in Des Moines, IA, and it was repeated in St. Paul, MN. Seventy-eight people participated in Des Moines, and 96 people participated in St. Paul. Each person received $40 for his or her participation. There were six experimental units at each location, each consisting of 13 to 16 participants.

This study utilized a random nth-price auction where each of the bidders submits a bid for a product, the bids are ranked from highest to lowest, and a random number (n) is selected between 2 and the number of participants. Then the good is sold to each of the (n-1) bidders at the nth price, so the bidders pay what they bid for the product or, more commonly, less. The nth-price auction closely parallels the Vickery second-price auction. These auctions capture the participant's true value for a product because overbidding may result in the participant having to pay more than the value they attribute to the product, and bidding too low may result in their missing out on a lucrative purchase. The main problem with the Vickrey second-price auction is that it fails to disclose the complete demand curve for the auctioned item for all the participants. People who might believe their bid is way above or below the market-clearing price, adjust their bid. This means some of the bids are not sincere.

The nth-price auction corrects for this problem. This method discloses more of the demand curve for an item by attracting bidders who might be off the margin. This auction method has two important components. The nth-price auction is 1) random and 2) endogenous. Because the nth-price is randomly selected, all bidders have the same positive probability of purchasing the item. This element is designed to engage all bidders to
participate using their true value for the item. The price is endogenous because the market-clearing price has some relation to the participants’ individual values of the product. Huffman et al. (2001, p. 10) states, "Each bidder should bid sincerely because he/she cannot use a random market-clearing price as a marker, and they all should be engaged because everyone has a chance to buy a unit of the good."

The products used for their study were tortilla chips, vegetable oil, and bags of potatoes. There were two rounds in the auction. In one of the rounds, participants bid on the three products that had a standard food label. In the other round, they bid on the same products, but the label indicated the food was GM. The sequence of rounds where participants bid on GM versus standard products was randomized. To prevent the problem of bid prices being reduced as participants moved along their individual demand curve, only one of the two rounds was chosen as the binding round. That is, participants recognized that they would be able/required to purchase products from only one of the two rounds.

Results of this study indicate that participants were willing to pay more for the product that was not GM than for the product that was labeled GM. Also, people who bid on food with the GM label in the first round paid a smaller premium for food with a standard label than the people who bid on food with a standard label first. This means the sequence in which consumers bid on the food items influenced how much they would pay for GM food.

**Auction Design**

For the current research, a nth-price experimental auction was also used to collect data on consumer willingness to pay for foods with and without GM ingredients. One
hundred twelve students from North Dakota State University (NDSU) were recruited to participate in the auction. Dr. Daniel Klenow from the NDSU Sociology department recruited students for participation. Monetary compensation of $15 was provided to eliminate budgetary constraints and encourage participation. Dr. Klenow used a nonprobability sample design. A sample of convenience was drawn from the NDSU population. A participation form was handed out to students in anthropology, sociology, and communications classes. Students who wished to participate filled out the bottom section, indicating the time they were willing to participate, and returned it to Dr. Klenow. Participants were reminded verbally or via e-mail about the time and date of their experimental auction. A fourth auction was conducted in an agribusiness class with majors in Agribusiness, Crop and Weed Sciences, and Agricultural Systems Management to increase sample size. Approximately 33 participants participated at three different time periods over a period of two days, and the fourth auction conducted a week later included seventeen students. The auctions took place at 7:00 p.m. on Tuesday, February 5, 2002, 10:30 a.m. and 1:00 p.m. on Wednesday February 6, 2002, and 11:00 on Thursday, February 14, 2002.

Each participant received a packet that included step-by-step instructions and necessary information. (Appendix A). Moderators reviewed the instructions orally with the participants. The information explained the purpose of the experiment and provided detailed instructions to guide them through the process.

The products bid on by participants were muffins, chocolate chip cookies, and potato chips. All of these products have ingredients (e.g., wheat, corn, oil), which can be grown with GM seed, and are commonly produced in North Dakota. Participants bid on
two variations of each of the three products discretely; one GM and one non-GM. The products were verified as being non-GM or regular using two different labels. One label was a standard nutritional label with the statement "This product does not contain genetically modified ingredients", while the second label was identical except it did not contain the non-GM statement. (Appendix B). The labeling method used for this study differs from the one utilized by Huffman et al. Huffman et al. used two versions of each product. One version was a standard nutritional label and the second version indicated that the product did contain GM ingredients.

The words for the labeling method were chosen carefully. The United States currently has a voluntary labeling policy for food products that do contain GM ingredients. Because of adverse controversy and public ignorance, it likely would not be a profitable strategy for companies to label food products as containing GM ingredients. On the other hand, it may be a positive strategy for companies that produce products that guarantee no GM ingredients to market them as such. This supports the enlisted label strategy adopted for the auction of labeling non-GM products with, "This product does not contain GM ingredients".

A short practice round was conducted before the actual auction. Participants bid on candy bars, cards, and pens to learn the process involved in the experimental auction. For the actual experimental auction, there were two rounds. During the first round, participants bid on the GM and non-GM variety of cookies, muffins, and chips. The students then were provided and instructed to read pro, con, or no information about the effects of biotechnology on the environment. (Appendix C). The information was not identified as biased. Participants then again bid on the six food items in the second round.
The products used in the auction were selected to meet a number of key criteria. First, consumers regardless of demographic characteristics universally purchase them. They all contain oil, which could be GM or not. The oil in these products, and that indicated on the label, was soybean, sunflower, corn, cottonseed, or canola. The cookies and muffins are products made with wheat flour. Currently, GM wheat varieties have been developed but are not scheduled for commercial use. The potato chips are made from potatoes, which also could be GM. Almost all of the possible GM ingredients mentioned are crops commonly produced in, and essential to North Dakota agriculture.

The bidding method used was the nth-order, as discussed previously. Bidders privately wrote the value of each individual product on a separate slip of paper. Using the nth order auction, the n-1 top bidders were required to purchase these items at the nth bid price. In an nth order auction, all bidders (k) turn in a bid. The bids are placed in order from highest to lowest. A random number (n) is chosen between 2 and k. The top n-1 bidders purchase the good at the nth price. Thus, no participant pays more then the value they placed on the product. Never did the total cost to the participants exceed the fifteen dollars provided for their participation.

Analysis

To meet the objectives set forth in Chapter I., the following analyses will be executed.

1. Estimate willingness to pay for GM versus non-GM food products that are identical in every other way.
a. A tobit regression will be executed using price bid for products as the
dependent variable and socioeconomic and other participant characteristics,
products (cookies, muffins, and chips), whether the product was GM versus
non-GM, and type of environmental information as independent variables.

2. Identify the influence of information and socioeconomic characteristics of the
respondent and their awareness of and concern about the environment on
willingness to pay.

  Willingness to pay is determined as the difference between two expenditure
functions. Individuals have expenditure functions that indicate the minimum amount of
money they would be willing to pay for a good in order to reach a certain satisfaction level.
Every good has a collection of characteristics. People price goods based on the collection
of attributes they possess, and will pay more or less for a good depending on the
characteristics the good contains.

  Lancaster describes that utility ranks goods indirectly through the attributes or
characteristics they hold (1966). He argues that a single good has multiple characteristics,
so consumers must decide what to consume based on preferences of those attributes. When
a new good is introduced to the market, it is expected to possess characteristics similar to
another good in the market. The new good may have all the same characteristics of an
existing good but in different proportions, or it may have a completely new attribute
(Lancaster, 1966). The new or different products in this research are those that contain GM
ingredients. They have similar attributes to products already in the market, but the GM
components are different. Since "consumption technology" in the modern economy is
complex, consumers need information to make consumption decisions. When a product appears in the market that has different characteristics than existing products, the consumption technology changes and consumers weigh characteristics to make purchasing decisions (Lancaster, 1966).

Data for this research came from auction participants bidding on food products. Participants bid the value to them individually for each product. Characteristics of each product, such as not containing GM ingredients, triggered specific bid amounts depending on how the bidder ranked the characteristics. Most of the bids were positive, but some were zero.

Economists commonly have to deal with data that is somehow incomplete. When reporting values less than or greater than a specific number, the data is censored. For example, when participants bid 0 for a certain product, but the true value of the item is -1 the reported bid of 0 is not completely accurate (Judge et al., 1988).

The basic regression model is:

\[ y_i = B x_i + e_i \]

If \( y_i \geq 0 \)
Then \( B x_i + e_i \geq 0 \)
Therefore \( e_i > -x_i B \)

If \( y \) can only be greater than or equal to zero, there is a lower bound for what the error term can take on. The distribution moves right and the error term moves away from zero. This means the expected value of the error term is no longer zero, but is a positive value, which means the estimator is biased (Judge et al., 1988).
The experimental auction done for this study was actually a two-stage, decision-making process. In the first stage, participants had to determine whether or not they would bid. In the second stage, if participants did bid, they had to determine how much the product was worth. When a bid of zero occurs, it is impossible to differentiate between a person not bidding and one actually assigning the product a value of zero. A two-step tobit procedure is used to correct for data censoring.

The tobit is a single-stage maximum likelihood procedure that shifts the distribution in order to compensate for the data being limited to numbers greater or equal to zero. More specifically, a probit analysis is used to develop probabilities that bids greater than zero will be observed and then weighs participants’ willingness to pay in order to determine reliable parameter estimates (Novak, 2000).
CHAPTER IV. RESULTS

Introduction

In this chapter, empirical results are presented. Demographic information about participants and a summary of their attitudes regarding different issues are included. The willingness to pay model is described and tobit regression results are reported.

Respondent Attitudes

A pre-auction questionnaire was filled out by each participant prior to bidding on products for the experimental auction. This questionnaire is included in Appendix A. Questions regarding GM product knowledge, recycling behavior and environmental beliefs, and basic demographic questions were included in the questionnaire. Participants also filled out a short post-auction questionnaire.

Participants of the experimental auctions were all North Dakota State University students. Of the 112 students participating, 30% were sociology majors, 26% were humanities majors, and 14% were agriculture majors. (Table 4.1)
The population was nearly evenly split by gender with males comprising 50.9%, and females comprising 49.1% of participants. Most of the participants (82.1%) were single. Twelve percent had children. Twenty-five percent lived alone. Of the participants who did not live alone, the number of roommates ranged from one to ten, with one being most common.

A large majority (83%) of the population included students who grew up under the Lutheran or Catholic faith. Most (93%) of the participants were white. Nearly three-fourths (72.3%) of students had a job aside from school. A majority of the participants fell into the income categories of less than $5000 (25%) or $5000 to $10,000 (32%).

Thirty percent of participants grew up on a farm. Participants were asked to identify their hometown. They were divided into four categories: rural towns (< 1,000 inhabitants), small cities (between 1,000 and 9,999 inhabitants), large cities (between 10,000 and 100,000 inhabitants), and metropolis, including Minneapolis/St. Paul and their

<table>
<thead>
<tr>
<th>Major</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sociology</td>
<td>34</td>
<td>30.3</td>
</tr>
<tr>
<td>Humanities</td>
<td>29</td>
<td>25.9</td>
</tr>
<tr>
<td>Agriculture</td>
<td>16</td>
<td>14.2</td>
</tr>
<tr>
<td>Psychology</td>
<td>7</td>
<td>6.3</td>
</tr>
<tr>
<td>Undecided</td>
<td>7</td>
<td>6.3</td>
</tr>
<tr>
<td>Hard Science</td>
<td>6</td>
<td>5.3</td>
</tr>
<tr>
<td>Computer Science</td>
<td>5</td>
<td>4.5</td>
</tr>
<tr>
<td>Natural Resources Management</td>
<td>5</td>
<td>4.5</td>
</tr>
<tr>
<td>Business</td>
<td>3</td>
<td>2.7</td>
</tr>
</tbody>
</table>
suburbs. Just over one-third of the participants (37.5%) were originally from a large city. One-quarter each were from rural towns and small cities. Nearly ten percent were from a large metropolis. Half of the participants reported currently living in an apartment. Others reported living with their parents, in a house, or in an NDSU dormitory. (Table 4.2)

Table 4.2. Participants’ location of residence

<table>
<thead>
<tr>
<th>Location</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parents</td>
<td>8</td>
<td>7.1</td>
</tr>
<tr>
<td>House, other than with parents</td>
<td>26</td>
<td>23.2</td>
</tr>
<tr>
<td>Apartment</td>
<td>57</td>
<td>50.9</td>
</tr>
<tr>
<td>Dorm</td>
<td>17</td>
<td>15.2</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>3.6</td>
</tr>
<tr>
<td>Total</td>
<td>112</td>
<td>100</td>
</tr>
</tbody>
</table>

Both pre- and post-auction surveys included questions regarding GM product knowledge, recycling behavior and attitudes of respondents. (Tables 4.3, 4.4, and 4.5). Approximately one-quarter each reported reading nutritional labels always, frequently, occasionally, and never. Most participants believed there are more non-GM substitutes for food products always (18.3%) or frequently (56.9%).

Table 4.3. GM knowledge questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Always</th>
<th>Frequently</th>
<th>Occasionally</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often do you read nutritional labels on food products?</td>
<td>24.1</td>
<td>26.8</td>
<td>25.9</td>
<td>23.2</td>
</tr>
<tr>
<td>If a food product has GM ingredients, how often is there a substitute for that product that contains no GM ingredients?</td>
<td>18.3</td>
<td>56.9</td>
<td>20.2</td>
<td>4.6</td>
</tr>
</tbody>
</table>
Approximately 45% of the participants said they used recycled products, but only 28% reported recycling products. Over three-quarters of participants agreed that more action needs to be taken to preserve the environment. Fewer agreed that man has upset nature’s balance (28.6%) or that pesticides are poisonous and should be prohibited (17%). Overall, although participants did not reveal evidence suggesting they are active environmentalists, they did express concern about the environment in general.

Income and academic major influenced participants’ behavior and perception. Participants reporting earnings of more than $20,000 annually indicated they recycled products more often than people in each of the three lower income brackets. Natural Resources Management majors strongly agreed to somewhat agreed with the statement "more action needs to be taken in order to preserve our natural environment". As a group, they more strongly agreed than did students in other disciplines. Level of agreement with the statement “healthy ecosystems require we let nature alone" did not differ by major.

Table 4.4. Recycling behavior questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Always</th>
<th>Frequently</th>
<th>Occasionally</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often do you use recycled products?</td>
<td>12.5</td>
<td>46.4</td>
<td>31.8</td>
<td>9.1</td>
</tr>
<tr>
<td>How often do you recycle newspapers, paper, plastic, or glass products?</td>
<td>16.1</td>
<td>28.6</td>
<td>25.0</td>
<td>30.4</td>
</tr>
</tbody>
</table>
Participants were asked how well informed they were regarding GM foods. Nearly a combined two-thirds said they were only somewhat informed (48.2%) or not informed at all (15.2%). Only eleven percent combined considered themselves extremely well informed (2.7%) or well informed (8%). Participants majoring in Crop and Weed Science, Animal and Range Science, and Natural Resources Management thought themselves to be better informed regarding GM food than those majoring in Business, Computer science, Psychology, Sociology, or Humanities. Participants in the latter majors did not consider themselves well informed.

Participants were also asked to indicate the level of risk they believe is associated with consuming GM foods. Most perceived there to be only a moderate (38.4%) or low (46.4%) level of risk or no risk (5.4%). In particular, participants majoring in Animal and Range Science, Computer Science, and Crop and Weed Science perceived little risk to be associated with consuming GM products. Perceived risk among these participants was

<table>
<thead>
<tr>
<th>Table 4.5. Environmental attitude questions</th>
<th>Strongly Agree</th>
<th>Somewhat Agree</th>
<th>Neutral</th>
<th>Somewhat Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>More action needs to be taken in order to preserve our natural environment.</td>
<td>14.3</td>
<td>52.7</td>
<td>17.9</td>
<td>15.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Man has upset nature's balance. Healthy ecosystems require we let nature alone.</td>
<td>3.6</td>
<td>25.0</td>
<td>38.4</td>
<td>29.5</td>
<td>3.6</td>
</tr>
<tr>
<td>Pesticides used on crops generally are carcinogenic and poisonous and should be prohibited.</td>
<td>1.8</td>
<td>15.2</td>
<td>36.6</td>
<td>36.6</td>
<td>9.8</td>
</tr>
</tbody>
</table>
lower than that of others. Participants majoring in Business, Psychology, and Sociology perceived there to be some risk associated with consuming GM products. Participants who had children perceived there to be a higher level of risk associated with consuming GM food than those who did not have children. Participants in the income brackets $5,000 to $10,000 and more than $20,000 perceived there to be a higher risk in consuming GM food than those in the $10,000 to $15,000 category. Participants who grew up in large metro areas perceived there to be a greater risk than those who grew up in rural areas or small cities.

**Tobit Regression**

The system of equations estimated for willingness to pay for GM products based on environmental impact information are provided in this section. Parameters in the estimation are presented in table 4.6.

**Table 4.6. Tobit regression parameters**

<table>
<thead>
<tr>
<th>Parameter Symbol</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Constant</td>
</tr>
<tr>
<td>Bf</td>
<td>Grew up on a farm</td>
</tr>
<tr>
<td>Bm</td>
<td>Married</td>
</tr>
<tr>
<td>Bc</td>
<td>Have Children</td>
</tr>
<tr>
<td>Bg</td>
<td>Gender</td>
</tr>
<tr>
<td>B/am</td>
<td>Agriculture Major</td>
</tr>
<tr>
<td>B/sm</td>
<td>Sociology Major</td>
</tr>
<tr>
<td>B/gm</td>
<td>GM</td>
</tr>
<tr>
<td>I_sp</td>
<td>Interaction term: Sociology major * Pro information</td>
</tr>
<tr>
<td>I_sc</td>
<td>Interaction term: Sociology major * Con information</td>
</tr>
<tr>
<td>I_ap</td>
<td>Interaction term: Agriculture major * Pro information</td>
</tr>
<tr>
<td>I_ac</td>
<td>Interaction term: Agriculture major * Con information</td>
</tr>
<tr>
<td>B/co</td>
<td>Cookie</td>
</tr>
<tr>
<td>B/pcc</td>
<td>Potato Chips</td>
</tr>
<tr>
<td>I_pgm</td>
<td>Interaction term: Pro information * GM</td>
</tr>
<tr>
<td>I_cgm</td>
<td>Interaction term: Con information * GM</td>
</tr>
<tr>
<td>E</td>
<td>Error Term</td>
</tr>
</tbody>
</table>
Table 4.7 shows the model parameters, parameter estimates, standard errors, t-statistics, and P-values.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C (Constant)</td>
<td>0.138889</td>
<td>0.028803</td>
<td>4.82201</td>
<td>.000</td>
</tr>
<tr>
<td>Bf (Grew up on farm)</td>
<td>0.053821</td>
<td>0.027112</td>
<td>1.98513</td>
<td>.047</td>
</tr>
<tr>
<td>Bm (Married)</td>
<td>0.427283</td>
<td>0.085577</td>
<td>4.99295</td>
<td>.000</td>
</tr>
<tr>
<td>Bc (Have children)</td>
<td>-0.351987</td>
<td>0.090513</td>
<td>-3.88882</td>
<td>.000</td>
</tr>
<tr>
<td>Bg (Gender)</td>
<td>0.046843</td>
<td>0.023279</td>
<td>2.01226</td>
<td>.044</td>
</tr>
<tr>
<td>Bam (Agriculture Major)</td>
<td>0.388875</td>
<td>0.039446</td>
<td>9.8585</td>
<td>.000</td>
</tr>
<tr>
<td>Bsm (Sociology Major)</td>
<td>0.123421</td>
<td>0.028444</td>
<td>4.33913</td>
<td>.000</td>
</tr>
<tr>
<td>Bgm (GM)</td>
<td>-0.045858</td>
<td>0.025293</td>
<td>-1.81309</td>
<td>.070</td>
</tr>
<tr>
<td>Is (Sociology*pro)</td>
<td>0.213578</td>
<td>0.093556</td>
<td>2.2829</td>
<td>.022</td>
</tr>
<tr>
<td>Isc (Sociology*con)</td>
<td>-0.152683</td>
<td>0.088456</td>
<td>-1.7261</td>
<td>.084</td>
</tr>
<tr>
<td>Iap (Ag major*pro)</td>
<td>-0.046893</td>
<td>0.125432</td>
<td>-0.373855</td>
<td>.709</td>
</tr>
<tr>
<td>Iac (Ag major*con)</td>
<td>0.251534</td>
<td>0.12477</td>
<td>2.01598</td>
<td>.044</td>
</tr>
<tr>
<td>Bco (Cookie)</td>
<td>-0.042438</td>
<td>0.027673</td>
<td>-1.53354</td>
<td>.125</td>
</tr>
<tr>
<td>Bpc (Potato chips)</td>
<td>0.190224</td>
<td>0.027696</td>
<td>6.86818</td>
<td>.000</td>
</tr>
<tr>
<td>Ip (Pro*GM)</td>
<td>-0.10134</td>
<td>0.060658</td>
<td>-1.67068</td>
<td>.095</td>
</tr>
<tr>
<td>Ic (Con*GM)</td>
<td>0.118331</td>
<td>0.056602</td>
<td>2.0906</td>
<td>.037</td>
</tr>
<tr>
<td>E (error)</td>
<td>0.410424</td>
<td>8.29E-03</td>
<td>49.4911</td>
<td>.000</td>
</tr>
</tbody>
</table>
With a normal ordinary least squares regression, the beta coefficient will measure
the marginal effects. When you have data truncated at zero, however, the beta coefficient
only measures the change for non-zero observations. The probability of a zero observation
must be included. When interpreting a tobit regression, it is necessary to look at the
marginal effect of the independent variables on the dependent variable. Table 4.8 gives the
marginal effects on willingness to pay of each independent variable.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Marginal Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>C (Constant)</td>
<td>0.12706</td>
</tr>
<tr>
<td>B₁ (Grew up on farm)</td>
<td>0.053821</td>
</tr>
<tr>
<td>Bᵣ (Married)</td>
<td>0.427283</td>
</tr>
<tr>
<td>Bₑ (Have children)</td>
<td>-0.351987</td>
</tr>
<tr>
<td>B₉ (Gender)</td>
<td>0.046843</td>
</tr>
<tr>
<td>B₃ (Agriculture Major)</td>
<td>0.593516</td>
</tr>
<tr>
<td>B₄ (Sociology Major)</td>
<td>0.184316</td>
</tr>
<tr>
<td>B₅ (GM)</td>
<td>-0.045858</td>
</tr>
<tr>
<td>Iₛₚ (Sociology*Pro)</td>
<td>0.112238</td>
</tr>
<tr>
<td>Iₛₜ (Sociology*Con)</td>
<td>-0.034352</td>
</tr>
<tr>
<td>Iₐₗ (Ag*Pro)</td>
<td>-0.148233</td>
</tr>
<tr>
<td>Iₐₜ (Ag*Con)</td>
<td>0.369865</td>
</tr>
<tr>
<td>B₆ (Cookie)</td>
<td>-0.042438</td>
</tr>
<tr>
<td>B₇ (Potato chips)</td>
<td>0.190224</td>
</tr>
<tr>
<td>Iₗ₉ₗ₅ (Pro*GM)</td>
<td>0.065345</td>
</tr>
<tr>
<td>Iₗ₉₄ₗ₅ (Con*GM)</td>
<td>0.217182</td>
</tr>
</tbody>
</table>

Two goodness of fit measures were calculated. First, McFadden's psuedo $R^2$ was
calculated (Table 4.9). Because a tobit is not a standard ordinary least squares, a basic $R^2$
formula is not an accurate measure of goodness of fit. This goodness of fit measure is
calculated by dividing the unrestricted log likelihood function (where all parameters are
calculated) by the restricted log likelihood function (all parameters other than the constant
held to zero) and subtracting that number from one. McFadden's 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. McFadden's \( R^2 \) is similar to a regular \( R^2 \) when using an ordinary least squares model, but diverges substantially when the model is non-linear or has a truncated distribution.

The second goodness of fit measure calculated for this model was the likelihood ratio. Using the chi-squared table, this ratio tests the hypothesis that all parameters are equal to zero. To calculate this measure, the unrestricted log likelihood function is subtracted from the restricted log likelihood function and then multiplied by negative two. The number from Table 4.9 (277.132) rejects the hypothesis that all parameters are equal to zero at a 99% confidence level.

<table>
<thead>
<tr>
<th>Goodness of Fit Measure</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>McFadden’s Pseudo ( R^2 )</td>
<td>.156</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>277.132</td>
</tr>
</tbody>
</table>

The model was also estimated for each individual product (cookies, muffins, and chips) separately. The separate models for cookies and muffins did not indicate results different from those indicated above. However, the potato chip model did reveal different results. When the model was calculated for potato chips only, two differences occurred. First, participants whose major area of study was agriculture did pay less for GM potato chips after reading con information. This is contrary to the previous results where con
information made agriculture students pay more for products with GM ingredients.

Second, con information, overall, influenced participants to pay less for GM products, which is consistent with expectations. On the other hand, the previous results indicate that con information made participants pay more for GM products.

A tobit model with fewer variables was specified in order to verify unexpected results from the analysis. Tables 4.10, 4.11, 4.12, and 4.13 show the results. The parameter signs and marginal effects are consistent with those of the initial regression. The likelihood ratio indicates the hypothesis that all parameters are equal to zero, cannot be rejected at a 90% confidence level. The parameters included in this model are presented in table 4.10.

<table>
<thead>
<tr>
<th>Parameter Symbol</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Constant</td>
</tr>
<tr>
<td>B&quot;gm</td>
<td>GM</td>
</tr>
<tr>
<td>I&quot;cgm</td>
<td>Interaction term: Con information * GM</td>
</tr>
<tr>
<td>I&quot;pgm</td>
<td>Interaction term: Pro information * GM</td>
</tr>
<tr>
<td>E</td>
<td>Error term</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>t-statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C (Constant)</td>
<td>.335450</td>
<td>.017842</td>
<td>18.8016</td>
<td>.000</td>
</tr>
<tr>
<td>B&quot;gm (GM)</td>
<td>-.045899</td>
<td>.028186</td>
<td>-1.62840</td>
<td>.103</td>
</tr>
<tr>
<td>I&quot;cgm (Con*GM)</td>
<td>.093782</td>
<td>.047802</td>
<td>1.96189</td>
<td>.050</td>
</tr>
<tr>
<td>I&quot;pgm (Pro*GM)</td>
<td>-.031418</td>
<td>.049848</td>
<td>-.630266</td>
<td>.529</td>
</tr>
<tr>
<td>E (error term)</td>
<td>.457849</td>
<td>.009246</td>
<td>49.5144</td>
<td>.000</td>
</tr>
</tbody>
</table>
Table 4.12. Basic model marginal effects of independent variables

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Marginal Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>C (Constant)</td>
<td>.22931</td>
</tr>
<tr>
<td>B_{gm} (GM)</td>
<td>-0.0459</td>
</tr>
<tr>
<td>I_{cgm} (Con*GM)</td>
<td>0.093782</td>
</tr>
<tr>
<td>I_{pgm} (Pro*GM)</td>
<td>-0.03142</td>
</tr>
</tbody>
</table>

Table 4.13. Basic model goodness of fit measures

<table>
<thead>
<tr>
<th>Goodness of Fit Measure</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>McFadden’s Pseudo R^2</td>
<td>.0057</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>5.3592</td>
</tr>
</tbody>
</table>
CHAPTER V. SUMMARY AND CONCLUSIONS

Introduction

Chapter V provides a brief summary of this thesis, including short discussions of the procedures used, and results of the tobit analysis. Key conclusions are also presented as are limitations of the research and suggestions for future research.

Summary of Thesis

Data for this research was obtained from an experimental auction conducted at North Dakota State University. Participants were North Dakota State University undergraduate and graduate students from various fields of study. Each was paid $15 for participation. Participants bid on chocolate chip cookies, blueberry muffins, and bags of potato chips. One version of each product had a standard nutritional label and the other version had an identical label including a statement that indicated it did not contain GM ingredients.

Participants bid on the products, read pro, con, or no information regarding the impacts of GM crops on the environment, and then bid on the same products again. A random nth price auction was used. The participants were informed before bidding that if they secured a binding bid they would be required to purchase the pertinent item.

Willingness to pay for GM products based on environmental impact information was estimated using a two-step tobit regression calculated in TSP. The dependent variable was price participants bid. Independent variables were auction products, demographic characteristics, and dummy variables representing version (GM or not), information (pro,
con), and interaction terms related to pro and con information, and GM products. The tobit method was employed to correct for the problem of data being truncated at zero.

**Results and Conclusions**

The effect of information regarding environmental impacts of GM crops on willingness to pay for GM food products was unexpected and inconsistent with the hypotheses, which resulted from the literature review. Results from the regression indicate that information about positive effects of GM crops on the environment led participants to increase bids for GM products, which was anticipated. However, negative information also had positive impact, increasing bids for GM products even more than positive information, which is contrary to expectations. The regression for the model with fewer variables also resulted in unexpected conclusions. Results from this regression indicate that pro information decreased participants' bids for GM products, while con information increased bids for GM products.

To further investigate these unexpected results, the level of risk participants assigned to the consumption of genetically modified foods elicited in both pre- and post-auction questionnaires were compared. The results showed that negative information about impacts of GM crops on the environment increased the risk participants associated with GM foods, and pro information decreased the associated risk. Specifically, participants were instructed to indicate what level of risk they believe is associated with the consumption of genetically modified foods. Participants were asked to indicate the level of risk from high risk to no risk on an eight number Likert Scale (one represented high risk and eight represented no risk). The mean difference between the pre- and post-question
answers for the con information group was .8974. The mean for the pro group was -.1852, and .2703 for the control group. Mean difference was statistically different between the con and both pro and no groups, and between the pro and con groups. The perceived level of risk associated with GM food products increased for participants who read con information and decreased for participants who read pro information. This supports the hypothesis that information can change participant perceptions about GM products, but contradict the results of the tobit analysis.

Tobit models were also specified for each product (cookies, muffins, and chips) separately. Regressions for the product specific models did not change the overall results. Participants, regardless of the product, still paid a premium for products that were labeled non-GM and pro information influenced bids for GM products in a positive manner. However, the chip specific model did have dissimilar results. This model indicated con information did in fact influence participants to decrease bids for GM products, even those people whose academic major was agriculture.

No one reason could be identified as the reason for the unexpected results. There are many possible contributing factors. The labeling method could have affected participant's bids. Since there was one standard label and one that contained the statement "This product does not contain genetically modified ingredients", there clearly was one version of each product that was different. Participants could have identified the non-GM version as different than ordinary while not fully understanding the product was completely free of GM ingredients. Participants might have actually believed that product contained GM ingredients, which is viewed as different from the norm.
Another factor might have been above average knowledge of agriculture. People who grew up on farms or who majored in agriculture may know more than the average person about agriculture and agricultural biotechnology. Fourteen percent of the participants were agricultural majors and 30% grew up on a farm. People who are knowledgeable on the subject of biotechnology perhaps did not appreciate trying to be persuaded. They may have adjusted their bids accordingly.

However, the results did illustrate that pro and con information affects various groups of people in different ways. Agricultural majors’ bids on GM products increased after reading con information and decreased after reading pro information, contrary to expectations. However, the expected results occurred for sociology majors. Sociology students bid less for GM products after reading con information, while those who read pro information thereafter bid more for GM products. This information is potentially beneficial to companies that use GM ingredients. These companies can focus promotional GM materials on specific target markets that may know little about the agriculture industry. This is also relevant to groups and individuals speaking out against use of biotechnology.

To compare perceptions and knowledge regarding GM products and environmental beliefs of sociology majors and agriculture majors, means for pre-auction questions are presented in Table 5.1. Please refer to Appendix A for complete question.

<table>
<thead>
<tr>
<th>Question</th>
<th>Agriculture Majors</th>
<th>Sociology Majors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How often do you read labels?</td>
<td>5.31</td>
<td>3.94</td>
</tr>
<tr>
<td>2. What percent of food is GM?</td>
<td>48.3</td>
<td>48.6</td>
</tr>
<tr>
<td>3. How much risk is associated with consuming GM food?</td>
<td>6.50</td>
<td>4.63</td>
</tr>
<tr>
<td>4. If a food product is GM, how often is there a non-GM substitute?</td>
<td>3.94</td>
<td>3.63</td>
</tr>
<tr>
<td>5. Regarding GM food, how informed do you consider yourself</td>
<td>4.50</td>
<td>6.13</td>
</tr>
<tr>
<td>6. More action needs to be taken to preserve our natural environment.</td>
<td>4.13</td>
<td>3.25</td>
</tr>
<tr>
<td>7. Man has upset nature's balance.</td>
<td>5.31</td>
<td>4.19</td>
</tr>
<tr>
<td>8. Pesticides are poisonous.</td>
<td>7.00</td>
<td>4.81</td>
</tr>
</tbody>
</table>
The overall influence of products being GM versus non-GM was statistically significant and supportive of the hypothesis. Bids for GM products were lower than those for products labeled as free of GM ingredients. This reveals a demonstrated preference for products which do not contain GM ingredients. This is supportive of the literature, especially the results of Huffman et al., who found that consumers are willing to pay more for non-GM products.

Results also support the literature on consumer attitudes about the GM labeling issue. The literature indicates a majority of consumers do read labels and say they would pay more for GM free products. The current findings concur. Since auction product labels were standard or standard with a GM-free comment, only people who actually read the labels could have differentiated between two otherwise identical products. The price premium placed on those products with the non-GM label indicates participants read the label.

A possible strategy for firms that are required to label products that contain GM ingredients would be to make GM products customary. Instead of spending money to ensure products are GM free, firms producing food products could simply label products as containing GM ingredients. If a great majority of food products were GM and labeled as such, consumers eventually would be unaffected by the indication. Although this strategy is probably not viable in the United States because of the voluntary GM labeling policy, it
could be utilized abroad in countries that have mandatory labeling policies for GM products.

Summary

Information supporting or opposing GM crops did not affect willingness to pay for GM products in a manner consistent with economic theory. However, the results may prove useful in market segmentation efforts. They demonstrate that information influences potential market segments differently. Overall, they showed that when given a choice, students will bid more for food products labeled as not containing GM commodities. These results highlight the importance of increasing consumer education efforts regarding GM crops.

Limitations and Future Research

The experimental design employed in the current research imposes limitations on its application. The design was constrained by budgetary considerations. The resulting population of participants was relatively homogeneous (North Dakota State University students). Caution is thus advised in applying the results to a wider population (e.g., consumers in general, consumers over a larger geographic range).

Environmental impact information used was both visually attractive and credible, yet its scope was limited. Technological and monetary constraints limited the environmental impact information to a one-page, scientific summary of GM facts. There are many other possibilities for promotion or demotion of the use of biotechnology. Firms and organizations use means such as radio and television advertisements, focus groups, pamphlets, and presentations to sway people’s perceptions.
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).

Finally, 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.

Suggestions for future research efforts to overcome these restrictions are proposed. Using different products in future research could widen the scope of findings for North Dakota agriculture. Healthful foods along with snack refreshments could appeal to a greater variety of people and provide more information regarding consumer willingness to pay. Creative labeling for the auction products may potentially add to the price premium people are willing to pay for products that are indicated as being GM free. Research that looks at the effects of various means of information on willingness to pay for GM products 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 a greater percentage of participants. If financially and geographically feasible, engaging a more diverse population to participate in a future study would be helpful. Results then could be generalized more easily over the comprehensive population.
LITERATURE CITED


Hoban, Thomas J. “Consumer Acceptance of Food Biotechnology.” Personal Correspondence (2000b).


Peel, Michael D. "Introduction and Historical Review of Biotechnology." NDSU Biotechnology Workshop (04 April 2001).


Welcome! Thank you for choosing to participate in an experiment about decision making. In this folder is a packet of information that you will need during the experiment. Once you have looked at a form during the experiment, feel free to go back and examine that form again if need be, however, please do not look ahead until we reach the right point in the experiment.

Please follow the instructions carefully. Please do not talk to any other participants.

I would like to emphasize that all information obtained today will be used only for group comparisons. No information on any individual will be divulged for any reason.

Please turn to the next page, and fill out the questionnaire.
Please answer the following questions by circling the appropriate choice or filling in the appropriate line

First, we are going to ask you a few questions about grocery shopping and your knowledge of grocery items.

When you buy a food product for the first time, how often do you read the information on the label before you buy? (Please circle a number)

1 2 3 4 5 6 7 8
ALWAYS NEVER

What percent of the food you consume do you think is genetically modified?
_________________ percent

What level of risk do you believe is associated with the consumption of genetically modified foods? (Please circle a number)

1 2 3 4 5 6 7 8
HIGH RISK NO RISK

If a food product has genetically modified ingredients, how often is there a substitute for that product that contains no genetically modified ingredients?

1 2 3 4 5 6 7 8
ALWAYS NEVER

Regarding genetically modified foods, how informed do you consider yourself? (Please circle a number)

1 2 3 4 5 6 7 8
EXTREMELY WELL INFORMED NOT INFORMED AT ALL

Now we are going to ask you some questions regarding your beliefs. Please indicate your level of agreement with the following statements by circling a number.

6. More action needs to be taken in order to preserve our natural environment.

1 2 3 4 5 6 7 8
STRONGLY AGREE STRONGLY DISAGREE
7. Man has upset nature’s balance. Healthy ecosystems require we let nature alone.

1 2 3 4 5 6 7 8
STRONGLY AGREE STRONGLY DISAGREE

8. Pesticides used on crops generally are carcinogenic and poisonous and should be prohibited.

1 2 3 4 5 6 7 8
STRONGLY AGREE STRONGLY DISAGREE

Now we are going to ask you some questions about yourself.

9. How often do you use recycled products?

1 2 3 4 5 6 7 8
ALWAYS NEVER

10. How often do you recycle newspapers, paper, plastic, or glass products?

1 2 3 4 5 6 7 8
ALWAYS NEVER

11. What is your Major? ________________________________

12. Do you have a job outside of attending school?
   a. Yes
   b. No
   If so, What is your job? ________________________________

13. Did you grow up on a farm?
   a. Yes
   b. No

14. What is the name of the city where you grew up? __________________________city_________state

15. What is the population of the city that you are originally from?

________________________ inhabitants

16. How many miles are you from the nearest grocery store? _________ miles

17. Where do you live?
   a. At my parent's home
   b. House / Duplex
   c. Apartment
   d. Dorm
   e. Other (please specify) ____________________________

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18. What best describes your marital status?
   a. Married
   b. Single with live-in partner
   c. Single
   d. Other (please specify___________________________)

17. What is your gender?
   a. Male
   b. Female

18. What is your age? _______

19. How many roommates do you have? _______

20. What was your religious affiliation when you were young?
   a. Baptist
   b. Catholic
   c. Jewish
   d. Lutheran
   e. Methodist
   f. Other (please specify ________________________)
   g. No religion when young

21. Do you have any children?
   a. Yes
   b. No

22. What is your ethnic background?
   a. Hispanic
   b. White (non-Hispanic)
   c. Black
   d. Asian
   e. Native American
   f. Other (please fill in) _________________________

23. What was your personal household income (before taxes) in 2001?
   a. Under $5,000
   b. $5,000 - $10,000
   c. $10,000 - $15,000
   d. $15,000 - $20,000
   e. more than $20,000
** Please go back over your survey. If for any reason, you left one or more questions unanswered, please write one of the two letter abbreviations to the left of the question number to indicate why you did not answer the question.
   UW – I am unwilling to answer
   DK – I don’t know

**Please write your ID# in the space provided on the first page of the questionnaire.
STOP

Please do not turn the page until instructed by your monitor.
Once again, I would like to thank you for participating in this experiment today.

Today we will be holding auctions of some common products. There will be some detailed instructions of how the auction works shortly.

Because we are trying to determine values of different products, we ask that you please refrain from communicating with other participants. If you have any questions the monitors will assist you, simply raise your hand.
How the Auction Works

Step One: Explanation of auction format

The nth price auction

We are going to hold what is called an nth price auction today. This type of auction has you write down your bids on a sheet of paper. The bids are private, so no one else will know what you are bidding. The way this auction works can be shown in 4 steps.

1. Examine the products
   Before we ask you to bid on a product, we will let you come up to the front of the room and examine the products that you will be bidding on.

2. Write down your bid for the product
   After the products are examined, you can write down what you would like to bid for the product on your “bid sheet”. The amount you write down is the value of the item to you, not what you think the price would be in a store.

3. Choosing of the nth price
   Once everyone has bid, we will determine what will be called the nth price. The nth price is randomly chosen. First a number between 2 and the number of people participating will be randomly drawn. The bids are then put in order from highest to lowest. The number drawn will determine which bid is used as the nth price and thus the purchase price for the product. Everybody who bids higher than this price will purchase the product at the nth price. So, you will never pay a price for a product higher than what you bid.

   (Your monitor will go through an example of this)

4. Determining who purchases products
   (Your monitor will go through an example of this)

   Please note that in this auction it is always in your best interest to bid your true value of the product. Unlike many auctions, in which you might bid less to try to get a deal, this auction does not reward that. This is because you do not necessarily pay your price, but you pay the nth price that is chosen randomly. Likewise, it is not in your interest to bid more than you are truly willing to pay, because you may have to pay more than you wanted to for the product.
STOP

Please do not turn the page until instructed by your monitor.
Step Two: Short quiz on auction format (this sheet will not be collected)

Short Quiz on auction format

True or False

1. The people who purchase products will always pay the amount they bid for a product.
   a) True
   b) False

2. If you have the fourth highest bid, and the randomly drawn n\textsuperscript{th} price is the 2\textsuperscript{nd}, you purchase the product should the round be binding.
   a) True
   b) False

3. I might get to pay less than my bid for a product, but I will never have to pay more than my bid for a product.
   a) True
   b) False

Multiple choice

4. If the bidding price that is randomly drawn is the 7\textsuperscript{th} price, how many people purchase the good?
   a) 4
   b) 5
   c) 6
   d) 7
   e) 8
STOP

Please do not turn the page until instructed by your monitor.
**Practice Rounds**

Step one: Explanation of the practice rounds

There will be two rounds of bidding in the practice rounds. We are about to begin the first practice round. Since some of the products are similar, only one of the two practice rounds will be binding. That is, only one of the two practice rounds will be chosen as the round where people will purchase goods (i.e., only one round “counts”). Since you do not know which round will be chosen, it is in your best interest to bid your true value for the products in both practice rounds. The round that binds has been computer generated, and will be revealed after the second practice round. In the binding round, the participants who get to purchase the product will pay the price they bid, or a lower price than the value indicated and take the product home.

Step two: Examining the product in practice round one (cards)

Step three: Bidding on the deck of cards, please fill out your bid on the bid sheet for cards provided.

**Please write your ID# on the bid sheet.**

**Remember:** You should write down the value of the product to you, not the value it would be in a store.
STOP

Please do not turn the page until instructed by your monitor.
Practice Rounds (continued)

Step 4: Examine the four products available in the second stage of the practice round.

Step 5: Fill out bids for the four products on the bid sheets provided for pens and candy bars.

**Please write your ID# on each of the bid sheets.

Now instead of one product to bid on, there are four. Please bid on these four products, and remember that only one of these two rounds will bind.

Step 6: Determination of the binding round (computer generated)

Step 7: Determine the n\textsuperscript{th} prices for each product (computer generated)

Step 8: Announcement of the auction winners for each product (goods and money will be exchanged at the end of the auction).
Please do not turn the page until instructed by your monitor.
First round of the Real Auction

Step 1: Examining the six products that are in the auction

Step 2: Please bid on these six products using the corresponding bid sheets provided.

**Please write your ID# on each of the bid sheets.

Again, there will be 2 rounds of bidding, but only one of the two rounds will be chosen as binding. This means people with “winning” bids will be required to purchase the products in only one of the rounds.

*** After you are done bidding, please read the information provided.
STOP

Please do not turn the page until instructed by your monitor.
Second round

Step 1: Examining the six products.

Step 2: Please bid on these six products using the corresponding bid sheets provided.

**Please write your ID # on each of the bid sheets.
STOP

Please do not turn the page until instructed by your monitor.
Second round (continued)

Step 3: Choose the binding round (computer generated)

Step 4: Choose the $n^{th}$ price for all three goods

Step 5: Post the winning prices

Step 6: Please fill out the post auction questionnaire on the next page

Step 7: The exchange of money and goods
Post-Auction Questionnaire
ID#_____

1. What level of risk do you believe is associated with the consumption of genetically modified foods? (Please circle a number)

    1  2  3  4  5  6  7  8
    HIGH RISK       NO RISK

2. What percent of the food you consume do you think is genetically modified?
_________________ percent

3. Regarding genetically modified foods, how informed do you consider yourself? (Please circle a number)

    1  2  3  4  5  6  7  8
    EXTREMELY WELL INFORMED    NOT INFORMED AT ALL

Now we are going to again ask you some questions regarding your beliefs. Please indicate your level of agreement with statements 4 to 6 by circling a number.

4. More action needs to be taken in order to preserve our natural environment.

    1  2  3  4  5  6  7  8
    STRONGLY AGREE     STRONGLY DISAGREE

5. Man has upset nature’s balance. Healthy ecosystems require we let nature alone.

    1  2  3  4  5  6  7  8
    STRONGLY AGREE     STRONGLY DISAGREE

6. Pesticides used on crops generally are carcinogenic and poisonous and should be prohibited.

    1  2  3  4  5  6  7  8
    STRONGLY AGREE     STRONGLY DISAGREE

7. How many people do you think get sick from genetically modified foods each year in the United States? (Note that there are approximately 300,000,000 people in the U.S.)

_________________________________

8. Who would you consider a reliable source of information regarding biotechnology?
_________________________________

9. How much confidence would you have in this source (circle number)?
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL CONFIDENCE</td>
<td>NO CONFIDENCE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Please make sure you filled in your ID# on the top right of the questionnaire.
APPENDIX B
### Nutrition Facts: Serving Size 1oz.

(28 g/about 17 chips)

<table>
<thead>
<tr>
<th></th>
<th>Calories 150</th>
<th>% Daily Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Fat 9g</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>Cholesterol 0mg</td>
<td>0 %</td>
</tr>
<tr>
<td></td>
<td>Sodium 160mg</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>Total Carbohydrate 15g</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>Protein 2g</td>
<td></td>
</tr>
</tbody>
</table>

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

**This product does not contain GM ingredients.
INGREDIENTS: FLOUR (WHEAT FLOUR, MALTED BARLEY FLOUR, NIACIN, IRON, POTASSIUM BROMATE, THIAMIN MONONITRATE, RIBOFLAVIN), CHOCOLATE CHIPS, SUGAR, BROWN SUGAR, SHORTENING, (PARTIALLY HYDROGENATED SOYBEAN & COTTONSEED OILS), MARGARINE, EGGS, HONEY, SALT, B&W (NATURAL & ARTIFICIAL FLAVORING), (DEXTROSE, CORN STARCH. LESS THAN .1%, TUMERIC, LESS THAN .1% APO CAROTENAL, ALPHA TOCOPHEROL, SODA, PECANS.

** This product does not contain GM ingredients.
INGREDIENTS: SUGAR, WHEAT FLOUR, ENRICHED BLEACHED (WHOLE FLOUR, MALTED BARLEY FLOUR, NIACIN, IRON, THIAMIN, RIBOFLAVIN), VEGETABLE SHORTENING (PARTIALLY HYDROGENATED SOYBEAN & COTTENSEED OIL, PROPYLENE GLYCOL MONOESTERS), MALTODEXTRINE, NONFAT MILK SOLIDS, DEXTROSE, MODIFIED FOOD STARCH, POWDERED EGG WHITE, SALT, LEAVENING, NATURAL AND ARTIFICIAL FLAVOR, BLUEBERRIES, WATER, EGGS, & SOYBEAN OIL.

** This product does not contain GM ingredients.
Genetically Modified Crop News Update

Fewer, less toxic pesticides used by farmers who grow genetically modified crops

- The USDA's Economic Research Service has determined that overall, genetically modified crops have reduced farmers' use of pesticides nationwide.
- Estimates indicate a 1.9 to 3 percent reduction of pesticide acre-treatments from 1997 to 1998 when genetically modified crops are grown instead of traditional crops.
- The use of genetically modified Bt crops reduces insecticide use overall; Bt corn has led to a 2-3 percent reduction in the use of insecticides to control the European corn borer.
- There has been a decrease in total pounds of herbicides applied to soybeans when they are produced with genetically modified seed.
- Genetically modified crop production uses glyphosate is used instead of other, more toxic herbicides. Glyphosate can be 5 to 6 times less toxic than the herbicides it replaces.

Yield gains

- The genetically modified crops Bt corn and Bt cotton are associated with significantly higher yields in "most years for some regions" according to the USDA ERS, 1999.

Soil and Water Conservation

- Genetically modified crops are associated with soil conservation because farmers don’t need to till the soil to control weeds.
- The production of genetically modified crops generates land and natural environment conservation due to more efficient crop production on current farm land. Less land needs to be plowed under for crop production.
- Some genetically modified crops can be engineered to tolerate drought, reducing the use of ground and surface waters for irrigation.
- Genetically modified crops that are herbicide resistant require less plowing, thus reducing wind erosion and water sediment damages.

Potential

- Less air and energy emissions are produced from genetically modified crops due to efficient transport of less perishable products.

Source: Ervin et al., 2000 and Batis and Ervin, 1999
Genetically Modified Crop News Update

Increases use of certain herbicides

- Planting transgenic crops that are resistant to specific herbicides may actually increase the use of these herbicides.
- 13.4 million pounds of glyphosate have been substituted on GM soybeans for 9.9 million pounds of other synthetic herbicides. The Economic Resource Service says that genetically modified soybeans have led to an increase in the use of the herbicide glyphosate.

Increased tolerance in certain insects

- Insects can rapidly adapt to environmental pressures. This means insects could become resistant to genetically modified crops that are insect resistant, thus leading to use of chemicals with higher toxicity.
- Huang et al. (1999) -- The inheritance of resistance to Bt toxin by the European corn borer is incompletely dominant. Thus the corn borer may become resistant to genetically modified Bt crops more quickly.

Lower yields

- Genetically engineered soybeans that are herbicide-resistant actually have a lower yield than traditional varieties.

Harming non-targeted species

- Herbicide-resistant crops could potentially interbreed with wild, weedy relatives -- leading the weedy relatives to become resistant to herbicides. Farmers would then have to increase the amount or toxicity of herbicides used in farming these genetically modified crops.

- Genetically modified crops that are pest-resistant may contain toxins that hurt non-target species such as insect predators, soil bacteria, birds, and invertebrates.

- Monarch butterfly larvae that feed on milkweed leaves dusted with pollen from the genetically engineered Bt corn have a higher mortality rate than those who feed on leaves with non-Bt pollen.

Genes could move to wild species, creating weeds

- The scientific community has little doubt that genes from genetically modified crops will move into the wild.
- These genes could thrive in the wild and increase the "weediness" of some wild plants by giving them a fitness advantage.

Batie and Ervin, 1999.