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

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Should the United States Regulate Mandatory Labeling for Genetically Modified Foods?*

Wallace E. Huffman
Charles F. Curtiss Distinguished Professor
Department of Economics
Iowa State University
Ames, IA 50011

Matthew Rousu
Research Economist
RTI International
3040 Cornwallis Road
Research Triangle Park, NC 27709

Jason F. Shogren
Stroock Distinguished Professor of Natural
Resource Conservation and Management
Department of Economics and Finance
University of Wyoming
Laramie, WY 82070

Abebayehu Tegene
Program Leader and Agricultural Economist
Food and Rural Economics Division
ERS, U.S. Department of Agriculture
Washington, DC 20036

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ABSTRACT

Public debate continues over whether the United States should regulate genetically modified (GM) foods by imposing a mandatory labeling policy. This paper develops a model that shows that a voluntary GM-labeling policy results in higher welfare than a regulated mandatory GM-labeling policy, if consumers can accurately read the signals in each market. We then develop an experiment that shows consumers behave as if they can accurately identify signals for GM foods. Our model and results support the perspective that the United States has been prudent in fending off calls for regulations demanding a mandatory GM-labeling policy.

Key Words: genetically modified foods, mandatory labeling, voluntary labeling, laboratory auctions, *n*th-price auction, vegetable oil, tortilla chips, russet potatoes

The use of biotechnology to create genetically modified products has been haled by some as a major new revolution in product innovation. Public debate, however, continues over whether the United States should impose new regulations that require a mandatory labeling policy for genetically modified (GM) foods. Favoring a mandatory labeling regulation for GM foods are such groups as Greenpeace (1997), Friends of the Earth (2001), and the Consumer's Union (Consumer Reports, 1999). Opposing mandatory GM labels include the Council for Biotechnology information (2001) and the U.S. Food and Drug Administration (FDA) (2001). This contentious issue has engaged debate from all sides of the spectrum, yet only modest economic work has examined the merits and pitfalls of a new regulation that requires mandatory labeling for GM foods in the United States.

This paper examines the potential welfare effects of imposing a mandatory GM-labeling policy in the United States. We first show that a mandatory labeling policy for GM foods results in welfare losses relative to a voluntary labeling policy—assuming consumers accurately understand the signals sent in each market regarding which food is GM. We then describe an experimental auction to test the critical presumption that consumers do indeed interpret the market signals identically. For a sample of adult consumers living in two major Midwestern cities, our results do not contradict the hypothesis that consumers can interpret voluntary and mandatory market signals identically. These findings suggest that it would be more efficient or welfare improving for the United States to continue its voluntary labeling policy and resist calls for new regulations that mandate labeling of GM foods.

1. BACKGROUND ON GM LABELS AND GM-LABELING POLICIES

Caswell (1998, 2000) has shown that the list of potential GM labeling policies is large, and includes mandatory labeling of GM foods, voluntary labeling of GM foods, and bans on all labeling. The policies that each country chooses are likely to be determined by competitive interest group politics (Olsen, 1965). An informed decision about labeling policies for GM foods should only be made after a careful benefit/cost analysis. Caswell points out that a voluntary labeling program is likely to be a better policy option for a country that has only a small segment of the population that is concerned about GM foods, while a mandatory labeling system is likely the best policy option in countries where most of the population wants to know if their food is GM. A model by Kirchhoff and Zago (2001) reached a similar conclusion—voluntary GM-labeling policies may be better for a country that has more consumers who are concerned with cost savings, while mandatory GM-labeling policies may be better for more GM-averse consumers.

The United States does not require mandatory labeling for most GM foods. In January 2001, the FDA issued a "Guidance for Industry" statement for labeling GM products, which stated that the only GM foods that need to be labeled are ones that have different characteristics from their non-GM versions. Labeling is not required for any other GM foods, but firms in the United States do have the option of voluntarily indicating whether their food is GM. Canada also has a similar voluntary labeling policy.

The European Union (EU) requires that all foods have the label "genetically modified" if any ingredient in the food is at least 1 percent GM. The European Parliament voted for stricter regulations in early 2001. The new regulations call for stricter labeling and monitoring of GM products and allow for the tracing of GM products through the food chain (CNN, 2001). The EU standards are the minimum standards that member countries must adhere to, although countries can have stricter standards. Several other countries around the world have mandatory labeling policies for GM foods, including Australia, Japan, and New Zealand. For a detailed review of labeling policies, see Rousu and Huffman (2001) or Phillips and McNeill (2000).

2. BENEFITS AND COSTS OF MANDATORY AND VOLUNTARY LABELING POLICIES

Some groups think that mandating GM labels would improve a society's welfare. Many environmental and consumer advocacy groups call for mandatory labeling of GM foods, which they believe benefits consumers (Greenpeace, 1997; Friends of the Earth, 2001; *Consumer Reports*, 1999). Greenpeace and Friends of the Earth both advocate labels on GM foods to give consumers the opportunity to choose whether to consume GM foods.

The U.S. Department of Agriculture (USDA), Economic Research Service, has analyzed the potential benefits of labels on foods (Golan et al., 2000). One benefit of labels is to make it easy for consumers to find content information on food products. Labeling of foods can lead to more informed choices by consumers. Also, some firms may want to avoid using a label that has negative connotations, which could lead firms to improve their product.

Caswell and Padberg (1992) recommended a comprehensive view of the benefits of labels on food products. These benefits can be above and beyond what are normally considered the typical benefits from labels. The benefits from food labels include increased consumer information, improved product design, and more consumer confidence in product quality. Also, labels can provide an option value, even for consumers who do currently read food labels. This option value exists because, if a food is labeled, consumers always have the option to read the label, either now or in the future, and that option has some value.

Although benefits might exist, implementing a mandatory labeling policy for GM foods would be costly. Biotechnology firms oppose mandatory labeling for all GM foods because they do not think foods should be specially labeled unless the food is inherently different from the conventional product (Council for Biotechnology Information, 2001). The USDA, Economic Research Service showed that costs associated with implementing a labeling policy (Golan et al., 2000) are significant. Identity preservation, to determine whether a particular food is GM, has significant fixed costs. When GM food is separated from non-GM food, the probability increases that the wrong product will be delivered to a buyer. For example, in the United States GM corn that was not approved for human consumption, known as Starlink corn, got into the U.S. food system in late 2000. Another possible cost is accidental contamination of non-GM crops by their GM counterpart. Farmers have to go to great lengths to ensure that non-GM crops are not accidentally contaminated with the GM variety. Among the things farmers need to do to ensure there is no contamination is to have buffer zones, which are zones between the GM and non-GM crops to prevent contamination. Farmers also need to make sure planting and harvesting equipment are not contaminated with residue from GM crops. All of these items imply real costs when a labeling policy is implemented. These added labeling and storage costs would drive a wedge between the price paid by consumers and received by producers resulting in higher prices for consumers and lower prices to producers.

Furthermore, labeling could change an industry’s structure (Golan et al., 2000). With some fixed costs associated with labeling, small firms may have higher per-unit labeling costs than large firms. This would mean increasing returns to scale and an incentive for firms to increase in size or close down. A labeling policy that decreases the number of firms could decrease competition and might increase prices for consumers. Another cost firms could face is reformulation costs, which could be large.

The USDA suggests that adding more information to food labels dilutes the other information given on the label. This concern seems most important when the labeling policy being considered would inform consumers of an attribute that may not affect human health (e.g., genetic modification). Furthermore, labeling without independent verification is unlikely to be useful. A new labeling policy would require resources for government or third-party verification.

Relatively few estimates of the costs of GM food labeling exist. The accounting/consulting firm KPMG was commissioned for a study in Australia and New Zealand to examine the costs of complying with new labeling laws. They estimated that the costs of the labeling laws could mean an increase in consumer prices from 0.5 percent to 15 percent, and that firms could also receive lower profits (Phillips and Foster, 2000). Even though they commissioned the study, the Australian New Zealand Food Standards Council (2001) disregarded KPMG's study, citing two flaws. Whether this council had legitimate problems with the study or were responding to political pressure, we do not know. Smyth and Phillips (2002) estimated that a voluntary identity preserved production and marketing system in Canada cost from 13 to 15 percent during 1995–1996. The Philippine Chamber of Food Manufacturers warned that mandatory GM food labels would increase production costs by 15 percent, and that the increased costs would be passed on to consumers (*AgBiotech Reporter*, 2001). One issue seems apparent: implementing a labeling policy for GM foods is costly, even if the exact magnitude of the costs is unknown.

3. EMPIRICAL MODEL

We develop a single-period model to examine the welfare effects of alternative labeling policies. Following the model of food certification in Crespi and Marette (2001) and the model of GM labeling by Kirchhoff and Zago (2001), our model compares the welfare of a mandatory GM-labeling policy to the welfare of a voluntary GM-labeling policy. Assume a firm produces one of two products, GM food or non-GM food. Without loss of generality, assume a firm could produce the GM food at a marginal cost of zero, while the marginal cost of non-GM food is $c > 0$. Firms also incur laboratory costs to test for GM content. Assume firms that have a product tested to determine the GM status of their product incur a marginal cost of $t > 0$.

Assume firms know whether their products are GM. Suppose a sufficient number of firms exist such that, when proper signals are available, many firms would be producing GM foods and many firms would be producing non-GM foods. Firms compete by Bertrand competition (by setting prices), so to examine the welfare effects of different labeling policies, one needs only look at the gains to consumers because under Bertrand competition firms earn zero profits, so they are indifferent to labeling policies.

All consumers have a value $f > 0$ for a food product (GM or non-GM). This could be thought of as the value consumers place on not starving. In addition, tastes for non-GM foods are assumed to be uniformly distributed across consumers, denoted by $q \in [0,1]$. For consumers who buy non-GM foods at a price of p_{NGM}, their indirect utility is $q + f - p_{NGM}$. For consumers who buy GM foods at a price of p_{GM}, their indirect utility is $f - p_{GM}$. For ease of welfare analysis, simplify the mass of consumers to one. Assume no positive or negative externalities of one consumer on another.[1]

Consider a baseline case where no labeling of products is allowed. Because non-GM foods are costlier than GM foods, only GM foods will be offered. GM foods will be offered at a price of zero, because Bertrand competition brings price down to marginal cost. The reason there is no non-GM food when labeling is banned is because consumers have no way of distinguishing between GM and non-GM foods. A premium cannot be charged for non-GM foods, which is needed to cover the higher costs of producing these foods. A consumer's total surplus is f. This outcome occurs because a separating equilibrium is unavailable, and non-GM foods cannot be accurately signaled, leading to the classic "lemons" problem (Akerlof, 1970). This problem could also occur in a voluntary labeling regime if testing costs are too high. We next consider the welfare effects of alternative labeling policies: a mandatory GM-labeling policy that requires testing all food products and a voluntary labeling policy that requires firms wishing to label their products as non-GM to test their products. All cases assume the regulator incurs a per-unit cost for certification and passes that cost onto firms: a discussion of fixed certification costs follows this analysis.

3.1 Mandatory Labeling Policy—All Products Must be Tested

Consider a mandatory GM labeling policy where all food products must be tested to determine if they are GM. Foods that are GM will be labeled as "genetically modified." Foods that are not GM will not be labeled (although labeling these products as non-GM does not change the

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[1]Fixed costs may also be associated with testing food products for GM content; we, however, are abstracting away from these costs. They would introduce nonlinearity into the decision process but would not alter the model's

analysis). A GM product has a constant marginal cost (and price) of t, and a non-GM product has a marginal cost (and price) of $c+t$.[2] The consumer surplus of individual *j* who purchases non-GM foods is

(1) $$CS^j = q^j + f - p.$$

The consumer surplus for all consumers who purchase non-GM foods is then

(2) $$CS_{ML}^{NGM} = \int_{q_{ML}}^{1} (q + f - p)dq = \int_{q_{ML}}^{1} (q + f - C - t)dq$$

(2A) $$CS_{ML}^{NGM} = (1 - q_{ML})\left(\frac{(1+q_{ML})}{2} + f - C - t\right),$$

where q_{ML} is the value of q where consumers are indifferent between consuming non-GM and GM foods under a mandatory labeling policy. Consumer surplus for individual *j* who purchases GM foods is

(3) $$CS^j = f - p.$$

Aggregate consumer surplus of those who purchase GM foods is

(4A) $$CS_{ML}^{GM} = \int_{0}^{q_{ML}} (f - p)dq = \int_{0}^{q_{ML}} (f - t)dq$$

(4B) $$CS_{ML}^{GM} = q_{ML} * (f - t).$$

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predictions.

[2]This is where our model differs substantially from Kirchoff and Zago's (2001) in that we assume that under a mandatory GM-labeling policy firms producing products would need to pay a per-unit charge, while Kirchoff and Zago assume the government would pay for all testing charges in a mandatory labeling regime.

3.2 Voluntary Labeling Policy—Only Non-GM Foods Need to be Tested

Consider a voluntary labeling policy that requires testing only the products that are to be labeled as non-GM. Non-GM products are labeled as non-GM. GM products are not labeled, and consumers will see this as a signal that these foods are GM. Once again, the marginal cost of testing a product is $t > 0$. Now a GM product has a price of 0, while a non-GM product has the same price of $c + t$. Consumer surplus of an individual who purchases non-GM foods is the same under either policy, as shown in equation (1). The aggregate consumer surplus of those who will purchase non-GM foods is

(5) $$CS_{VL}^{NGM} = \int_{q_{VL}}^{1} (q + f - p)dq = \int_{q_{VL}}^{1} (q + f - C - t)dq$$

(5A) $$CS_{VL}^{NGM} = (1 - q_{VL})\left(\frac{(1 + q_{VL})}{2} + f - C - t\right).$$

q_{VL} is the value of q when consumers are indifferent between consuming non-GM and GM foods under a mandatory labeling policy. Consumer surplus for individual *j* who purchases GM foods under a voluntary policy is

(6) $$CS^{j} = f - p = f \,.$$

Therefore, the aggregate consumer surplus of those who purchase GM foods is

(7) $$CS_{VL}^{GM} = \int_{0}^{q_{VL}} (f)dq = q_{VL} * f \,.$$

Consider a third possible labeling policy that requires labeling GM products as such and not labeling non-GM products. For this policy, however, firms need to test only those products they want to avoid labeling "genetically modified." Firms that do not test will be forced to label their foods as GM. Once again, the marginal cost of testing a product is $t > 0$. For this case, a GM product will have a price of 0, while a non-GM product has a price of $t + a$. This mandatory labeling policy gives the same welfare as the voluntary labeling policy.

This model has shown that consumer welfare is greater under the voluntary labeling policy. If one considers only consumers and firms in a market (and not third-party groups), then a voluntary labeling policy for GM foods Pareto dominates a mandatory policy. This is because voluntary and mandatory labeling policies send the same signal, but additional testing and segregation costs occur under a mandatory policy. This model assumes only that food testing would imply a higher marginal cost; when other costs of a mandatory labeling policy are also considered, such as a possible increase in market concentration, mistakes in labeling, and dilution of the other information on the food label (Golan et al., 2000), the prediction that a voluntary labeling policy yields higher welfare than a mandatory policy is strengthened.

In a market structure where firms compete by quantity (Cournot model), one obtains the same result if the number of firms producing GM foods and non-GM foods stays the same when a switch is made from a voluntary policy to a mandatory policy. A change from a voluntary to a mandatory labeling policy has no effect for an individual who consumes non-GM foods and yields a decrease in welfare for those who consume GM foods. Under the Cournot model, however, firms that produced GM foods would earn lower profits under the mandatory policy. The result that a voluntary labeling policy yields higher welfare than a mandatory labeling policy appears to be robust to the type of model used to analyze the problem.

Where the regulator incurs a fixed cost for testing in a mandatory labeling policy and passes the cost along to producers, passing it along as a fixed user fee is always less efficient than passing the costs along as a per-unit user fee (Crespi and Marette, 2001). An efficient certification process will result in the regulator splitting the fixed cost into per-unit user fees, and the analysis for the per-unit certification cost applies.

Many environmental groups are calling for a mandatory labeling policy on GM foods (Greenpeace, 1997; Friends of the Earth, 2001) despite the fact that consumers could purchase non-GM foods under a voluntary labeling policy by looking for foods with a non-GM label on it. This model presents an explanation for this behavior. Suppose the utility of environmental groups is positively related to the number of individuals who consume non-GM foods (and negatively related to the number of individuals who consume GM foods). A mandatory labeling policy imposes additional costs for testing on GM foods and therefore increases the number of individuals who would purchase non-GM foods. The passage of a mandatory GM-labeling law would increase the utility of environmental groups.

3.3 When Will a Voluntary Labeling Policy Not Allow for Signals?

When testing to see if a product is made using genetic modification, no one will consume non-GM foods if the test is too costly. For any consumer that has $q - C - t < 0$, he will not purchase the non-GM food, because he is better off buying the GM food and obtaining a consumer surplus of f. So if the consumer who places the highest value on non-GM food ($q = 1$) finds it too costly to purchase non-GM foods, ($C + t > 1$), nobody will buy non-GM foods because the signal is too costly.

This analysis implicitly assumes that consumers can distinguish the signal that a food is GM and a signal that a food non-GM equally well. This is a contentious point about which many groups, including Greenpeace (1997) and Friends of the Earth (2001), strongly disagree. These groups are calling for a mandatory labeling policy in the United States because, as Greenpeace (1997) puts it, “customers must have the right to know.” We conducted experimental auctions to see if consumers behave as if they see the same signal under alternative labeling regimes or if consumers read the signals differently. A discussion of the experimental design follows.

4. EXPERIMENTAL DESIGN

The ongoing GM-labeling debate has been fueled by information provided by proponents and opponents of mandatory labeling. Proponents of voluntary labeling policies say they are less expensive, because only the firms that wish to label their products must incur the labeling costs. In a mandatory labeling regime, all firms would need to incur additional costs, whether the costs are due to product testing, label design, segregation, mistakes in labeling, etc. Many proponents of mandatory labeling of GM foods say that consumers have a “right to know” what they are consuming, and proponents claim that governments should mandate labels for foods made through genetic modification.

With this general background in mind, we designed a new set of six treatments that complement our earlier work (Huffman et al., 2001; Rousu et al., 2002) by incorporating the private-information-revealing feature of experimental auction markets (also see Smith 1976; Hoffman et al., 1993; Fox et al., 1998) and the rigorous randomized treatment design of statistical experimental design We designed a set of experimental auctions in which adult consumers who are randomly assigned to the various treatments bid on actual foods that differed only by the types of labels on the foods. Some consumers bid on foods with *positive GM labels*—the labels that would arise in a *mandatory* labeling regime; others bid on food with *negative GM labels*—the labels that would arise in a *voluntary* labeling regime.[3]

The specific purpose of this experiment is to test whether consumer bidding behavior for GM and GM-free food is indistinguishable in two experimental markets—one within a mandatory labeling policy and one with a voluntary labeling policy. If bidding behavior for GM and GM-free food is similar across the two markets, the results would not contradict the hypothesis that consumers accurately read the signals in both markets. Our empirical model suggests that a voluntary labeling policy is more efficient—provided consumers accurately assess which food is GM. If the behavior for GM foods differed across labeling regimes, we could reject the hypothesis that labeling is irrelevant to choice. Here a mandatory labeling policy would not necessarily lead to a welfare loss. But if bidding behavior for GM foods is independent of the labeling policy, we could not reject the implications of our empirical model—that a voluntary labeling policy is more efficient for consumers than a mandatory labeling policy.

The experimental design consisted of four biotech information-labeling treatments with each treatment replicated at least twice. The treatments were randomly assigned to ten experimental

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[3]These experimental markets were chosen to emulate the mandatory and voluntary GM-labeling regimes currently in place throughout the world. Our mandatory regime reflects the labels consumers might find in Europe, where foods that are GM must be labeled as such. Our voluntary labeling regime captures the labels consumers might see in the United States, where food manufacturers can label their products as nongenetically engineered if they choose. We do not examine several other potential but currently nonimplemented labeling policies, including a mandatory labeling policy that requires all non-GM foods to label themselves or a policy that requires every food product in a market to be labeled as GM or non-GM.

units, each consisting of 13 to 16 consumers drawn from the households of two major urban areas and who were paid to participate.

We now describe the four elements in our GM labeling experiments—the GM food, the auction mechanism, the experimental units, and the specific steps in the experiment, which includes the detailed information on the labels.

We anticipated that consumers might react differently to GM content for foods of different types. Believing that one food item was unlikely to reveal enough information, we settled on three items: a 32-ounce bottle of vegetable oil,[4] a 16-ounce bag of tortilla chips (made from yellow corn), and a 5-pound bag of russet potatoes. In the distilling and refining process for vegetable oils, essentially all of the proteins (which are the components of DNA and the source of genetic modification) are removed leaving pure lipids. Minimal human health concerns should arise from consumption of the oil, but people might still fear that the production of GM foods could harm the natural environment. Tortilla chips are highly processed foods russet potatoes are purchased as a fresh product and generally baked or fried before eating, and consumers might have human health or environmental concerns or both.

Valuation experiments use an auction mechanism to induce people to reveal their preferences for new goods and services (e.g., see Shogren et al., 1994). We used the random *n*th-price auction for our GM food experiments because it is designed to engage both the on- and off-the-margin bidders (see Shogren et al., 2001).[5] The random *n*th-price works as follows. Each of *k* bidders submits a bid for one unit of a good; then each of the bids is rank-ordered from highest to lowest. The auction monitor then selects a random number—the *n* in the *n*th-price auction, which is drawn from a uniform distribution between 2 and *k*, and the auction monitor sells one unit of the good to each of the *n*–1 highest bidders at the *n*th-price. For instance, if the monitor randomly selects *n* = 4, the three highest bidders each purchase one unit of the good priced at the fourth highest bid. Ex ante, bidders who have low or moderate valuations now have a nontrivial chance to buy the good because the price is determined randomly. This auction increases the probability that insincere bidding will be costly.

Auctions were planned and conducted in two Midwestern U.S. cities: Des Moines, IA, and St. Paul, MN, in 2001. The Iowa State University Statistics Laboratory acquired the sample for us using a random phone book sample. The consumers were asked if they would participate in a group session that related "to how people select food and household products," and they were

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[4]For the oil, soybean oil was used for the mandatory-labeling trials, and canola oil was used for the voluntary-labeling trials. The soybean oil was initially used in the April experiments. We then tried to purchase non-GM soybean oil in 32 oz. bottles and were unsuccessful. The bids for the vegetable oil follow the same trend as the other products and are discussed in the results section of the paper. The other products (and packaging) were absolutely identical, except for the presence or absence of genetic modification.

[5]The auction combines elements of two classic demand-revealing mechanisms: the Vickrey (1961) auction and the Becker-DeGroot-Marschak (1964) random pricing mechanism. The key characteristic of the random *n*th price auction is *a random but endogenously determined* market-clearing price. Randomness is used to give all participants a positive probability of being a purchaser of the auctioned good; the endogenous price guarantees that the market-clearing price is related to the bidders' private values.

informed that the session would last about 90 minutes.[6] They were also told that at the end of the session each participant would receive $40 in cash for his/her time. From the initial sample of usable randomly selected numbers, the percentage of people who accepted the offer to participate and then showed up at the auction was approximately 19 percent. Our total sample size of participants is 142.

We held ten experimental units, four in April and six in December. The four April trials were also used in Rousu et al. (2002) and Huffman et al. (2001). The results from the other six trials conducted in December have not been included in previous papers. Below we discuss the ten steps of the auction. Table 1 summarizes the characteristics of the auction participants.

Figure 1 shows the ten steps in each experimental unit. In Step 1 when participants arrived at the experiment, they signed a consent form agreeing to participate in the auction. After they signed this form, they were given $40 for participating and an ID number to preserve their anonymity. The treatments were randomly assigned to each experimental unit, so the observed and unobserved characteristics of observations are uncorrelated with the treatments. The participants

[6]We considered the possibility that the demand for GM foods may change over the 8 months between auctions, so we replicated two experimental units, using the exact same procedures. We found no evidence that willingness to pay for GM-labeled foods had changed over time. Note that subjects were also told that at the end of a session each participant would receive $40 in cash for their time. The sessions were held at the Iowa State University Learning Connection, 7th and Locust Street, Des Moines (and lower level of the Classroom Office Building, University of Minnesota, St. Paul). Three different times were available each auction day (9 am, 11:30 am, and 2 pm), and willing participants were asked to choose a time that best fit their schedule. Participation per household was limited to two adult individuals, and they were assigned to different groups. The Statistics Laboratory followed up by sending a letter to willing participants that contained more information including a map and instructions on when and where the meeting would be held, directions for getting there, and a telephone number to contact for more information.

then read brief instructions and filled out a questionnaire. The questionnaire was purposefully given to consumers before the experiment to elicit demographic information and to capture consumers' prior perception of GM foods before bidding, which allowed us to compare their prior beliefs to their posterior beliefs after the experiment.

In Step 2, participants were given detailed instructions (both oral and written) about how the random *n*th-price auction works, including an example written on the blackboard. After the participants learned about the auction, a short quiz was given to them to ensure that everyone understood how the auction worked. All experimental instructions are available from the authors on request.

Step 3 was the first practice round of bidding, in which participants bid (in a real auction) on a brand-name candy bar. The participants were all asked to examine the product and then to place a bid on the candy bar. The bids were collected and the first round of practice bidding was over. Throughout the auctions, when the participants were bidding on items in a round, they had no indication of what other items they may be bidding on in future rounds.

Step 4 was the second practice round of bidding, and in this round the participants bid separately on three different items. The products were the same brand-name candy bar, a deck of playing cards, and a box of pens. Participants knew that only one of the two rounds would be chosen at random to be binding, which prevented anyone from taking home more than one unit of any product. By using only round binding, we avoid problems of demand reduction that can occur in multi-unit auctions. The consumers first examined the three products and then submitted their bids.

After the two practice auction rounds were completed, the binding round and the binding *n*th-prices were revealed in Step 5. All bid prices were written on the blackboard, and the *n*th-price was circled for each of the three products. Participants could see immediately what items they won, and the price they would pay. The participants were told that the exchange of money for goods was in another room nearby and would take place after the entire experiment was completed.

In Step 6, participants received one of two potential info-packets that provided nonfood-label information about biotechnology (for a detailed look at how information affected the demand for foods labeled as GM, see Rousu et al., 2002). These info-packets were produced as follows. We created three information sources: (1) the *industry perspective*—a collection of statements and information on genetic modification provided by a group of leading biotechnology companies, including Monsanto and Syngenta; (2) the *environmental group perspective*—a collection of statements and information on genetic modification from Greenpeace, a leading environmental group; and (3) the *independent third party perspective*—a statement on genetic modification approved by a third-party group, consisting of a variety of people knowledgeable about GM goods, including scientists, professionals, religious leaders, and academics, who do not have a financial stake in GM foods. We limited each information source to one full page, organized into five categories: general information, scientific impact, human impact, financial impact, and environmental impact. Appendix A shows the exact format and wording of the three information sources.

These information sources were then randomized to create the two info-packets: (1) both pro- and antibiotechnology and (2) probiotechnology, antibiotechnology, and independently verifiable.[7] These info-packets were then randomized among all ten experimental units, with each info-packet going to four experimental units. By giving all participants both positive and negative information on GM foods, and by giving some participants a third-party perspective on GM foods, we could determine the willingness to pay for individuals who received all perspectives on the GM food debate.

Once we distributed the appropriate info-packet to the participants in a given unit, we then conducted two auction rounds. The rounds were differentiated by the food label—either the food had a standard food label or a label that indicated the status of genetic modification. Figure 2 shows the exact format of the label used for potatoes.[8] In one round (which could be Round 1 or 2 depending on the experimental unit), participants were bidding on the three food products each with the standard food label. We made these labels as plain as possible to avoid any influence on the bids from the label design. In the other round, participants were bidding on the same three food products with either a GM label or a non-GM label. The GM and non-GM labels differed from the standard label only by the inclusion of one extra sentence. The GM label said "This product is made using genetic engineering," while the non-GM label said "This product is made without genetic engineering." For each experimental unit, participants knew that only one round would be chosen as the binding round that determined auction winners.

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[7]The order of the positive information and negative information was, also, randomized across consumers. Participants who received the third-party, verifiable information always received it after the other information sources.

[8]Note that our labels are clearly displayed on the front of the package, where consumers would see them. See Noussair et al. (2002) for evidence of how consumers are not always likely to read food-labels that are on the back of packages.

In Step 7, participants bid on three different food products: a bottle of vegetable oil, a bag of tortilla chips and a bag of potatoes, either with the standard label or the label indicating the product's GM status. Six groups bid on foods with plain labels and foods with labels saying "made using genetic modification." Four groups bid on foods with plain labels and foods with labels saying "made without using genetic modification." The participants were instructed to examine the three products and then to write down their sealed bid for each of the three goods. Participants bid on each good separately. The monitor then collected the bids from the people and told them they were next going to look at another group of food items. Figure 3 summarizes the four treatments.

Step 8 had participants examine the same three food products, each with a different label from Round 1.[9] Again the participants examined the products and bid on the three products separately. The bids were then collected from all of the individuals. In contrast to early experimental auction work using repeated trials, this auction used only two rounds to avoid any chance of affiliation of values and changes in willingness to pay due to the posted-market behavior of other bidders (see List and Shogren, 1999; Knetsch, Tang, and Thaler, 2001).

Step 9 selected the binding round, and the binding random *n*th-prices for the three goods. The winners were notified. In Step 10, each participant was asked to complete a brief post-auction

[9]By replicating treatments and having one group bid on the plain-labeled foods in Round 1 and the GM (or non-GM) labeled foods in Round 2, we are controlling for any potential round effects. The null hypothesis that the round the consumer bid on foods led to the same bids could not be rejected at a 5 percent level for any of the three goods under both a t-test and a Wilcoxon Rank-Sum test. Hence, the order in which consumers saw the items did not appear to matter.

questionnaire, and then the monitors dismissed the participants who did not win. The monitors and the winners then exchanged money for goods, and the auction winners were also dismissed.

Although we followed standard experimental auction valuation procedures (e.g., Shogren et al., 1994), we made several refinements to our experimental design to better reflect consumer purchases. First, our subjects submitted only one bid per product. We have stepped back from the protocol of using multiple repeated trials and posted market-clearing prices to avoid any question of creating affiliated values that can affect the demand-revealing nature of a laboratory auction (see, for example, List and Shogren, 1999). Second, we do not endow our subjects with any food item and then ask them to "upgrade" to another food item; rather participants are paid $40 and then bid on different foods in only two trials. This avoids the risk that an in-kind endowment effect distorts the participant's bidding behavior (e.g., Lusk and Shroeder, 2002) and of any credit constraint. Third, each consumer bid on three unrelated food items, such that if he or she did not have positive demand for one or two products, we could still obtain information from them on their preference for genetic modification based on the second and (or) third products. Fourth, we randomly assigned treatments to the experimental units—now estimating treatment effect is simply the difference in means across treatments (see Wooldridge, 2001).

Fifth, we used adult consumers over 18 years of age from two different Midwestern metropolitan areas that were chosen using a random digit dialing method. The demographics of our sample do not perfectly match the U.S. census demographic characteristics for these regions, but they are similar and provide a sufficient representation for our initial probe into labeling and information for GM products (see Appendix A for the demographic characteristics of the areas). In addition, because we use common food items available to shoppers in grocery stores and supermarkets, we wanted adults rather than students to better reflect a typical household of consumers. Although several studies have used college undergraduates in laboratory auctions of food items (including Lusk et al., 2001a and Hayes et al., 1995), they are not the best choice for participants when the items being auctioned are ones sold in grocery stores or supermarkets. Using a national random sample of grocery store shoppers, Katsara et al. (2001) show that the share of college-age (18 to 24) shoppers falls far below their share in the population—8.5 percent of shoppers versus 12.8 percent in the U.S. Census of Population. College students obtain a large share of their food from school cafeterias and a small share from grocery stores and supermarkets compared to older shoppers (Carlson, Kinsey, and Nadav, 1998). Although our participants are slightly skewed toward women, Katsara et al. (2001) show that women make up a disproportional share of grocery shoppers—83 percent of shoppers versus 52 percent in the U.S. Census of Population. A sample primarily of grocery store shoppers also weakens the sometimes-stated need for having students participate in several rounds of bidding to stabilize bids for food items. We also minimize Hawthorne effects in bidding (Melton et al., 1996).

Sixth, information from our laboratory experiments is complemented by information obtained from pre- and post-experiment surveys administered to participants. The pre-auction survey allowed us to obtain socio-demographic information and information on participants' beliefs about GM and other technologies before treatment. This information is potentially useful for explaining bidding behavior. Post-auction questions were used to solicit information from participants on who they would trust to provide verifiable information on GM technology, a concept introduced in the experiments.

Finally, the reason these experiments are conducted is novel. We derived a model that shows that a voluntary labeling policy for GM foods is superior to a mandatory labeling policy, if the critical assumption that consumers identically read signals accurately in both markets. The novelty is that we actually are testing this critical assumption using experiments—a step that most studies do not attempt.

5. DATA AND RESULTS

Table 2 shows the mean and median bids. Eighty-six participants were in treatments that bid on the plain-labeled and GM-labeled food products, while 56 participants were in treatments that bid on the plain-labeled and non-GM-labeled food products. For the participants who bid on the GM-labeled and plain-labeled foods, consumers discounted the GM-labeled oil by an average of 11 cents, the GM-labeled chips by 8 cents, and the GM-labeled potatoes by 8 cents. The participants who bid on the plain-labeled food and the non-GM-labeled food discounted the plain-labeled oil by an average of 4 cents, the plain-labeled chips by 7 cents, and the plain-labeled potatoes by 9 cents.

Our main goal is to determine whether consumers can accurately decipher which food is GM irrespective of the labeling treatment. To determine whether consumers perceive the GM signals differently in the two markets, we first examine the difference in bids for the *perceived GM product* and the *perceived non-GM product*. In the mandatory-labeling trials, the GM-labeled food is the perceived GM product; the plain-labeled food is the perceived non-GM product. In the voluntary-labeling trials, the plain-labeled food is the perceived GM product; the non-GM labeled food is the perceived non-GM product.

Table 3 presents results from a test of the null hypothesis that no difference in bids for the perceived GM and the perceived non-GM bids exists. For all three products, we reject the null hypothesis that consumers' bids for the perceived GM and the perceived non-GM foods are equal. This result suggests that the average consumer bids less for the food that is signaled as GM, which supports earlier findings reported by Huffman et al. (2001) and Lusk et al. (2001a).

Table 4 presents results from tests of the null hypothesis that the bids for the perceived GM and non-GM products are equal across the two treatments. Did consumers bid the same for the plain-labeled product in the GM-labeled treatment as they did for the non-GM-labeled product in the non-GM treatment? For each product, we test two separate null hypotheses:

(8) $$H_0 : Bid_{pos\_label}^{GM-labeled} = Bid_{neg\_label}^{non-labeled}$$

(9) $$H_0 : Bid_{neg\_label}^{non-GM-labeled} = Bid_{pos\_label}^{non-labeled}.$$

The null hypothesis in expression (8) tests the hypothesis that the bids for the perceived GM foods and the bids for the perceived non-GM foods are the same in either labeling treatment. The superscripts indicate the type of food product; the subscripts indicate the labeling treatment. The null hypothesis in expression (9) tests the hypothesis that the bids for the perceived non-GM labeled foods are the same in both trials. Table 4 shows that one cannot reject the null hypothesis that the average bids are identical. This suggests that consumers accurately read the signals for which food is GM under either a mandatory or a voluntary labeling regime.

The size of the discount for the perceived GM food provides additional evidence about consumers' perception of the signals from the two labeling regimes. We tested null hypotheses that consumers did not discount the perceived GM food in the two markets differently. Table 5 provides the results. The first column shows the difference in bids in the mandatory-labeling trials; the second column shows the difference in bids in the voluntary-labeling trials. The third column is the difference between these columns. The absolute difference is an average of 7 cents for vegetable oil, 1 cent for the tortilla chips, and 1 cent for the potatoes. At the 10 percent significance level, the tests show that one cannot reject the null hypothesis that the difference in bids is zero for any of the three food products.[10] Although none of the differences are statistically significant, at first glance it is curious that the mean discount under mandatory and voluntary labeling regimes is virtually identical for the tortilla chips and potatoes, yet it is considerably larger for the vegetable oil. A possible explanation for the vegetable oil having an average of 7-cents difference is the fact that we used two different types of vegetable oils.[11]

Consumers discounted perceived GM food the same, irrespective of whether the market had mandatory or voluntary GM labeling. This result provides additional evidence that consumers receive the same signals under either regime. By not rejecting the thesis that consumers know GM from non-GM food regardless of the labeling regimes, the results support our empirical analysis—the less-expensive voluntary GM-labeling policy could yield greater overall welfare than a mandatory GM-labeling policy. Without speculating beyond the reach of the lab, this finding supports those who believe the United States has been prudent in avoiding calls to initiate a mandatory GM-labeling policy.

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[10]Regression models were also fitting to test whether demographic characteristics made a difference on the discount for the perceived GM food. No demographic characteristic affected significantly the discount for the perceived GM food. Also, one could not reject the null hypothesis that third-party information did not affect the difference in the discount for the perceived GM food.

[11]To check the robustness of the results, we also ran Wilcoxon Rank-Sum tests to see if one could reject that consumers had different behavior for the different label types. The results for the Wilcoxon Rank-Sum tests are similar to those of the t-test results, showing that one cannot reject the null hypothesis that consumers perceive the signals from the two labeling policies the same.

6. CONCLUSION

GM food labeling remains an important and politically contentious issue in the United States. Many groups call for mandatory labeling of GM foods, while many others want to keep labeling voluntary. This paper provides evidence that a voluntary labeling policy is more efficient than a mandatory labeling policy in the United States. The reason is that voluntary labeling policies are less expensive and still give consumers the choice to consume GM or non-GM foods. This result depends on consumers' ability to read signals identically in either market, a conclusion that our auction market evidence could not reject. One further avenue for research would be to examine the international dimension to GM food labels, say in Europe or Australia. For example, do consumers in those countries read the same signals of genetic modification in voluntary labeling markets as in mandatory labeling markets? The key issue is the relevance and usefulness of the mandatory labeling policies throughout the world.

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Figure 1: Steps in the experiment

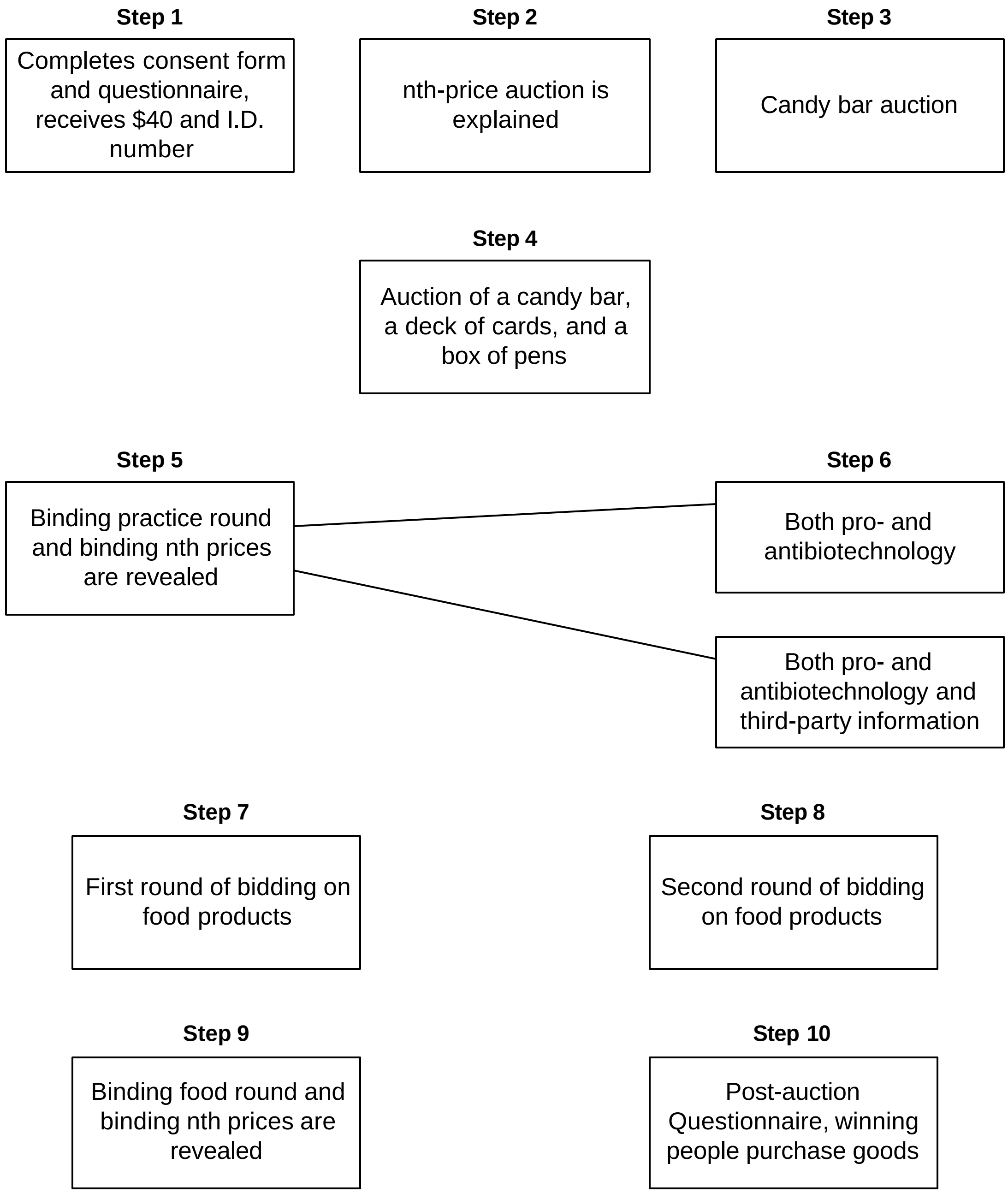

Figure 2: The three types of labels used for the potatoes

Russet Potatoes

Net weight 5 lb.

Russet Potatoes

Net weight 5 lb.

This product is made without
using genetic modification

Russet Potatoes

Net weight 5 lb.

This product is made using
genetic modification (GM)

Figure 3: Information and labeling given to the four treatments

Treatment	Labeling regime type	Third party	Number or trials per treatment
1.	Voluntary regime	No	2
2.	Voluntary regime	Yes	2
3.	Mandatory regime	No	4
4	Mandatory regime	Yes	2

Table 1: Characteristics of the auction participants

Variable	Definition	Mean	St. Dev
Gender	1 if female	0.60	0.49
Age	The participant's age	51.40	18.1
Married	1 if the individual is married	0.65	0.48
Education	Years of schooling	14.74	2.36
Household	Number of people in participant's household	2.56	1.49
Income	The household's income level (in thousands)	51.60	33.40
White	1 if participant is white	0.92	0.27
Read_L	1 if never reads labels before a new food purchase	0.02	0.14
	1 if rarely reads labels before a new food purchase	0.11	0.32
	1 if sometimes reads labels before a new food purchase	0.32	0.47
	1 if often reads labels before a new food purchase	0.36	0.48
	1 if always reads labels before a new food purchase	0.18	0.39

Table 2: Mean bids

	n	Mean Bid	Std. Dev.	Median	Minimum	Maximum
A. Mean bids when participants bid on food in a mandatory GM-labeling market						
GM oil	86	0.63	0.65	0.50	0	2.75
Oil	86	0.74	0.75	0.50	0	3.29
GM chips	86	0.61	0.70	0.43	0	3.25
Chips	86	0.69	0.72	0.50	0	2.89
GM potatoes	86	0.59	0.54	0.50	0	2.00
Potatoes	86	0.67	0.54	0.50	0	2.25
B. Mean bids when participants bid on food in a voluntary GM-labeling market						
NGM oil	56	0.80	0.80	0.50	0	4.75
Oil	56	0.76	0.68	0.50	0	3.00
NGM chips	56	0.75	0.81	0.50	0	4.00
Chips	56	0.68	0.77	0.50	0	4.00
NGM potatoes	56	0.84	0.75	0.75	0	4.00
Potatoes	56	0.75	0.70	0.68	0	4.00

Table 3: T-test for null hypothesis that bids for the perceived GM food are equal to bids for perceived non-GM food (n = 142)

	Difference	**T-Test Statistic**
Oil	0.08	2.04*
Chips	0.07	2.64**
Potatoes	0.09	3.31**

*Statistically significant at the 5 percent level.

**Statistically significant at the 1 percent level.

Table 4: T-test for null hypothesis that bids for perceived GM and non-GM foods are equal under alternative labeling regimes (n = 142)

Perceived GM/ Non-GM Food	Mean Bid— Mandatory Regime	Mean Bid— Voluntary Regime	Difference	T-Test Statistic
GM oil	0.74	0.80	0.06	1.10
Non-GM oil	0.63	0.76	0.13	0.45
GM chips	0.69	0.75	0.06	0.56
Non-GM chips	0.61	0.68	0.07	0.53
GM potatoes	0.59	0.75	0.16	1.53
Non-GM potatoes	0.67	0.84	0.17	1.57

Table 5: T-test of null hypothesis that differences of biding differences are equal under two regimes

	Difference—Mandatory Regime	Difference—Voluntary Regime	Difference	T-Test Statistic
Oil	0.11	0.04	0.07	0.90
Chips	0.08	0.07	0.01	0.03
Potatoes	0.09	0.08	0.01	0.20

Appendix A: Information Given to Participants. Antibiotechnology Information

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

General Information

Genetic modification is one of the most dangerous things being done to your food sources today. There are many reasons that genetically modified foods should be banned, mainly because unknown adverse effects could be catastrophic! Inadequate safety testing of GM plants, animals, and food products has occurred, so humans are the ones testing whether or not GM foods are safe. Consumers should not have to test new food products to ensure that they are safe.

Scientific Impact

The process of genetic modification takes genes from one organism and puts them into another. This process is very risky. The biggest potential hazard of genetically modified (GM) foods is the unknown. This is a relatively new technique, and no one can guarantee that consumers will not be harmed. Recently, many governments in Europe assured consumers that there would be no harm to consumers over mad-cow disease, but unfortunately, their claims were wrong. We do not want consumers to be harmed by GM food.

Human Impact

Genetically modified foods could pose major health problems. The potential exists for allergens to be transferred to a GM food product that no one would suspect. For example, if genes from a peanut were transferred into a tomato, and someone who is allergic to peanuts eats this new tomato, they could display a peanut allergy.

Another problem with genetically modified foods is a moral issue. These foods are taking genes from one living organism and transplanting them into another. Many people think it is morally wrong to mess around with life forms on such a fundamental level.

Financial Impact

GM foods are being pushed onto consumers by big businesses, which care only about their own profits and ignore possible negative side effects. These groups are actually patenting different life forms that they genetically modify, with plans to sell them in the future. Studies have also shown that GM crops may get lower yields than conventional crops.

Environmental Impact

Genetically modified foods could pose major environmental hazards. Sparse testing of GM plants for environmental impacts has occurred. One potential hazard could be the impact of GM crops on wildlife. One study showed that one type of GM plant killed Monarch butterflies.

Another potential environmental hazard could come from pests that begin to resist GM plants that were engineered to reduce chemical pesticide application. The harmful insects and other pests that get exposed to these crops could quickly develop tolerance and wipe out many of the potential advantages of GM pest resistance.

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

General Information

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

Scientific Impact

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

Human Impact

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

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

Financial Impact

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

Environmental Impact

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

Information given to participants, independent, verifiable information

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

General Information

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

Scientific Impact

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

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

Human Impact

While many genetically modified foods are in the process of being put on your grocers' shelf, there are currently no foods available in the U.S. where genetic modification has increased nutrient content.

All foods present a small risk of an allergic reaction to some people. No FDA approved GM food poses any known unique human health risks.

Financial Impact

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

Environmental Impact

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

Appendix B: Demographic Characteristics of Polk County, IA (including Des Moines area) and Ramsey County, MN (including St. Paul area)

Variable	Definition	Polk	Ramsey	Average
Gender	1 if female	0.52	0.52	0.52
Age	Median age	45.70	45.70	45.70
Married	1 if the individual is married*	59.50	51.40	55.50
Education	Years of schooling**	13.52	13.76	13.64
Income	The median household's income level (in thousands)	46.10	45.70	45.90
White	1 if participant is white	0.90	0.80	0.85

Note: All variables are for individuals of all ages, except for married, which is for individuals 18 or older; education, which is for individuals 25 or older; and age, which is for individuals 20 or older.

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

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