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Consumer's Resistance to Genetically Modified Foods: The Role of Information in an Uncertain Environment

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Keywords
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Controversies Over the Adoption of Genetically Modified Organisms

Consumer's Resistance to Genetically Modified Foods: The Role of Information in an Uncertain Environment

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Consumer's Resistance to Genetically Modified Foods: The Role of Information in an Uncertain Environment*

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Abstract

Genetically modified (GM) foods have been engulfed in considerable controversy, and the early optimism has been dampened. Information issues—labeling and asymmetric information—are central to the GM-food debate. Furthermore, it is important to understand the reaction in developed countries to GM-foods because they set the tone of the world market in grains, oilseeds, and animal products. New results are reported from a statistical analysis of the market characteristics that push consumers in a high-income country to resist GM foods, with an emphasis on negative information from environmental groups and third-party, verifiable information, which could neutralize private information distributed by interested parties. A unique sample of adult consumers participated in laboratory auctions of three food products with randomized labeling and information treatments. A key finding is that GM information supplied by environmental groups increases the probability that consumers are out of the market for GM-foods. Third-party verifiable information, however, dissipates most of the negative effect of the environmental group perspective. Selective adoption of GM crops seems likely to raise world welfare but Western Europe's banning of GM imports and technology will largely affect them negatively.

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1. Introduction

During the last century, large increases in real per-capita income have occurred in the currently high-income countries. Research and Development (R&D) has been the source of improvements in existing goods and the introduction of new goods. Only recently has the full importance of successful new goods to economic growth been discovered (Hausman, 1996; Boskin et al., 1998). Not all seemingly useful new goods, however, have been adopted. For example, genetically modified (GM) foods have been engulfed in considerable controversy, and the early optimism about GM foods has been dampened. Information issues are central to the GM-food debate. Furthermore, it is important to understand the reaction in developed countries to GM-foods, because they set the tone of the world market in grains, oilseeds, and animal products.

In our history, other useful new goods have been adopted slowly. They include pasteurization of milk a century ago, nuclear power starting fifty years ago, and irradiated meat and poultry over the past decade. In the United States, early opposition to the pasteurization of milk was widespread, with opponents saying, among other things, that pasteurization was not needed and that consumers had the 'right to drink raw milk' (Hotchkiss, 2001). Pirtle (1926) notes that the slow adoption of pasteurization resulted in thousands of deaths that could have been prevented at a very low social cost.

The early prospects for nuclear power were good, but major and persistent resistance developed in Europe and the United States to electricity generated by nuclear power (Grübler, 1996). Although nuclear power is relatively cheap to produce and low in traditional environmental pollutants (e.g., CO_2, nitrous oxides, and sulfur oxides), environmental groups like Greenpeace and Friends of the Earth have lobbied and demonstrated against using the technology. Ruttan (2001) indicates that these groups helped increase the public's risk perception of nuclear power in the United States, forcing stringent safety standards to be enacted that contributed to a quadrupling of plant costs in just less than a decade. Thus no new nuclear power plants have been ordered in the United States since 1978. The image problems of nuclear power have carried over to irradiated foods during the past decade. Although irradiation of meat and poultry essentially eliminates all harmful-to-human-health bacteria like *E-coli* and *salmonella*, it has encountered stiff resistance (Nestle, 2002; Fox, 2002). Failing to irradiate meat and poultry has resulted in a significant number of annual deaths that were preventable at small marginal social cost.

In 1973, Cohen and Boyer discovered the technique of recombinant DNA (rDNA). The Cohen-Boyer patent for gene-splicing technology was awarded in 1980, which enabled the "Gene Revolution" starting in the 1990s (OTA, 1989). Early optimism existed in the United States, Canada, Argentina, and even in the

European Union (Fernandez-Cornejo and McBride, 2002). Furthermore, the agricultural biotech industry, (e.g., Monsanto and Syngenta), has promoted strongly GM-technology and foods, and has lobbied against labeling (CBI, 2001). In Europe, when food concerns unrelated to genetically modified organisms (GMOs) arose in the late 1990s, the green party leaders and the organic farmers demonstrated and lobbied against GMOs. They have been vocal opponents of agricultural biotechnology, creating websites, holding protests, issuing press releases, and burning down field trials of new GM crops. One argument they have made is that 'customers must have the right to know' what foods are genetically modified (*Greenpeace*, 1997, 2001; *Friends of the Earth*, 2001). Another argument is to pursue the International 'precautionary principle,' which emphasizes potential future unknown harmful effects but ignores current real benefits that currently would occur to producers and others (Paarlberg, 2001; Johnson, 2002). The European Union has been swayed by these arguments (Hoban, 1998; Paarlberg, 2001). In 1997, the European Union established a policy requiring the labeling of GM-foods. The next year, they imposed a temporary moratorium on the registration of new GM crop varieties for release to farmers. In September 2003, the European Union passed new legislation that imposed traceability and labeling requirements on GMOs, and food and feed products were to be regulated (European Parliament and Council, 2003)

The GM-food debate is engulfed in information issues—labeling and asymmetric information. The labeling issue encompasses the effects on consumer demand (and agricultural biotech companies) of 'plain labels,' which are silent about potential GM content; labels stating that a food contains GM organisms or that food is GM-free, which is interpreted to mean that a food has minimal or no GM content (i.e., it does not exceed an agreed-upon threshold, such as 1 percent or 5 percent impurity). Asymmetric information is central to the GM-controversy. Interested parties, such as the biotech industry (e.g., Monsanto, Syngenta), and international environmental groups (e.g., Greenpeace, Friends of the Earth, and Action Aid), disseminate GM information through various media that promote their particular private interests. Consumers and farmers, however, are exposed to the information of interested parties as the interested parties make purchasing decisions.

The consequences of new technologies and new products can be great, affecting the welfare of current and future generations. This article examines the effects of diverse information on the probability that consumers are out of the market for GM foods and places the emphasis on information from environmental groups, and on a third-party source (Huffman and Tegene, 2002; Huffman et al., 2003). For this study, we collected unique data from adult consumers in the United States who participated in laboratory auctions of three food types that had randomly assigned labeling and information treatments. Our key findings are that when consumers are treated to environmental-group perspectives of GMOs, it

increases the probability that they are out of the market for GM foods. Third party, verifiable information, dampens the effectiveness on consumers of the environmental-group perspective. An important finding is that negative information on GM foods from environmental groups, an interested source, can stymie technology adoption.

2. Data

We used data from the experiments described in Huffman et al. (2003). We now briefly highlight the main elements of our design. Consumers might react differently to GM content in different types of food or they might dislike some food products. Therefore using only one food item in a laboratory auction seemed unlikely to reveal enough information, given the sizeable fixed cost of conducting the experiment. Three food items were chosen for our willingness to pay (WTP) auctions: vegetable oil (made from soybeans), tortilla chips (made from yellow corn), and russet potatoes. In the distilling and refining process for vegetable oils, essentially all of the proteins (which are the components of DNA and the source of genetic modification) are removed leaving pure lipids. Minimal human health concerns should arise from GM oil, but consumers may worry that either the GM soybeans affect the environment or the GM soybeans are inadequately distilled. Tortilla chips are highly processed foods that may be made from GM or non-GM corn, and consumers might have human health and environmental concerns about this product. Russet potatoes are purchased as a fresh product and are generally fried or baked before eating. Similar to tortilla chips, consumers might see both human health and environmental risks from eating GM-russet potatoes.

We are interested in the effects of diverse information, given labeling, on consumer demand for food products that might be genetically modified. In our experiments, the two labels—GM and plain—were clearly displayed on the fronts of each food package (Huffman et al., 2003). A one-page summary organized under five different headings—general information, scientific information, human impact, financial impact, and environmental impact was prepared, with pro-GM information from Monsanto and Syngenta, which are large agribusiness companies; anti-GM information was provided by Greenpeace, a leading environmental group and non governmental organization (NGO), which opposes genetic modification; and third-party or verifiable information from informed but financially disinterested sources. The exact information disseminated can be found in Huffman et al. (2003) or can be obtained by the authors upon request. This information was organized into six information treatments: pro-GM, anti-GM, pro-GM and anti-GM, pro-GM and verifiable, anti-GM and verifiable, and all three types. The six information treatments were randomly assigned to 12 experimental units, with each unit consisting of 12 to 16 individuals.

We followed standard experimental auction-valuation procedures (Smith, 1976; Shogren et al., 1994), with refinements to the design to better reflect consumer purchases. First, our subjects submitted only one bid per product to avoid any question of creating affiliated values that can affect the demand-revealing nature of a Vickrey-style auction (List and Shogren, 1999). Second, endowment effects were minimized by not endowing our subjects with a food item and then asking them to 'upgrade' to another food item, because that methodology can cause distorted bid prices (Lusk and Schroeder, 2002). Third, consumers bid on three unrelated food items: vegetable oil, corn chips and russet potatoes—so we obtained useful information on their tastes for genetic modification even if a subject disliked one or two products. Fourth, treatments were assigned randomly to experimental units, and the estimation of treatment effects was simply the difference in means across treatments (Wooldridge, 2002). We also randomized within treatments (e.g., order of pro- and anti-biotech information when an experimental unit received both types). Third party, verifiable information was always presented last.

Fifth, adult consumers over 18 years of age from two large metropolitan areas in the United States were chosen as participants by a random digit-dialing method (Table 1 for summary statistics).[1] Subjects were paid a participation fee of $40. We used common food items available to shoppers in grocery stores and supermarkets, and preferred adults who were not primarily college students. (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.) Table 1 contains sample mean values of the adults who participated in our experiments. The concentration of women reflects women's greater involvement in households' decisions on food and household products. Also, using individuals chosen randomly minimizes the chance that participants change their behavior only because they are participants in an experiment with specific objectives, i.e., it minimizes the Hawthorne effect (Melton et al. 1996).

Sixth, a Vickrey 2nd price auction is used frequently in WTP experiments, but it does not engage 'off the margin bidders.' For new products, researchers are interested in the location of the completed demand curve—not just one segment of it. We used the random *n*th price auction, which has the advantage that it is demand revealing in theory, and the auction attempts to engage bidders at all locations along the demand curve (Shogren et al., 2001). For example, each of k bidders submits a bid for one unit of a good; for instance, if the monitor randomly selects $n = 4 <= k$, the four highest bidders each purchase one unit of the good priced at the fourth-highest bid. This random *n*th price auction increases the odds that insincere bidding will lead to a loss. Consumers, who 'won' the auction, purchased the products.

[1] See Huffman et al. (2003) for means of attributes of survey areas.

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

Variable	Definition	Mean	St. Dev.
Gender	1 if female	0.62	0.49
Age	The participant's age	49.50	17.50
Married	1 if the individual is married	0.67	0.47
Education	Years of schooling	14.54	2.25
Household	Number of people in participant's household	2.78	1.65
Income	The household's income level (in thousands)	57.00	32.60
White	1 if participant is white	0.90	0.30
Informed[a]	1 if an individual considered him/herself at least somewhat informed regarding GM foods	0.42	0.49
Labels1	1 if the treatment bid on foods with GM labels in Round 1	0.52	0.50

[a]Information about participant's prior beliefs; information collected from participants in pre-auction questionnaire.
Source: Adapted from Huffman et al. (2003:490).

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

3. A Model

The model is one of a consumer demand function in which demand is determined by the physical attributes of the food item, the GM-content (as labeled), information (agricultural biotech industry, environmental, and/or third party), and socio-economic attributes of the shopper and his or her household. The hypothesis is that the environmental-group perspective on genetic modification shifts a consumer's demand curve to the left or downwardly and verifiable information shifts the demand curve to the right or upwardly. If demand is reduced

sufficiently, grocery store managers will not stock a product. We define two tests for being 'out of the market' for a GM-food item. The strong test assumes that a consumer is out of the market for a GM-food when he or she bids zero for the GM food item (when he or she bids a positive amount for the plain-labeled counterpart). The weak test assumes that a consumer is out of the market for a GM-food when he or she reduces his or her bid by at least one-third relative to their bid for a similar plain-labeled product. Given that marking margins are generally less than 20 percent (Kiesel, Buschena, and Smith, 2002) a 33 percent or larger reduction in willingness to pay would most likely mean that grocery store managers would not stock a product.

The key hypotheses are: (1) when the environmental group perspective on genetic modification is released to consumers, it increases the probability that consumers are out of the market for GM-labeled foods; and (2) given that the consumers have received the environmental-group perspective on GMOs, the release of third-party, verifiable information dampens the effects of environmental group information on consumers, and thereby makes consumers less likely to be out of the market for GM foods.

The empirical evidence we are looking for is contained in descriptive statistics of experimental results and Probit models explaining the probability of a consumer being out of the market for GM-labeled foods (Wooldridge, 2002).

4. Results

First, we consider the percentage of consumers who are out of the market for the GM-labeled products (Table 2). Part A of Table 2 shows the results for the strong test, examining the percentage of consumers who bid zero for the GM-labeled food items. The percentage of consumers who are out of the market for an item using the strong test ranges from 8.9 percent for vegetable oil to 12.9 percent for tortilla chips. Part B shows the results for the weak test, examining the percentage of consumers who discounted their bids for the GM-labeled food items by at least one-third relative to their bids for the plain-labeled items. The percentage of consumers who are out of the market for an item using the weak test ranges from 19.2 percent for vegetable oil to 23.9 percent for tortilla chips.

Tables 3 and 4 present results from fitting Probit models explaining the probability of laboratory participants being out of the market for GM-labeled food items given particular information treatments. In Table 3, the dependent variable takes a "1" if the participant is out of the market for a GM-labeled food item via the strong test (i.e., bids zero for the GM-labeled food item while bidding some positive amount for a plain-labeled counterpart), and a "0" otherwise. In Table 4, the dependent variable takes a "1" if a participant is out of the market for a GM-food item (i.e., has reduced his or her bid by at least one-third relative to the

Table 2. Percentage of Consumers Who are Out of the Market for GM-Labeled Food Items: Excludes Double-Zero Bids

Part A: Percentage of Consumers who Bid Zero for a GM-Labeled Food Item

	Observations	Out of Market	Percent Out of Market
Vegetable Oil only	146	13	8.9
Tortilla Chips only	155	20	12.9
Potatoes only	159	20	12.6

Part B: Percentage of Consumers Whose Bid for a GM-Labeled Food Item is 2/3's the Amount They Bid for the Plain-Labeled Food Item, or Lower

	Observations	Out of Market	Percent Out of Market
Vegetable Oil only	146	28	19.2
Tortilla Chips only	155	37	23.9
Potatoes only	159	35	22.0

Source: Authors' Calculations.

plain-labeled item), and a "0" otherwise. Both tables show separate results for the bottle of vegetable oil, the bag of potatoes, and the bag of tortilla chips.

The estimated coefficients from Probit models fitted to our sample of laboratory participants explains the probability that an auction participant is out of the market for a food item. The results show that release of the environmental-group perspective on genetic modification in the experiment increases the probability that a participant is out of the market for each of the three GM-food items. The impact is statistically significant at the 5 percent level for the tortilla chips using the strong test and for russet potatoes and vegetable oil using the weak test. This result has important implications. If an international environmental NGO wishes to slow scientific progress or reduce trade, it could disseminate large amounts of negative information, even if the information is highly biased. With asymmetric information, it could even disguise true intentions by telling consumers it wants to keep them "fully informed" of the consequences of a product or technology, or by telling consumers to be very cautious until all the negative claims are disproved, hence the "precautionary principle." Even if individuals do not fully believe the information, negative GM information will increase the uncertainty about products that might be genetically modified or about processes using genetic modification, and which have been shown to decrease the likelihood of adoption(Purvis et al., 1995). With a significant reduction in consumer demand, supermarket managers may discontinue carrying an item, which reduces consumers' choices, and with a collapse in the market for a food item, farmers would discontinue using GM-technology to produce the raw products needed for particular foods. Given that technological change is one of

Table 3. Probit Model: Dependent Variable is 1 if a Consumer Bids Zero for the GM-Labeled-Product and 0 Otherwise (N=172, Standard Errors in Parenthesis)[a]

	Food Item		
Regressors	Vegetable Oil	Russet Potatoes	Tortilla Chips
Environmental Perspective	0.836	0.623	0.874**
	(0.52)	(0.44)	(0.43)
Biotech Industry Perspective	–0.383	–0.604*	–0.321
	(0.36)	(0.33)	(0.32)
Third-Party Perspective	–0.036	–0.234	–0.475
	(0.327)	(0.29)	(0.30)
Household Income	0.002	–0.002	0.006
	(0.00)	(0.00)	(0.00)
Labeled GM1st Round	0.772**	0.565*	0.582*
	(0.38)	(0.32)	(0.06)
Informed Before Trials	0.107	.0439	0.107
	(0.34)	(0.30)	(0.30)
Intercept	–2.499**	–1.916**	–2.196**
	(0.76)	(0.63)	(0.61)

[a] Each commodity is considered separately and the parameters of each Probit model are estimating using maximum likelihood estimation.
* Statistically significant at the 10 percent level.
** Statistically significant at the 5 percent level.
Source: Authors' compilations.

the driving forces behind the escalating standards of living, stalling adoption of new goods broadly could lead to a significant reduction in future social welfare.

The results reported in Tables 3 and 4 also show that when the third-party perspective is released in the experiment after participants have received the environmental-group perspective, it decreases significantly, at the 5 percent level, the probability that participants are out of the market for GM-labeled foods. The impact is statistically significant for two of the three food items using the weak test. This result provides evidence that a third-party perspective, which provides neutral but verifiable information on genetic modification and GM-foods can significantly reduce the probability that markets for GM-foods collapse.[2] In addition to the value verifiable information has by providing consumers with

[2] Johnson et al. (2001) find that consumers trusted environmental groups more than some third-party (e.g., government) sources. We were careful to separate our discussion of third-party information from government sources of information.

Table 4. Probit Model: Dependent Variable is 1 if a Consumer Bids at Least One-Third Less For a GM-Labeled Product than Plain Labeled Product and 0 Otherwise (N=172, Standard Errors In Parenthesis)[a]

	Food Item		
Regressors	Vegetable Oil	Russet Potatoes	Tortilla Chips
Environmental Perspective	0.864**	0.820**	0.460
	(0.37)	(0.38)	(0.31)
Biotech Industry Perspective	–0.359	–0.694**	–0.489*
	(0.30)	(0.28)	(0.28)
Third-Party Perspective	–0.691**	–0.714**	–0.186
	(0.28)	(0.26)	(0.24)
Household Income	0.004	–0.001	0.005
	(0.00)	(0.00)	(0.00)
Labeled GM1st Round	–0.143	–0.014	–0.117
	(0.27)	(0.27)	(0.25)
Informed Before Trials	0.493	.0654**	0.447*
	(0.28)	(0.27)	(0.25)
Intercept	–1.378**	–0.962*	–1.057**
	(0.52)	(0.63)	(0.46)

[a] Each commodity is considered separately and the parameters of each Probit model are estimating using maximum likelihood estimation.
* Statistically significant at the 10 percent level.
** Statistically significant at the 5 percent level.
Source: Authors' compilations.

objective information on the risks and benefits of genetic modification (estimated in Rousu et al. (2002) at U.S. $2.6 billion), verifiable information can increase the number of real options that consumers have in supermarkets.

When the biotech industry perspective in the experiment is released, the probability of a participant being out of the market for a GM-labeled food product is reduced, which is statistically significant for one of the three food items using the strong test and two of the three food items using the weak test (Tables 3 and 4). Although the agricultural biotech industry perspective frequently gets bad press, our results suggest that it can also reduce the probability of consumers being out of the market for GM-labeled foods. In addition, consumer pre-experiment beliefs are important factors for understanding the demand for GM-labeled foods. When a participant reported in our pre-experiment questionnaire that he or she was at 'least somewhat informed' about GM-technology and

products, he or she had a significantly higher probability of being out of the market for GM-foods (Table 4).[3]

5. Conclusions and Implications

This article has provided new insights into and empirical evidence on factors affecting resistance to new products by consumers in a high-income country. Our evidence is derived from a unique data set. We applied a sound statistical experimental design that randomly assigned labeling and information treatments to experimental units of adult consumers who participated in laboratory auction experiments of three food items that might be genetically modified.

We uncovered several useful results. First, we showed that bids by the participants for food items are affected in plausible ways by the release of diverse information. Furthermore, no single perspective is a dominating source covering up the effects of other perspectives. Second, when participants bid on foods with GM labels, they were significantly more likely to be out of the market. Third, when participants received the environmental group perspective, they had a significantly higher probability of being out of the market for GM-labeled food items. Fourth, given that the environmental-group perspective was released, the release of third party, verifiable information dissipated most of the negative effect of the environmental group perspective on participants. Verifiable information can be an effective policy tool used to moderate resistance to new products and to keep new food products as options in supermarkets, thereby increasing consumers' range of choices.

Our results present an alternative explanation for negligible demand by the Europeans for GM foods. Europeans may have a strong preference for a natural or traditional production process, and this preference causes them to resist GMOs (Zechendorf, 1998). An alternative interpretation is that NGOs, largely Greenpeace and Friends of the Earth, have been more prevalent in Europe than they have been in the United States, disseminating larger amounts of negative GM-information, creating skepticism and doubt about GM technology.

[3] An individual's household income, education, gender, or age do not have a statistically significant effect on the probability of a participant being out of the market for any of the GM-food products.

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