Consumer Purchases of Biotech Sweet Corn: Results from a Market Experiment

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Abstract

In the increasingly consumer-driven food system, consumer preferences toward agricultural biotechnology have the potential to influence decisions about development and adoption of biotech crop varieties. Current knowledge about consumer attitudes toward biotech foods is largely based on a number of consumer surveys and a growing body of experimental auctions. This paper reports results of a market experiment designed to isolate the effect of the use of biotechnology on consumer choices between two otherwise identical products. Two related varieties of fresh-market sweet corn were grown, labeled, and sold side-by-side in nine participating grocery stores in the Philadelphia area. Sales data indicate a market share of biotech corn of about 45 percent, with store-specific shares varying between 10 and 80 percent. Over 700 surveys were collected in stores. Surprisingly, only 65 percent of respondents noticed that there were two types of corn for sale despite the labeling and merchandising, and 87 percent of the sample spent one minute or less choosing their corn. About half of the respondents had heard of biotechnology before, and 16 percent volunteered the biotechnology trait as an influence on their purchase decision. Approximately 40 percent of the sample purchased some of the biotech variety, with several respondents purchasing some of each.

In the increasingly consumer-driven food system, consumer preferences toward agricultural biotechnology have the potential to influence decisions about development and adoption of biotech crop varieties. Because foods whose ingredients were developed using modern biotechnology ("biotech foods") are usually not labeled, consumers have not had the opportunity to reveal their preferences for biotech traits in the marketplace.

Current knowledge about consumer attitudes toward biotech foods is largely based on a number of consumer surveys and a growing body of experimental auctions (reviewed in James, 2004). Most surveys find that awareness of biotech foods is low (usually around 50%), that knowledge is shallow, and that attitudes are split in favor of and against the use of modern biotechnology in developing crop varieties. Another common finding is that a majority of consumers express a desire for biotech foods to be labeled. As indicators of consumer preferences, surveys may suffer from hypothetical bias, in which responses may not accurately

predict market behavior; for instance, consumers may overstate their willingness to pay to avoid biotech foods. Experimental auctions more closely approximate consumer behavior by including financial incentives. Experimental auctions conducted by Tegene et al. found that, on average, consumers were willing to pay 14 percent less for genetically modified (GM) foods, relative to their non-GM counterparts (Tegene et al., 2003).

This paper reports results of a market experiment in which consumer choices made in the marketplace are observed and measured. The purpose of the study was to assess consumer willingness to purchase biotech food in a market environment, using fresh sweet corn as the specific product of interest. The market experiment was designed to isolate the effect of the use of biotechnology on consumer choices between two otherwise identical products. Two related varieties of fresh-market sweet corn were grown, labeled, and sold side-by-side in nine participating grocery stores in the Philadelphia area. Sales results indicate the potential market share for labeled biotech foods in the geographic area of study. Survey results indicate consumer characteristics associated with an increased willingness to purchase biotech food and the role price played in their decision.

Experimental Design

Approximately 12 acres of Syngenta's Boreal white supersweet 78-day sweet corn were grown at the Pennsylvania State farm in Landisville, PA. Half of the acreage was devoted to a Bt variety of Boreal. This hybrid is closely related to the conventional variety, but includes the Bt gene. The Bt gene produces a protein that is toxic to certain types of worms, and therefore builds worm control into the corn. Production was split among four separate plantings to maximize the time period in which corn was available in stores. Weather conditions compressed the

harvesting window, which began August 12 and ended August 30, 2003 (sales extended through Labor Day weekend, September 4, 2003).

Throughout the study, every effort was made to keep the quality of the two types of corn as similar as possible. Corn was harvested by hand so that the maturity of each ear was monitored (as opposed to machine harvesting, in which all ears are harvested at the same time, regardless of the degree of maturity). As corn was labeled and packed, ears with worm or insect damage were discarded, so that all ears, regardless of whether or not they were protected by the Bt gene, were relatively free of pest damage. Corn was refrigerated during storage and transport to maintain quality. However, storage and handling conditions varied among participating stores, so corn could have differed in quality while on display. Regardless of store-specific conditions, it is likely that the conventional corn was "cleaner" of worm damage than it would be in normal conditions. A more realistic comparison might have been between clean ears of Bt-corn and wormy ears of conventional corn, but the difference in quality would have made it difficult to isolate the effects of the biotech trait.

Identity preservation from the field to the grocery check-out stand was important to ensure that consumers could select the type of corn they wanted, and also so sales data were as accurate as possible. Therefore, each ear of corn was labeled. Recognizing that the words used to describe the two types of corn could significantly influence results, we conducted an informal survey of 23 faculty and professionals whose work relates to agricultural biotechnology, asking for their opinions about several possible labels. Respondents agreed that labels should include terms that most consumers would recognize and understand, but that do not convey value statements.

For the biotech variety, the acronyms “GM” or “GMO” may have been recognizable by consumers, but carry negative connotations, as those terms are most often used by organizations that oppose biotechnology. Labeling the corn as “Bt,” while accurate and objective, would probably be unfamiliar to the average consumer. “Genetically Engineered” was considered to be accurate and relatively recognizable, as it is frequently used in media reports. However, the term was thought to have negative, scary, and possibly even inflammatory connotations. Ultimately, corn was labeled as “Biotech.” Although this term is not technically accurate in the sense that biotechnology includes a number of techniques (including plant breeding), it was expected to be relatively recognizable and would not necessarily convey positive or negative connotations. In addition, if biotech foods were labeled voluntarily, “Biotech” would be much more likely to be chosen by food manufacturers or retailers than the other options considered.

For the non-Bt sweet corn, we considered several possible labels. “Regular” sweet corn was not favored because it was vague and implied that there was something irregular about the other sweet corn. A few respondents thought “traditional” was an apt descriptor for the non-Bt corn, but others noted that it could be construed as an heirloom variety. Simply referring to the non-Bt variety as “Sweet Corn,” with no descriptor, was favored by several respondents. They noted that such a label is how non-Bt sweet corn is currently marketed, and that additional words or descriptors might confuse consumers. The primary objection to omitting an adjective for the conventional variety was that the structure of the signs would be different. About the same number of respondents favored calling the non-Bt corn “Conventional.” While some consumers may not understand the implicit comparison being made, the term has been used to compare production to organic methods, and so it may be recognized.

Each ear of corn was labeled with a sticker that included a price-lookup number and the label "Conventional Sweet Corn" or "Biotech Sweet Corn" (see figure 1). In addition to the label used on each ear of corn, store signage included the type of corn, and a brief phrase providing additional information. This choice was based on results from focus groups conducted for the Food and Drug Administration, in which consumers expressed a preference for labels that included information about how or why biotechnology was used (Levy and Derby, 2000). The biotech variety was labeled as "Biotech Sweet Corn: Developed Using Biotechnology to Control Pest Damage." The description of the conventional corn was written to be somewhat parallel: "Conventional Sweet Corn: Developed and Grown Using Conventional Methods."

Near the corn displays, pamphlets were available for consumers who wanted to learn more about the two varieties. The tri-fold pamphlet summarized how the two varieties were developed, how worms were controlled, and the safety, regulation, and nutritional composition (see excerpts in figure 2). Information provided was as objective and unbiased as possible, without subjective or value-laden statements or language. Two versions of the pamphlets were developed, the key difference being that one included panels on why biotechnology is used, arguments about whether biotech is the "right" way to grow food, and how they affect the environment. The goal in including this additional information in one version was to determine whether it influenced purchasing decisions one way or another. In practice, it appeared that very few consumers read the brochures (or even picked them up), so the effect of information is likely to have been minimal.

The relative prices of the two types of corn were varied over time at each of the participating stores. At times, biotech corn was sold at a discount, sometimes at a price premium, and sometimes at the same price as the conventional corn. Delivery and sales data for

each type of corn at each store were collected. In addition, students approached consumers who purchased either type of corn and administered a short survey designed to assess consumer awareness and knowledge of biotechnology, their trust in grocery stores and the government, shopping behaviors and demographic characteristics.

Participating Stores

Nine stores in the Philadelphia area participated in the study. Four of the stores were in the inner city, and the other five were in outlying areas. Table 1 includes some general characteristics of the stores and demographic data for the store's trading area. Stores were subjectively rated as either upscale or downscale based on the overall appearance of the store. Upscale stores tended to be more modern, with large areas for produce and café areas for prepared foods. Downscale stores tended to be older in appearance, with fewer resources devoted to store décor and prepared foods. Table 1 also includes the median income for each store's trading area, as calculated by Spectra Marketing Inc. using census data. Median incomes ranged from $42,397 to $95,502, compared to the national median income of $47,741. Table 1 also includes the percent of the population in the store trading areas that have college degrees and that are non-white.

Clearly, stores fall in one of two categories: upscale stores with a relatively educated, high income, and predominantly white clientele; and downscale stores with lower income and a more ethnically diverse clientele. One exception is store number 9. Although technically the residents of the store-trading area have a very high median income ($93,444, nearly double the national median income) with a high proportion of the population that is college educated, the store was classified as downscale. The discrepancy is probably a result of a few high-income area codes on the periphery of the store trading area.

Sales Data

Stores were asked to set the price of conventional corn as they normally would, and to vary the relative price of conventional and biotech corn according to a randomly generated schedule. There were five possible pricing schemes: biotech sold at a 25% discount, 10% discount, at the same price, and at a 10% or 25% premium relative to conventional corn. Each time a store changed its price, it was to change to the next pricing scheme on its schedule. While price variation was considered to be an important element of the study, several factors limited the degree to which prices were varied. First, because of the compressed harvest window, corn was only for sale in stores for approximately three weeks, and several of the stores only changed their prices once a week. Second, several of the stores belonged to marketing cooperatives whose advertising circulars featured sweet corn on special for several days. Those stores were constrained to the advertised price (for both types of corn). Finally, at some points in the study, it was difficult to ensure that stores adhered to the pricing schedule.

Because each type of corn had a unique price-lookup number, sales of each type of corn were collected (both in quantities and value). Figure 3 shows the market share of biotech corn (as a percent of the total quantity sold) at each store for the entire period of the study, with median income of the store-trading area on the horizontal axis. Market shares ranged between about 10 and 80 percent. Importantly, the data system of store 3, which had the lowest recorded market share, broke down before sales data were collected, so this estimate is not very reliable. Ignoring the data point for store 3 in figure 3, there seems to be a clear positive relationship between the market share of biotech corn and median income in the store's area. Overall,

biotech corn accounted for approximately 40 percent of the corn sold during the study, although this number could understate the true market share because of the problems with store 3.

Daily market shares of biotech corn, expressed as the percent of total corn sold that was the biotech variety, were estimated as a function of the relative price of the biotech variety on that day, median income, and a dummy variable that equaled one if the score was downscale and zero if it was upscale. Results of this regression are presented in table 2. Results indicate that as the median income of the store's trading area increases, the market share of biotech corn increases at a decreasing rate. Income effects are mitigated at downscale stores. While the effect of relative prices is not statistically significant for upscale stores, the price-downscale interaction term is significant at the 10 percent level, indicating that price only has a statistically significant effect on biotech market share at downscale stores. Specifically, the market share of biotech corn decreases as it becomes more expensive relative to the conventional variety, as we would expect. These results imply an expected biotech market share of approximately 57 percent for an upscale store with median income of $70,000 and the same price charged for the two types of corn. For a downscale store with a median income of $44,000 and the same price charged, the expected market share would be approximately 31 percent.

Survey Results

In addition to the sales data, survey data were collected. As scheduling allowed, students stood in the produce section where they could unobtrusively observe shoppers. After a shopper had chosen his/her corn and began to leave the corn display area, the student approached the shopper and asked if s/he would complete a brief survey. The number of surveys collected from each store and responses to key questions are included in table 3. Over 700 surveys were collected.

Respondents were predominantly female and white, with high incomes relative to the national median.

Throughout the process of designing the experiment, we assumed that consumers would notice the store signage. The first question of the survey, "When you chose your sweet corn today, did you notice that there were two different kinds for sale?" was added at the last minute. Surprisingly, only 64 percent of respondents ***noticed*** that there were two types of corn for sale despite the labeling and merchandising. Responses to this question allow for an interesting comparison of the percent of respondents who purchased some biotech corn considering all survey respondents and just those who noticed that there were two types of corn. This comparison is a crude way of inferring whether the biotech trait had a positive or negative influence on choices. Approximately 40 percent of the sample purchased some of the biotech variety, with several respondents purchasing some of each. Considering only respondents who noticed that there were two types of corn for sale, the percent purchasing biotech was very similar (39 percent compared to 38 percent). This comparison and the fact that only 16 percent of respondents mentioned biotechnology as influencing their decision suggest that the biotech trait had a relatively small influence on purchasing behavior.

Two logit models were estimated. One estimated the likelihood that a consumer would notice that there were two types of corn for sale as a function of time spent making the choice and consumer characteristics. Those results are shown in table 4. Although this model accurately predicted just over half of the responses, it is statistically significant (i.e., the null hypothesis that all coefficients are jointly equal to zero can be rejected at the 5 percent level of confidence). Not surprisingly, the likelihood of noticing the two types of corn increased as time spent increased. Consumers who spent about a minute (as opposed to the base case, which was

to spend less than a minute) were 62% more likely to notice. Consumers with higher incomes were also more likely to notice the two types of corn. Consumers fell into one of seven income categories, and each increase in income category increased the odds of noticing the two types of corn by 17 percent.

Another logit regression estimated the likelihood that a consumer would purchase some biotech sweet corn. The model, reported in table 5, fit the data reasonably well, with 67 percent of the responses predicted correctly and overall statistical significance. Relative prices had a statistically significant effect on willingness to purchase the biotech variety. A categorical variable was created and set equal to -1 when biotech corn was sold at a discount, 1 when it was sold at a premium, and 0 when it was priced the same as the conventional variety. For each increase in the relative price of biotech corn, the likelihood of purchasing biotech corn decreases by 27 percent. Consumers who spent more time making their decision were more likely to buy some biotech corn than those who spent less than a minute making their decision. Finally, respondents with higher incomes and more favorable opinions of science and technology were more likely to purchase the biotech variety. Notably, whether or not the respondent had heard of biotechnology previously had a statistically insignificant effect on the likely of a biotech purchase.

Concluding Thoughts

Results from this market experiment suggest that labeling foods as being derived from biotechnology will not eliminate their demand. In the case of sweet corn, approximately 40 percent of consumers were willing to purchase a biotech variety. In addition, the quality and appearance of biotech and conventional corn was held as similar as possible, but survey results

indicate that appearance has a major influence on consumer decisions. Therefore, if a biotech variety were clearly of higher quality, the market potential is likely to be much higher than the observed range. Market share data suggest that upscale store serving a high-income consumer base would have more success in selling labeled biotech foods. Links between consumer attributes and the type of corn purchased suggest a profile of consumers who would be more likely to purchase labeled biotech foods.

While specific to the Philadelphia area and the particular product considered, this study fills a gap in current knowledge about consumer preferences for biotech and non-biotech foods. Survey results consistently show a majority of consumers expressing a preference for labels, but in contrast, 36 percent of survey respondents did not read them in this market environment, and very few were influenced by them. These results seem to suggest that the costs of a mandatory labeling policy would not be justified by the relatively minor influence the use of biotechnology had on purchasing decisions.

References Cited

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Levy, A.S. and B.M. Derby "Report on Consumer Focus Groups on Biotechnology." Unpublished, 2000.

Tegene, A., W.E. Huffman., M. Rousu, and J.F. Shogren. The Effects of Information on Consumer Demand for Biotech Foods: Evidence from Experimental Auctions. Technical Bulletin Number 1903. 2003. Washington, D.C., Economic Research Service, U.S. Department of Agriculture.

Figure 1. Stickers Identifying Type of Corn

Figure 2. Excerpts from Pamphlet Describing Conventional and Biotech Corn

Conventional and Biotech Sweet Corn — What's the Difference?

Conventional and biotech sweet corn are similar in many ways. The main differences are in how they were developed and how worms are controlled.

The following table clarifies some of the key differences between conventional and biotech sweet corn.

	Conventional	Biotech
Variety development	Plant breeding	Plant breeding and modern biotechnology
Worm control	Variety of methods, including pesticides	Built into corn, pesticides are rarely necessary
Safety, regulation and nutrition	Sprays applied are approved by EPA	Plant varieties approved by EPA and USDA
	According to the FDA, the two varieties do not differ in terms of their nutritional composition	

EPA = Environmental Protection Agency
FDA = Food and Drug Administration
USDA = United States Department of Agriculture

Conventional Sweet Corn

Conventional varieties are developed using traditional methods:
- Developed using selective plant breeding methods, as are most new plant varieties
- Closely related plants are cross-fertilized, and the resulting hybrid will have some traits of each "parent"
- Selective breeding combines many traits at once, so it can take a long time to get a good combination of traits

Conventional varieties require a variety of methods to control insects:
- Examples include crop rotation, planting pest-resistant crop varieties and conserving the population of insects that destroy pests harmful to the crop
- Pesticides are applied only when pest populations grow beyond an acceptable level

Chemicals require government approval:
- Chemicals applied to corn must be approved by the EPA and be used according to their specifications
- This sweet corn has been grown in compliance with the EPA's specifications

Biotech Sweet Corn

Biotech varieties are developed using more exact methods:
- Developed using a combination of selective breeding and methods of modern biotechnology
- Modern biotechnology takes a piece of DNA associated with a particular trait from one organism and puts it into a plant's DNA
- A more precise method of developing plant varieties since a single trait is transferred

This Biotech corn offers built-in protection to control some insects:
- Biotech varieties require many of the same pest control methods that conventional varieties do
- Biotech corn includes a gene from bacteria called Bacillus thuringiensis, and is often called "Bt corn"
- The Bt gene produces a protein that is toxic to certain types of worms (moth larvae), building worm control into the plant and reducing the need for pesticides

Biotech crops require government approval for use:
- New crop varieties developed using biotechnology must be approved by the USDA, the FDA and the EPA
- These agencies have determined this biotech sweet corn is safe for human consumption

Why farm biotech crops?

Many of the biotech crops currently available make it easier for farmers to control insects or weeds. Farmers' benefits from planting biotech crops depend on pest pressure and production costs. Biotech seeds usually cost more than conventional seeds. Some potential benefits of planting biotech crops are:
- Decreased pest damage, pesticide use and soil erosion
- More flexibility in how farm labor is managed
- Increased yields and farm income

The most commonly grown biotech crops in the United States are soybeans, corn and cotton. In 2003, 81 percent of the soybeans, 40 percent of the corn and 73 percent of the cotton grown in the United States were biotech varieties (*National Agricultural Statistics Service Acreage Report*, June 2003). Other biotech crops are being developed that will provide benefits to consumers, such as produce that will not spoil as quickly and produce with extra vitamins.

Is biotechnology the "right" way to grow food?

Some people say using biotechnology to produce food is "messing with Mother Nature." Others say we have been manipulating plants to provide plentiful and tasty food for a long time by breeding plants. One difference between modern biotechnology and plant breeding is that traits may be moved between unrelated organisms (like from a soil bacterium to a corn plant) using modern biotechnology, while traits may be moved only between related plants (like from one corn plant to another corn plant) using plant breeding. Whether this difference or any other aspect of biotechnology makes it a better or worse way to produce food is a matter of individual opinion.

How do biotech crops affect the environment?

All methods of food production affect the environment. There may be both positive and negative environmental effects from adopting biotech crops. Some people are concerned that:
- Biotech crops may cross-pollinate with other plants
- Pests may build resistance to biotech crops
- Biotech crops may harm insects that do not damage crops

Some environmental benefits of biotech crops are:
- Reduced use of pesticides — The National Center for Food and Agricultural Policy found the use of biotech crops reduced pesticide use by 46 million pounds in 2001 *(www.ncfap.org)*
- Decreased soil tillage — Another study by the Conservation Technology Information Center found that adoption of biotech crops is reducing soil tillage, resulting in less soil erosion, better air and water quality, less fossil fuel consumption, reduced release of greenhouse gasses and a more natural habitat *(www.ctic.purdue.edu)*

Scientists continue working to determine the negative and positive environmental effects of different methods of food production.

Figure 3. Store-Specific Market Share of Biotech Corn, as Percent of Total Quantity Sold

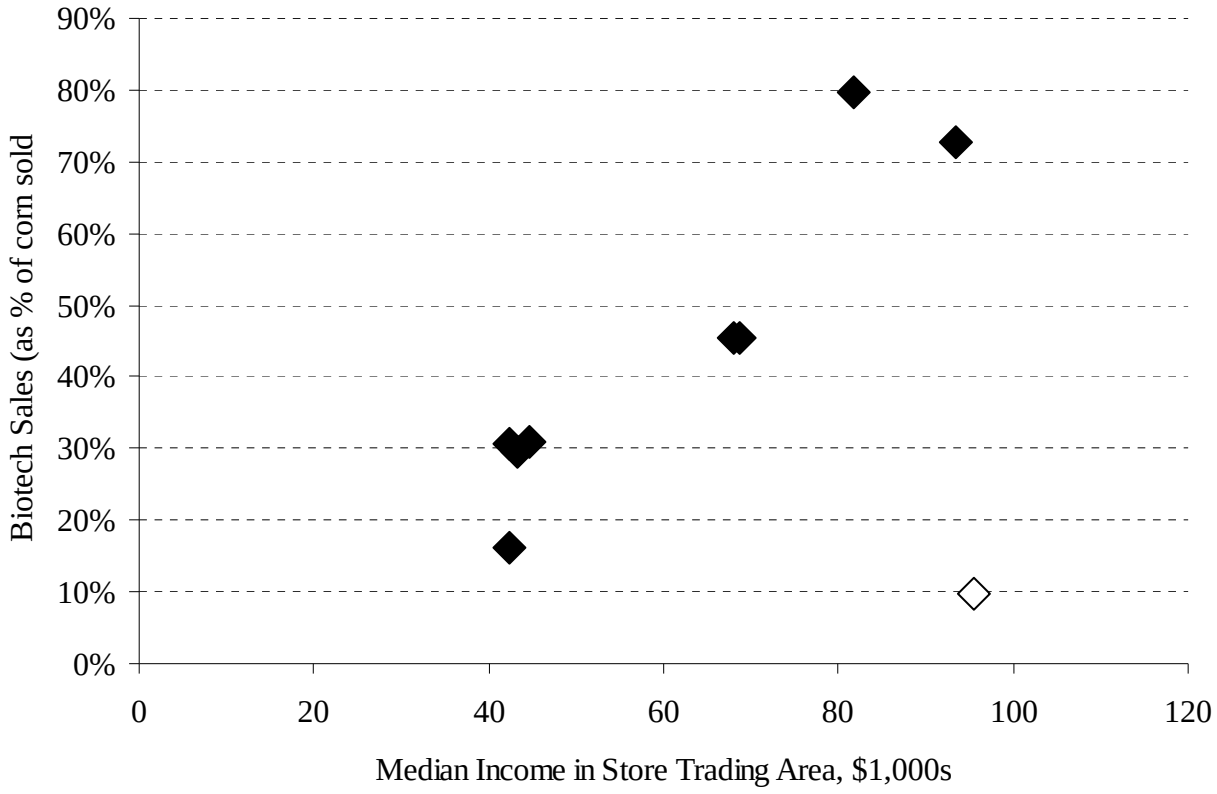

Table 1. Characteristics of Stores and Residents in Store Trading Area

Store #	City or Suburb (direction from city)	Up- or Down-scale	Median Income	% of Population with College Degree	% of Population that is Non-White
1	Suburb (NW)	Up	68,723	21.1	5.4
2	Suburb (NW)	Up	67,997	29.4	15.0
3	Suburb (W)	Up	95,502	44.3	14.4
4	City	Down	42,397	9.6	20.0
5	City	Down	43,184	8.7	42.3
6	City	Down	44,728	15.5	17.8
7	City	Up (small)	42,262	36.2	53.5
8	Suburb (N)	Up	81,740	36.3	15.3
9	Suburb (N)	Down	93,444	39.1	4.1
National			47,741	20.8	31.8

Source: Spectra Marketing Systems, Inc., 2003.

Table 2. Regression of Biotech Market Share on Store Characteristics and Relative Prices

Dependent Variable: Share of Corn Sold that was Biotech Variety

Independent Variable	Estimated Coefficient	t-value
Intercept	-16.7297	-14.03
Median Income	0.4393	14.57
Median Income^2	-0.0028	-14.92
$P_{biotech}/P_{conventional}$	0.0710	0.91
$D_{downscale}$	14.5343	8.87
$D_{downscale}$ * Median Income	-0.3568	-7.35
$D_{downscale}$ * Median Income^2	0.0022	6.65
$D_{downscale}$ * $P_{biotech}/P_{conventional}$	-0.1543	-1.69

Note: Median income is expressed in $1,000s

Table 3. Summary of Survey Data, by Store

Store #	Up- or Down-scale	Number of Surveys Collected	Noticed Two Types of Corn	Purchased Some Biotech	
			% of Total Sample	% of Total Sample	% of Those Who Noticed Two Types
1	Up	114	76	46	44
2	Up	104	55	41	37
3	Up	52	73	37	34
4	Down	80	53	38	45
5	Down	13	77	46	50
6	Down	55	73	40	40
7	Up (small)	16	44	31	29
8	Up	128	63	35	30
9	Down	156	65	37	38
Total		718	64	39	38

Table 4. Results from Logit Regression Explaining Likelihood of Noticing Two Types of Corn

Dependent variable = 1 if Individual Noticed Two Types of Corn, 0 Otherwise

Independent Variable	Coefficient Estimate	P-value on Ho: coeff = 0	Odds Ratio
Intercept	-0.48	0.17	
Dummy for spent about a minute	0.48	0.03	1.62
Dummy for spent 1-5 minutes	0.43	0.15	1.54
Dummy for > 5 min	0.67	0.42	1.95
Income category	0.16	0.01	1.17
% Correct predictions = 51%			
P-value for Ho that all coefficients jointly equal zero < 0.05			

Table 5. Results from Logit Regression Explaining Likelihood of Purchasing Some Biotech Corn

Dependent Variable = 1 if Individual Purchased Some Biotech, 0 Otherwise

Independent variable	Coefficient Estimate	P-value on H_0: coeff=0	Odds Ratio
Intercept	-1.05	0.06	
Category variable for relative prices	-0.32	0.02	0.73
Income category	0.11	0.07	1.12
Time spent deciding	0.37	0.00	1.45
Concern about pesticides	-0.11	0.33	0.90
Disagree that tech. moving too fast	0.24	0.07	1.28
Noticed two types	-0.32	.09	0.73
Heard of biotech	0.12	0.53	1.12

% Correct predictions = 67%

P-value for Ho that all coefficients jointly equal zero < 0.01