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The effects of prior beliefs and learning on consumers' acceptance of genetically modified foods

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Abstract

New food products using genetically modified crops appeared in U.S. supermarkets starting in 1996, and consumers' perceived some risks. This paper examines the role of consumers prior beliefs about genetic modification and of diverse, new information on their willingness to pay for foods that might be genetically modified. We use data from economics experiments and show that participants who had informed prior beliefs discounted GM-labeled food products more highly than those who had uninformed prior beliefs. Uninformed participants were especially susceptible to information from interested and third parties. In contrast, informed participants were generally not affected significantly by new information.

JEL classification: C91; D12; D82

Keywords: Laboratory experiments; *n*th-Price auction; Food labels; Diverse information; Learning; Prior beliefs; Consumers; Willingness to pay

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New food products made from genetically modified crops appeared in U.S. supermarkets starting in 1996. The genetic modification consisted of herbicide tolerance and insect resistance that have been introduced into field crops through the use of techniques in modern biotechnology. Herbicide tolerance and insect resistance are so-called input traits that reduce the expected cost of production to farmers (Fernandez-Cornejo and McBride, 2002; FAO, 2004) but have no direct benefit to consumers and pose some risks (Chern and Rickertsen, 2004; FAO, 2004). Consequently, GM products have been subject to much controversy (claims by environmental groups of reducing biodiversity, new food safety concerns due to allergens, and ethical concerns regarding the movement of genes across species), and they have raised important new issues in trade talks especially between the U.S. and the European Union.

Huffman et al. (2003) examined the effects of GM-food labels on bidding behavior of participants in an experimental auction, and Rousu et al. (2004) developed a methodology to value the contribution of third-party information in a setting with conflicted information. These papers, however, have not focused on the contributions of subjective prior beliefs about genetic modification in an experimental auction-market setting. Consumers have subjective prior beliefs about attributes of goods (Akerlof, 1970; Hirshleifer and Riley, 1992; Molho, 1997; Stigler, 1961) and frequently obtain new information to update these prior beliefs, for example, Bayesian learning (DeGroot, 1970; Molho, 1997, pp. 248–249, Tirole, 2003, p. 373).[1] This paper examines in depth the role of consumer's prior beliefs about genetic modification and diverse, new information about genetic modification on their "willingness to pay" for foods that might be genetically modified. The information is of two broad types: subjective prior beliefs that arise from prior investments in information and new information from interested and disinterested parties. In the GM-food debate, the interested parties are the agricultural biotech industry and environmental groups. The agricultural biotech industry consists of the private companies that market crop input traits and distribute pro-biotech information such as Monsanto, Syngenta, and Pioneer Hibred, and the Council for Biotechnology Information, a private trade association. The environmental groups are largely Greenpeace, Friends of the Earth, and Action Aid, which disseminate anti-biotech information. Furthermore, Huffman and Tegene (2002) have speculated about the potential value of independent, third-party information in such a conflicted market, and Rousu et al. have injected independent, third-party information into a set of economic experiments to assess its value.[2] In these experiments, food-label types and information treatments were randomly assigned to sessions or trials. In this setting, participants who perceived themselves to be at least somewhat informed about genetic modification bid significantly less for GM-labeled foods than those who considered themselves to be uninformed. This raises an important issue of how prior information affects the interpretation of new information, which this study emphasizes.

If consumers place heavy weight on information from interested parties, including cheap talk, their welfare will be lower than if they use objective information (Akerlof, 1970; Molho, 1997; Morris and Shin, 2002). One hypothesis is that consumers who have uninformed priors have their bidding behavior affected by information from one or more interested parties, but consumers who have informed priors are relatively unaffected (Schultz, 1975; Huffman, 2001; Tversky and Kahneman, 1981; Kahneman, 2003). Another hypothesis is that the presence of third-party information affects the way that consumers use information from interested parties in placing bids.

[1] These beliefs could, however, be uninformative or diffuse (DeGroot, 1970).

[2] Independent, third-party information is sometime referred to as verifiable information (Milgrom and Roberts, 1986).

This research builds on the strength of a unique data set that we collected from laboratory auctions that combined the methods of economic experiments, statistical experimental design, and survey design (Rousu et al.). Our auctions were "willingness to pay" experiments constructed such that it was in each participant's best interest to state her true preferences, and furthermore, the winners were expected to "pay" what they "say" or "bid." Because of the cost of running a large number of experiments at different locations, we chose two locations (major cities) and a modest number of participants.[3] The model, results, and conclusions follow.

1. The conceptual framework

We review a few pieces of relevant literature and then present our model. Other studies have shown that people place much less weight on prior beliefs than on new information when bidding on lotteries (e.g., see Grether, 1980 or Tversky and Kahneman, 1974). We extend this work in two important ways. First, we adopt the Bayesian concept of subjective beliefs instead of assuming that prior beliefs are always "fact" or objective beliefs (DeGroot). Second, we examine how prior beliefs and new information from interested and disinterested parties affect a consumer's willingness to pay for a new product that might cause environmental or human harm (i.e., they pose some potential risks).

A consumer's utility from consuming genetically modified food products is modeled as depending on her prior beliefs about genetic modification. Following Kivi and Shogren (2005), state-dependent indirect utility functions are defined for a "good outcome" $U(Y)$ and a "bad outcome" $V(Y-L)$ that are independent of an individual's prior beliefs or the amount of new information that she has acquired/received. The indirect utility functions give maximum utility for a given level of income, Y and $Y-L$, and they are weighted by the individual's subjective probabilities conditioned on her prior beliefs: p^{I}, probability of a bad outcome, given the participant has informed prior beliefs, and $p^{\text{no-I}}$, probability of bad outcome given the participant has uninformed prior beliefs, to obtain a consumer's expected utility:

$$U(Y - \mathrm{WTP}^{\mathrm{I}}) = \mathrm{EU}^{\mathrm{I}} = p^{\mathrm{I}}(I, \inf)V(Y - L) + (1 - p^{\mathrm{I}}(I, \inf))U(Y), \tag{1}$$

$$U(Y - \mathrm{WTP}^{\text{no-I}}) = \mathrm{EU}^{\text{no-I}} = p^{\text{no-I}}(\inf)V(Y - L) + (1 - p^{\text{no-I}}(\inf))U(Y). \tag{2}$$

A consumer's indirect utility is a function of household income, Y, minus her willingness to pay for the food products. A consumer is assumed to perceive that the "bad state" will occur with probability p, which differs between those who have informed and uninformed prior beliefs. The posterior probability of a bad (good) outcome is determined by prior beliefs and new information on GM technologies and food, denoted by "inf".

After normalizing utility such that $U=1$ and $V=0$, we simplify the representation of a consumer's expected utility:

$$\mathrm{EU}^{\mathrm{I}} = (1 - p^{\mathrm{I}}(I, \inf)), \tag{3}$$

[3] An alternative methodology is a state preference or contingent value survey. In these surveys a random sample of households are contacted and asked to respond to hypothetical product preference or willingness to pay options. This approach has the advantage of being able to be administered relatively inexpensively to a large sample, which can give precision (for examples see Johnston et al., 2001). However, because responses are hypothetical, they are not bound by a budget constraint. This can lead to hypothetical biases or credibility problems that do not vanish as the sample size increases. For examples, see Diamond and Hausman (1994) and Fox et al. (1998).

$$\mathrm{EU}^{\text{no-I}} = (1 - p^{\text{no-I}}(\text{inf})). \tag{4}$$

Next, consider a consumer's determination of the subjective probability of a bad outcome on GM foods, given the following parameterization:

$$p^{\text{I}} = \alpha_0 + \alpha_{\text{inf}}, \tag{5}$$

$$p^{\text{no-I}} = \alpha_{\text{inf}}. \tag{6}$$

Now α_0 is the effect of an informed consumer's prior beliefs about GM on her posterior beliefs about GM, and α_{inf} is the effect of new information on her posterior beliefs. If prior beliefs are informative, that is, they are not diffuse priors (DeGroot, 1970), then we assume $0 < \alpha_0 < p$. We hypothesize that consumers who have uninformed prior beliefs place more weight on information from interested parties than participants who have informed priors. Also we hypothesize that the injection of third-party information affects the way that consumers use information from interested parties in placing bids. Rearranging Eqs. (5) and (6), we obtain the following relationship between posterior probabilities:

$$p^{\text{I}} = p^{\text{no-}p^{\text{I}}} + \alpha_0. \tag{7}$$

Substitute for p^{I} in Eq. (3), we obtain

$$\mathrm{EU}^{\text{I}} = (1 - p^{\text{no-I}} - \alpha_0), \tag{8}$$

and taking the difference in expected utility between Eqs. (4) and (8), we obtain

$$U(Y - \mathrm{WTP}^{\text{I}}) - U(Y - \mathrm{WTP}^{\text{no-I}}) = -\alpha_0. \tag{9}$$

We have shown formally that consumers who have the same indirect utility values and receive the same information treatment have differences in expected utility that are due only to *prior beliefs*. More generally, differences in expected utility are due to differences in prior beliefs and information treatments.

Willingness to pay for GM-labeled foods could be higher or lower, depending on the prior beliefs and the content of the new information they obtain/receive. Our experimental design and data allow us to test for the effects of prior beliefs under different information treatments.

2. Data

The observations and data for this paper are from a unique set of economic experiments reported in Rousu et al. and in Huffman et al. A brief overview of the design is presented here; the full design can be found in Huffman et al. or obtained from the authors upon request. We were interested in auctioning three rather dissimilar food products: vegetable oil, tortilla chips, and potatoes. In the refining process for vegetable oils, say from soybean oil, all of the protein is removed leaving pure lipid or fat, and the resulting oil will be chemically indistinguishable irrespective of the use of GM or non-GM soybeans to make the oil. The tortilla chips are a processed product made from yellow corn that might be contaminated by GM-traits, and consumers might have different concerns for GM content here than in russet potatoes that were genetically modified for virus resistance.

Because we use common food items available to shoppers in grocery stores and supermarkets, we wanted adults who were not primarily students to reflect better a typical household's decisions

on grocery store food purchases.[4] Our participants are adults from the population of individuals 18 years of age or older and were chosen randomly from two major Midwestern metropolitan areas by a random digital dialing method. They were contacted by an independent agency to obtain their agreement to participate, given instructions of how to get to the project site, and told that they would be paid $40 for their participation.[5]

We ran two concurrent sessions for each time slot on auction days, and participants were alternately assigned to each group/session as they arrived, each group/session consisting of 13–16 individuals. Upon arrival at the lab site, participants were given an ID number, asked to complete a questionnaire containing questions about their social-economic characteristics and prior beliefs about new technologies, and paid $40. Each session or trial/session followed exactly the same protocol. Participants were first asked to engage in a round of bidding on a candy bar to learn the mechanism of the random *n*th-price auction. The random *n*th-price auction mechanism has been shown to be superior to a 2nd-price Vickery auction for eliciting consumers' entire demand curve for new goods (Shogren et al., 2001). After winners were chosen, they were asked to engage in a second practice round containing a candy bar, box of pens, and a deck of cards to get them familiar with placing three bids simultaneously. Winning bids were announced, and participants were given a short quiz on the auction mechanism that was followed by discussion and clarification. This was done to check up on participants' understanding of the auction mechanism.

Next, one of the six information treatments was randomly assigned and released in each session or trial. These treatments were constructed from the three basic information types defined for these experiments. They were the: (1) *industry perspective*—provided by a group of leading biotechnology companies, including Monsanto and Syngenta (Council for Biotechnology Information, 2001); (2) *environmental group perspective*—from Greenpeace, a leading environmental group or biotech antagonist (Greenpeace International, 2001a,b; Friends of the Earth, 2001, 2003); (3) *third-party perspective*—from an independent group of scientists, professionals, religious leaders, and academics, none with a financial stake in GM foods. This third type of information is to be viewed as an informed objective assessment, given the state of science, and without significant direct financial interest in genetic modification. The three information types were packaged into *six information treatments*: (1) the biotech industry perspective; (2) the environmental group perspective; (3) agricultural biotech industry and environmental perspectives; (4) agricultural biotech industry and third-party perspectives; (5) environmental group and third-party perspectives; or (6) all three perspectives. When a trial/session received pro- and anti-biotech information, the order was randomized among the participants. Third-party information, however, was always distributed last.

Next, they were asked to view the three experimental foods (vegetable oil made from soybeans, tortilla chips made from yellow corn, and russet potatoes) and to place their bids. They were then asked to view another set of these three goods, having different GM-food-label information, and

[4] Although several studies have used only college undergraduates in laboratory auctions of food items (including Lusk et al., 2001; 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. For example, Katsaras et al. (2001), using a national random sample of grocery store shoppers, showed that the share of college-age (18–24 years) 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 et al., 1998).

[5] They were told that the study was being conducted by Iowa State University and that it involved consumer decision making on food and household products. No mention was made of experiments or GM-products.

Table 1
Characteristics of auction participants ($N = 172$)

Variable	Definition	Mean	S.D.
Gender	1 if female	0.62	0.49
Age	The participant's age	49.5	17.5
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)	57.0	32.6
White	1 if participant is white	0.90	0.30

place a new set of bids.[6] In one round participants were bidding on food products that were labeled as genetically modified (GM) and in the other round the food products had a plain-label.[7] Among the two rounds of bidding on experimental goods, one was chosen randomly by the auction monitor to be a binding round in which winners were expected to complete their exchange of money for experimental goods. The actual exchange took place in an adjacent room.[8]

Table 1 summarizes the demographic characteristics of participants. Although our participants are slightly skewed toward women, Katsaras et al. showed that women make up a disproportional share of grocery shoppers: 83 percent of shoppers versus 52 percent in the U.S. Census of Population. Although the demographics of the sample do not perfectly match the population reported by the U.S. census demographic characteristics for these regions, they are similar and provide a sufficient representation for our initial probe into labeling and information for GM products (see Appendix A, available on the JEBO website, for the demographic characteristics of the areas).

The pre-auction questionnaire contained the question: "Regarding genetically modified foods: How informed do you consider yourself?" The participants were offered the following six options: extremely well informed, well informed, somewhat informed, not very informed, not informed at all, and I do not know. In particular, this information was collected before the start of the lab auction of GM-foods and release of new information.[9] Table 2 summarizes these responses and shows that 41.9 percent of the 172 participants were at least somewhat informed about genetic modification before our auction experiments. The other 58.1 percent were classified as "uninformed."

3. Results

Sample mean information for average bid prices for GM- and plain-labeled foods for all participants and for participants who had informed and uninformed priors are reported in Table 3.[10]

[6] Participants were never told how many total rounds of bidding they would engage in. All participants engaged in a total of four rounds of bidding including the two practice rounds. At the start of the auction of the food products that might be GM, the participants were told that they would be expected to purchase a maximum of one unit of each auctioned commodity. After the second round of bidding on food products that might be GM, the auction part of the experiment ended.

[7] The sequence was determined randomly.

[8] Contrary to most economics experiments our participants engage in very few rounds of bidding, which reduces behavior modification associated with the experience of participating in our experiment.

[9] We made no effort to test participant's beliefs for objectiveness; they are subjective beliefs.

[10] We tested whether there were differences in the other demographic characteristics of those who perceived themselves as informed and uninformed, such as age and gender, and there were no differences between these groups that were statistically significant at the 10-percent level.

Table 2
Response of participants to the pre-experiment question of "How informed are you about genetic modification?" ($N = 172$)

Category	Relative frequency (percent)
Extremely well informed	3.5
Well informed	5.8
Somewhat informed	32.6
Not very informed	40.1
Not informed at all	15.7
I do not know	2.3

Source: Pre-auction questionnaires.

Among all participants and commodities, average bids were 14 percent lower for GM than for plain-labeled commodities (part A). Among participants who had informed prior beliefs about GM foods, the average difference for the bid price of a plain-labeled product less the bid price for GM-labeled counterpart was 18 percent (part B). Among participants who had uninformed prior beliefs, the average difference for the bid price of a plain-labeled product less the bid price for the GM-labeled counterpart was 11 percent (part C). Across the two groups, informed and uninformed, the difference is 49 percent. The difference between these two percentages is not significantly different from zero at the 5-percent level.

What is the impact of subjective prior beliefs about genetic modification in a market with new information from interested parties? Table 4 summarizes the mean differences in bid prices from participants for GM- and plain-labeled food products due to the release of information from interested parties, the agricultural biotech industry or environmental NGOs, given prior beliefs.

Table 3
Mean bids for participants by commodity and type

	Mean bid	S.D.	Median	Minimum	Maximum
(A) Mean bids—all participants and treatments ($N = 172$)					
GM OIL	0.91	0.84	0.75	0	3.99
OIL	1.05	0.85	1.00	0	3.79
GM CHIPS	0.93	0.86	0.70	0	3.99
CHIPS	1.08	0.85	0.99	0	4.99
GM POTATOES	0.78	0.67	0.69	0	3
POTATOES	0.91	0.67	0.80	0	3.89
(B) Mean bids for participants who had informed prior beliefs about genetic modification ($N = 72$)					
GM OIL	0.93	0.88	0.77	0	3.99
OIL	1.10	0.89	1.00	0	3.79
GM CHIPS	0.86	0.81	0.75	0	3.50
CHIPS	1.05	0.74	1.00	0	2.99
GM POTATOES	0.73	0.61	0.75	0	2.30
POTATOES	0.92	0.59	0.88	0	2.00
(C) Mean bids for participants who had uninformed prior beliefs about genetic modification ($N = 100$)					
GM OIL	0.90	0.82	0.68	0	3.25
OIL	1.01	0.82	0.99	0	3.29
GM CHIPS	0.97	0.90	0.69	0	3.99
CHIPS	1.10	0.92	0.99	0	4.99
GM POTATOES	0.81	0.72	0.60	0	3.00
POTATOES	0.90	0.73	0.75	0	3.89

Table 4
Mean difference in bid prices of participants for plain-labeled less bid price for GM-labeled food products due to information from interested parties, conditional on prior beliefs

Information treatments	Vegetable oil	Tortilla chips	Potatoes
(A) Participants who did not receive third-party GM-information			
Received only pro-biotechnology information, given informed priors ($N=13$)	−\$0.10, $p=0.63$	\$0.11, $p=0.32$	\$0.02, $p=0.93$
Received only pro-biotechnology GM-information, given uninformed priors ($N=17$)	\$0.03, $p=0.68$	\$0.00, $p=0.94$	−\$0.08, $p=0.13$
Received only anti-biotechnology GM-information, given informed priors ($N=8$)	\$0.50, $p=0.12$	\$0.61*, $p=0.09$	\$0.52**, $p=0.05$
Received only anti-biotechnology GM-information, given uninformed priors ($N=21$)	\$0.34***, $p<0.01$	\$0.37***, $p<0.01$	\$0.32***, $p<0.01$
Received pro-biotechnology and anti-biotechnology GM-information, given informed priors ($N=10$)	\$0.51, $p=0.12$	\$0.29*, $p=0.08$	\$0.40**, $p=0.05$
Received pro-biotechnology and anti-biotechnology GM-information, given uninformed priors ($N=18$)	\$0.00, $p=0.97$	\$0.01, $p=0.90$	\$0.07, $p=0.24$
(B) Participants who received third-party GM-information			
Received pro-biotechnology and third-party GM-information, given informed priors ($N=14$)	\$0.13, $p=0.17$	\$0.09, $p=0.52$	\$0.07, $p=0.28$
Received pro-biotechnology and third-party GM-information, given uninformed priors ($N=14$)	−\$0.09, $p=0.26$	\$0.07, $p=0.43$	−\$0.05, $p=0.38$
Received anti-biotechnology and third-party GM-information, given informed priors ($N=13$)	\$0.07, $p=0.17$	\$0.10, $p=0.55$	\$0.20*, $p=0.08$
Received anti-biotechnology and third-party GM-information, given uninformed priors ($N=16$)	\$0.29, $p=0.21$	\$0.33*, $p=0.10$	\$0.26*, $p=0.08$
Received pro-biotechnology, anti-biotechnology and third-party GM-information, given informed priors ($N=14$)	\$0.16*, $p=0.08$	\$0.10*, $p=0.07$	\$0.10, $p=0.15$
Received pro-biotechnology, anti-biotechnology and third-party GM-information, given uninformed priors ($N=14$)	\$0.03, $p=0.77$	−\$0.08, $p=0.28$	−\$0.06, $p=0.42$

* Statistically significant at the 10-percent level using a two-sided t-test.
** Statistically significant at the 5-percent level using a two-sided t-test.
*** Statistically significant at the 1-percent level using a two-sided t-test.

Part A examines the bid prices in a market without third-party information. When participants – both those who had informed and uninformed prior beliefs – received only the industry perspective, the mean bid price differences between GM- and plain-labeled products were very small, less than plus or minus 11 cents per product. For participants who had informed prior beliefs about genetic modification and received only the environmental group perspective, the mean bid

price differences were 50–60 cents per product, but only the 52 cent difference for potatoes was significantly different from zero at the 5-percent level. For participants who had uninformed prior beliefs, mean bid price differences were less, 32–37 cents per product, and all are significantly different from zero at the 5-percent level. For participants who had informed priors and received both the agricultural biotech and environmental group perspectives, the discount for GM products is an average of 29–51 cents per product, but the 40 cent differential for potatoes is the only one of these three differences that is significantly different from zero at the 5-percent level. In contrast, those participants who had uninformed prior beliefs did not discount GM-products.

Part B of Table 4 examines bids from consumers who received third-party information. When participants, both with informed and uninformed prior beliefs, received only pro-biotech information followed by third-party information, the mean bid-price difference between GM- and plain-labeled food items was small and similar to those reported in part A. When participants had informed priors and received anti-biotech information followed by third-party information, mean bid price differences were 7–20 cents per food item, which is much smaller than the outcome without third-party information (as reported in part A). The most significant of these three outcomes is again for potatoes, but now the bid price difference is only significant at the 10-percent level. When those who had uninformed priors receive this same set of information treatments, the bid price differences are similar to those in part A in which third-party information was excluded. With third-party information, the differences are at best significant at the 10-percent level. When participants who had informed priors received all three types of new information, their mean bid price differences were only 10–16 cents per product, which is much lower than the outcome when third-party information was not injected (as reported in part A). Two of these differences are different from zero at only the 10-percent level. When participants who had uninformed priors received all three types of information, however, their mean price differences were similar to those reported when third-party information was not injected. Bidding behavior was affected by prior beliefs, new information from interested parties, and by injection of third-party information.

In Table 5, we report the results for statistical tests of bid price differences for plain and GM-labeled products, conditional on participant's prior beliefs about genetic modification. Part A reports the results for statistical tests for participants who did not receive third-party information. This is a "difference-in-differences" test (see Wooldridge, 2002, pp. 283–291, 128–131). We report results from tests of the null hypothesis that the difference-in-mean bid-price difference for plain-labeled and GM-labeled food items is zero across participants who had informed and uninformed prior beliefs. When the participants received only the agricultural biotech industry perspective or the environmental group perspective, no significant difference-in-differences existed at the 5-percent significance level.[11] If they received the pro-biotech and anti-biotech perspectives, the estimate of the difference-in-differences estimator was significantly different from zero for potatoes (5-percent level) and tortilla chips (6-percent level). The estimate of the difference-in-differences estimator, however, was not significantly different for vegetable oil (p-value of 8 percent).[12]

Part B of Table 5 reports additional difference-in-differences results for a situation in which third-party information was injected. The information treatments are: (i) pro-biotech and third-party, (ii) anti-biotech and third-party, and (iii) all three types of information. None of the estimates of the difference-in-difference estimator for these tests is significantly different from zero at the

[11] We use a consistent method for labeling the construction of differences-in-differences, but we do not specifically examine the signs of these differences-in-differences estimates, but focus instead on their statistical significance.

[12] Wilcoxon Rank-Sum tests were also conducted and provided similar results.

Table 5
Do the informed and uninformed bid differently?

Information treatments	Vegetable oil	Tortilla chips	Potatoes
(A) Participants who did not receive third-party information			
Received pro-biotechnology GM-information only ($N=30$)	$t=0.67$, $p=0.51$	$t=-0.92$, $p=0.37$	$t=-0.55$, $p=0.59$
Received anti-biotechnology GM-information only ($N=29$)	$t=-0.61$, $p=0.54$	$t=-0.92$, $p=0.36$	$t=-0.99$, $p=0.33$
Received both pro-biotechnology and anti-biotechnology GM-information ($N=28$)	$t=-1.83$, $p=0.08$	$t=-1.94$, $p=0.06$	$t=-2.22$, $p=0.04$
(B) Participants who received third-party information			
Received pro-biotechnology and third-party GM-information ($N=28$)	$t=-1.85$, $p=0.08$	$t=-0.15$, $p=0.89$	$t=-1.45$, $p=0.16$
Received anti-biotechnology and third-party GM-information ($N=29$)	$t=0.87$, $p=0.39$	$t=0.92$, $p=0.36$	$t=0.36$, $p=0.71$
Received pro-biotechnology, anti-biotechnology, and third-party GM-information ($N=28$)	$t=-0.93$, $p=0.36$	$t=-2.00$, $p=0.06$	$t=-1.66$, $p=0.11$

Test of null hypothesis that difference in mean bid price differences for plain-labeled less bid price for GM-labeled food items is zero for participants who had informed and uninformed prior beliefs.

5-percent level. The third-party information lowers the relative weight placed on information received from interested parties when bids are placed on food items that might be genetically modified. Furthermore, when third-party information is injected into the experiment, prior beliefs about genetic modification have relatively little impact on bidding behavior of participants. Both participants who had informed and uninformed prior beliefs behaved in our experiments as if they took the third-party information seriously.

Next we test for differences in bid prices due to information treatment effects for people who received third-party information, conditional on prior beliefs. Table 6 reports this new round of difference-in-differences tests. The null hypothesis is that the difference in mean bid prices for plain-labeled and GM-labeled food items under two different information treatments is zero, holding prior beliefs of participants constant. For participants who held uninformed prior beliefs, the estimate of difference-in-differences estimator is significantly different from zero (5-percent level) for all three food items when participants receive pro- versus anti-biotech information. They are also significantly different from zero when participants receive anti-biotech information versus pro-biotech and anti-biotech information. In fact these two sets of hypotheses produced t-values that look very similar (part A). When participants received pro- versus pro- and anti-biotech information the estimate of the difference-in-difference estimator was not significantly different from zero. When participants had informed priors, none of the estimates of the differences-in-differences estimator was significantly different from zero at the 5-percent level (part B). Clearly, prior beliefs affect the relative weight placed on new information from informed parties when third-party information is unavailable.

Now we examine the effects of different combinations of information from interested parties when third-party information is injected, conditional on prior beliefs. This is another test employing the difference-in-differences estimator. For participants who had uninformed priors, three of nine tests in Table 7, part A, for the estimate of the difference-in-differences estimator are rejected at the 6-percent level: for potatoes when participants received only pro-biotech information versus

Table 6
Results for difference-in-differences estimator

Information treatments	Vegetable oil	Tortilla chips	Potatoes
(A) Participants whose prior beliefs were uninformed about genetic modification			
Received only pro-biotechnology GM-information vs. received only anti-biotechnology GM information	$t = 2.11$, $p = 0.04$	$t = 2.71$, $p = 0.01$	$t = 3.53$, $p = 0.00$
Received only pro-biotechnology GM-information vs. received pro-biotechnology and anti-biotechnology GM-information	$t = 0.20$, $p = 0.84$	$t = -0.04$, $p = 0.97$	$t = -1.96$, $p = 0.06$
Received only anti-biotechnology GM-information vs. received pro-biotechnology and anti-biotechnology GM-information	$t = 2.03$, $p = 0.05$	$t = 2.68$, $p = 0.01$	$t = 2.26$, $p = 0.03$
(B) Participants who had informed prior beliefs about genetic modification			
Received only pro-biotechnology GM-information vs. received only anti-biotechnology GM-information	$t = 1.78$, $p = 0.09$	$t = 1.76$, $p = 0.09$	$t = 1.72$, $p = 0.10$
Received only pro-biotechnology GM-information vs. received pro-biotechnology and anti-biotechnology GM-information	$t = -1.76$, $p = 0.09$	$t = -0.96$, $p = 0.35$	$t = -1.45$, $p = 0.16$
Received only anti-biotechnology GM-information vs. received pro-biotechnology and anti-biotechnology GM-information	$t = -0.02$, $p = 0.98$	$t = 0.98$, $p = 0.34$	$t = 0.43$, $p = 0.68$

Null hypothesis that difference in bid prices for plain-labeled less bid price for GM-labeled food items under different information treatments is zero, given participants' prior beliefs (no third-party information).

received only anti-biotech, and for tortilla chips and potatoes when participants received only anti-biotech information versus pro- and anti-biotech information. For participants having informed prior beliefs (part B), none of the coefficients of the difference-in-differences estimator is significantly different from zero at the 6-percent level. With the injection of third-party information, we continue to find that participants who have uninformed prior beliefs bid differently on plain-labeled versus GM-labeled food products than for those who had informed prior beliefs. Those who are uninformed behave as if they place greater weight on new information than the informed even when it comes from interested parties.

Individuals who had informed prior beliefs about genetic modification coming into our experiments discounted GM-labeled food products more highly than those participants having uninformed prior beliefs. This behavior suggested that their prior information was somewhat negative. Participants who had uninformed prior beliefs about genetic modification before our experiments exhibited the greatest change in bidding behavior due to the injection of new information. Information from interested parties caused a significant change in their bidding behavior, and when third-party information was injected these outcomes were further modified. Those who have informed prior beliefs were relatively unaffected by all types of new information. They may already have made a significant investment in information about genetic modification, and the marginal impact of new information including third-party information was small and not statistically significant.

Table 7
Results for differences-in-differences estimator when participants received third-party GM-information

Information Treatments	Vegetable Oil	Tortilla Chips	Potatoes
(A) Participants who had uninformed prior beliefs about genetic modification			
Bid prices when received pro-biotechnology and verifiable GM-information vs. bids when received anti-biotechnology and third-party GM-information	$t = 1.53$, $p = 0.14$	$t = 1.22$, $p = 0.23$	$t = 1.99$, $p = 0.06$
Bids when received pro-biotechnology and verifiable GM-information vs. bids when received pro-biotechnology, anti-biotechnology, and third-party GM-information	$t = -0.93$, $p = 0.36$	$t = 1.37$, $p = 0.18$	$t = 0.16$, $p = 0.87$
Bids when received anti-biotechnology and verifiable GM-information vs. bids when received pro-biotechnology, anti-biotechnology, and third-party GM-information	$t = 0.99$, $p = 0.33$	$t = 1.95$, $p = 0.06$	$t = 1.98$, $p = 0.06$
(B) Participants who had informed prior beliefs about genetic modification			
Bids when received pro-biotechnology and verifiable GM-information vs. bids when received anti-biotechnology and third-party GM-information	$t = -0.55$, $p = 0.58$	$t = 0.03$, $p = 0.97$	$t = 1.13$, $p = 0.27$
Bids when received pro-biotechnology and verifiable GM-information vs. bids when received pro-biotechnology, anti-biotechnology, and third-party GM-information	$t = -0.25$, $p = 0.80$	$t = -0.03$, $p = 0.98$	$t = -0.42$, $p = 0.68$
Bids when received anti-biotechnology and verifiable GM-information vs. bids when received pro-biotechnology, anti-biotechnology, and third-party GM-information	$t = -0.89$, $p = 0.38$	$t = 0.02$, $p = 0.98$	$t = 0.78$, $p = 0.44$

Null hypothesis that difference in bid price for plain-labeled less bid price for GM-labeled food items under different information treatments is zero, conditional on participants' prior beliefs.

4. Discussion and conclusions

This paper has shown that prior beliefs and new information (both from interested parties and third-party sources) affect bidding behavior of people who participated in our auction market experiments for food items that might be genetically modified. This contradicts the earlier findings of Viscusi (1997) and Tversky and Kahneman (1974, 1992) who argued that people frequently ignore base rates. One potential explanation for this difference of outcome is that instead of measuring prior beliefs as objective knowledge (e.g., monetary lotteries), we asked lab participants to give us information about their prior knowledge about genetic modification. They were asked the following question: "How informed are you about genetic modification?" and they were given five options: extremely well informed, well informed, somewhat informed, not very informed, not informed at all. This information is subjective, and we use this as their subjective prior belief. Furthermore, we examined their use of prior beliefs and new information to inform decision on willingness to pay for common food items available in grocery stores and supermarkets and not in a lottery.

These results have implications for information policies by showing how both skeptics and proponents of new technologies (i.e., interested parties) might try to manage information to achieve private objectives. This is most likely to occur when much is unknown scientifically about the impacts of new technologies or when third-party information is limited or unavailable (Milgrom and Roberts, 1986; Huffman and Tegene, 2002). Opponents to a new technology may try to target people who are relatively uninformed about the technology. Proponents of the technology may try to target people who have informative prior beliefs for maximum effectiveness. This reasoning might explain why the Council for Biotechnology Education (a pro-GM organization) funds TV commercials during family and sports programming but the anti-GM groups invest in carrying out dramatic and spectacular shows of opposition for new technologies (e.g., with colorful, vocal demonstrations) that may be carried by a variety of media outlets. People who are uninformed seem less likely to use common media sources regularly.

In this study we have used a relatively blunt measure of prior beliefs about genetic modification; future research might examine the objectiveness of these beliefs and attempt to illicit strengths of pro-biotechnology and anti-biotechnology prior beliefs and the way that they affect willingness to pay.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jebo.2005.04.019.

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