5-15-2002

Are US Consumers Tolerant of GM foods?

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Selected Paper at the 2002 American Agricultural Economics Association
Annual Meeting in Long Beach, California

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This work was supported through a grant from the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Agreement 00-52100-9617 and by the Iowa Agriculture and Home Economics Experiment Station, Ames, IA

Consumers are reluctant to accept new food products they perceive as risky, which includes those products that involve some form of genetic modification (GM). GM foods remain controversial as some groups want GM foods banned (Greenpeace, 2001; Friends of the Earth, 2001); while others believe GM foods can help feed the world (Council for Biotechnology Education, 2001; Gates, 2001). But since a complete GM ban has thus far been politically infeasible, environmental and consumer groups have successfully lobbied for labeling of genetically modified foods in dozens of countries, including Australia, China, Japan, Korea, and member countries of the European Union.

A key issue in the labeling debate is *tolerance*, the acceptable percentage of GM-impurity. Counties have accepted *positive tolerance standards* because a zero tolerance standard is prohibitively costly, and a perfect segregation system can never be guaranteed (Shoemaker *et al*, 2001; Golan, Krissoff, and Kuchler, 2002).[1]

The European Union, for instance, revised its mandatory GM-labeling policy in January 2000 to contain a positive tolerance level—all foods have to be labeled as *GM* if any ingredient in the product is at least 1% GM (Rousu and Huffman, 2001). Australia's GM-labeling policy is identical. Other countries have laxer tolerance thresholds. Japan tolerates up to 5% impurity before a GM label is needed. Other countries have less restrictive tolerance levels. Korea allows a 3% tolerance of GM material, and Brazil allows a 4% tolerance. Thailand has different tolerance levels for different products—5% for soybeans, 3% for corn (Shipman, 2001).

The United States currently does not require labeling of GM foods and does not have a positive tolerance standard. The question we address herein is how US consumers react to a positive tolerance standard for GM ingredients. Using the tools of statistical experimental design, we design an experimental auction using three GM-products to test two hypotheses: (a) the mean consumer bids for the GM-free product equals the mean bid for the GM-threshold products, set either at 1% or 5%; and (b) the mean bids for the 1%-GM-product equals the mean bids for the 5%-GM-product threshold.[2] Our results suggest that we can reject the first hypothesis (a) but not the second one (b). Our results suggest that consumers reduce their demand by about 10% relative to the certain baseline, irrespective of whether the GM-threshold is set at 1 or 5 %. This then suggests a policy direction—if a tolerance level is to be used in the US, a 5%-GM threshold is likely to be more efficient than a 1%-GM threshold because the 5% level is less costly to meet and demand reduction is independent of the tolerance level.

Experimental Design

Previous experimental auctions examined the willingness to pay for GM foods. Using potatoes, vegetable oil, and tortilla chips, U.S. consumers from the Midwest discounted GM-labeled foods by an average of 14 percent and the discount could be higher, depending on the information the consumer received (Rousu *et al*, 2002). Noussair, Robin, and Ruffieux (2002) conducted experimental auctions using consumers in France and found that consumers valued biscuits with a 1% and a 0.1% tolerance threshold differently (they also were bidding on non-GM and GM biscuits – 4 biscuits total). Their results also found that consumers did not appear to think that 0.1% GM or 1% GM content was as good as a GM free product. One problem with their experimental design is that they were selling consumers four different biscuits that were, in their words, close substitutes. Selling four close substitutes leads to demand reduction by consumers perceiving the potential of obtaining multiple units (List and Lucking-Reilly, 2000) which could potentially cause a confounding problem where one does not know if bid reduction is due to genetic modification or demand reduction.

Our experimental auction markets use a randomized treatment design of statistical experimental design used in Huffman et al. (2002) and Rousu et al. (2002). In our auctions, consumers bid on three food products that differed by the tolerance labels on the foods. All consumers bid on foods with a non-GM label certified to be completely free of genetically engineered material in one trial, and in the other trial consumers bid on foods with a non-GM-label indicating that a certain percentage genetically modified material, either 1% or 5%, was tolerated. These specific tolerance threshold levels are of particular importance as they match up with the current European and Japanese standards and would be the likely tolerance choices of the United States should a standard be enacted.

The experimental design has two treatments. The treatments are randomly assigned to three experimental units, each consisting of 13 to 16 consumers drawn from households in the Des Moines, Iowa, area and who are paid to participate. Our total sample size is forty-four consumers, and table 1 summarizes the demographic characteristics of our sample. Seventy percent of participants were female. The mean age was 49.7.[3] Fifty-nine percent were married. The average participant had more than two years of college education and the average household size was 2.75. The household income is over fifty thousand dollars, and ninety-five percent are white. Other than the high percentage of females, the demographic characteristics of our participants indicate that our experiments is a representative sample of the Midwestern cities of the United States.[4]

Consider now the four elements in experiments—the GM food, the auction mechanism, the experimental units, and the specific steps in the experiment. First, we anticipated consumers might react differently to GM content for foods of different types. Believing that one food item was unlikely to reveal enough information, we selected three items: vegetable oil made from canola; tortilla chips made from yellow corn; and Russet potatoes.[5] Second, following our earlier work, we used the random *n*th-price auction for our GM-food experiments because it is designed to engage both the on- and off-the-margin bidders (also see Shogren *et al*. 2001).[6]

Third, all auctions were conducted in Des Moines, Iowa. Participants in the auctions were consumers contacted by the Iowa State University Statistics Laboratory. The Statistics Laboratory used a sample of randomly selected telephone numbers to solicit participants. These numbers were called by an employee of the ISU Statistics Laboratory to make sure that it was in fact a residence, and then asked to speak to an adult in the household—a person who was 18 years of age or older. They were told that "Iowa State University was looking for people who were willing to participate in a group session in Des Moines that related to how people select food and household products."[7]

Fourth, the experiment had nine specific steps. Step 1: each consumer signed a consent form, and was given $40 for participating and an ID number to preserve the participants' anonymity. The participants then read brief instructions and filled out a questionnaire.[8] Step 2: participants were given detailed instructions about how the random *n*th-price auction works. A short quiz was given to ensure everyone understood how the auction worked. Step 3: the random nth-price auction was introduced by having the consumers bid on one brand-name candy bar. Each consumer examined the candy bar, submitted a bid, and the auction was run.[9]

Step 4: the second practice round of bidding was run, and here consumers bid separately on three different items: the same brand-name candy bar, a deck of playing cards, and a box of pens. Participants knew that only one of the two rounds would be chosen at random to be binding, which prevented anyone from taking home more than one unit of any product. Following Melton *et al*. (1996), this random binding round eliminates the threat of a person reducing his bids due to him potentially buying more than one unit. The consumers first examined the three products and then submitted their bids. Step 5: the binding round and the binding *n*th-prices were revealed to the consumers. All bid prices were written on the blackboard, and the *n*th-price was circled for each of the three products. Participants could see what items they won, and the market-clearing price. The participants were told that the exchange of money for goods was in another room nearby, and would take place after the entire experiment was completed.

Step 5: the GM-food products were introduced for the next two rounds of bidding. The two bidding rounds were differentiated by the food label—either a non-GM label certified to be GM-free or a non-GM label that indicated the tolerance of GM material (see Figure 1).[10] In one round (which could be round 1 or 2 depending on experimental unit), participants bidding on the three food products each with the certified non-GM food label. In the other round, participants bidding on the same three food products with the 1% or 5%-GM food tolerance levels. Consumers knew that only one round would be chosen as the binding round that determined auction winners.

Step 6: consumers submitted sealed bid for the potatoes, vegetable oil, and tortilla chips, either with the certified non-GM label or the GM-tolerant label. Each consumer bid on each good separately. The monitor collected the bids, and then told the them they would now look at another group of food items. Step 7: consumers examine the same three food products, each with a different label from round 1. Again they examined the products, and submitted their bids.[11] Step 8: the monitor selected the binding round and the binding random *n*th-prices for the three goods, and notified the winners. Step 9: each consumer completed a brief post-auction questionnaire, and the monitors dismissed the participants who did not win. The monitors and the winners then exchanged money for goods, and the auction ended.

Data and Results

Two main results emerge from our experiment. First, consumers reduced their demand for the products having GM-tolerance levels relative to the GM-free benchmark. Table 2 shows the mean and median bids by food type. Twenty-eight participants bid in the 5% tolerance treatments; sixteen participants bid in the 1% treatment. Overall, the mean consumer bid less on the food product with the GM-tolerance labels relative to the GM-free products. Consumers bid 7 cents less on the GM-tolerant oil, 14 cents less on the tortilla chips, and 9 cents less on the potatoes.[12] Consumers discounted the foods with the GM-tolerance by an average of 7 to 13 percent. This is a significant demand reduction for 1%- and 5%-GM products. In comparison, Huffman *et al.* (2002) observed consumers discounted food by an average of 14 percent that had a GM-label without a tolerance level. Pooling all observations,[13] table 3 shows we can reject the null hypothesis that bidding behavior over GM-tolerance labels is identical to that for the GM-free benchmark for the tortilla chips and the potatoes, and not for the vegetable oil.[14] Consider the 1% and 5%-GM treatment separately, we cannot reject the null hypothesis that bids different for 5 of 6 products.[15] This significant discount for the GM-tolerant food is consistent with Viscusi *et al*. (1987) findings. In that study, consumers initially purchased a given product when told that it injured 15 out of 10,000 who used the product, but over two-thirds of the consumers were unwilling to purchase the same product when the chance of injury increased to 16 out of 10,000. This indicates a strong reference risk effect, which could help explain why consumers placed such a large discount on the GM-tolerant food.

Second, consumers discounted the 5%-GM products by the same amount as they discounted the 1%-GM food. Table 5 shows that at the 5 percent significance level we cannot reject the null hypothesis that demand reduction is independent of the GM tolerance level. This supports the view that if a GM-tolerance policy is enacted in the US, consumers might not place a greater value on a 1%-GM relative to a 5%-GM tolerance. Because of the higher segregation and handling cost of a 1% tolerance threshold compared to a threshold of 5%, society may be better off implementing a higher tolerance threshold. Consumers value GM-free products, but if GM contamination does exist, the marginal willingness to pay to avoid more contamination, from 1% to 5%, are small.

This result is consistent with the theory of surrogate bidding (for a good review see Shogren, 2002). This is where consumers reveal the same willingness to pay to avoid varying levels of contamination. Surrogate bidding has been shown to exist in other food markets. Hayes et al (1995) used experimental auctions to show that consumer bids to reduce risk by eliminating a cluster of foodborne pathogens were indistinguishable from bids to reduce specific pathogens. Using a survey, Hammitt and Graham (1999) found the same result, that consumers were insensitive to probabilities.

Conclusion and Implications

In our experimental treatments, consumers reduce their demand by an average of 7%-13% for each food product with a 1% and 5% tolerance for GM-material relative to GM-free food. We found no evidence, however, that consumers value a food with a 1%-GM tolerance greater than a food with a 5%-GM tolerance. These results support the notion that if the United States decides to allow a tolerance of GM material in food products, the 5% tolerance would be best socially. This occurs because consumers do not value a 1% tolerance more, and it is less expensive for food producers to comply with a higher tolerance level.

We found consumers were willing to pay a large premium to avoid contamination in an uncontaminated product but were not willing to pay to reduce contamination in a product that already had a small amount of contamination. An interesting extension of this work would be to see if this result generalizes to other products by examining the marginal willingness to avoid small amounts of contamination in other products. If our result generalizes to a broad range of products this would have an significant influence on many aspects of environmental policy. For instance, it would help explain the fierce opposition to drilling in the Alaska Wildlife area. It would also indicate that if proponents of drilling were initially successful in getting a small amount of oil drilling, it would be easier to convince the public to further increase drilling over time.

Future research remains to be done. More information is needed on the cost of producing non-GM crops at different tolerance levels. Also, this project could be replicated internationally to provide evidence on the efficiency of GM-tolerance policies in foreign countries, e.g. Europe and Japan. Trading across countries would be easier if all countries maintained the same tolerance. If research could show that consumers have similar values for tolerance levels across countries, this research could be useful for better understanding whether uniform GM-tolerance standards across countries makes sense.

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Figure 1: The three types of labels used for the tortilla chips

Vegetable Oil

Net weight 32 fl. oz.

This product is made without
genetic engineering *

* This product is certified to BE FREE OF ANY
GM-material.

Vegetable Oil

Net weight 32 fl. oz.

This product is made without
genetic engineering *

* Subject to a 1% tolerance, that is up to
1% of any ingredient could be genetically
engineered.

Vegetable Oil

Net weight 32 fl. oz.

This product is made without
genetic engineering *

* Subject to a 5% tolerance, that is up to
5% of any ingredient could be genetically
engineered.

Table 1. Characteristics of the Auction Participants

Variable	Definition	Mean	St. Dev
Gender	1 if female	0.70	0.46
Age	The participant’s age	49.7	17.1
Married	1 if the individual is married	0.59	0.50
Education	Years of schooling	14.49	2.41
Household	Number of people in participant’s household	2.75	1.42
Income	The households income level (in thousands)	50.6	36.8
White	1 if participant is white	0.95	0.21
Read_L	1 if never reads labels before a new food purchase	0.02	0.15
	1 if rarely reads labels before a new food purchase	0.02	0.15
	1 if sometimes reads labels before a new food purchase	0.34	0.48
	1 if often reads labels before a new food purchase	0.41	0.50
	1 if always reads labels before a new food purchase	0.20	0.41

Table 2. Mean Bids

A. Mean bids – all participants

	n	mean bid	std. dev.	Median	Minimum	Maximum
OIL	44	0.99	0.92	0.75	0	3.50
OIL - TOL	44	0.92	0.76	0.75	0	2.50
CHIPS	44	1.13	0.99	0.82	0	5.00
CHIPS - TOL	44	0.99	0.80	0.75	0	3.49
POTATOES	44	0.95	0.71	0.89	0	3.00
POTATOES - TOL	44	0.86	0.67	0.84	0	3.00

B. Mean bids when participants bid on food with a 5% tolerance level.

	n	mean bid	std. dev.	Median	Minimum	Maximum
OIL	28	0.94	0.81	0.75	0	3.00
OIL - TOL	28	0.88	0.71	0.68	0	2.50
CHIPS	28	0.99	0.77	0.75	0	3.00
CHIPS - TOL	28	0.90	0.69	0.73	0	2.00
POTATOES	28	0.83	0.64	0.75	0	3.00
POTATOES - TOL	28	0.76	0.65	0.75	0	3.00

C. Mean bids when participants bid on food with a 1% tolerance level.

	n	mean bid	std. dev.	Median	Minimum	Maximum
OIL	16	1.06	1.12	0.75	0	3.50
OIL - TOL	16	0.97	0.85	0.88	0	2.39
CHIPS	16	1.38	1.28	1.13	0	5.00
CHIPS - TOL	16	1.13	0.98	0.77	0	3.49
POTATOES	16	1.15	0.81	1.00	0	3.00
POTATOES - TOL	16	1.03	0.69	0.99	0	2.00

Table 3. T TEST – Non-GM foods with and without GM tolerance levels

A. T-Test on whether difference in bids are different – all observations.

	Bid Non-GM	Bid w/ tolerance	Difference	T-Test Statistic
Oil	0.99	0.92	0.07	1.24
Chips	1.13	0.99	0.14	2.44 **
Potatoes	0.95	0.86	0.09	1.70 *

B. T-Test on whether difference in bids are different – 5% tolerance.

	Bid Non-GM	Bid w/ tolerance	Difference	T-Test Statistic
Oil	0.94	0.88	0.06	1.05
Chips	0.99	0.90	0.09	1.51
Potatoes	0.83	0.76	0.07	1.33

C. T-Test on whether difference in bids are different – 1% tolerance.

	Bid Non-GM	Bid w/ tolerance	Difference	T-Test Statistic
Oil	1.06	0.97	0.09	0.71
Chips	1.38	1.13	0.25	1.93 *
Potatoes	1.15	1.03	0.12	1.08

Table 4. T-Test on whether consumers value foods with a 1% tolerance differently than foods with a 5% tolerance.

	Non-GM Premium – 5%	Non-GM Premium – 1%	Difference	T-Test Statistic
Oil	0.06	0.09	-0.03	-0.20
Chips	0.09	0.25	-0.16	-1.33
Potatoes	0.07	0.12	-0.05	-0.47

[1] While no literature exists on the costs of a low tolerance for GM foods, Klein and Brester (1997) estimated the cost for a zero-tolerance directive for beef packing companies. They found that zero-tolerance beef directive might cost society over $3 billion dollars annually.

[2] Note some argue it is impossible to claim that a product is 100% GM-free, saying that more accurate testing equipment would detect GM material on almost any food that was made, even non-GM foods. Our auction sold foods that were tested and found to not contain GM material – thus we claimed in the auctions that the foods were certified to have no GM content.

[3] This age is about average for the metropolitan area when one considers that we only used adults 18 years of age or older in our auction.

[4] Demographic information for the city of Des Moines can be found at Midwest Profiles (2001), at http://www.profiles.iastate.edu/.

[5] In the distilling and refining process for vegetable oils, essentially all of the proteins, which are the components of DNA and source of genetic modification, are removed leaving pure lipids. Minimal human health concerns should arise from consumption of the oil, but people might still fear that genetic modification could harm the natural environment. Tortilla chips are highly processed foods that may be made from GM or non-GM corn, and consumers might have human health or environmental concerns or both. Russet potatoes are purchased as a fresh product and are generally baked or fried before eating. Consumers might reasonably see the potential concentration of genetic modification as being higher in potatoes than in processed corn chips. Consumers might see both human health and environmental risks from eating Russet potatoes.

[6] The random *n*th-price works as follows. Each of *k* bidders submits a bid for one unit of a good; then each of the bids is rank-ordered from highest to lowest. The auction monitor then selects a random number—the *n* in the *n*th-price auction, which is drawn from a uniform distribution

between 2 and *k*, and the auction monitor sells one unit of the good to each of the *n*-1 highest bidders at the *n*th-price. For instance, if the monitor randomly selects $n = 4$, the three highest bidders each purchase one unit of the good priced at the fourth-highest bid. *Ex ante*, bidders who have low or moderate valuations now have a nontrivial chance to buy the good because the price is determined randomly. This auction increases the probability that insincere bidding will be costly (Shogren *et al*. 2001).

[7] The sessions were held on December 1, 2001, and potential participants were informed that the sessions would last about 90 minutes. Participants were also told that at the end of the session that they would receive $40 in cash for their time. The sessions were held at the Iowa State University Learning Connection, 7th and Locust Street, Des Moines. Three different times were available, 9 am, 11:30 am, and 2 pm, and willing participants were asked to choose a time that best fit their schedule. Participation per household was limited to two adult individuals, and they were assigned to different groups. To willing participants, the Statistics Laboratory followed up by sending a letter containing more information, including a map and instructions on when and where the meeting would be held, directions for getting there, and a telephone number to contact for more information. From the initial sample of randomly selected numbers, the percentage (not adjusted for unusable numbers) of people who accepted the offer to participate and then showed up to the auction was approximately eight percent. Considering participants had to forgo a good portion of their Saturday our response rate seems quite reasonable.

[8] All experimental instructions are available from the authors on request.

[9] Throughout the auctions, when the participants were bidding on items in a round, they had no indication of what other items they may be bidding on in future rounds.

[10] Note that our labels are all on the front of the package, where consumers would surely see them. Read Noussair *et al* (2002) for evidence how consumers are not always likely to read labels on the back of packages.

[11] The order in which consumers see the different labeled products may cause different bids (see Huffman et. al. 2001). For participants in the 5% tolerance treatments, one experimental unit bid on foods with the non-GM labels in the first trial and the 5% tolerance labels in the second trial, while another experimental unit viewed the food labels in the opposite order. The participants who bid on the one percent tolerance labels all bid on the certified non-GM foods in the first trial and the non-GM foods with the 1% tolerance in second trial. We intended to have a second group bid on foods with the 1% labels in the first trial and the certified non-GM labels in the second trial, but, we were unable to due this because of a technical difficulty. A Wilcoxon rank-sum test failed to reject the null hypothesis that the discount for the GM-tolerant food in the 5% tolerance treatment were the same in both rounds at a 5% level of significance for any of the three products. Therefore, the problem that prevented us from obtaining an additional experimental unit of people who bid on the non-GM foods with one percent tolerance did not appear to alter our results. (All results not shown in the tables are available from the authors upon request).

[12] Table 2 also shows that consumers bidding on 5%-GM tolerance discounted the oil by 6 cents, the tortilla chips by 9 cents, and the potatoes by 7 cents. Consumers bidding on 1%-GM tolerance discounted the vegetable oil by 9 cent, the tortilla chips by 25 cents, and the potatoes by 12 cents. T-tests could not reject the null hypothesis that the bids for the non-GM foods differed across treatments – this is a good consistency check and does not reject the hypothesis that the bidding behavior was reasonable. Between 32%-41% of consumers bid less for the GM-

tolerance food - the percentage varies by food product.

[13] Because the participants in the three separate treatments were independent of each other, one can pool the data to test whether consumers discounted the GM-tolerant food.

[14] We also ran Wilcoxon Signed-Rank tests and the results were similar – the bids on the vegetable oil were not statistically different at any conventional significance level, the bids for the tortilla chips were significantly different at the five percent level, and the bids for the potatoes were significantly different at the fifteen percent level.

[15] We also ran several regressions to test if demographic characteristics, like consumer's gender, household income, race, or age could explain the difference in bids for the certified non-GM labeled food and the GM-tolerant food. No demographic characteristic has a statistically significant impact on the difference in bids.