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Essays in the measurement of consumer preferences in experimental auction markets

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Essays in the measurement of consumer preferences in experimental auction markets

by

John Andrew Fox

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DEDICATION

To Eileen

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CHAPTER 1. GENERAL INTRODUCTION

The primary focus of this thesis is to apply a relatively new technique, laboratory experimental auctions, to examine consumer preferences for food products which have not yet reached the market. The laboratory experimental auction method was developed by Shogren *et al.*(1994) to estimate willingness to pay for increased levels of food safety. It features a Vickrey (1961) second-price auction in which the highest bidder pays an amount equal to the second-highest bid and uses real products, real money, and an explicit obligation to consume a food product. The Vickrey auction has been shown to accurately reveal preferences because it eliminates the incentive to underbid true value which is present in a first-price auction.

Predicting consumer reaction to new products currently relies on hypothetical surveys, focus groups, and taste panels. The biases inherent in these hypothetical methods can produce misleading results (Whitehead 1991). Thus a producer or processor may avoid a new technology because results from biased surveys suggest unfavorable consumer reaction. The advantage of experimental auctions is that they are more realistic than surveys, taste panels, or focus groups and therefore can provide a more reliable assessment of consumer preferences. Better forecasts of consumer reaction reduce uncertainty for developers and potential users of new products or processes, and thus contribute to better decisions in marketing, promotion, and adoption.

This thesis investigates consumer preferences for two new food products, bovine somatotropin (bST) and irradiated pork, both of which have had substantial time lags between product development and commercialization. Bovine somatotropin is a synthetic replicate of a naturally occurring hormone that was developed to boost milk yield in dairy cows. It was approved for commercial use by the Food and Drug Administration (FDA) in February 1994 but the approval process was considerably delayed, perhaps due to objections from consumer advocacy groups. Food irradiation is a process which uses electromagnetic energy to kill bacteria thus rendering food safer for human consumption and delaying spoilage. Irradiation has been approved for pork since 1987 for control of the parasite *Trichinella* which causes trichinosis. Despite its proven benefits and safety, food processors, under threat of consumer boycotts organized by anti-irradiation activists, have been reluctant to use irradiation. At present there is only one commercial food irradiation facility in the U.S. and only four retail outlets offer irradiated food products.

Time lags between product development and commercialization impose costs not only on product developers but also on society in general because of foregone benefits. For example, food irradiation has the potential to significantly reduce the number of deaths and illnesses which occur each year from foodborne pathogens. The lack of reliable methods for predicting consumer reaction to new products is a contributing factor in these time lags. Anti-technology activists can exploit the biases in hypothetical surveys in order to convince policy makers and producers that consumers do not want these products. Given recent failures with approved products (e.g. breast implants) policy makers are less likely to approve new products in the face of what they may perceive as unfavorable public attitudes. Likewise, processors with brand names to protect will avoid controversial technologies at the hint of adverse consumer reaction.

The experimental auction method comes close to replicating the decision making process undergone by consumers faced with new food products in retail stores. By providing more reliable indications of consumer acceptability of new products, this method can mitigate the opportunities for anti-technology activists to exploit uncertainty about consumer reactions, enhance the environment in which approval or adoption decisions are made, and therefore reduce time lags between product development and approval or commercialization.

Dissertation Organization

This manuscript consists of three self-contained papers which are linked via technique and subject matter. Each paper either has been or will be submitted to an economic journal, and thus each follows the format of the relevant journal. The first paper, "CVM-X: Calibrating Contingent Values with Experimental Auction Markets," uses bids from an experimental auction to calibrate bids from a hypothetical survey. The object of valuation is a participant's willingness to pay to upgrade from a typical pork sandwich to an irradiated pork sandwich or vice-versa. Comparing values between the survey and the experiment demonstrates the extent and direction of bias in hypothetical values.

The second paper is titled "Effects of Alternative Descriptions of Food Irradiation on Preferences for Irradiated Pork in Experimental Auctions." This paper exploits the flexibility of the experimental auction method not only to quantify consumer preferences but also to investigate the impact of alternative descriptions of the product on those preferences. The paper investigates the effect on participants' bids to upgrade from non-irradiated to irradiated pork of favorable and unfavorable descriptions of the irradiation process. The third paper, "Determinants of Consumer Acceptability of Bovine Somatotropin," investigates regional differences in consumer acceptability of milk from cows treated with bST. Data from experimental auctions is used to investigate the relationship between acceptability of "bST milk" and socioeconomic and anthropomorphic factors.

Following the papers is a general summary. References cited in the general introduction and general summary are included in the literature cited section. The author conducted all of the laboratory experiments on which the papers are based. The first two papers were written in consultation with Dr. D. J. Hayes, Dr. J. F. Shogren, and Dr. J. B. Kliebenstein. Financial support for this research was provided by the Food Safety Consortium.

CHAPTER 2. CVM-X: CALIBRATING CONTINGENT VALUES WITH EXPERIMENTAL AUCTION MARKETS*

A paper to be submitted to the American Economic Review

John A. Fox, Jason F. Shogren, Dermot J. Hayes, and James B. Kliebenstein**

Abstract

Doubts about the accuracy of values obtained by the contingent valuation method (CVM) reflect a need to validate or calibrate those values. We design and implement an alternative method, CVM-X, which validates and calibrates values using a laboratory experiment. Using bids to upgrade from a typical to an irradiated pork sandwich (and vice-versa), we find significant differences between the hypothetical bids obtained in a survey and those subsequently obtained in a non-hypothetical laboratory auction with non-student participants.

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Introduction

Do people actually do what they say they will? This remains the central question in the debate over the contingent valuation (CVM) of nonmarket goods (see the recent exchange between Diamond/Hausman and Hanemann). If people do what they say, there is no problem, and economic values elicited from hypothetical questions can provide useful information. If they do not, problems will ensue. Existing data suggest they do not - hypothetical bids tend to overstate "real" values obtained in actual markets (see Bishop and Heberlien; Bohm; Boyce and McCollum; Dickie *et al.*; Duffield and Patterson; Kealy *et al.*; Neill *et al.*; Seip and Strand; Shogren (1991); Shogren and Crocker).[1] Consequently, in its proposed regulations for natural resource damage assessment, the U.S. National Oceanic and Atmospheric Administration (NOAA) has recommended that CVM values be deflated by a default factor of fifty percent unless they can be calibrated to actual market data. This arbitrary default factor will serve as a guideline until it can be determine if there is a systematic bias in hypothetical behavior

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[1] For example, Neill *et al.* (1994) found CVM bids for a framed picture significantly greater than those elicited in a real second-price auction. Duffield and Patterson compared contingent values and actual contributions for a water leasing trust fund finding that the average contribution was similar across surveys but that the survey requesting a contribution had a much lower participation rate. Similarly, Boyce and McCollum (1993) concluded that their hypothetical market for bison hunting permits overestimated true value primarily due to the lower preponderance of zero bids. The NOAA panel (Arrow *et al.*) recognized an upward bias in the CVM and their recommendations stress conservative design wherever possible. The panel also stressed the importance of validation: "External validation of the CV method remains an important issue. A critically important contribution could come from experiments in which state-of-the-art CV studies are employed in contexts where they can in fact be compared with "real" behavioral willingness to pay for goods that can actually be bought and sold."

that can be statistically measured and corrected with a calibration function (see Blackburn *et al.*).

This paper introduces the concept of CVM-X into the calibration debate. CVM-X, as defined by Shogren (1993), consists of four basic steps. First, run a CVM survey and elicit hypothetical values for the good in question. Second, bring subsamples of the CVM respondents into the laboratory and elicit real bids for the actual good in an incentive compatible auction that employs real goods, real money, and repeated market experience. Experimental markets provide people with a well-defined incentive structure that enables the researcher to more accurately elicit the value of a nonmarket good, product, or process (Coursey). Third, estimate a calibration function relating the auction market bids of the subsample to their hypothetical bids (and other factors if appropriate). Fourth, use the estimated calibration function to adjust the values of CVM respondents who did not participate in the laboratory auction. Implicit in CVM-X is a test of validity since we can directly compare hypothetical bids with those elicited under non-hypothetical conditions in the laboratory. The idea is that CVM-X can be a cost-effective tool that combines the advantages of CVM and experimental auction markets, increasing the validity and accuracy of surveys while broadening the scope of nonmarket valuation in the lab.

We apply the CVM-X method to the valuation of reduced risk of food-borne illness achieved with food irradiation. Our results show a hypothetical bias of approximately 10 percent in the median bid to upgrade from a non-irradiated to an irradiated pork sandwich, and a bias of almost 50 percent in the median bid to upgrade from an irradiated sandwich to a non-irradiated sandwich.

The rest of this paper is organized as follows. The next section describes the application of the CVM-X method to consumer acceptance of food irradiation, and outlines the analytical framework underlying the elicited values. The third section describes the four-step implementation and the results from the CVM-X application. We offer our conclusions in the final section.

CVM-X Application: Trichinella Risk and Food Irradiation

The objective individual chance of infection from the food-borne pathogen *Trichinella* is approximately 1 in 2,400 annually. Of those individuals who do get sick, one out of one hundred will die from the illness (Bennett *et al.*). In response to this risk, the United States Food and Drug Administration (FDA) has recently approved irradiation treatment of pork to control *Trichinella*. Irradiation of pork products can reduce by greater than 99 percent the viability of Trichinella organisms present in the meat (Brake *et al.*). While most scientist agree that products treated by irradiation are completely safe, opponents of irradiation still call for more research on potentially harmful effects.

Food irradiation has been approved for a number of products, and market tests with irradiated fruit have indicated a high degree of acceptability to consumers.[2] However, irradiated foods are not yet widely available in the U.S., and many people are

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[2] An in-store study on consumer response to irradiated papayas in California indicated a high degree of acceptance (Bruhn and Noell).

unfamiliar with the process thereby giving it a feature common to many CVM goods.[3] This lack of familiarity and the ability to represent risk reduction in a tangible, private good that can be bought and sold on the auction block makes irradiated pork a salient product for testing the CVM-X method.

Following Buhr *et al.*, we use a split-valuation design with two experimental treatments to separate and value the positive and negative attributes of food irradiation. Consider an agent endowed with a non-irradiated pork sandwich which has a 1 in 2.6 million chance of causing trichinosis (see Shin *et al.*). A representative individual's expected utility, EU_i, given a non-irradiated pork sandwich is

$$\bar{EU}_i = \pi_i \; U(M,S_0) + (1-\pi_i) \; U(M,H) \tag{1}$$

where M denotes wealth, S_0 a state of food borne illness, H a state of health, and π_i is the individual's subjective probability of contracting trichinosis that allows for combining prior perceptions with the risk information provided (see Hayes *et al*). Assume $U(M, S_0) < U(M, H)$.

Now allow the agent to exchange the non-irradiated sandwich for an irradiated sandwich that has zero probability of causing trichinosis. Because Trichinella is now rarely found in pigs in the United States and because it takes a fairly substantial number of viable organisms to cause trichinosis, we were comfortable with offering participants a

[3] Irradiated food products are currently available at only 4 retail outlets in the United States; 3 in Florida, 1 in Illinois.

guarantee that the consumption of an irradiated pork sandwich would not result in trichinosis. But since the individual may perceive other risks associated with irradiation, i.e. cancer, his or her expected utility with the irradiated sandwich is

$$E\tilde{U}_i = \theta_i\ U(M-R_i,S_1) + (1-\theta_i)\ U(M-R_i,H) \tag{2}$$

where R_i ($R_i \geq 0$) is the ex ante willingness to pay or the option price bid to upgrade to the irradiated sandwich, S_1 is a state of illness associated with irradiation, and θ_i is the agents' subjective probability of contracting some illness associated with irradiation. The implied assumption is that in a state of health, the agent is indifferent to having consumed a non-irradiated or an irradiated sandwich.

The bid, R_i, equalizes expected utility from both sandwiches

$$\pi_i\ U(M,S_0) + (1-\pi_i)\ U(M,H) = \theta_i\ U(M-R_i,S_1) + (1-\theta_i)\ U(M-R_i,H) \tag{3}$$

A positive bid occurs if

$$\pi_i\ U(M,S_0) + (1-\pi_i)\ U(M,H) < \theta_i\ U(M,S_1) + (1-\theta_i)\ U(M,H) \tag{4}$$

If $\pi_i \leq \theta_i$, the agent's subjective probability of contracting trichinosis does not exceed that of contracting an illness associated with the irradiated sandwich, and it can be shown that a necessary condition for a positive bid is $U(M,S_0) < U(M,S_1)$, i.e., utility is lower when ill from trichinosis than when ill from a condition associated with irradiation. If $\pi_i > \theta_i$, there will be a positive bid unless utility when ill from trichinosis exceeds by a certain amount that when ill from a condition associated with irradiation.

Implementation and Results

Step 1 - The Survey

The starting sample was restricted to 250 residents of the local county. Because the initial contact was made by letter, the sample was selected from telephone directory listings rather than from all potential telephone numbers as in random digit dialing procedures. We mailed an introductory letter explaining the nature of the survey for which the subject had been selected. We subsequently made telephone contact with 208 subjects, from which we obtained 182 interviews, a response rate of 87.5 percent. We sought as participants those most responsible for food shopping within the household.

The survey instrument was developed with input from statisticians, veterinarians, and food scientists experienced in survey design and food safety. Pretesting was conducted, following which minor changes were made to the descriptions of irradiation and trichinosis, and the order of two questions was reversed. A training session was conducted with professionals interviewers prior to the pretest.[4]

The survey began with attitudinal questions related to diet and food safety. Demographic information was collected at the end. Following descriptions of trichinosis

[4] The introductory letter and survey instrument are contained in Appendix A.

and food irradiation, participants were offered a hypothetical choice between a sandwich made with irradiated pork meat described as having a zero chance of causing trichinosis, and a typical sandwich with non-irradiated pork described as having a 1 in 2.6 million chance of causing trichinosis. Table 1 shows that of the 174 pork-eaters in the sample, 131 (75 percent) indicated a preference for the irradiated pork sandwich. Previous surveys on acceptability of irradiated meat products have found similar results. For example, a national survey conducted for the American Meat Institute (1993) observed that 60 percent of participants said they were willing to pay 10 cents more for irradiated hamburger if irradiation reduced bacteria levels. In our survey, we deliberately excluded the "no preference" option although this answer was all we could elicit from four participants.

Using an open-ended valuation question, each participant was then asked to reveal the maximum he or she would be willing to pay to upgrade from their less preferred sandwich to their sandwich of choice.[5] Among the 131 pork eaters preferring the irradiated sandwich, the average hypothetical bid to upgrade was $0.61. Of the 38 preferring non-irradiated, the average bid to upgrade to a non-irradiated sandwich was

[5] There remains some debate over the appropriate choice of valuation question. Some argue that the closed-ended or discrete choice approach is more appropriate since it is easier for participants to understand, while others argue that open-ended is more appropriate because it provides more information. Recently, Cummings et al. (1992) found that the discrete choice method tends to overstate true willingness to pay.

$0.58. Note that two participants refused to submit a bid, both stating that they would pay "a lot more" for the non-irradiated sandwich.[6]

At the end of the interview, participants who were pork eaters were asked if they would participate in a consumer economics experiment in return for a payment of $30.00. Those interested were asked to give a convenient time for participation. The interviewers made no connection between the interview and the experiment. If asked, they informed subjects, honestly, that they did not know anything about the experiments. Of the 174 eligible, 130 indicated they would be willing to participate. When contacted about possible dates for an experiment, 48 subjects had either changed their minds or were unavailable (see Table 1).

Table 2 shows the mean and median bids and some demographic characteristics for the two groups and for the subgroups participating in experiments. Figures 1 and 2 illustrate the distributions of hypothetical bids. Participation rates were similar between the two groups - 58 of 131 preferring irradiated (44 percent) and 20 of 38 preferring non irradiated (53 percent). Since we wanted to include as many participants as possible in the experiments, we did not select on the basis of demographic or socio-economic characteristics. Table 2 and Figures 1 and 2 indicate, however, that our subsamples were representative of the larger groups.

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[6] Both subjects agreed to participate in experiments. They were taken aside during the experiment and told that in order to continue, they had to give a dollar bid. One gave a bid of $1.00, and the other $20.00. Bids from these two subjects are not included in any tables or statistical analysis.

Step 2 - The Experimental Auctions

Using Buhr *et al.*'s split-valuation design, we assigned participants to one of two treatments given their preference for the two types of pork sandwiches - the Irradiated treatment and the Non-irradiated treatment.[7] Those preferring irradiated pork were assigned to the Irradiated treatment, and were endowed with a non-irradiated sandwich and given the opportunity to bid for an irradiated sandwich. Those preferring non-irradiated pork were assigned to the Non-irradiated treatment, and were endowed with an irradiated sandwich and given the opportunity to bid for a non-irradiated sandwich.

For both treatments, the general procedures of the experimental auctions followed Shogren *et al.* (1994a). Each treatment had two stages. In stage one, participants were familiarized with the auction mechanism by auctioning brand name candy bars. Over five trials, each participant submitted a sealed bid to exchange his/her endowed candy bar for the auctioned candy bar. Following each trial, the I.D. number(s) of the highest bidder(s) and the market price were displayed. After all five trials, we controlled for wealth effects by randomly selecting one of the five trials to be the binding trial that determined who would receive the auctioned candy bar.

Stage two introduced the meat products. Each auction (except in group 10) consisted of 10 trials, each with a uniform chance of being randomly selected as the binding trial.

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[7] We use the term treatment to refer to the two main types of experiment - one involving bids for irradiated pork, the other involving bids for non-irradiated pork. The subtreatments are the different types of auction mechanism employed i.e., 2nd price auction, random n^{th} price auction, and one-shot. We use the term group or experiment to refer to the individual experimental units of which there are 10.

Following each trial, the I.D. number of the highest bidder and the market price from the auction were publicly displayed. Participants had previously been informed that they would have to eat a sandwich in order to leave with their income. All sessions were run at a meat tasting laboratory at a major midwestern university.

At the beginning of stage two, participants were given a note reminding them of their hypothetical bid from the telephone survey.[8] They were informed that their hypothetical bid would be their non-hypothetical bid for trial 1 of the auction. After the winner's I.D. number and market price for trial 1 were posted, they were then asked to bid in trial 2. The auction proceeded until trial 5, when participants were given a guided tour of a food irradiation facility, and a detailed description of the food irradiation process. Questions about the irradiation process were answered at that time. Subjects then returned to the auction room, and restarted their bidding for trials 6 through 10. Note that for group 10 there was a one-shot auction, which did not have ten trials. Instead, participants bid once in the belief that it would be their only bid. The winner's I.D. number and market price were posted and participants were then given the tour of the irradiation facility, following which they were allowed to change their previous bids.

[8] Reminding participants of their hypothetical bids could bias our results in favor of the CVM if subjects are unwilling to change their bid i.e., unwilling to admit that they were wrong on the survey, not wishing to appear foolish etc. This did not appear to be a problem - 50 of 78 experimental subjects changed their bid between trials 1 and 2, 29 of those by $0.25 or more. Of 58 subjects in the Irradiated treatment, only 10 (17%) kept the same bid between the survey, the 2nd trial, and the final bid. In the Non-Irradiated treatment, 6 of 20 (30%) participants maintained the same bid.

Groups 1,2,3,4 and 10 used a Vickrey second price, sealed bid auction mechanism. In the second price auction, the highest bidder in the binding trial purchased the product at a price equal to the amount of the second highest bid. Groups 5,6,7,8, and 9 used a variant of the Vickrey auction - a random n^{th} price auction (see Shogren *et al.* 1994b). With the random n^{th} price mechanism there is a uniform chance within each trial that the auction will be a second, third, fourth, etc. highest bid auction. For example, if, in the binding trial, the auction had been randomly drawn to be a fourth price auction, then the three highest bidders would purchase the good at a price equal to the fourth highest bid. See Appendix B for a transcript of the experimental instructions.

Tables 3a and 3b summarize the groups and provide the bidding patterns in trial 1 (hypothetical), trial 2, and trial 10. Figures 3 and 4 plot the mean bid over all 10 trials for each group. For the three groups in the Non-irradiated treatment, the mean hypothetical bid exceeded that of trials 2 and 10. Note that in two of the three groups, the mean bid gradually fell between trials 1 and 10. In the third, group 7, there was a sudden drop between trial 1 and 2 followed by a gradual recovery until trial 10. In the Irradiated treatment, the mean hypothetical bid exceeded the mean bid in trial 2 in all 7 groups, and exceeded the mean bid in trial 10 in 5 of the 7 groups.

For groups in the Irradiated treatment, information about irradiation after trial 5 appears to have had minimal impact on mean bids. The exception appears to be group 1 where the mean bid increased in trial 6 but declined in trial 7. This movement in the mean is attributable to one bidder. These patterns suggest that repeated market experience accounts for most of the movement in mean bids between trials 2 and 10. In group 8 in the Non-irradiated treatment there appears to be a downward shift in the mean bid in response to new information - evidence that the new information reassured some bidders of the safety of the irradiated product.

Comparison of Survey and Experiment Table 4 shows mean and median bids and the variance of bids taken across all individuals in both treatments. Because some participants (18 of 53 bidding for irradiated pork in multiple trial experiments, 8 of 20 bidding for non-irradiated pork) did not lock in a constant bid, we did not use trial 10 to represent the final experienced bid. Instead we used an average over trials 8, 9, and 10 because the variability of participants bids between trials was minimized over this three trial interval.

For the first four auction trials (trial 2 to trial 5), participants were given essentially the same information about food irradiation and trichinosis as was given to them in the telephone survey. The only extra information participants had when they submitted their first auction bid was the I.D. number of the highest bidder and the amount of the second highest bid in their group. The differences in bidding between the survey (trial 1) and the first auction trial (trial 2) for the most part represent the effect of placing survey participants in a non-hypothetical situation. Table 4 shows that the difference between the survey and trial 2 is greater in the Non-irradiated treatment.

Also note in Table 4 the reduction in the variance of bids between the survey and auction which we illustrate for three groups in Figure 5. This reflects the increased precision of the non-hypothetical auction bids. If there is an incentive for strategic over- or under-bidding in the hypothetical survey, we would expect real values to have a tighter distribution than hypothetical values. The reduction in variance is more pronounced in the Non-irradiated treatment where we suspected the potential for strategic overbidding to be greatest. The Moses test for equality of dispersion parameters indicated that the reduction in variability was significant at the 0.05 level in both treatments.[9] Similar reductions in variance have been reported elsewhere, see for example Schulze *et al.* or Shogren(1990).

a) *Bids for Non-Irradiated Pork*: Figure 6 shows the distributions of trial 1 (hypothetical), trial 2, and final (avg. 8-10) bids to upgrade to a non-irradiated sandwich. The average final bid of $0.25 is less than half the average hypothetical bid of $0.67. Much of this discrepancy can be attributed to one bidder with a $5.00 hypothetical bid and consistent zero bids in the experiment. There is also a discrepancy in median bids - $0.20 in the survey compared to $0.01 in final bids. However, with one participant recording a substantial increase between survey and experiment, from zero to $1.10, the Wilcoxon signed-rank test did not reject equality of the distributions (Table 5). Correlation between hypothetical and final bids, as measured by the Spearman rank correlation coefficient, was low at .27 and not significant ($p > 0.20$).

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[9] We used the nonparametric test since the F test is unreliable when the populations of interest are not normally distributed. (See Daniel, p92)

b) *Bids for Irradiated Pork*: Figure 7 shows the distributions of bids to upgrade to an irradiated pork sandwich. The median bid falls from $0.50 in the survey to $0.30 in trial 2, then increases to $0.42 in final experienced bids. The Wilcoxon test rejects equality of the distributions for hypothetical and trial 2 bids, and also for trial 2 and final bids. It appears that placing subjects in the non-hypothetical auction environment affects bidding behavior, as does repeated experience with the auction market. The correlation between hypothetical and final bids is again quite low at 0.41 ($p < 0.002$).

Sensitivity to Outliers Much attention has been given to the treatment of outliers in contingent valuation studies, and cases occur where conclusions may rest on their inclusion/exclusion (Gregory and Furby). To account for this issue we have focused the analysis on medians and used nonparametric tests.

A potential advantage of the CVM-X procedure is that, in the context of relating hypothetical bids to "real" bids, it allows one to identify outliers and protest bids. A case in point is the hypothetical bid of $5.00 for the non-irradiated sandwich which reduces to zero in the auction. Without knowing that the market bid was in fact zero, $5.00 might not have been considered unrealistic as a bid to avoid eating irradiated pork.

In this particular study there seems to be a greater tendency to overstate the hypothetical bid on the part of subjects bidding to acquire the non-irradiated sandwich. Even with the elimination of the $5.00 bid, the mean hypothetical bid ($0.44) is 65 percent larger than the mean final bid ($0.27). The proportion bidding zero remains almost constant, so the decrease is due to the scaling back of higher bids. It appears as though there may be an element of protest built into the larger hypothetical bids to demonstrate disapproval for the irradiation process.

Another example of a protest bid was provided by one of the two participants who refused to state a bid in the survey. Before the experimental auction the subject was reminded of the survey question and asked if she could provide a bid. Based on her perceptions of food irradiation at that time she had serious doubts about the safety of the process. As a result, she found it difficult to formulate a bid, explaining that it was impossible to value a human life. Finally, the bid of $20.00 was given. In the experimental auction the bid quickly fell to $1.00 in trial 2 and to $0.02 by the end of the experiment. In this case, the true bid was overstated in the survey by a factor of a thousand.

Step 3 - The Calibration Function

Figures 8 and 9 illustrate how individuals' hypothetical bids compare with their experienced final bids from the experimental auction. While the distributions of bids appear similar between the survey and experiment, there are substantial differences at the individual level. As noted above, we calculated the correlation coefficients between final and hypothetical bids at 0.41 in the Irradiation treatment and 0.27 in the Non-irradiation treatment.

For participants in the Irradiated treatment the calibration function that relates hypothetical bids, HYP_i, to market bids, $FINAL_i$, is

$$FINAL_i = \alpha + \beta_1 \; HYP_i + \beta_2 \; T2 + \beta_3 \; T3 + \epsilon \tag{5}$$

where T2 and T3 are dummy variables for the random n^{th} price and one-shot sub-treatments. Table 6 presents the calibration function results. The intercept term and the coefficient on the hypothetical bid are both positive and significant for bids for irradiated pork. We reject the hypothesis that final bids equal hypothetical bids ($\alpha = 0$, $b_1 = 1$). Likewise, we reject the NOAA default calibration level ($\alpha = 0$, $b_1 = 0.5$). Models 1b and 1c reflect the effects of sub-treatments and groups. The coefficients suggest a tendency for subjects in the random n^{th} price and "one-shot" sub-treatments to have lower final bids, but these effects are not statistically significant. Group effects are statistically significant in two cases.

Models 2a and 2b suggest that group effects are important among the subjects bidding for non-irradiated pork. In both models the coefficient on the hypothetical bid is negative reflecting the poor correlation between final and hypothetical bids. Elimination of the outlying bid ($5.00) had a small effect, with the intercept changing to 0.26 ($t = 2.49$) and the slope coefficient becoming positive (0.02) but remaining statistically insignificant ($t = 0.15$).

Step 4 - Hypothetical Bid Calibration

We applied the calibration function (Model 1a) to the bids of the 131 subjects who preferred irradiated pork. Calibration resulted in a mean bid of $0.48 compared to the survey mean of \$0.61. The calibrated median bid was \$0.46, implying that the survey, with a median at \$0.50, overestimated median willingness to pay by approximately 9 percent.

To calibrate bids from the Non-irradiated treatment we used coefficients resulting from elimination of the outlying bid ($\alpha = 0.26$, $b_1 = 0.02$). Calibration with these coefficients resulted in a mean bid of \$0.27 down from the survey mean of \$0.58. The calibrated median was \$0.27 down from \$0.45. The NOAA default calibration of 50 percent appears to be appropriate in this situation.

Are hypothetical bids biased? At the individual level, the answer must be "yes". Of 58 participants in the Irradiated treatment, 23 (40 percent) decreased their bid between the survey and trial 2 by an average of \$0.51, while 14 participants (24 percent) increased their bid by an average of \$0.16. As the experiment proceeded, bids increased, and the final bids in the experiment corresponded quite closely, on average, to those in the hypothetical survey.

In the Irradiated treatment we can regard the deviations between survey and experimental bids as being due to hypothetical bias in the true random sense (Mitchell and Carson, p191). There is no motivation to underbid strategically for a preferred private good in either treatment. Strategic underbidding (or protest zeros) commonly occurs when subjects believe that they should not have to pay for the good in question, e.g. improved air quality. They underbid their true value because they feel that someone else should pay. With a private good - in this case one that has been identified as being preferred to an endowed alternative - this motivation to underbid is absent. We also believe that there are few in the general public who feel strongly enough about the need for food irradiation that they would overbid strategically in the Irradiated treatment. Thus the errors in hypothetical bids are random and probably occur due to the lack of market discipline.

However, we do believe that in the Non-irradiated treatment, where participants are bidding to avoid the irradiated product, there is motivation for some subjects to overbid strategically in the survey. For these subjects, larger hypothetical bids allow them the opportunity to demonstrate their disapproval of food irradiation. In the Non-irradiated treatment, the upward bias in hypothetical bids compared with trial 2 occurs not because the **number** of overbidders exceeds the number of underbidders, but because of the **magnitude** of the overbids. There were 5 hypothetical overbids averaging $2.04 compared to 8 hypothetical underbids averaging $0.23. The incentive to overbid strategically produces the upward bias in the survey values.

To summarize - in the Irradiated treatment, the survey provided a reasonable estimate (within 10 percent) of true median willingness to pay in the absence of strategic overbidding. In the Non-irradiated treatment, the NOAA calibration (50%) provided a reasonable adjustment to mean or median willingness to pay in the presence of strategic overbidding. However, in neither treatment did the survey or NOAA calibration provide reasonable estimates of individual willingness to pay.

Conclusions

We have demonstrated how the CVM-X method can be used to verify and calibrate contingent values with experimental auction markets. Using a randomly selected sample of adult subjects, we found that the average respondent asked to value an upgrade from typical to irradiated pork (and vice versa) bid more in a hypothetical survey than in a non-hypothetical laboratory auction with real monetary incentives. The upward bias in hypothetical bids was greater in the sample bidding to avoid the irradiated pork. Our calibration procedure led us to conclude that the hypothetical median bid for irradiated pork was overstated by about 9 percent ($0.46 vs. $0.50) and the median bid for non-irradiated pork overstated by about 70 percent ($0.27 vs. $0.45).

One can argue that the test of validity entailed in the CVM-X method is a test of convergent rather than criterion validity[10] since valuation in the lab may be subject to its own set of biases. Smith (1992) takes a rather pessimistic view - "Accuracy is impossible to judge because economists can never know the "true" values people place on any commodity - marketed or nonmarketed." Regardless, we believe that an experimental market using an incentive compatible auction gets about as close as one reasonably can to "true" values. Furthermore, the CVM-X method uses within-subject comparisons, the advantages Smith notes in the same article. We conclude, based on the

[10] Convergent validity refers to a situation in which neither of two measures is assumed to be a truer measure of the underlying construct than the other. With convergent validity the appropriate question is whether the measure (hypothetical bid) is correlated with another measure (auction bid) of the same theoretical construct (true willingness to pay). Criterion validity assumes that the alternative measure (auction bid) accurately represents the theoretical construct (true willingness to pay). See Mitchell and Carson, p190-209.

low level of correlation between the hypothetical and experimental values, that our survey failed to measure accurately individual willingness to pay for a private risk reduction. These results show that estimates of use value for a private good are not generally immune to systematic bias.

An important feature of CVM-X is that it allows for the provision of substantially more information and context (for a subsample of participants) than would be possible in any large survey. In our application, participants in the subsample were shown an actual food irradiation facility. The laboratory setting, with subjects who have made and been compensated for a time commitment, provides an opportunity to elicit values under conditions of full information and complete attention. A related advantage is that calibration of values based on appropriately selected subsamples provides for substantial cost savings in contingent valuation surveys by avoiding the need for large scale personal interviewing. As always with experimental methods, replication allows testing for the robustness of the outcome.

The primary aim of this paper is to present an application of the CVM-X method. Our application does not, nor do most CVM studies, adequately account for substitution possibilities. In the context of this exercise, substitutes would include private risk reduction strategies (cook your own pork) and alternative public interventions such as HACCP (Hazard Analysis and Critical Control Point) procedures. Substitution possibilities have been incorporated in experimental auctions (see Shogren *et al.* [1994c]), and need to be explored in our context as well.

So where do we go from here? CVM practitioners are, of course, primarily interested in public goods and programs, items generally lacking the deliverability of a pork sandwich. Application of CVM-X to the domain of public goods requires deliverable surrogates - an example is provided by Harrison *et al.*'s use of local wetlands in the bias function approach to calibration. We envision a combination of CVM-X and bias functions in which a series of CVM-X studies would value progressively larger amounts of the public good. For example, to value wetlands preservation first apply CVM-X to one acre of wetland, then 10 acres, 100 acres, and so on up to a realistic maximum. For each CVM-X calculate the required calibration function and test for transferability to the next level. Use of CVM-X in this manner can provide the appropriate calibration for a survey valuing national wetlands preservation.

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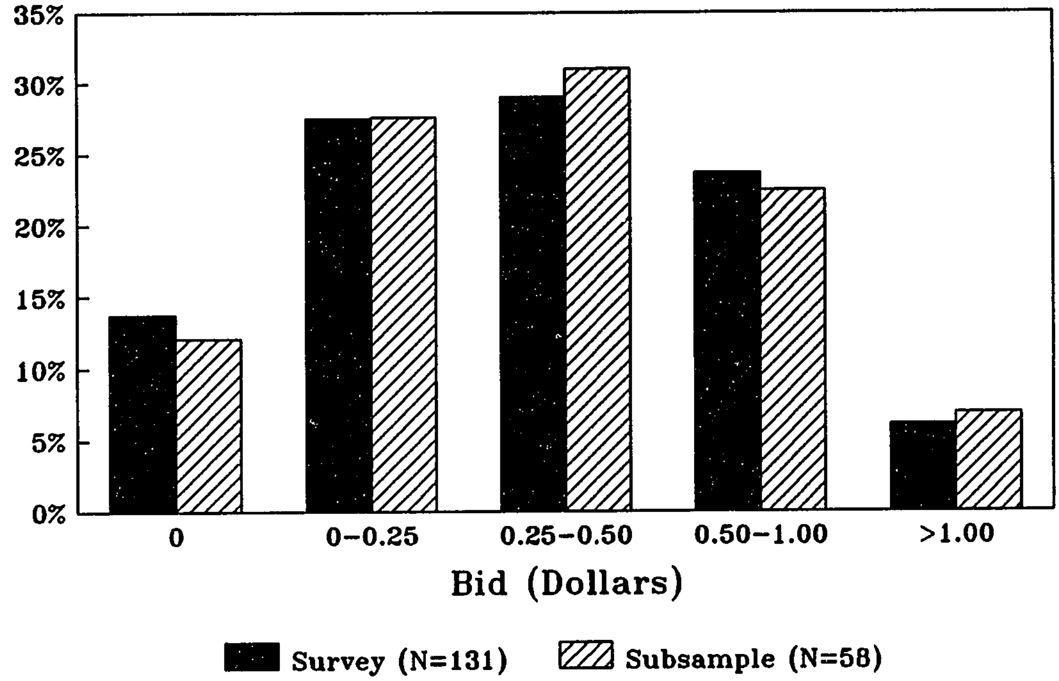

Figure 1: Distributions of hypothetical bids to upgrade to irradiated pork.

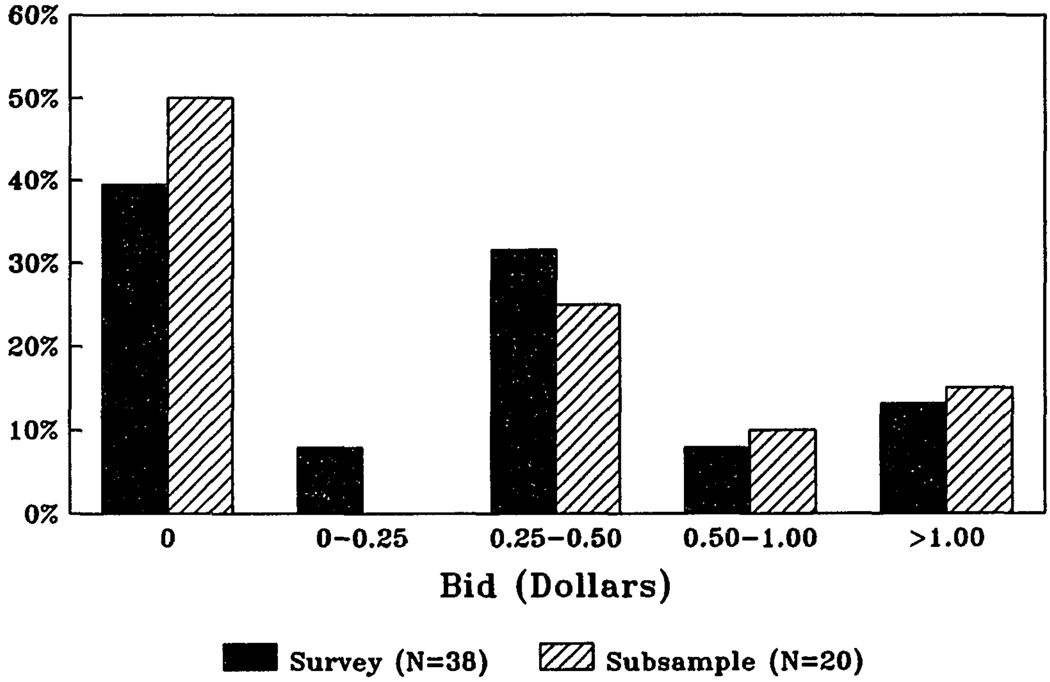

Figure 2: Distributions of hypothetical bids to upgrade to non-irradiated pork.

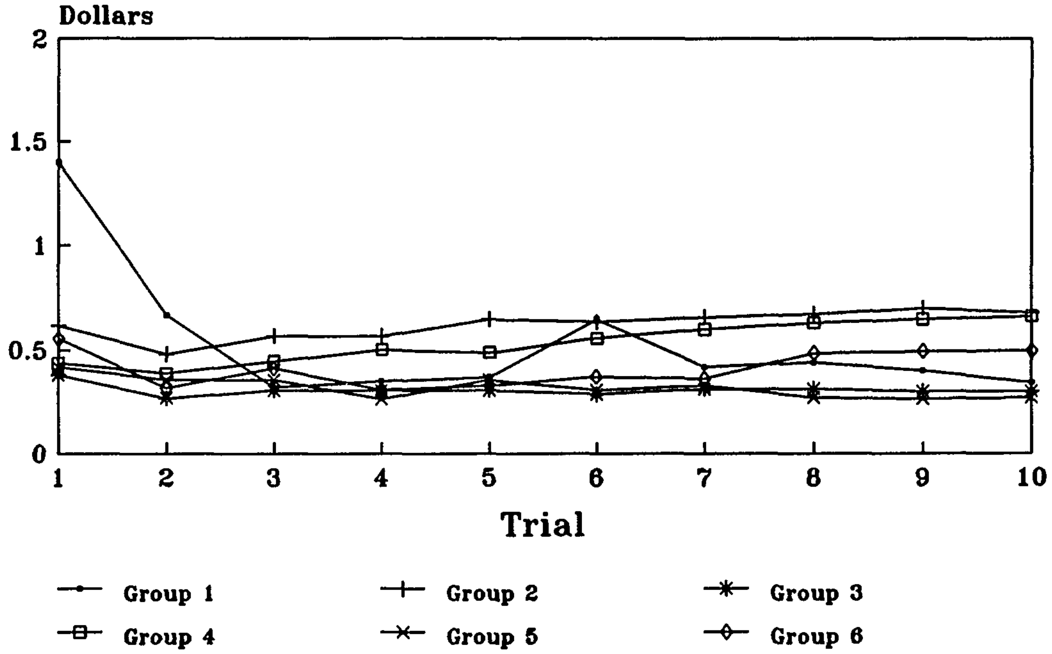

Figure 3: Average bid to upgrade to irradiated pork.

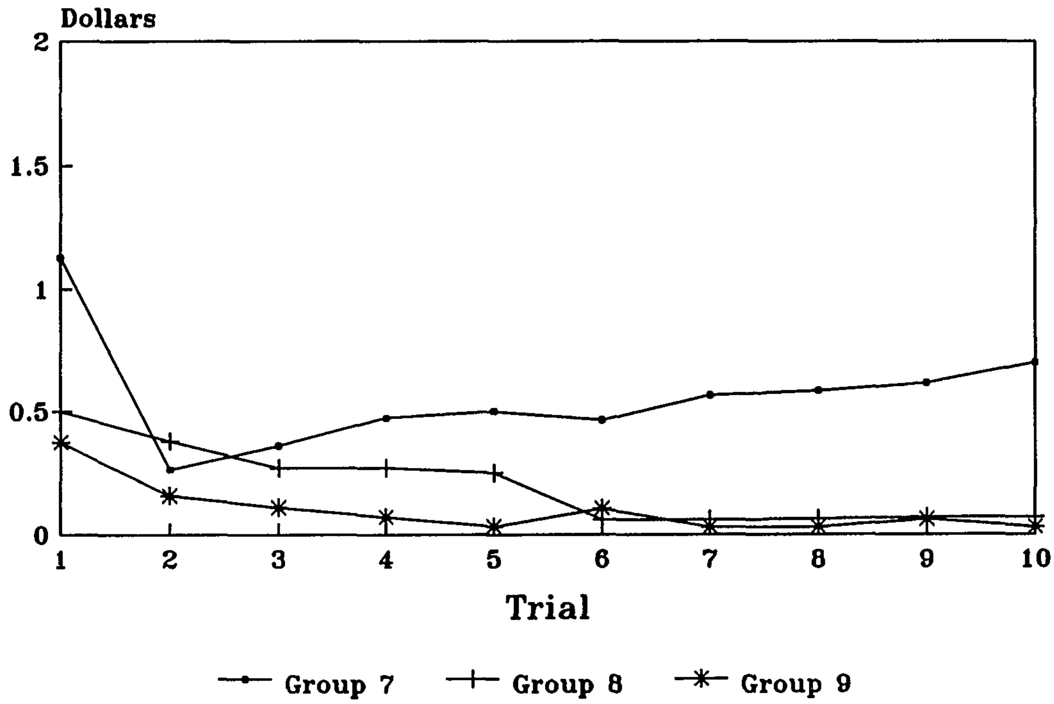

Figure 4: Average bid to upgrade to non-irradiated pork.

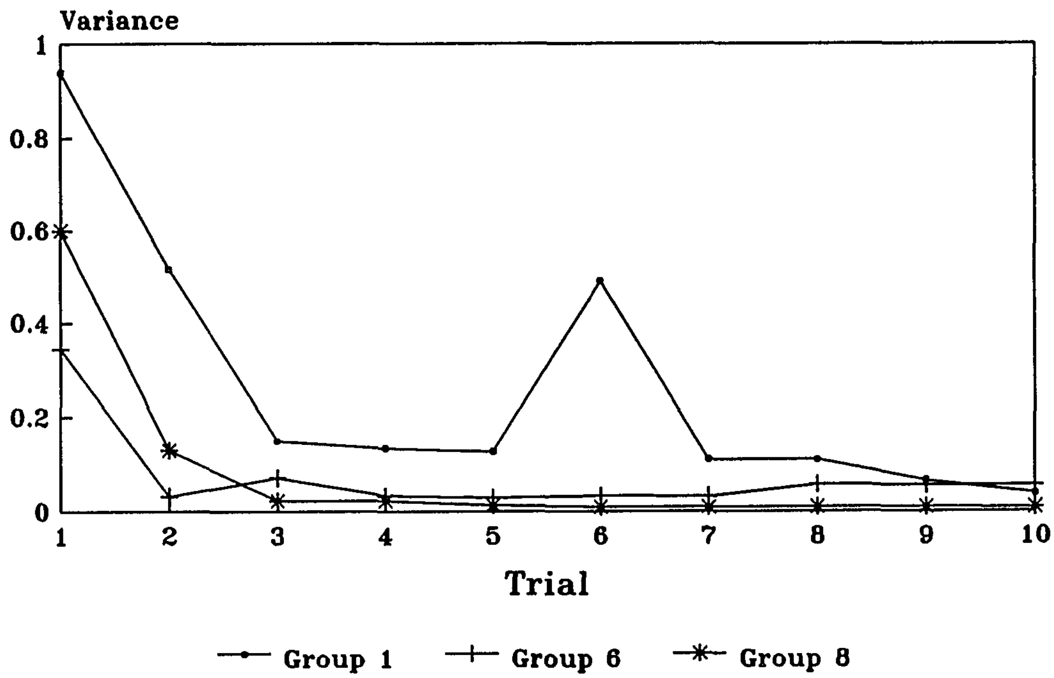

Figure 5: Variance of bids for selected experiments.

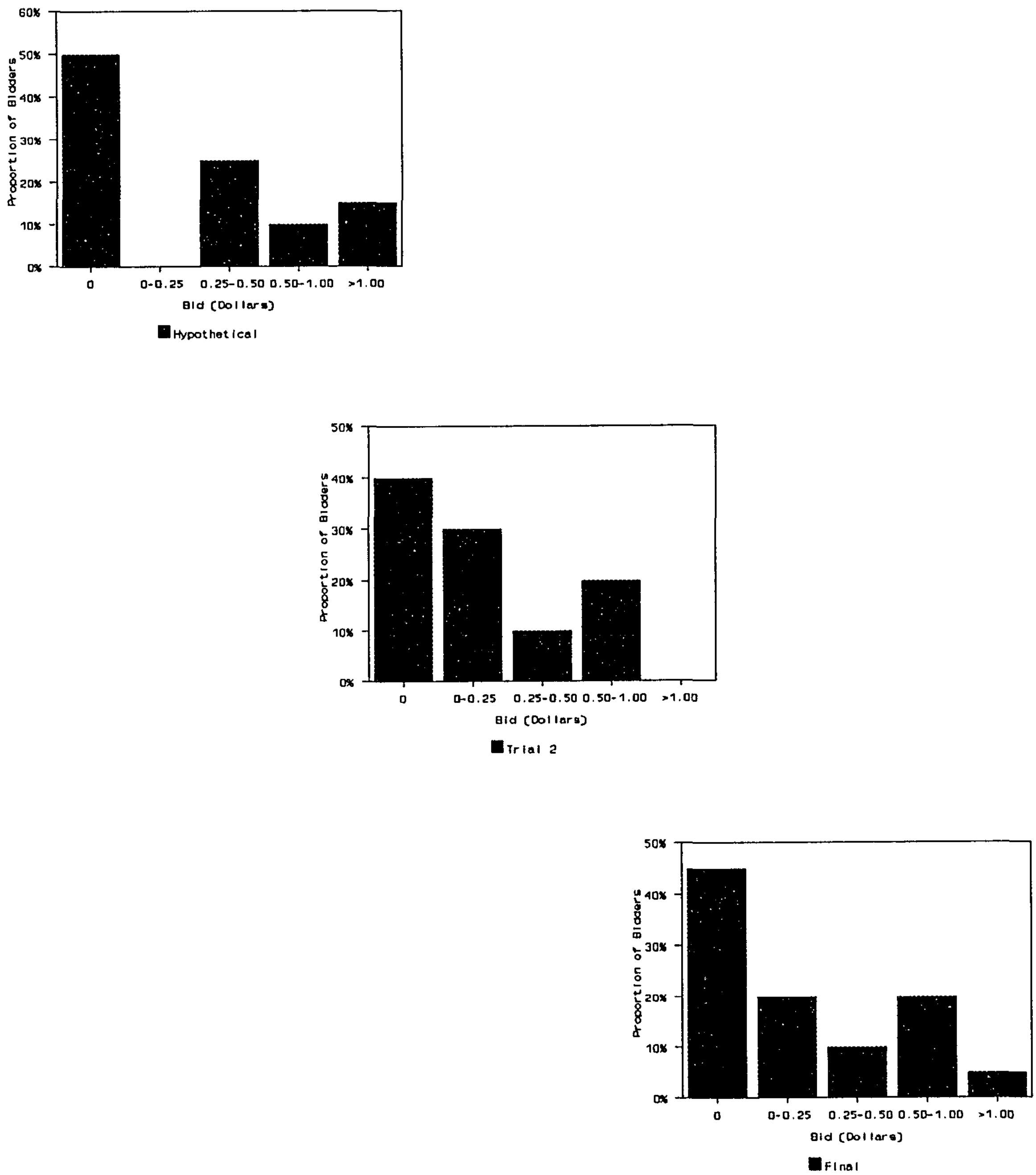

Figure 6: Distributions of Hypothetical, Trial 2, and Final Bids for Non-Irradiated Pork.

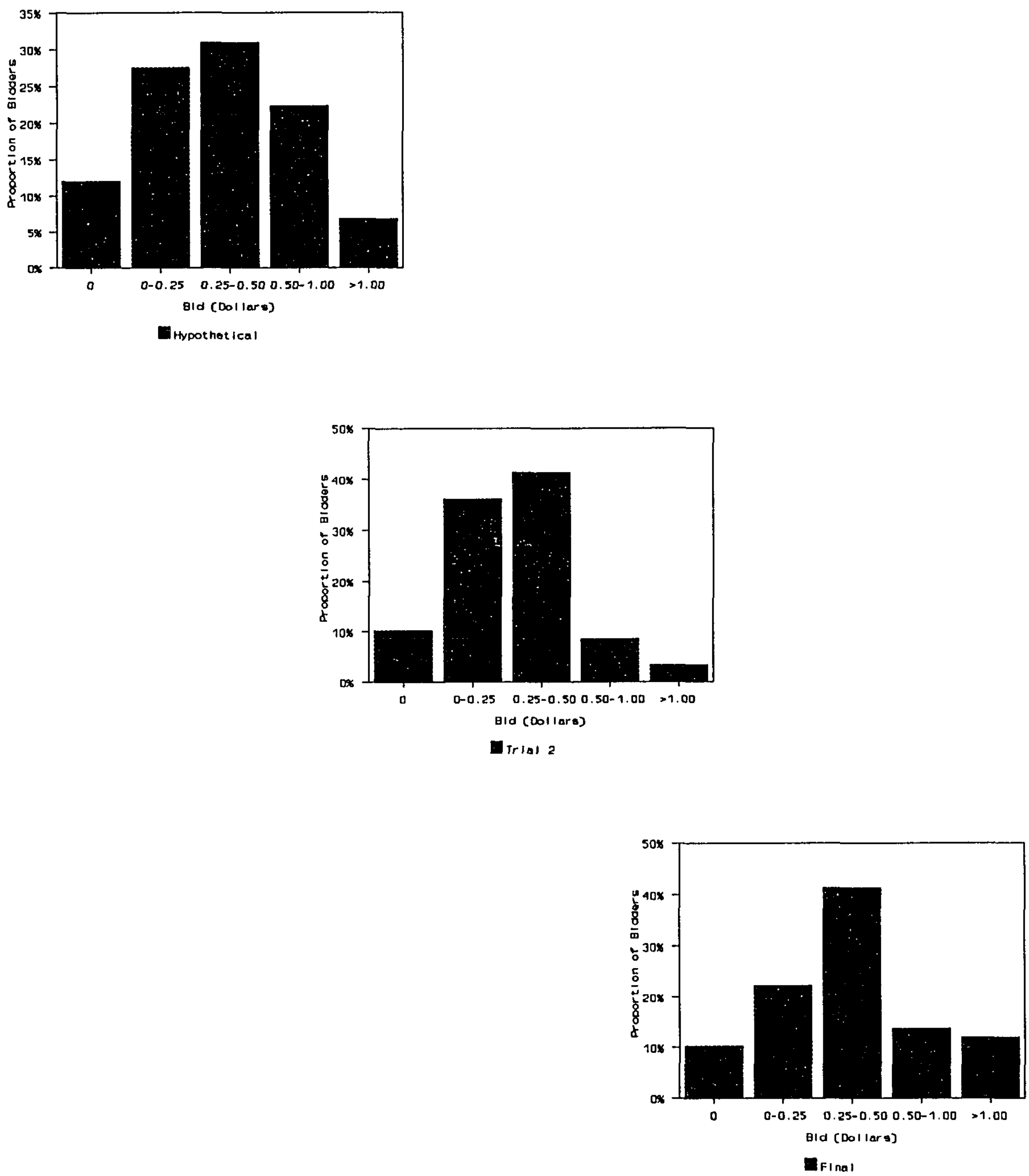

Figure 7: Distributions of Hypothetical, Trial 2, and Final Bids for Irradiated Pork.

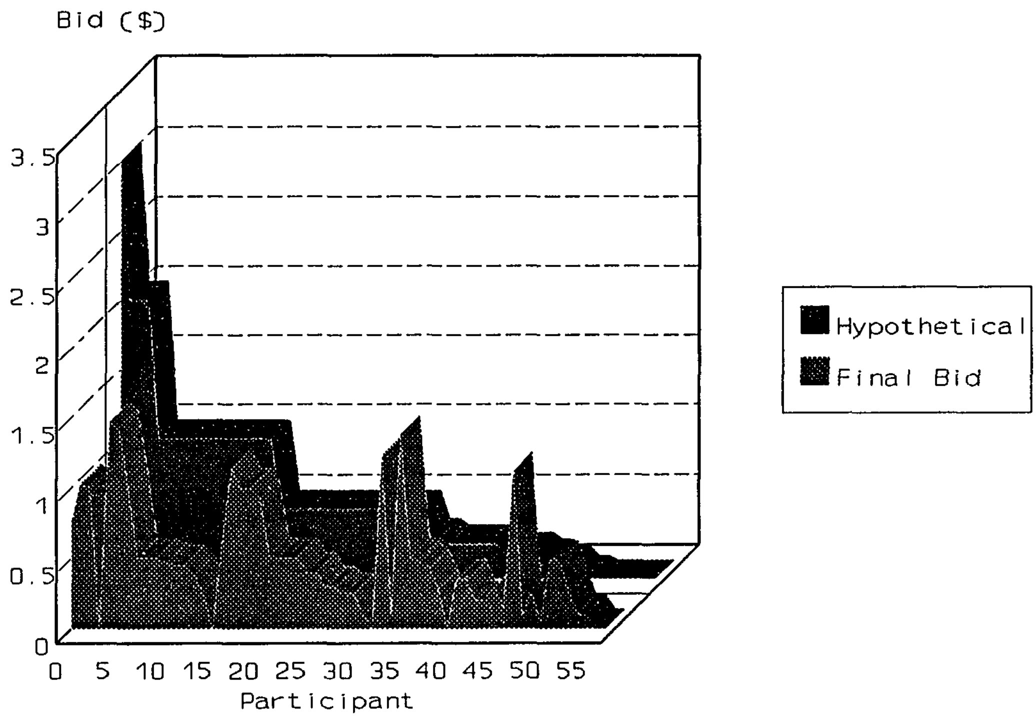

Figure 8: Hypothetical and final bids to upgrade to irradiated pork. Ranked by hypothetical bid.

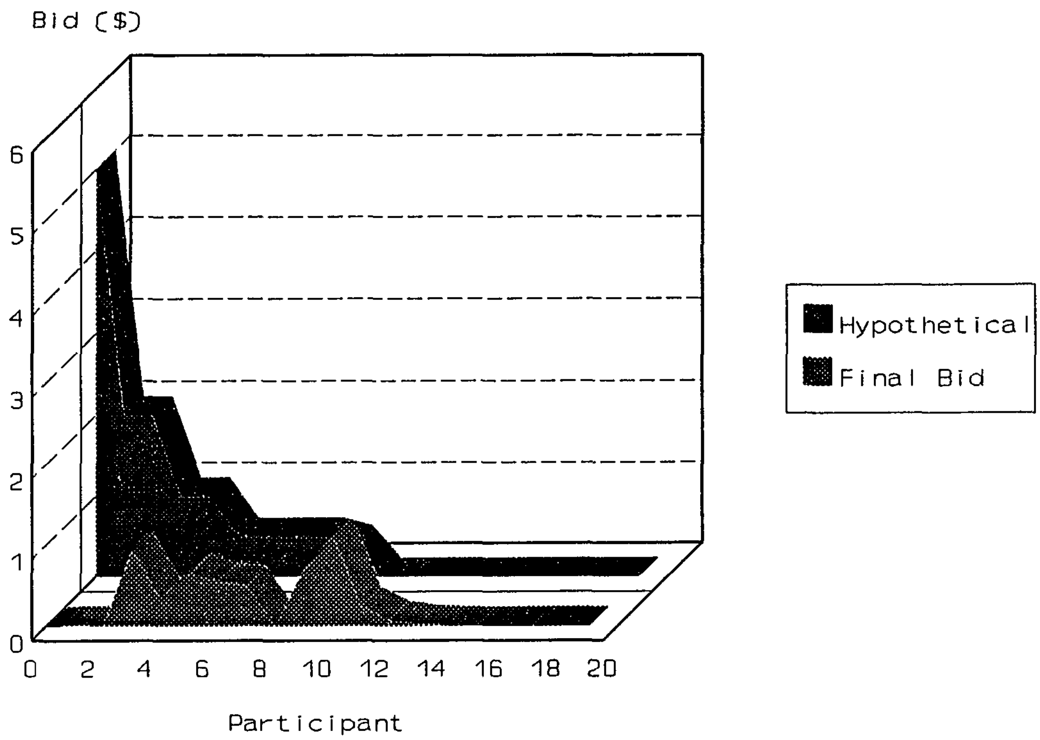

Figure 9: Hypothetical and final bids to upgrade to non-irradiated pork. Ranked by hypothetical bid.

Table 1: Summary of the CVM-X Survey.

Preference	Irradiated	Non-Irradiated	No Preference	Total
Participated	58	22	2	82
Later Declined	39	8	1	48
"No" up front	34	10	0	44
Non pork eater	6	1	1	8
Total	137	41	4	182

Note: Of the 22 people preferring non-irradiated pork who actually participated in experiments, 2 had refused to give a hypothetical bid in the survey. At the beginning of the experiment, when pressed for their WTP value, their hypothetical bids were $1.00 and $20.00. Bids from those 2 participants are not included in subsequent tables nor in the statistical analyses.

Table 2: Selected Characteristics of Survey Participants.

Preference	Irradiated Pork		Non-Irradiated Pork	
Variable	N = 131	Laboratory Subsample (N=58)	N = 38	Laboratory Subsample (N=20)
Age	43.4	39.7	41.4	40.7
Sex (% male)	.32	.33	.26	.20
Education	5.1	5.3	5.1	5.3
Income	3.5	3.5	3.8	4.1
Average Bid (Variance)	\$0.61 (0.94)	\$0.58 (0.34)	\$0.58 (0.85)	\$0.67 (1.37)
Median Bid	\$0.50	\$0.50	\$0.45	\$0.20
Zero Bids(%)	18 (.14)	7 (.12)	15 (.39)	10 (.50)

Description of Variables:

Age — Actual age in years.

Sex — Categorical variable: 0 if female, 1 if male.

Education — Categorical variable: 1 = Grade 8 or less; 2 = Grades 9-11; 3 = High school grad.; 4 = Some technical, trade, or business school; 5 = Some college, no degree; 6 = College graduate; 7 = Some graduate work; 8 = Masters degree; 9 = Ph.D, D.V.M., D.D.S., M.D., etc.

Income — Categorical variable: 1 = less than \$10,000; 2 = \$10,000 to \$20,000; .... 6 = \$50,000 to \$70,000; 7 = \$70,000 to \$100,000; 8 = more than \$100,000.

Table 3: Summary of Experiments.

3a. Bidding to upgrade to Irradiated.

No.	Group	N	Trial 1 Mean (Var) Median	Trial 2 Mean (Var) Median	Trial 10 Mean (Var) Median
1	A	5	1.40 (0.94) 1.00	0.67 (0.52) 0.50	0.34 (0.04) 0.45
2	A	11	0.62 (0.33) 0.50	0.48 (0.09) 0.50	0.68 (0.18) 0.75
3	A	8	0.38 (0.07) 0.28	0.27 (0.02) 0.25	0.30 (0.02) 0.35
4	A	13	0.44 (0.16) 0.25	0.39 (0.14) 0.30	0.66 (0.33) 0.50
5	B	7	0.42 (0.16) 0.25	0.36 (0.09) 0.30	0.27 (0.01) 0.30
6	B	9	0.56 (0.34) 0.50	0.32 (0.03) 0.25	0.50 (0.06) 0.50
10	C	5	0.60 (0.04) 0.50	0.26 (0.03) 0.25	0.23 (0.03) 0.25

3b. Bidding to upgrade to Non-irradiated.

No.	Group	N	Trial 1 Mean (Var) Median	Trial 2 Mean (Var) Median	Trial 10 Mean (Var) Median
7	B	7	1.13 (2.57) 0.50	0.26 (0.06) 0.25	0.70 (0.14) 0.70
8	B	5	0.50 (0.60) 0	0.38 (0.13) 0.25	0.07 (0.01) 0.05
9	B	8	0.38 (0.48) 0	0.16 (0.11) 0	0.03 (0.01) 0

Note: Trial 1 is the hypothetical bid from telephone survey. Group A is the Vickrey 2nd price auction with 10 trials. Group B is the Vickrey random n^{th} price auction with 10 trials. Group C is the Vickrey 2nd price "one-shot" auction in which Trial 2 is represented by the first non-hypothetical bid and Trial 10 by the revised bid.

Table 4: Comparison of Hypothetical and Experimental Auction Bids.

Preference	Irradiated (N=58)			Non-Irradiated (N=20)		
	Survey	Trial 2	Final	Survey	Trial 2	Final
Mean Bid	0.58	0.39	0.48	0.67	0.25	0.25
Variance	0.34	0.12	0.15	1.36	0.10	0.12
Median	0.50	0.30	0.42	0.20	0.05	0.01
Zero bids	7	6	6 (6)*	10	8	9 (10)

Note: Trial 2 is the first non-hypothetical auction bid. The final bid is an average over trials 8 to 10 except for Experiment 10 where it is represented by the revised "one-shot" bid.

* Averaging over the three final trials may hide zero bids for some participants who have not locked in at their final bid. The number in parentheses is the average number of zero bids received in trials 8, 9, and 10.

Table 5: Comparison of Distributions with Wilcoxon signed-rank test.

Null Hypothesis	Hypothet. = Trial 2		Hypothet. = Final		Trial 2 = Final	
Bids for	N[1]	13	N	13	N	12
Non-Irrad.	Min(T^-T^+)	39	Min(T^-T^+)	35	Min(T^-T^+)	35
	Result	Accept	Result	Accept	Result	Accept
Bids for	N	37	N	48	N	36
Irradiated	Z[2]	3.02	Z	1.01	Z	2.74
	Result	Reject	Result	Accept	Result	Reject

Note: N is the effective number of observations after deleting ties. For N > 15 the distribution of T is assumed to be approximately normal. (Freund and Walpole, p527). Rejections are valid at the 0.01 level of significance.

Table 6: Comparing Final and Hypothetical Bids.

Variables	Bids for Irradiated			Bids for Non-Irradiated	
	OLS Regression Coefficients				
	Model 1A	Model 1B	Model 1C	Model 2A	Model 2B
Constant	.36 (5.20)	.43 (5.41)	.03 (.14)	.28 (2.99)	.76 (9.31)
Hyp.Bid	.20 (2.35)	.19 (2.30)	.26 (2.95)	-.04 (-.53)	-.12 (-3.11)
T2		-.13 (-1.2)			
T3		-.32 (-1.8)	.05 (.20)		
Group 2			.49 (2.48)		
Group 3			.18 (.81)		
Group 4			.50 (2.51)		
Group 5			.13 (.59)		
Group 6			.32 (1.54)		
Group 8					-.63 (-5.70)
Group 9					-.67 (-6.76)
N	58	58	58	20	20
Standard Error	.38	.37	.35	.36	.18
Log likelihood	-24.76	-22.69	-16.44	-7.07	7.52
R^2	.09	.15	.32	.02	.77

Note: T2 represents the random N^{th} price auction. T3 represents the "One-shot" auction in Experiment 10. *t* statistics are given in parentheses.

Appendix A

Introductory Letter and Survey

October 28, 1993

Mr.() ()
( )
( )

Dear () (),

The Economics Department at Iowa State University is conducting a study with Story County residents regarding their knowledge, opinions and concerns related to food safety.

Your household was scientifically selected to be included in this study and we would be grateful for your help. Within the next two weeks you will be contacted by telephone and the person who is most responsible for food purchases in your home will be asked to participate in a brief telephone interview. This will take 5-10 minutes. There are no risks to participants in the project and your voluntary participation is extremely important to the study. Any information provided will be kept strictly confidential and released in summary form with information from all who are interviewed.

We hope that you will take a few minutes of your time to assist us with this study which will improve our understanding of people's concerns about the many issues related to food safety in our country. If you have any questions regarding the study, please call Toni Genalo, Project Coordinator, at 515-294-5244, and she will be happy to help you. Thank you for your consideration.

Sincerely,

Dermot Hayes, Ph.D.
Associate Professor

Food Safety Study
Statistical Laboratory, Iowa State University
& The Department of Economics

Int. ID# __ __

Date Interviewed: __ __/__ __

Food Purchaser's Name:__________

a.m.
Start Time: __ __:__ __
p.m.

Day	Date	Time	Int.	Outcome
________	___/___	__ __ : __ __	__ __	________
________	___/___	__ __ : __ __	__ __	________
________	___/___	__ __ : __ __	__ __	________
________	___/___	__ __ : __ __	__ __	________
________	___/___	__ __ : __ __	__ __	________

Hello, this is (your name) calling from the Statistics Department at Iowa State University. Is this the (name) residence? Recently, Iowa State University sent you a letter about a research study we are conducting for the Economics Department about food safety.

1. Did you receive this letter?
   1 = Yes
   2 = No →
   3 = Don't know →

EXPLAIN PROJECT - READ LETTER IF NECESSARY.

As the letter stated, we would like to talk to the person in your household who is most responsible for purchasing food. Is that you?
   1 = Yes
   2 = No →

GET PERSON OR GET NAME AND CALL BACK.

________________/________________
(Call back person) (Name)

We would like to discuss your perceptions and opinions related to the foods we eat. Before I do that, I want to assure you that any information you provide will be kept strictly confidential and used only for the purposes of this research. If you feel any question is too personal, you do not have to answer it. This will take 5-10 minutes of your time.

I will begin by asking you a question about your eating habits.

2a. Do you ever eat meat? This includes beef, pork, chicken, turkey, as well as wild game.

1 = Yes
2 = No → **GO TO Q.3.**

b. Do you eat...

	Yes	No
beef........................	1	2
poultry....................	1	2
pork.......................	1	2
fish.........................	1	2

3a. Have you ever had food poisoning?

1 = Yes → b. How did you find out you had it?
2 = No ____________________
3 = **MAYBE, THINK SO BUT UNSURE**
9 = **DON'T KNOW**

4. From what you know about your immediate family, have any of them had food poisoning?

1 = Yes
2 = No
3 = **MAYBE, THINK SO BUT UNSURE**
9 = **DON'T KNOW**

5. How concerned are you about the safety of the food you buy? Would you say you are...

   1 = Not at all concerned
   2 = Slightly concerned
   3 = Somewhat concerned, or
   4 = Very concerned

6. There are many procedures used in processing food to control bacteria and produce safer food. We would like to know how concerned you are about the safety of these procedures. Using a scale of 1 to 5, where "1" means that you are <u>not concerned at all</u> and "5" means that you are <u>very concerned</u>, tell me how concerned you are about each food processing method. How concerned are you about the safety of <u>(method)</u>? What number from "1" to "5" indicates how you feel about the safety of this process?

	Not at all				Very
Pasteurization..	1	2	3	4	5
Chemical treatments such as chlorination..	1	2	3	4	5
Canning..	1	2	3	4	5
Freezing..	1	2	3	4	5
Irradiation...	1	2	3	4	5
Fermentation, e.g. the process used to make cheese and yogurt...	1	2	3	4	5
Food preservatives.......................................	1	2	3	4	5

PROBE - NO DEFINITIONS WILL BE GIVEN. IF RESPONDENT IS RELUCTANT AND FEELS UNINFORMED, SAY: "From what you know about the process, etc." IF THEY REFUSE TO ANSWER, NOTE AS "DK."

7. Next, I will ask you about certain foods. I would like to know which of the following you would consider safe or not safe for you to eat. Here's the first one (food). Would you consider (it/them) safe or unsafe to eat?

	Safe	Unsafe	DON'T KNOW
Meat from animals that have been given antibiotics at approved levels?......	1	2	9
Meat from animals that have been given hormones at approved levels?......	1	2	9
Foods that have been treated with irradiation?......	1	2	9
Meat that has nitrite?......	1	2	9
Foods made at home with raw eggs, such as homemade ice cream or mayonnaise?......	1	2	9
Eating raw beef?......	1	2	9
Meat that has been both cooked and refrigerated at the store?......	1	2	9

8. Next, I would like to know how knowledgeable you are about a process used on food called irradiation. Would you say you...

   1 = never heard of food irradiation →

   2 = have heard of it, but don't know much about it →

   GO TO Q.11.

   3 = know something about it

   4 = know a lot about it

DO NOT DEFINE IRRADIATION.

9. What do you think are the advantages, if any, of irradiating food?

____

10. What do you think are the disadvantages, if any, of irradiating food?

____

11. Let me explain what the process does. The irradiation process is used to kill insects, parasites, and bacteria such as Salmonella and E.coli that can cause food borne illness and food spoilage.

Again, using a scale of 1 to 5, where "1" means that you are not concerned and "5" means that you are very concerned, how concerned are you (concern)? What number from 1 to 5 would you choose if 1 means not at all concerned and 5 means very concerned?

	Not at all				Very
that irradiated food could be radioactive............	1	2	3	4	5
about whether levels of nutrients and vitamins may be reduced in irradiated food....................	1	2	3	4	5
about whether irradiation causes environmental pollution..	1	2	3	4	5
about whether irradiation would increase the cost of food..	1	2	3	4	5
that irradiation could produce cancer causing substances...	1	2	3	4	5
about whether eating irradiated foods could cause birth defects...	1	2	3	4	5

12. I am going to read a list of foods. Would you tell me how likely or unlikely it is that you would buy the food if it was treated with approved doses of radiation and properly labeled as irradiated. How likely is it that you would buy (food) that have been irradiated? Would you say it is very likely, somewhat likely, not too likely, or not at all likely?

	Very likely	Somewhat likely	Not too likely	Not at all likely
Fruits and vegetables	1	2	3	4
Poultry products	1	2	3	4
Pork products	1	2	3	4
Beef products	1	2	3	4
Seafood	1	2	3	4

13. Raw meats may contain bacteria and parasites such as Salmonella, E.coli, and Trichinella, which can cause food-borne illness. Irradiation can kill these bacteria and parasites. Knowing this, how likely would you be to buy irradiated meat rather than non-irradiated meat. Are you...

    1 = Very likely
    2 = Somewhat likely
    3 = Not too likely
    4 = Not at all likely to buy irradiated meat?
    9 = **DON'T KNOW**

Next, I will tell you more about the irradiation of pork for the control of the parasite, Trichinella, which causes a disease called Trichinosis. The symptoms of the disease are abdominal pains, vomiting, diarrhea, headaches, fever,and the chills. Each year, about 100 cases of Trichinosis are diagnosed in the United States, but the actual number of cases is probably much higher. Of the people who get Trichinosis, about 1 out of 100 will die.

By using the irradiation process, which has been approved by the Food and Drug Administration, the risk of contracting trichinosis is almost eliminated.

The process uses either gamma rays, x-rays, or electrons to kill organisms, like Trichinella. The level of radiation used to treat pork does not cause food to become radioactive. The Food and Drug Administration concluded that irradiation of pork does not present a health hazard and it does not affect the nutritional value of food.

14a. Knowing this, if you were offered a choice of two pork sandwiches - one which has been irradiated, reducing your chance of getting trichinosis to almost zero, and one that has not been irradiated, which gives you a 1 in 2.6 million chance of contracting Trichinosis, which would you choose? The irradiated pork or the nonirradiated pork?

1 = Irradiated → **GO TO Q.c.**

2 = Non-irradiated → **ASK Q.b.**

3 = **NO PREFERENCE, GO TO Q.c.**

b. Let's imagine that you have a grilled pork sandwich which has been irradiated. This sandwich costs $2.00. How much more would you be willing to pay to get a sandwich which has not been irradiated?

$__.__ __ **GO TO Q.15.**

c. Let's imagine that you have a grilled pork sandwich which has not been irradiated. This sandwich costs $2.00. How much more would you be willing to pay to get a sandwich which has been irradiated?

$__.__ __

15. In this last part of the interview, I would like a bit of background information about you...

DO NOT ASK: CODE SEX.

1 = Male
2 = Female

16. How old were you on your last birthday?

__ __

17. What is the highest level of education you have completed? Please include college, vocational or technical training.

1 = Grade 8
2 = 9 - 11
3 = H.S. Grad., G.E.D.
4 = Some technical, trade, business school
5 = Some college, no degree
6 = B.S., B.A. complete
7 = Some graduate work, no degree
8 = M.S., M.A., etc.
12 = Ph.. D., D.D.S., M.D., etc.

18. Are you currently employed...

1 = full-time

2 = part-time

3 = unemployed.

4 = retired, →

5 = disabled, →

6 = a full-time student, or →

7 = a homemaker →

GO TO Q.20.

19. What is your occupation? **[WHAT DO YOU MAKE OR DO?]**

____

20. In order to see if we are getting a cross section of all people, I would like to know your approximate household income for all people living there? Please include wages and salaries, business or farm income, social security or retirement income, alimony, child support, or any other sources of income. What was the household 1992 income, before taxes? Was it...

01 = Less than $10,000
02 = 10,000 up to 20,000
03 = 20,000 up to 30,000
04 = 30,000 up to 40,000
05 = 40,000 up to 50,000
06 = 50,000 up to 70,000
07 = 70,000 up to 100,000
08 = More than $100,000
77 = Don't know
99 = REFUSED

21. Are you currently...

1 = Married or living in a marriage like relationship
2 = Divorced
3 = Separated
4 = Widowed or
5 = Single and never married

22. a. How many people live in your household, including yourself?

___ ___ people

b. How many children are living there who are under 18?

___ ___ children

23.a. Approximately how much do you spend per week for your household on food? Would you say...

1 = Less than $25
2 = $26 - $50
3 = $51 - $100
4 = $101 - $150
5 = $151 or more

b. Approximately how much do you spend in an average week on meat, fish or poultry products?

$________

24. Compared to other people your own age, would you say your physical health is...

1 = Excellent
2 = Good
3 = Fair, or
4 = Poor

25. Before we close, I want to thank you for your help with our research. I would also like to offer you the chance to earn $30.00. We would like to have you come to Iowa State at a time which is convenient for you sometime in the next month. We will be conducting a consumer experiment on food preferences and food safety with people like yourself and it will take about 1 1/2 hours of your time. There is no risk to you in this experiment. For your participation, you will be paid $30.00. Would you be willing to do that?

1 = Yes
2 = No → **DISCUSS ANY FEARS, ETC. IF NO, GO TO END.**

May I please have your name and I would like to verify your address and telephone number. **[RECORD BELOW.]**

26. We will submit your name to the researchers conducting the experiments and one of them will call you within the next 2 weeks to schedule an appointment. Are days, evenings, or weekends best for you?

    1 = Days
    2 = Evenings
    3 = Weekends

27. Which (days, evenings, weekends) are better?

[END:]

Thank you so much for all of your help with our study. The University is grateful for the time you have given us. Good night!

END TIME: __ __:__ __ a.m. / p.m.

COMMENTS: ____

FOR OFFICE USE

ID __ __ __ NAME: ____________________________________

ADDRESS: ______________________________ ____________
CITY

TELEPHONE: 515-__ __ __ - __ __ __ __

Porkeater? ____
Yes

Q.14a.	14b	14c
1=Irradiated	NA	$__.__ __
2=Nonirradiated	$__.__ __	NA
3=No preference	NA	$__.__ __

Appendix B

Experimental Instructions

General Instructions

You are about to participate in an experiment about decision making. Please follow the instructions carefully.

Specific Instructions

You will receive $30 for participating in this experiment. Your take home income will consist of your initial income ($30) minus the value of goods purchased.

The experiment has two stages. In stage 1 you will be asked to decide how much you would be willing to pay for different candy bars. In stage 2 you will be asked to decide how much you would be willing to pay for different meat products.

You will submit your bidding price on a recording card. You cannot reveal your bids to any other participant. Any communication between bidders will result in an automatic penalty of $3.

CONSENT FORM

You are about to participate in an experiment in willingness-to-pay for a food product.

We need your signed consent if you are to act as a subject. Your participation in the experiment is completely voluntary and you may withdraw from the experiment at any time without prejudice to you. Results from the experiment will be strictly confidential. Any name associated with the experiment will be deleted upon completion of the experiment.

If you consent to participate in the experiment, please sign the consent form below.

#____

I have read the consent form statement and agree to act as subject in the experiment, with the understanding that I can withdraw from the experiment at any time without prejudice to me.

______________   ___/___/___

Signature   Date

ABOUT YOU #___

1. Your sex: ____ Male ____ Female

2. Your age:
   ____ 19 or under
   ____ 20-24
   ____ 25-29
   ____ 30-34
   ____ 35-39
   ____ 40-44
   ____ 45-49
   ____ 50 or over

3. How many individuals live in your household, including yourself? ____
   If you have children, how old are they? ____ ____ ____ ____

4. Do you eat red meat? ____ Yes ____ No
   Do you eat poultry? ____ Yes ____ No
   Do you eat fish? ____ Yes ____ No

5. How often do you eat red meat, poultry, fish?
   Number of times you eat red meat per week? ____
   Number of times you eat poultry per week? ____
   Number of times you eat fish per week? ____

6. Have you ever had food poisoning?

   ____ Yes ____ No ____ Don't know

7. If you became sick with a food-borne disease, how much money would you lose per day in addition to medical costs (i.e., lost wages)?

   ____ dollars per day

8. How healthy do you consider your diet?

Could be a lot healthier	Could be somewhat healthier	Is healthy enough	Is healthy as it could possibly be	Not sure
1	2	3	4	5

9. Are you currently on a diet? ____ Yes ____ No

   Explain ____

10. Over the past year, what are you eating more, less or the same amount of to ensure a healthy diet?

Vegetables/Fruits	___ More	___ Less	___ Same
Red Meats	___ More	___ Less	___ Same
Poultry	___ More	___ Less	___ Same
Fish	___ More	___ Less	___ Same
Sugar	___ More	___ Less	___ Same
Fiber	___ More	___ Less	___ Same
Salt	___ More	___ Less	___ Same
Dairy Products	___ More	___ Less	___ Same
Calories	___ More	___ Less	___ Same
Starch/Potatoes/Pasta	___ More	___ Less	___ Same
Organic foods	___ More	___ Less	___ Same
Vit./Min. Supplements	___ More	___ Less	___ Same

11. On a scale of 1 to 5 with 1 being 'not concerned' and 5 being 'very concerned', indicate how you feel about the following nutritional characteristics of food.

Item	Not Concerned				Very Concerned
Fat content	1	2	3	4	5
Cholesterol levels	1	2	3	4	5
Salt content	1	2	3	4	5
Calories	1	2	3	4	5
Sugar content	1	2	3	4	5
Vit./Min. content	1	2	3	4	5
Preservatives	1	2	3	4	5
Fiber content	1	2	3	4	5
Chemical additives	1	2	3	4	5
Freshness	1	2	3	4	5
Less red meat	1	2	3	4	5
Artificial sweetener	1	2	3	4	5
Processed foods	1	2	3	4	5
Less frying	1	2	3	4	5
Junk food	1	2	3	4	5
Protein value	1	2	3	4	5

12. On a scale of 1 to 5 with 1 being 'not at all hazardous' and 5 being 'very serious hazard', rank the hazard level of each of the following.

Item	Not at all Hazardous				Very Serious Hazard
Fats	1	2	3	4	5
Cholesterol	1	2	3	4	5
Salt	1	2	3	4	5
Sugar	1	2	3	4	5

13. On a scale of 1 to 5 with 1 being 'not at all serious' and 5 being 'very serious', rank how you feel each of the following affects food safety.

Item	Not at all serious				Very Serious
Spoilage	1	2	3	4	5
Pesticides & Herbicides	1	2	3	4	5
Chemicals	1	2	3	4	5
Additives/preservatives	1	2	3	4	5
Pollution	1	2	3	4	5
Bacteria/salmonella	1	2	3	4	5
Bugs/pests/rats	1	2	3	4	5
Antibiotics	1	2	3	4	5
Irradiation of food	1	2	3	4	5
Animal growth enhancers	1	2	3	4	5
Genetic engineering/biotechnology	1	2	3	4	5

14. On a scale of 1 to 5 with 1 being 'not concerned' and 5 being 'very concerned', rank how you feel regarding the following issues in production agriculture.

Item	Not concerned				Very concerned
Crop Production					
Soil erosion/tillage	1	2	3	4	5
Pesticides/herbicides	1	2	3	4	5
Genetic engineering/biotech	1	2	3	4	5
Livestock Production					
Confinement systems	1	2	3	4	5
Animal welfare	1	2	3	4	5
Antibiotics	1	2	3	4	5
Growth enhancers	1	2	3	4	5
Genetic engineering/biotech	1	2	3	4	5

Instructions for Stage 1

1. You <u>own</u> the candy bar in front of you.

2. Let's say you are willing to pay $x for your candy bar and $y for a different candy bar. The difference ($y - $x) is what you are willing to pay to exchange your candy bar for the other candy bar. If you do not wish to exchange your candy bar for the other candy bar, a zero willingness to pay is appropriate.

   You will be asked to indicate your willingness to pay to trade your candy bar for the other candy bar. Do <u>not</u> state what you would pay for the entire other candy bar. Only state the <u>difference</u> ($y - $x) you are willing to pay.

3. When the experiment begins we will ask you to write your bid for the other candy bar on the recording card. We will collect your bids and display the I.D. numbers of the winning bidders and the price they will pay for the other candy bar on the blackboard.

4. There will be five rounds of bidding (trials). However, only one trial will be binding. After the five trials, a number will be randomly selected to determine which trial is binding. The highest bidders in that trial will exchange their candy bars for the other candy bar and must pay the displayed price (<u>which will be the highest rejected bid in that trial</u>).

   In each round of bidding the number of "different" candy bars to be sold will be determined by a random drawing. For example, in Trial 1 we may sell 3 of the other candy bars. In that case the three highest bidders in Trial 1 will trade candy bars and will pay an amount equal to the <u>4th</u> highest bid in that trial.

Note: Ties will be decided by a coin toss.

Note: In this auction it is in your best interest to bid the amount that you are truly willing to pay to change one candy bar for the other. If you bid more than your true willingness-to-pay you increase your chances of purchasing the other candy bar but you may have to pay a price that is greater than what you are willing to pay. On the other hand, if you bid less than the amount that you are truly willing to pay then you may lose the chance to purchase the other candy bar at a price that you would be willing to pay.

Questions for Stage 1 #____

Please answer the following questions, which are designed to help you understand stage 1. Do not hesitate to ask the researchers if you have questions.

1. Suppose that person A is the highest bidder in the first trial, person B is the highest bidder in the third trial, and person C is the highest bidder in the fifth trial. If, after five trials are finished, and if only 1 candy bar was available to be sold in each trial, we randomly select the third trial, then who will trade their candy bar for the other candy bar? ____

2. If $a is the highest bid in the third trial, and the second highest bid is $b, what price would be paid for the other candy bar? $____

3. If your bid is not the highest in the third trial, which is randomly selected, how much will you pay for the other candy bar? $____

4. Suppose there were 2 candy bars available to be sold in the third trial, and the third trial was binding. If person B was the highest bidder, person D was the 2nd highest bidder, and person E was the third highest bidder, who would trade their candy bar for the other type of candy bar? ____ ____ ____

5. In question 4, how much would the high bidders pay for the other candy bar? The answer is: the amount that person ____ bid.

Questions for Stage 2 #____

1. There are ten bidding trials. Suppose person A is the highest bidder in the second trial, person B is the 2nd highest bidder, and person C is the 3rd highest bidder and the second trial is selected to be the binding trial. If only 1 Type II sandwich were available to be sold in the second trial, then who will buy that Type II sandwich? ____

2. If there were 2 Type II sandwiches available in the second trial, then who will buy that Type II sandwich? ____ ____

3. If there were 2 Type II sandwiches available in the second trial, then what price would be paid? The answer is: the amount that person ____ bid.

Please answer the following questions. #____

1. Have you ever heard of the food borne pathogen Trichinella ? ___ yes ___ no

2. How many people do you think become ill from Trichinella in the United States <u>over one year</u>?
   Answer: ___________ out of 1 thousand people

3. What foods do you think are the important sources of Trichinella in the United States? Please list the type of food items.

   _____________ _____________ _____________

4. Have you ever heard of or read about irradiation for food products ?
   ____ yes
   ____ no

5. Where have you heard or read about irradiation ?

   _____________ _____________ _____________

6. How would you characterize your attitude towards food irradiation ?
   ____ positive
   ____ negative
   ____ neutral

Instructions for Stage 2

Step 1. There are two types of pork meat. The features of each are described below.

Type I

This pork meat has a typical chance of being contaminated with Trichinella. If you eat this meat there is about a 1 in 2.6 million chance of contracting Trichinosis.

Type II

This pork meat has been treated by irradiation to control Trichinella. Because of this treatment we can guarantee that this meat will not cause Trichinosis.

Step 2. You own a grilled pork sandwich made from the **Type I** pork meat. Everyone has the same **Type I** meat.

Step 3. Let's say you are willing to pay $y for the **Type I** meat and $z for the **Type II** meat. The difference ($z - $y) is what you are willing to pay to exchange **Type I** for **Type II**. Please indicate your willingness to pay to exchange your **Type I** meat for the **Type II** meat. Only state the difference ($z - $y) that you are willing to pay. If you do not wish to exchange your **Type I** meat for the **Type II** meat, then a bid of zero is appropriate.

Step 4. There will be ten trials. After all ten trials are complete, we will randomly select one binding trial to determine who buys the **Type II** meat.

As in the candy bar auction, the number of Type II sandwiches available for sale in a particular trial will be determined by a random drawing. The price will be the amount of the highest rejected bid.

Note: The meat will have to be consumed to leave with the take-home income. This applies to all participants, not just the winning bidders.

Note: In this auction it is in your best interest to bid the amount that you are truly willing to pay to change one sandwich for the other. If you bid more than your true willingness-to-pay you increase your chances of purchasing the other sandwich but you may have to pay a price that is greater than what you are willing to pay. On the other hand, if you bid less than the amount that you are truly willing to pay then you may lose the chance to purchase the other sandwich at a price that you would be willing to pay.

Trichinella

Pork products can be irradiated for the control of a parasite, Trichinella, which causes a disease called Trichinosis. The symptoms of the disease are abdominal pains, vomiting, diarrhea, headaches, fever, and the chills. Each year, about 100 cases of Trichinosis are diagnosed in the United States, but the actual number of cases is probably much higher. Of the people who get Trichinosis, about 1 out of 100 will die.

By using the irradiation process, which has been approved by the Food and Drug Administration, the risk of contracting trichinosis is almost eliminated.

The process uses either gamma rays, x-rays, or electrons to kill organisms like Trichinella. The level of irradiation used to treat pork does not cause food to become radioactive. The Food and Drug Administration concluded that irradiation of pork does not present a health hazard and it does not affect the nutritional value of food.

Information for Trials 6-10

Type I	Type II
This pork meat has a typical chance of being contaminated with Trichinella. If you eat this meat there is about a 1 in 2.6 million chance of contracting Trichinosis.	This pork meat has been treated by irradiation to control Trichinella. Because of this treatment we can guarantee that this meat will not cause Trichinosis.

Irradiation of Pork Products:

The U.S. Food and Drug Administration (FDA) has recently approved the use of ionizing radiation to control Trichinella in pork products. Based on it's evaluation of several toxicity studies, the FDA concluded that the irradiation of pork products at approved levels did not present a toxicological hazard to consumers nor did it adversely effect the nutritional value of the product.

Irradiation of pork products at approved levels results in a 10,000 fold reduction in the viability of Trichinella organisms present in the meat.

Description of Irradiation:

The forms of ionizing energy used in food processing include gamma rays, x-rays, and accelerated electrons. Ionizing energy works by breaking chemical bonds in organic molecules. When a sufficient number of critical bonds are split in the bacteria and other pests in food, the organisms are killed.
The energy levels of the gamma rays, accelerated electrons, and x-rays legally permitted for processing food do not induce measurable radioactivity.

Description of Trichinosis:

The symptoms of Trichinosis during the pathogen's intestinal maturation phase are abdominal pains, nausea, vomiting, and diarrhea. During muscular migration there is edema of the upper eyelids, headaches, fever, sweating and chills.

Of those individuals who get sick, about 1 individual out of 100 will die annually.

Please take the time to answer the following questions before you leave. ___ #

1. Please record any comments you may have regarding the experiment. For example, did you find it interesting or boring, was the auction too complicated, was it explained well, etc.

2. If you changed your bid at any stage during the auction, could you briefly explain how and why you changed your bid.

3. Having completed the experiment, how would you characterize your attitude to food irradiation.

___ positive
___ negative
___ neutral

If your attitude to food irradiation changed, what was the reason for the change.

AGREEMENT OF UNDERSTANDING FORM

#____

The risks you took in eating this food are identical to those you take when eating meals you prepare at home or purchase when eating out.

Please sign below to indicate that you have read and understood the above announcement.

______________ ___/___/___

Signature Date

CHAPTER 3. EFFECTS OF ALTERNATIVE DESCRIPTIONS OF FOOD IRRADIATION ON PREFERENCES FOR IRRADIATED PORK IN EXPERIMENTAL AUCTIONS*

A paper to be submitted to the American
Journal of Agricultural Economics

John A. Fox, Jason F. Shogren, Dermot J. Hayes,
and James B. Kliebenstein**

Abstract

Using a non-hypothetical laboratory experimental auction we examine the effects of alternative descriptions of the food irradiation process on willingness to pay to upgrade from a typical pork sandwich to one irradiated for control of *Trichinella*. We find that a positively biased description of food irradiation increases willingness to pay, a negatively biased description decreases willingness to pay, and when combined the negative description dominates the positive description resulting in lower willingness to pay.

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Introduction

Contingent valuation studies have shown that differences in the level and type of information provided to respondents will affect willingness to pay (WTP) values for a good. For example, Samples *et al.* (1986) found that changes in the descriptions of three endangered species had a significant effect on the division of respondents' fixed hypothetical allocations among the three species. Hoevenagel and van der Linden (1993) found that providing extra information on an ecological good - a clean environment - had a significant effect on WTP values. Bergstrom *et al.* (1990) found that providing extra information on wetlands had a significant effect on willingness to pay values. Boyle (1989) found that while additional information about a trout fishery did not affect mean values, it did reduce the variance of values significantly.

To date, all of these studies have been based on hypothetical surveys. To the best of our knowledge this paper is the first to measure these effects under non-hypothetical conditions. We use a randomly selected sample of adult subjects in a laboratory experimental auction. The objective is to investigate the effects of alternative descriptions of food irradiation on willingness to pay to upgrade from a typical pork sandwich to one irradiated for control of *Trichinella.*

Our study is not an investigation of framing effects in the sense defined by Cummings, Brookshire, and Schulze (1986). The descriptions of the irradiation process that we use were chosen to reflect polar attitudes to food irradiation - one for and one against. The favorable description emphasizes the safety and benefits of the process, while the unfavorable description emphasizes the potential risks. Both are based on literature currently available to the public. What we are interested in learning is whether, and to what extent consumers' perceptions of the benefits of food irradiation are susceptible to negative messages from groups opposed to the process. Given recent approvals of irradiation for pork and poultry products, this issue is currently germane to food safety policy.

The Setting

Most scientists agree that food products properly treated by irradiation are safe, but some consumer groups such as Food and Water, Inc., are actively campaigning to halt adoption of the food irradiation process. The Food and Drug Administration (FDA) has approved irradiation for a number of food products including pork and poultry for control of *Trichinella* and *Salmonella*, but irradiated food products are not yet widely available; to date they are sold only at three locations in Florida, and one in Illinois, and there is only one commercial food irradiation facility in operation.

There have been a number of studies on consumer attitude to food irradiation. Schutz *et al.*(1989) and Malone Jr.(1990) found that 45 percent and 36 percent of respondents in national surveys indicated a willingness to purchase irradiated food. A survey conducted for the American Meat Institute (1993) found that 60 percent of participants said they would be willing to pay 10 cents more for irradiated hamburger if irradiation reduced bacteria levels. In an experimental setting, Fox *et al.* (1993) found that when consumers were provided with a neutral, scientific description of the facts concerning food irradiation, 90 percent preferred the irradiated product. Market tests for irradiated papayas (Bruhn and Noell), irradiated mangoes (Giddings), and irradiated strawberries (Marcotte) have been successful. Other studies have shown that attitudes to irradiation can be positively influenced with additional information (Bruhn *et al.*, Terry and Tabor)

For the most part, surveys on acceptability have been conducted in a sheltered informational setting in that none incorporated negative statements such as those used by Food and Water,Inc. Of the market tests, only that for strawberries involved the presence of anti-irradiation activists. It comes as no surprise then that food processors have not rushed to adopt food irradiation. In fact, Food and Water,Inc. has convinced many major food companies, under threat of consumer boycott, not to use the irradiation process, and has successfully lobbied to defeat proposed irradiation facilities in Hawaii and Alaska. The activities of, and publicity given to, these pressure groups thus constitutes a major barrier to widescale adoption of food irradiation.

Our objective in this paper is to investigate how consumers respond to information about food irradiation. We are particularly interested in the way consumers respond to the mutually contradictory descriptions that often appear in media sources.

Methods

The study covered six groups of adult subjects recruited from a random sample of names purchased from a commercial survey company. One hundred and ninety nine introductory letters (Appendix A) were mailed and telephone contact was subsequently made with 125 potential participants. Of the 125, 78 indicated that they would be willing to participate in an experimental session lasting not more than two hours in return for a payment of $40.00. No information regarding the nature of the study was given - it was described only as a consumer economics experiment. Sessions were scheduled for 8.30 am, 10.45 am, and 1.00 pm on Saturday 7 May, and Saturday 21 May, 1994. Of the 78 subjects willing to participate, 59 indicated that they could attend on those dates. Ten subjects were allocated to each of five sessions, with nine subjects allocated to the sixth. Actual participation was nine subjects in four sessions, ten in one, and seven in another. Participants were the primary food shoppers of their households.

Each of the six experiments consisted of two stages (See Appendix B for experimental instructions). Initially, subjects were given a number for identification, asked to complete a questionnaire dealing with food and nutritional issues and demographics, and were paid the $40.00 participation fee. In Stage 1 of each experiment subjects were provided with a candy bar (Brand X) and informed that a different candy bar (Brand Y) would be auctioned. The purpose of this stage was to teach the participants how the auction process worked. Five rounds of bidding (trials) were conducted, each with equal probability of being binding. The I.D. number of the highest bidder and the amount of the second highest, mean, and lowest bid were revealed following each trial. At the end of Stage 1, a number was drawn to determine which round would be binding. The highest bidder in that round then exchanged his/her Brand X candy bar for the Brand Y candy bar and paid the market price which was the second highest bid in that round.

Prior to Stage 2, participants were asked to indicate whether or not they had heard of Trichinella and food irradiation. They were also asked to characterize their attitude to food irradiation as positive, negative, or neutral. Participants then received the following descriptions of two pork sandwiches:

Type I: This is a typical pork sandwich. The pork in this sandwich has a typical chance of being contaminated with *Trichinella.*

Type II: The pork in this sandwich has been treated by irradiation to control *Trichinella.* Because of this treatment we can guarantee that this pork will not cause Trichinosis.

Subjects were asked to record their subjective assessments of the risk of contracting Trichinosis from the typical (Type I) sandwich by answering the question:

If 1 million people ate the typical sandwich, how many do you think would become ill from Trichinosis? ______________

They were also asked to indicate whether they considered the irradiated (Type II) sandwich to be much safer, somewhat safer, about as safe as, somewhat less safe than, or much less safe than the typical pork sandwich.

Next, participants were informed that they had been endowed with a typical pork sandwich (Type I), and that a Type II (irradiated) pork sandwich would be auctioned. They were informed that, in order to complete the experiment and leave with their take home income, they would have to consume either a typical or an irradiated pork sandwich. They were then provided with a neutral description of the food irradiation process. This description informed them that irradiation of pork had been approved by the U.S. Food and Drug Administration for control of *Trichinella*, and that the process did not cause food to become radioactive. The information also described the forms of ionizing energy used in the process. In addition, participants received a description of the symptoms of trichinosis and were informed that the objective odds of contracting trichinosis from the Type I sandwich were approximately 1 in 2,628,000. The comparative safety question was then repeated to determine the effect of this information on perceptions about the irradiated sandwich. Five rounds of bidding (trials) were then conducted, with the 2nd high, mean, and lowest bid revealed following each trial.

The comparative safety question was repeated a third time following trial 3. There were two reasons for repeating this question. First, we wanted to see whether the information we revealed about the distribution of bids had an effect on subjects' assessment of the irradiated sandwich. Second, the answer to this question would serve as a consistency check on participants' understanding of the auction, i.e. it would be inconsistent for a participant to rank the irradiated sandwich less safe and yet bid a positive amount to upgrade to it.

After the fifth trial, additional information was provided. Groups 1 and 2, which comprise Treatment A, received a positive description of the irradiation process based on information provided by the American Council on Science and Health. This informed participants; of the proven effectiveness and safety of food irradiation, that it leaves no residue, that it had been approved by the American Medical Association and the World Health Organization, that it was currently used in over 20 countries, and that it could help prevent many of the more than 9,000 deaths from food-borne illness that occur each year in the United States.

Groups 3 and 4, comprising Treatment B, received a negative description of irradiation based on information from Food and Water, Inc. This informed participants that irradiation produced known carcinogens called radiolytic products in food, that it resulted in lower levels of essential vitamins, that irradiation was unnecessary since proper cooking killed all pathogens in food, that it would eliminate warning signs of the botulin toxin, that food irradiation was linked to the U.S. nuclear weapons and nuclear power industries, and that it necessitated the transportation of radioactive materials which posed dangers for plant workers and nearby communities. Groups 5 and 6, comprising Treatment C, received both the positive and negative descriptions of irradiation following trial 5.

After participants had read the new information, the question on relative safety was given for a fourth time. Bidding recommenced for trials 6 to 10, with relative safety assessed for the final time following trial 8. After 10 trials, a number was drawn to determine who would purchase the Type II sandwich. Before subjects received their sandwiches, they were asked to complete a short exit survey on their bidding behavior. They were also asked to estimate the risk of trichinosis from the typical sandwich, even though this information had been given to them during the experiment and was still in their possession. Finally, they were asked again to characterize their attitude to food irradiation as positive, negative, or neutral. Participants then consumed their sandwiches with the winner consuming the Type II sandwich. Before leaving participants had the option of participating in a short guided tour of the food irradiation facility during which any questions about the process were addressed.

Results and Discussion

Bidding Patterns

Figure 1 shows the behavior of the mean bids in each of the three treatments.[1] Some conclusions are immediately apparent. The positive description of food irradiation provided following trial 5 caused the average bid to increase in Treatment A. Following trial 6, the average bid continued to increase until trial 10. Four participants in group 1, and two participants in group 2 bid zero prior to information (Table 1). The zero bid

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[1] Groups 1 and 2 in Treatment A had nine participants each. Groups 3 and 4 in Treatment B had ten and nine participants. Groups 5 and 6 in Treatment C had nine and seven participants.

indicated indifference or a potential preference for the typical non-irradiated sandwich. Following information, the number of zero bidders fell to two and zero.

In Treatment B, the negative description of irradiation caused bids in groups 3 and 4 to decrease between trials 5 and 6. Following trial 6, the average bid for irradiated pork remained stable in both groups, and was lower than in any of the trials prior to the negative description. The number bidding zero increased from six to nine following the negative description of irradiation. In group 4, with nine participants, the number bidding zero increased from five to eight.

Treatment C shows the effect of providing simultaneously both the positive and negative descriptions of irradiation. The average bid decreased following trial 5. In group 5, the average bid tended upward over the first five trials indicating that some participants were submitting successively larger bids to obtain the preferred irradiated pork. Following trial 5, the upward trend was reversed, and over trials 6 through 10 the average bid for irradiated pork steadily decreased. Seven of the nine participants in group 5 bid a positive amount for irradiated pork in trial 5. All seven reduced their bid between trials 5 and 6, but only one participant reduced his/her bid to zero. One participant raised his /her bid between trials 5 and 6 - from zero to $0.10. Because all bids for irradiated pork fell, we concluded that the negative information had a stronger impact than the positive information. Unlike Treatment B, a majority of participants (six of nine) continued to bid for the irradiated pork suggesting that the positive description helped to preserve their preference for the irradiated product.

In group 6 the average bid was similar to that of group 5 in the first round of bidding, but steadily decreased over the first five trials, a pattern not observed in the other groups. In fact, only two of the seven participants in group 6 consistently bid for irradiated pork over the first five trials. Following provision of the positive and negative descriptions of irradiation, the downward trend continued. At the end of the experiment, all of the seven participants submitted zero bids.

Risk and Relative Safety Assessments

Prior to receiving objective odds of contracting trichinosis, 39 of 53 participants (74%) judged the irradiated pork sandwich to be safer than the typical pork sandwich (Table 2). Even though a majority of participants overestimated the risk of trichinosis (Figure 2), more participants (43 or 81%) judged the irradiated sandwich to be safer after receiving the objective odds (see Assessment #2 in Table 2). Between the 2nd and 3rd assessments, eight subjects lowered their relative safety assessments for the irradiated pork by one category. The different types of information presented following trial 5 caused a total of 33 participants to change their assessments (Table 3). In Treatment A (positive information), nine of 18 participants raised their safety assessment by 1 category. In Treatment B (negative information), 15 of 19 participants lowered their safety assessment - two participants lowered their assessment by the maximum of four categories (far safer to far less safe). In Treatment C (positive and negative information), nine of 16 reduced their assessments - none increased. These results are consistent with the increase in bidding in Treatment A, and the reductions in the other two treatments. Following information, 16 of 18 participants in Treatment A ranked the irradiated sandwich safer - in Treatments B and C, one of 19 and five of 16 ranked irradiated safer.

We cross checked relative safety assessments with previous and subsequent bids to check for consistency. We found that for four subjects, one in Treatment B and three in Treatment C, positive bids were submitted to upgrade to irradiated pork while at the same time it was assessed as somewhat less safe than typical pork. Furthermore, two of the three in Treatment C recorded a negative attitude toward irradiation at the end of the experiment. We considered that these two subjects either did not understand the objective of the auction or were bidding simply out of curiosity and that their bid did not represent true willingness to pay. We exclude these two subjects from the analyses that follow.

Figure 2 indicates that a majority of participants at the conclusion of the experiment recorded risk assessments for trichinosis consistent with the information they received. Three subjects reported posterior risk estimates of greater than one thousand cases of trichinosis per million Type 1 sandwiches. This suggests that either they did not understand the question or did not read or believe the information given them. The distribution of prior risk assessments shows a peak at 100 cases per million. Nine subjects (17%) were accurate, recording risk of less than one case per million sandwiches, while an additional nine recorded risk between one and 10 cases per million - the objective odds are less than 0.5 per million.

Awareness and Attitude to Irradiation

Forty-one of 53 participants (77%) indicated that they had heard of food irradiation. This figure corresponds closely with the American Meat Institute survey reporting that 73 percent of respondents had heard of irradiation. Knowledge of food irradiation is increasing - Malone Jr.(1990) reported that 25% of participants in a 1987 survey had heard of irradiation while for Schutz *et al.*(1989) the figure was 60 percent. The number having heard of irradiation was fairly consistent across our treatments - 16 of 18 in Treatment A, 14 of 19 in Treatment B, and 11 of 16 in Treatment C. Of the 41 who were aware of food irradiation, 5 indicated a negative attitude toward it, 10 a positive attitude and the remainder were neutral. Of the 12 participants unaware of irradiation, one indicated a negative attitude and the remainder were neutral.

Participation in the experiments brought about considerable changes in attitude to irradiation. In Treatment A, eight of 18 participants recorded a more favorable attitude at the end of the experiment than at the beginning. In Treatment B (negative information only), eight of 19 recorded a less favorable attitude and one a more favorable attitude. The person who indicated the improved attitude was consistently the highest bidder in his group and indicated that he discounted the negative description when he read that it came from a consumer advocacy group. In Treatment C, six of 16 recorded a less favorable attitude and three a more favorable attitude at the end of the experiment.

Regression Analysis

We conducted separate analyses - one before information and one after information - to test whether differences in participant characteristics could account for differences in willingness to pay between the groups. To eliminate the effect of arbitrary fluctuations in the bids of participants who did not lock in a fixed bid, we use as dependent variables the averages over two three-trial intervals. Prior to information we use each participants' average bid over trials three to five, and following information we use the average bid over trials eight to ten. We eliminated from the analysis the bids of two participants who showed inconsistencies between bids, relative safety assessments, and attitude to irradiation.

With a large proportion of bids at zero, ordinary least squares is not appropriate because it does not account for the qualitative difference between a positive bid (indicating preference for irradiated pork) and a zero bid (indicating indifference or potential preference for the typical pork). This qualitative choice is the issue of primary interest. We want to know whether the negative description causes preferences to shift away from irradiated pork, and if so to what extent can pro-irradiation messages prevent that shift. The appropriate tool to analyze this choice is probit analysis. Probit assumes that the observed dichotomous dependent variable indicates the sign of a latent continuous variable, i.e.

$$Y_i^* = X\beta + \epsilon_i$$

where

$$Y_i = 0 \;\; if \;\; Y_i^* \leq 0; \quad Y_i = 1 \;\; if \;\; Y_i^* > 0$$

When $Y_i=1$, there is a positive bid for irradiated pork; when $Y_i=0$ the bid is zero.

Based on previous research (Bruhn *et al.*, Malone Jr.) we selected gender and age as potential explanatory variables. We also hypothesized that concern for food safety and initial assessments of trichinosis risk would affect the choice between the irradiated and non-irradiated pork. The results of probit analysis are presented in Table 5. The low number of observations is reflected in the scarcity of significant t-statistics but the models perform well in classifying zero and positive bids with correct prediction rates of 73 and 80 percent. For pre-information bids, increasing concern for food safety has a positive and significant effect on the probability of bidding for the irradiated sandwich. The negative coefficient on sex indicates that males were less likely to bid but the effect was not significant. Treatment effects were not significant.

The analysis of post-information bids clearly indicates the effects of the alternative descriptions of irradiation. Following information participants in Treatment A are significantly more likely to bid for irradiated pork than those in Treatments B and C. The difference between treatment B and the baseline treatment (C) is not significant - in fact the difference is somewhat less post-information than pre-information. This suggests that there was little difference between presenting groups with negative information or with both positive and negative information - i.e. the effect of negative information dominated that of positive information in Treatment C.

Why does negative information dominate?

The negative description may dominate simply because it conveys the impression that the probability of illness from the irradiated pork is greater than that from the typical pork regardless of what is stated in the positive description. However, the concept of loss aversion, as described by Tversky and Kahneman (1991) offers an alternative explanation for the dominance of the negative description.

Loss aversion implies that from a given reference point (the typical sandwich), losses (outcomes below the reference point) loom larger than corresponding gains (outcomes above the reference point). In other words, increases in the probability of illness (losses) have a greater impact on value than do corresponding decreases in the probability of illness (gains). Figure 3 illustrates the concept in the context of this experiment. The probability of illness and value associated with the Type I (typical) pork sandwich are represented by the origin.

Positive information about irradiation informs participants of the reduced probability of contracting trichinosis and reassures them that irradiation is safe, i.e. there are no other risks. Given positive information, point a represents the reduced probability of illness associated with the irradiated sandwich, and a' represents the associated value. Negative information creates the opposite impression. It minimizes the potential reduction in trichinosis risk from irradiated pork by stating that proper cooking also kills these pathogens, while at the same time it introduces the risk of cancer from irradiated food. Thus points **b** and **b'** represent the increased probability of illness and associated value for the irradiated pork given the negative description.

Figure 3 depicts a situation where the increases and decreases in probability of illness associated with the positive and negative descriptions are of equal magnitude. With loss aversion, the impact on value of the negative description exceeds that of the positive description. Thus, when both descriptions are offered at the same time, the negative description has the greater impact on value, and there is a bias in favor of the status quo represented by the typical sandwich.

Conclusions

The bidding patterns and statistical analysis suggest that the effect of negative information about irradiation had a stronger impact on participants' perception of irradiation than did the positive description. Seventeen of 35 participants who received the negative description of irradiation had previously submitted a positive bid for irradiated pork. After receiving the negative description, all 17 participants immediately reduced their bids. Of the 17, eight reduced their bid to zero, but six of these zero bids occurred when participants did not simultaneously receive the positive description. This suggests that the positive description may have helped maintain the preference for irradiated pork among a number of participants who received negative information.

These results demonstrate the ability of the anti-irradiation lobby to influence consumer perceptions and thus have strong implications for the effort to promote food irradiation. Loss aversion implies that to succeed in turning consumers against food irradiation, the anti-irradiation lobby need not convince them that the risks with irradiated food are greater than with non-irradiated food, but only that there are risks. The dominance of negative information suggests that aggressive promotion of the irradiation concept may not by itself be successful. What may also be required are regulations similar to those requiring truth-in-advertising which would restrict the anti-irradiation lobby from disseminating misleading information.

Comments provided in the exit survey offer clues to what elements of the messages from both sides had the greatest impact. Among the reasons given for lowering the bid for irradiated pork, the most commonly cited was the perception of increased cancer risk from the irradiated sandwich (15 cites). Other important factors were environmental concerns (9 cites), loss of botulism warning signs (8 cites), and the use of radiation (7 cites). The factor most often cited as a reason for increasing the bid for irradiated pork was reduced risk of illness or death. This was usually mentioned in association with a realization of the scope of the food safety problem - few people seem aware of the numbers who die from food poisoning each year (see Hayes *et al.* 1994). This suggests that promoters of food irradiation should try to increase awareness of the magnitude of food safety problems and show how food-irradiation can safely and effectively reduce food safety risk.

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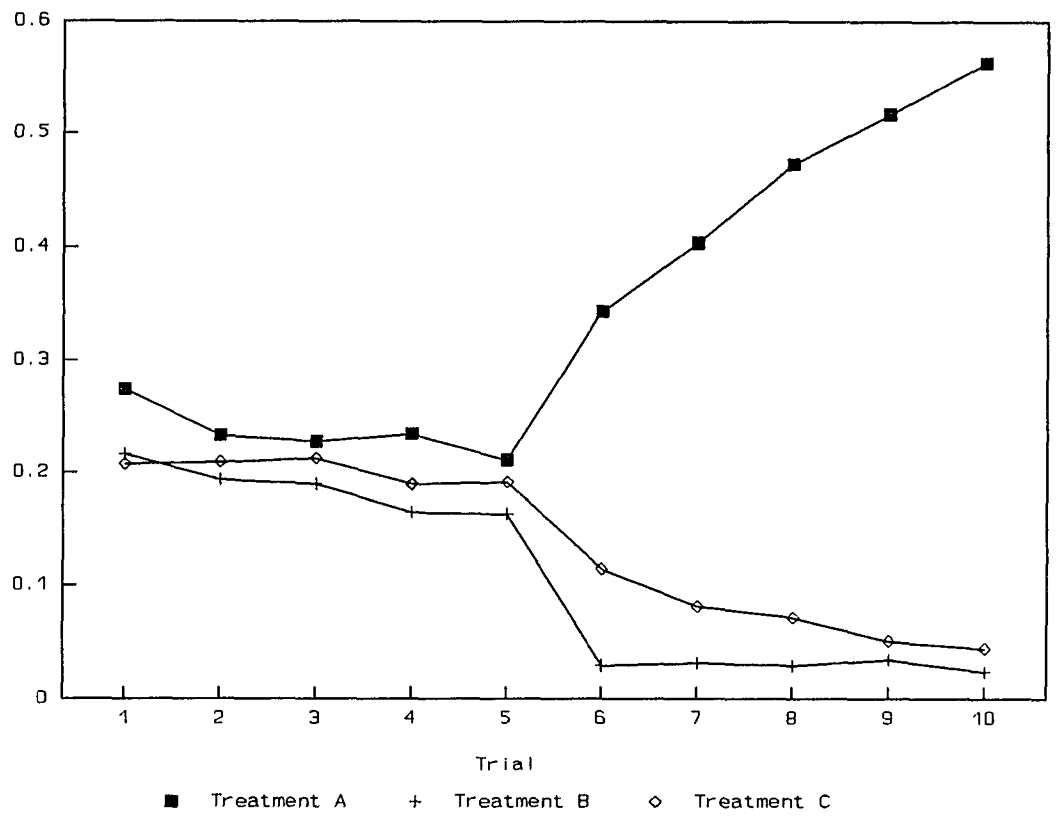

Figure 1: Average bid to upgrade to irradiated pork.

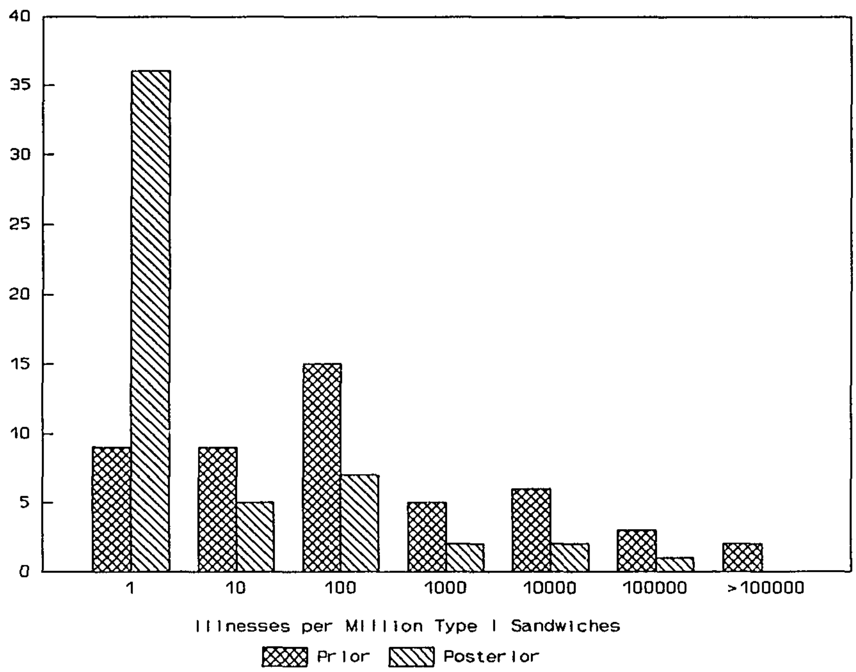

Figure 2: Prior and posterior assessments of the risk of illness from typical (Type I) pork.

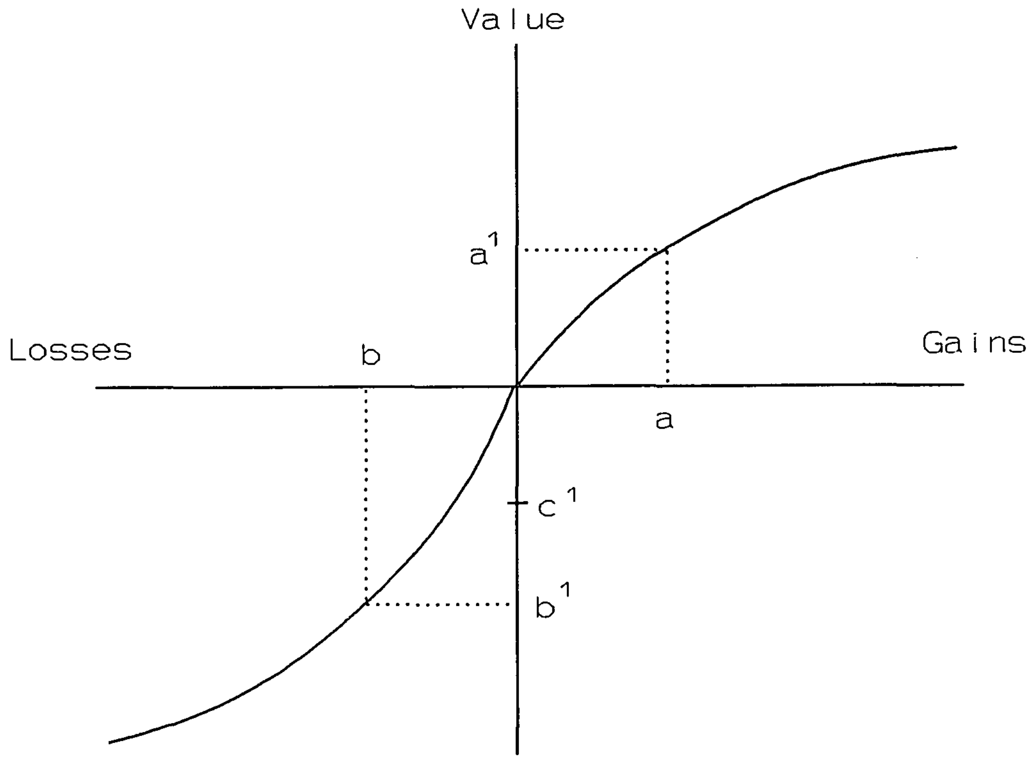

Figure 3: An illustration of loss aversion.

Table 1. Number of Zero Bidders for Selected Trials.

Group	Number in Group	Number of Zero Bidders			
		Trial 1	Trial 5	Trial 6	Trial 10
Group 1	9	4	3	2	2
Group 2	9	0	2	0	0
Group 3	10	3	6	9	9
Group 4	9	5	5	8	8
Group 5	9	1	2	2	3
Group 6	7	5	5	6	7
Total	53	18	23	27	29

Table 2. Assessments of Relative Safety for the Type II (Irradiated) Sandwich.

Safety relative to Type I (typical)	Assessment # 1	2	3	4	5
Far Safer	12	14	11	7	7
Somewhat Safer	27	29	27	15	16
About as Safe	11	9	14	18	15
Somewhat less Safe	3	1	1	9	10
Far less Safe	0	0	0	4	5
Total	53	53	53	53	53

Note: Assessment #1 Prior to receiving objective odds of contamination with *Trichinella* for the Type I (typical) sandwich. Prior to bidding.

Assessment #2 After receiving objective odds of contamination with *Trichinella* for the Type I (typical) sandwich. Prior to bidding.

Assessment #3 After bidding trial #3.

Assessment #4 After receiving additional information following bidding trial #5.

Assessment #5 After bidding trial #8.

Table 3. Effect of Information on Relative Safety Assessments.

Safety relative to Type I (typical)	Treatment A		Treatment B		Treatment C	
Assessment # -->	3	4	3	4	3	4
Far Safer	1	6	6	0	4	1
Somewhat Safer	12	10	7	1	8	4
About as Safe	4	2	6	10	4	6
Somewhat less Safe	1	0	0	4	0	5
Far less Safe	0	0	0	4	0	0
Total	18	18	19	19	16	16

Table 4. Variable Definition and Values.

	Definition	Mean (S.D.)	Median
<u>Dependent Variables.</u>			
PreBid	Average Bid ($) Trials 3-5	0.19 (0.22)	0.10
PostBid	Average Bid ($) Trials 8-10	0.21 (0.43)	0
<u>Independent Variables</u>			
Risk	Log of Subjective risk of trichinosis. (Cases per million sandwiches)	4.44 (3.94)	4.47
Concern	Concern for food safety. 1 - not concerned 5 - very concerned	3.96 (0.94)	4
Age	Categorical variable	5.65 (2.22)	6
Sex	1 if male	0.35	
TmtA	Treatment A (Positive Information)	N = 18	
TmtB	Treatment B (Negative Information)	N = 19	

Note: Age: 1 = <19; 2 = 20-24; 3 = 25-29; 4 = 30-34; 5 = 35-39; 6 =40-44; 7 = 45-49; 8 = 50 or over.

Table 5. Probit Analysis.

Variable	PreInfo	PostInfo
Intercept	-1.05 (-0.93)	-0.31 (-0.28)
Risk	0.04 (0.76)	0.03 (0.63)
Concern	0.44 (1.80)*	-0.07 (-0.30)
Sex	-0.45 (-1.06)	0.02 (0.04)
Age	0.07 (0.70)	0.02 (0.15)
TmtA	-0.27 (-0.46)	1.65 (3.01)***
TmtB	-0.89 (-1.63)	-0.65 (-1.30)
Number of Obs.	51	51
Positive Bids	36	24
% Correct Predictions	0.73	0.80
R^2	0.29	0.41

Note: Numbers in parentheses are t-statistics. The superscripts *, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent levels.

Treatment C (Positive and Negative Information) is the baseline treatment in both regressions.

Appendix A

Introductory Letter

26 April, 1994

((ms))((fname))((lname))
((add1))
((add2))
((city))((state))((zip))

Dear ((ms))((lname)),

The Economics Department at Iowa State University is conducting research with residents of central Iowa regarding their knowledge and concerns related to food safety. Your household was scientifically selected to be included in this study and we would be grateful for your help.

Within the next two to three weeks you will be contacted by telephone and the person who is most responsible for food purchases in your home will be asked if they would be interested in participating in a consumer experiment at Iowa State. This session would take less than 2 hours of your time and would take place on a Saturday. It would involve no risk to you and you would be paid $40.00 for participating.

To date we have had over 300 people from the Ames and Story County area participate in similar sessions and we have received positive comments from almost all of those participants. Most people said they found the experience to be interesting and informative and we have had about 60 people participate in a second session.

If you have any questions regarding the study, please call Sean Fox at 515-294-7119, and he will be happy to help you. Thank you for your consideration.

Sincerely,

Dermot J. Hayes, Ph.D.
Associate Professor

Appendix B

Experimental Instructions

General Instructions

You are about to participate in an experiment about decision making. Please follow the instructions carefully.

Specific Instructions

You will receive $40 for participating in this experiment. Your take home income will consist of your initial income ($40) minus the value of goods purchased.

The experiment has two stages. In stage 1 you will be asked to decide how much you would be willing to pay for different candy bars. In stage 2 you will be asked to decide how much you would be willing to pay for differing meat products.

You will submit your bidding price on a recording card. You cannot reveal your bids to any other participant. Any communication between bidders will result in an automatic penalty of $3.

CONSENT FORM

You are about to participate in an experiment in willingness-to-pay for a food product.

We need your signed consent if you are to act as a subject. Your participation in the experiment is completely voluntary and you may withdraw from the experiment at any time without prejudice to you. Results from the experiment will be strictly confidential. Any name associated with the experiment will be deleted upon completion of the experiment.

If you consent to participate in the experiment, please sign the consent form below.

#____

I have read the consent form statement and agree to act as subject in the experiment, with the understanding that I can withdraw from the experiment at any time without prejudice to me.

_______________ ____/___/____

Signature Date

ABOUT YOU #____

1. Your sex: ____ Male ____ Female

2. Your age:
   ____ 19 or under
   ____ 20-24
   ____ 25-29
   ____ 30-34
   ____ 35-39
   ____ 40-44
   ____ 45-49
   ____ 50 or over

3. How many individuals live in your household, including yourself? ____
   If you have children, how old are they? ____ ____ ____ ____

4. Please indicate the highest level of education you have completed:

   ____ Grade 8
   ____ 9-11
   ____ H.S.Grad, G.E.D.
   ____ Some technical, trade, business school
   ____ Some college, no degree
   ____ B.S., B.A. complete
   ____ Some graduate work, no degree
   ____ M.S., M.A., etc.
   ____ Ph.D., D.D.S., M.D., etc.

5. Please indicate approximate Household income for 1993:

   ____ Less than $10,000
   ____ 10,000 to 20,000
   ____ 20,000 to 30,000
   ____ 30,000 to 40,000
   ____ 40,000 to 50,000
   ____ 50,000 to 70,000
   ____ 70,000 to 100,000
   ____ More than 100,000

6. Do you eat red meat? ____ Yes ____ No
   Do you eat poultry? ____ Yes ____ No
   Do you eat fish? ____ Yes ____ No

7. How often do you eat red meat, poultry, fish?
   Number of times you eat red meat per week? ____
   Number of times you eat poultry per week? ____
   Number of times you eat fish per week? ____

8. On a scale of 1 to 5, with 1 being "not concerned" and 5 being "very concerned" how concerned are you about the safety of the food you buy? ____

9. Have you ever had food poisoning?

   ____ Yes ____ No ____ Don't know

10. If you became sick with a food-borne disease, how much money would you lose per day in addition to medical costs (i.e., lost wages)?

   ____ dollars per day

11. Compared to other people your own age, would you say your physical health is...

   ____ Excellent
   ____ Good
   ____ Fair
   ____ Poor

12. How healthy do you consider your diet?

Could be a lot healthier	Could be somewhat healthier	Is healthy enough	Is healthy as it could possibly be	Not sure
1	2	3	4	5

13. Are you currently on a diet? ____ Yes ____ No

   Explain ____

14. Over the past year, what are you eating more, less or the same amount of to ensure a healthy diet?

Vegetables/Fruits	___ More	___ Less	___ Same
Red Meats	___ More	___ Less	___ Same
Poultry	___ More	___ Less	___ Same
Fish	___ More	___ Less	___ Same
Sugar	___ More	___ Less	___ Same
Fiber	___ More	___ Less	___ Same
Salt	___ More	___ Less	___ Same
Dairy Products	___ More	___ Less	___ Same
Calories	___ More	___ Less	___ Same
Starch/Potatoes/Pasta	___ More	___ Less	___ Same
Organic foods	___ More	___ Less	___ Same
Vit./Min. Supplements	___ More	___ Less	___ Same

15. On a scale of 1 to 5 with 1 being 'not concerned' and 5 being 'very concerned', indicate how you feel about the following nutritional characteristics of food.

Item	Not Concerned				Very Concerned
Fat content	1	2	3	4	5
Cholesterol levels	1	2	3	4	5
Salt content	1	2	3	4	5
Calories	1	2	3	4	5
Sugar content	1	2	3	4	5
Vit./Min. content	1	2	3	4	5
Preservatives	1	2	3	4	5
Fiber content	1	2	3	4	5
Chemical additives	1	2	3	4	5
Freshness	1	2	3	4	5
Less red meat	1	2	3	4	5
Artificial sweetener	1	2	3	4	5
Processed foods	1	2	3	4	5
Less frying	1	2	3	4	5
Junk food	1	2	3	4	5
Protein value	1	2	3	4	5

16. On a scale of 1 to 5 with 1 being 'not at all hazardous' and 5 being 'very serious hazard', rank the hazard level of each of the following.

Item	Not at all Hazardous				Very Serious Hazard
Fats	1	2	3	4	5
Cholesterol	1	2	3	4	5
Salt	1	2	3	4	5
Sugar	1	2	3	4	5

17. On a scale of 1 to 5 with 1 being 'not at all serious' and 5 being 'very serious', rank how you feel each of the following affects food safety.

Item	Not at all serious				Very Serious
Spoilage	1	2	3	4	5
Pesticides & Herbicides	1	2	3	4	5
Chemicals	1	2	3	4	5
Additives/preservatives	1	2	3	4	5
Pollution	1	2	3	4	5
Bacteria/salmonella	1	2	3	4	5
Bugs/pests/rats	1	2	3	4	5
Antibiotics	1	2	3	4	5
Irradiation of food	1	2	3	4	5
Animal growth enhancers	1	2	3	4	5
Genetic engineering/biotechnology	1	2	3	4	5

18. On a scale of 1 to 5 with 1 being 'not concerned' and 5 being 'very concerned', rank how you feel regarding the following issues in production agriculture.

Item	Not concerned				Very concerned
Crop Production					
Soil erosion/tillage	1	2	3	4	5
Pesticides/herbicides	1	2	3	4	5
Genetic engineering/biotech	1	2	3	4	5
Livestock Production					
Confinement systems	1	2	3	4	5
Animal welfare	1	2	3	4	5
Antibiotics	1	2	3	4	5
Growth enhancers	1	2	3	4	5
Genetic engineering/biotech	1	2	3	4	5

Instructions for Stage 1

1. You own the candy bar in front of you.

2. You will be asked to indicate the amount you would be willing to pay to trade your candy bar for a different candy bar. Do not state what you would pay for the entire other candy bar. Only state the difference you are willing to pay to change the candy bar you own for the other candy bar.

   For example, let's say you are willing to pay $x for your candy bar and $y for a different candy bar. The difference ($y - $x) is what you are willing to pay to exchange your candy bar for the other candy bar. If you prefer the candy bar you own, and do not want to trade it for the other candy bar, a zero bid is appropriate.

3. We will ask you to write your bid for the other candy bar on a recording card. We will collect your bids and display the I.D. number of the highest bidder and the price he/she will pay for the other candy bar on the blackboard. The price paid by the highest bidder will be the amount of the 2nd highest bid.

   For example, if the highest bid is $a and the second-highest bid is $b, the highest bidder will receive the other candy bar and must pay $b.

4. There will be five rounds of bidding (trials), but only one trial will be binding. After the five trials are complete, we will draw a number to determine which trial is binding. The highest bidder in that trial will exchange his/her candy bar for the other candy bar and pay the displayed price (i.e. the 2nd highest bid)

Note: Ties will be decided by a coin toss.

Note: In this auction it is in your best interest to bid the amount that you are truly willing to pay to change one candy bar for the other. If you bid more than your true willingness-to-pay you increase your chances of purchasing the other candy bar but you may have to pay a price that is greater than what you are willing to pay. On the other hand, if you bid less than the amount that you are truly willing to pay then you may lose the chance to purchase the other candy bar at a price that you would be willing to pay.

Questions for Stage 1 #___

Please answer the following questions, which are designed to help you understand stage 1. Do not hesitate to ask the researchers if you have questions.

1. Suppose that person A is the highest bidder in the first trial, person B is the highest bidder in the third trial, and person C is the highest bidder in the fifth trial. If, after five trials are finished, we randomly select the third trial, then who will trade their candy bar for the other candy bar? ____

2. If $a is the highest bid in the third trial, and the second highest bid is $b, what price would be paid for the other candy bar? $____

3. If your bid is not the highest in the third trial, which is randomly selected, how much will you pay for the other candy bar? $____

Questions for Stage 2 #____

Please answer the following questions, which are designed to help you understand stage 2. Do not hesitate to ask the monitors if you have questions.

1. There will be ten bidding trials. If person A is the highest bidder in the first trial, person B is the highest bidder in the eighth trial, and the eighth trial is selected, who will receive the product? ____

2. If your $\$\alpha$ bid is the highest in the eighth trial, and the second highest bid is $\$\beta$, what price will you pay for the product? $____

Please answer the following questions.

1. Have you ever heard of the food borne pathogen *Trichinella* ? ____ yes ____ no

2. What foods do you think are the important sources of *Trichinella* in the United States?

   Please list the type of food items.

   ____________ ____________ ____________

3. Have you ever heard of or read about irradiation for food products ? ____ yes ____ no

4. Where have you heard or read about irradiation ?

   ____________ ____________ ____________

5. How would you characterize your attitude towards food irradiation ? ____ positive ____ negative ____ neutral

Instructions for Stage 2

In Stage 2 you will be bidding on pork sandwiches. Here is a brief description of the sandwiches.

Type I

This is a typical pork sandwich. The pork in this sandwich has a typical chance of being contaminated with *Trichinella.*

Type II

The pork in this sandwich has been treated by irradiation to control *Trichinella.* Because of this treatment we can guarantee that this pork will not cause Trichinosis.

1. You own a grilled pork sandwich made from the **Type I** pork meat. Everyone has the same **Type I** meat.

2. Let's say you are willing to pay \$y for the **Type I** meat and \$z for the **Type II** meat. The difference (\$z - \$y) is what you are willing to pay to exchange **Type I** for **Type II.** Please indicate your willingness to pay to exchange your **Type I** meat for the **Type II** meat. Only state the difference (\$z - \$y) that you are willing to pay. If you do not wish to exchange your **Type I** meat for the **Type II** meat, then a bid of zero is appropriate.

3. There will be ten trials. After all ten trials are complete, we will randomly select one of the ten trials to be the binding trial that determines who buys the **Type II** meat.

Note: The meat will have to be consumed to leave with the take-home income. This applies to all participants, not just the winning bidders.

Note: In this auction it is in your best interest to bid the amount that you are truly willing to pay to change one sandwich for the other. If you bid more than your true willingness-to-pay you increase your chances of purchasing the other sandwich but you may have to pay a price that is greater than what you are willing to pay. On the other hand, if you bid less than the amount that you are truly willing to pay then you may lose the chance to purchase the other sandwich at a price that you would be willing to pay.

#____

Type I

This is a typical pork sandwich. The pork in this sandwich has a typical chance of being contaminated with *Trichinella.*

Type II

The pork in this sandwich has been treated by irradiation to control *Trichinella.* Because of this treatment we can guarantee that this pork will not cause Trichinosis.

1. If 1 million people were to eat a Type I (typical) sandwich, how many of them do you think would become ill from Trichinella.

   ____

2. Do you consider the Type II (irradiated) sandwich to be:

   ____ far safer than Type I

   ____ somewhat safer than Type I

   ____ about as safe as Type I

   ____ somewhat less safe than Type I

   ____ far less safe than Type I

Type I

This is a typical pork sandwich. If you eat this pork, there is approximately a 1 in 2,628,000 chance that you will become ill from Trichinella.

Type II

The pork in this sandwich has been treated by irradiation to control Trichinella. Because of this treatment we can guarantee that this pork will not cause Trichinosis.

Food Irradiation

The U.S. Food and Drug Administration (FDA) has recently approved the use of ionizing radiation to control Trichinella in pork products and Salmonella in poultry. Based on it's evaluation of several toxicity studies, the FDA concluded that irradiation of food products at approved levels did not present a toxicological hazard to consumers nor did it adversely effect the nutritional value of the product.

Irradiation of pork products at approved levels results in a 10,000 fold reduction in the viability of *Trichinella* organisms present in the meat.

The forms of ionizing energy used in food processing include gamma rays, x-rays, and accelerated electrons. Ionizing energy works by breaking chemical bonds in organic molecules. When a sufficient number of critical bonds are split in the bacteria and other pests in food, the organisms are killed.
The energy levels of the gamma rays, accelerated electrons, and x-rays legally permitted for processing food do not induce measurable radioactivity in food.

This description is based on a review of the scientific literature on food irradiation.

Trichinella

Pork products can be irradiated for the control of a parasite, Trichinella, which causes a disease called Trichinosis. The symptoms of the disease are abdominal pains, vomiting, diarrhea, headaches, fever, and the chills. Each year, about 100 cases of Trichinosis are diagnosed in the United States, but the actual number of cases is probably much higher. Of the people who get Trichinosis, about 1 out of 100 will die.

By using the irradiation process, which has been approved by the Food and Drug Administration, the risk of contracting trichinosis is almost eliminated.

The process uses either gamma rays, x-rays, or electrons to kill organisms like Trichinella. The level of irradiation used to treat pork does not cause food to become radioactive. The Food and Drug Administration concluded that irradiation of pork does not present a health hazard and it does not affect the nutritional value of food.

2. #____

Type I

This is a typical pork sandwich. If you eat this pork, there is approximately a 1 in 2,628,000 chance that you will become ill from Trichinella.

Type II

The pork in this sandwich has been treated by irradiation to control Trichinella. Because of this treatment we can guarantee that this pork will not cause Trichinosis.

Do you consider the Type II (irradiated) sandwich to be:

____ far safer than Type I

____ somewhat safer than Type I

____ about as safe as Type I

____ somewhat less safe than Type I

____ far less safe than Type I

3. #____

Type I

This is a typical pork sandwich. If you eat this pork, there is approximately a 1 in 2,628,000 chance that you will become ill from Trichinella.

Type II

The pork in this sandwich has been treated by irradiation to control Trichinella. Because of this treatment we can guarantee that this pork will not cause Trichinosis.

Do you consider the Type II (irradiated) sandwich to be:

____ far safer than Type I

____ somewhat safer than Type I

____ about as safe as Type I

____ somewhat less safe than Type I

____ far less safe than Type I

Type I

This is a typical pork sandwich. If you eat this pork, there is approximately a 1 in 2,628,000 chance that you will become ill from Trichinella.

Type II

The pork in this sandwich has been treated by irradiation to control Trichinella. Because of this treatment we can guarantee that this pork will not cause Trichinosis.

Food Irradiation

Food irradiation (also called ion pasteurization) is a process that destroys harmful bacteria and pathogens by treating foods with ionizing radiation.

Food irradiation has been shown to be highly effective in destroying *Trichinella* in pork, *Salmonella* in poultry, *E.coli* in beef, and other bacteria and parasites responsible for food poisoning. Extensive research has proven that this process is a safe and reliable way to improve the quality of food. Because food irradiation does not involve washing foods with chemicals and leaves no residue in food, it is safer than many current food processing techniques.

The Food and Drug administration has approved irradiation for use on wheat, potatoes, pork, poultry, fruits, vegetables and spices. The process has also been approved the American Medical Association and the World Health Organization. It has been successfully used in over 20 countries since 1950. Food irradiation is especially useful for those most at risk from food-bone illness such as victims of AIDS, organ transplant patients, and the elderly, and was approved for hospital diets in the U.K. as far back as 1969.

Each year as many as 9,000 people die in the U.S. from food-borne illness. Millions more suffer short term illness due to pathogens such as Salmonella, Listeria and E.coli. By eliminating these pathogens from food, irradiation can help to greatly reduce the number of food borne illnesses.

This description is based on information supplied by the American Council on Science and Health, a consumer education association.

Type I

This is a typical pork sandwich. If you eat this pork, there is approximately a 1 in 2,628,000 chance that you will become ill from Trichinella.

Type II

The pork in this sandwich has been treated by irradiation to control Trichinella. Because of this treatment we can guarantee that this pork will not cause Trichinosis.

Food Irradiation

Food irradiation is a process whereby food is exposed to radioactive materials, and receives as much as 300,000 rads of radiation -the equivalent of 30 million chest x-rays- in order to extend the shelf life of the food and kill insects and bacteria.

While it is unlikely that food products themselves will become radioactive, irradiation results in the creation of chemicals called radiolytic products in food. Some radiolytic products are known carcinogens. Studies have also suggested that irradiation may be linked to cancer and birth defects. Furthermore, foods exposed to radiation contain lower levels of essential vitamins.

Food irradiation can kill most of the pathogenic bacteria present in food, but so can proper cooking. Moreover, doses of radiation that are adequate to kill *Salmonella* or *Trichinella* are not enough to kill the bacteria that cause botulism. However, such doses would kill the bacteria which signal spoilage through a foul odor. Thus, with irradiation, we would not be able to rely on the usual warning signs that tell us when food is dangerous to eat.

Food irradiation was developed in the 1950's by the Atomic Energy Commission. The objective was to seek potential uses for the byproducts of nuclear weapons production. Today's food irradiation industry is a private, for-profit business enterprise with ties to the U.S. nuclear weapons and nuclear power industries.

Food irradiation also poses potential environmental dangers because of the use of radioactive materials in the process. Workers can be exposed on the job, and entire communities can be exposed in the event of a leak from the plant. Plus, radioactive materials would have to be transported around the country, putting thousands of people at risk in the case of a traffic accident.

This description is based on information supplied by Food and Water, Inc., a consumer advocacy group.

4. #____

Type I

This is a typical pork sandwich. If you eat this pork, there is approximately a 1 in 2,628,000 chance that you will become ill from Trichinella.

Type II

The pork in this sandwich has been treated by irradiation to control Trichinella. Because of this treatment we can guarantee that this pork will not cause Trichinosis.

Do you consider the Type II (irradiated) sandwich to be:

____ far safer than Type I

____ somewhat safer than Type I

____ about as safe as Type I

____ somewhat less safe than Type I

____ far less safe than Type I

5. #____

Type I

This is a typical pork sandwich. If you eat this pork, there is approximately a 1 in 2,628,000 chance that you will become ill from Trichinella.

Type II

The pork in this sandwich has been treated by irradiation to control Trichinella. Because of this treatment we can guarantee that this pork will not cause Trichinosis.

Do you consider the Type II (irradiated) sandwich to be:

____ far safer than Type I

____ somewhat safer than Type I

____ about as safe as Type I

____ somewhat less safe than Type I

____ far less safe than Type I

Exit Questions #____

Please answer the following questions before you leave.

1. What type of risk(s), if any, did you associate with the Type II (irradiated) sandwich.

   ____

   ____

   ____

2. If 1 million people were to eat a Type I (typical) sandwich, how many of them do you now think would become ill from Trichinella.

   ____

3. Did you change your bid at any stage in the auction? ____ Yes ____ No

4. If you changed your bid, did you ____ Increase ____ Decrease ____ Both

4a. What piece of information caused you to increase your bid? Was it:

   ____ Market prices

   ____ Description of irradiation

   ____ Other

What part of the description caused you to increase your bid?

____

____

4b. What piece of information caused you to decrease your bid? Was it:

____ Market prices

____ Description of irradiation

____ Other

What part of the description caused you to decrease your bid?

____

____

5. Having completed the experiment, how would you characterize your attitude to food irradiation.

____ positive

____ negative

____ neutral

Thank you for participating.

CHAPTER 4. DETERMINANTS OF CONSUMER ACCEPTABILITY OF BOVINE SOMATOTROPIN*

A paper to be submitted to the Review of
Agricultural Economics

John A. Fox**

Abstract

Consumer acceptability of bovine somatotropin (bST) is investigated using a non-hypothetical laboratory experimental auction. The auction procedure was used to determine willingness to pay to exchange milk from a cow that had been treated with bST for "normal" milk. Heckman's two-stage method was used to model the subjects' bids for "normal" milk. The results show that the primary determinant of acceptability of bST is the subject's level of concern with genetic engineering and biotechnology. Significant male/female differences were also found.

* Thanks to Bruce Babcock, Dermot Hayes, and Jason Shogren for valuable comments and suggestions.

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Introduction

Following much investigation and debate the Food and Drug Administration (FDA) approved bovine somatotropin, a growth hormone for dairy cows, for commercial use in February 1994. FDA regulations do not require labelling of milk or milk products from animals treated with synthetic bST but they do not preclude the labelling of products from untreated animals. A number of supermarket chains have indicated that they will not carry milk from treated animals and at least one ice cream manufacturer (Ben & Jerry's) refuses to use milk from treated animals. Since consumers will effectively have a choice between milk products from bST treated or untreated animals, the commercial success or failure of this new technology will depend critically on consumer reaction.

To date the most common means of investigating consumer concerns about issues such as bST have been surveys. McGuirk and Kaiser (1991) conducted a survey of consumers in New York and Virginia. About one quarter of their respondents expressed some doubt about the safety of "bST milk" and respondents in both states indicated that they would decrease their purchases of fluid milk by 18-20 percent if bST were introduced. Smith and Warland (1992) summarize the results of a number of consumer surveys regarding attitudes towards bST. They found that 56.7 percent of the survey respondents were negatively inclined towards bST.

However, the situation faced by an interviewee in a survey differs from that which potential buyers of new products will experience in retail stores. The relative lack of realism, information and time that constrain the survey approach makes it difficult to elicit true attitudes and can lead to responses that depend on the way the question was asked (Buhr et al.). Surveys also provide respondents with the opportunity to provide strategic rather than true responses (see Whitehead for an example). A person who opposed the introduction of bST might therefore find it advantageous to overstate the amount by which his/her milk purchases would decline in the hope of sending a message to potential users of the product. Furthermore, many surveys on bST do not explicitly account for the availability of milk products from untreated animals.

This study uses a non-hypothetical auction method similar to that used by Shogren et al.(1994) to investigate consumer acceptability of milk produced by animals treated with bST. I account for the availability of both types of milk by asking auction participants to bid to exchange one type of milk for the other. The next section of this paper outlines the advantages of the experimental approach and describes in detail the experimental design used in this study. In the third section I present a statistical model based on a procedure developed by Heckman (1976, 1979) and in the fourth I discuss the results. The final section contains some concluding remarks.

Methodology

Laboratory experimental auctions (Coursey, Cox et al., Shogren) have specific advantages over hypothetical survey techniques. The methods used in this study involved real food, real money and actual monetary consequences[1] for the participants. Participants were given full information about the product and repeated opportunities to participate in an auction market. Because the market required participants to realize the actual monetary consequences of their bidding, they had an incentive to bid honestly.

Subjects were paid $18 to participate in an experiment but were informed that a product would have to be consumed in order for them to leave with their take-home income. This "requirement-to-consume" ensured that participants paid careful attention to the process and gave serious consideration to the bids they made.

A third advantage of the experimental method is the potential for eliminating non-response bias. Low response rates are a common problem with survey techniques (Cummings et al.). For example, in the survey reported by McGuirk and Kaiser only one-third of the surveyed households responded. In this study, potential participants were not given any information about the experiment at the time they were recruited. Thus, willingness to participate is independent of a subject's attitude to the product under consideration.

The experiments used an incentive compatible, sealed-bid auction mechanism designed to induce participants to bid an amount equal to their true willingness-to-pay. In this auction (Vickrey), the highest bidder receives the product but pays an amount equal to the second highest bid. The fact that the winning bidder does not have to pay the amount that he/she bids removes the incentive to underbid one's true value which is present in a first price auction. In the Vickrey second price auction there is no benefit from either overbidding or underbidding one's true valuation of the item being auctioned. This mechanism has been successfully applied in various experimental settings (Coursey, Shogren et al.) but it should be noted that, in some situations, the demand revealing properties of the Vickrey auction have been challenged (Coursey and Smith, Kagel et al.). Repeated trials of this auction mechanism are used to allow for learning (see Menkhaus et al. for a review of auction methods).

Experimental Design

Each experiment consisted of three stages.[2] In Stage 1 participants were given a general description of the type of study in which they would be participating and were asked to sign a consent form if they agreed to participate. They were then asked to complete a questionnaire which was used to collect information about dietary habits and experiences, attitudes and beliefs about food safety issues and some demographic information.

Stage 2 was designed to familiarize the participants with the second-price, sealed-bid auction. Each participant was given an identification number (ID), a $3 endowment, and a regular sized, brand name candy bar (brand X). A different candy bar (brand Y) was displayed, and participants were asked to submit a sealed-bid indicating the maximum he or she would be willing to pay to exchange brand X for brand Y. After all bids were collected, the monitor displayed on the blackboard the ID number of the highest bidder, and the market price—the second-highest bid. Five auction trials were conducted. Note that to control for wealth effects, participants were fully aware that only one of the five trials would be binding.[3] The binding trial was randomly selected after all five trials were complete. The highest bidder in the binding trial exchanged his or her brand X candy bar for brand Y and paid the market price, i.e. the second highest bid in the binding trial. The cash transaction reminded all participants that their bidding had real monetary consequences.

Stage 3 introduced the milk products. Each participant was given a $15 endowment and a 16 oz glass of Type I (bST) milk. A Type II (typical) glass of milk was then auctioned using 20 trials. For the first 10 trials, participants were provided with the following descriptions:

> Type I: This milk was produced by a typical dairy cow that received synthetic bovine somatotropin in research trials.
>
> Type II: This milk was produced by a typical dairy cow.

After the 10th trial, the monitor provided the following information about bST:

> Bovine somatotropin (bST) is a protein produced in the pituitary gland of a dairy cow that regulates and stimulates milk production. Through advances in genetic engineering, synthetic bST can now be manufactured using recombinant DNA technology. It is then injected into cows to increase milk yields. The frequency of these injections may range from once a day to once every 14 to 28 days.
>
> Dairy cows treated with artificial bST have produced from 10 to 25 percent more milk in experimental trials. They have also shown an increase in feeding efficiency. The amount of bST in milk from treated cows has not been shown to

differ from that found naturally in milk. However, there is concern by some people that too little research has been conducted to assure the safety of milk and dairy products from cows treated with bST. bST is currently under regulatory review and is expected to be approved soon by the Food and Drug Administration.

Ten "informed" bids were then elicited. At the end of the auction one of the 20 trials was randomly selected to be binding. The highest bidder in the binding trial received the Type II milk and paid the second-highest bid in the binding trial. Everyone else kept the Type I milk. All participants were required to drink their milk in order to leave with their take-home-pay and were aware of this requirement at the beginning of the milk auction.

The experiments were carried out at five universities in Iowa, Arkansas, Massachusetts and California between July 1992 and March 1993. Fifteen undergraduate students from a range of degree programs participated in each experiment. Care was taken to replicate the experiments as closely as possible in a similar environment at all five locations. All experiments were conducted by the same investigator.

Data

Independent variables were obtained from the participants' responses to the questionnaire which was completed at the beginning of the experiment and from a question about bST asked before the milk auction. Among the questions asked were level of concern for food safety, level of concern for animal welfare, prior knowledge of bST, and attitude toward biotechnology. In most questions the participant was required to rank his/her level of concern on a scale from 0 to 4. Some variables were constructed as a simple average of responses to several related questions. Table I presents the variable definitions and average values.

Figure 1 shows how the mean bid of each of the five experiments behaves through the twenty rounds of bidding. It indicates that for some groups, in particular urban California, the information given to subjects following Trial 10 had a significant effect on the average bid for "normal"[4] milk. We focus the analysis on two areas - the first bid to avoid "bST milk", and the effect on bids of the information presented following trial 10. Analyzing the first bid is analogous to analyzing the participants initial gut reaction to being confronted with the choice between the two types of milk. Figure 2 shows the frequency distribution of these first round bids.

To examine the effect of new information on bidding we needed to choose representative trials. We considered a number of issues in making these choices. First, previous work with multiple trial auctions (Coursey) has found that a number of trials are required before subjects settle on their true willingness-to-pay. For this reason we decided not to choose from trials 1,2, and 3 nor from trials 11,12, and 13. Second, due to the possibility of final trial effects, we decided not to use Trial 20. We could have chosen one trial at random between say trial 4 and trial 9 before information and from trials 14 to 19 following information but this involved the possibility of choosing a non-representative trial such as trial 9 in rural California. Instead, we decided to use an average bid over a three trial interval where bids attained the greatest degree of stability.

In the first half of the auction bids were most stable over trials 4 to 6 in rural California, over trials 6 to 8 in Arkansas, over trials 7 to 9 in urban California, and over trials 8 to 10 in Iowa and Massachusetts. Following the description of bST after trial 10 the bids were most stable over trials 14 to 16 in all locations except Massachusetts where we used the average over trials 18 to 20. Figures 3 and 4 show the frequency distributions of the stabilized bids. They look somewhat similar to Figure 2, with 21 and 34 zero bids compared to 33 for the first trial. However, comparing the distributions does not reveal the extent to which individual bidders might have changed their bids as a result of obtaining new information or market experience.

Statistical Model

The distributions of bids for "normal" milk show that over 40% of all bids are zeros. Conventional regression methods such as OLS will not adequately account for the qualitative difference between zero (limit) bids and positive (nonlimit) bids (Greene). One possible solution is to discard the zero observations and perform OLS only on the positive bids. This implies an assumption that the subset of positive bids is randomly drawn from the population of all bids. In the present case, however, it is clear that there is self-selection by participants into the subset of positive bids. Least squares analysis ignores this selection and the resulting estimates will be biased.

The Tobit model (Tobin) is commonly used to deal with zero consumption or cases in which the dependent variable is censored. One feature of this model is the fact that limit observations are treated as corner solutions (Blaylock and Blisard). However, the assumption that a zero bid represents a traditional corner solution may not be applicable in the present case. First, subjects were not income constrained having just received an $18 participation fee. Second, while it is likely that zero bidders would consume the "normal" milk if it were cheaper than the "bST milk", such a scenario is unlikely to occur in reality.

A more general method of dealing with models involving censored, truncated or self-selection data was proposed by Heckman (1976, 1979). Heckman's approach considers the bias that arises in such cases to be a case of omitted variable bias. The two-stage procedure he proposed involves estimating the values of the omitted variable in the first stage and then including those estimates as regressors in the second stage to allow consistent estimation by least squares. An advantage of this method is that it provides a measure of the degree of self-selection.

Even in the absence of selection bias, the two stage method facilitates an intuitively appealing decomposition of the bidding decision. The first decision faced by the participant is whether or not to bid for the "normal" milk. If the participant considers the "bST milk" and the "normal" milk to be equivalent the decision will be to not bid (i.e. to bid zero). For the participant who considers the "normal" milk to be superior, the second decision is how much to bid for the "normal" milk. Heckman's procedure, by modelling the two stages separately, allows different variables to influence each decision and furthermore allows a single variable to have different effects in each stage. An example illustrating this feature of a two-stage estimator is described in Fin and Schmidt (1984).

Consider a model of the bidding process to be as follows[5]:

(1a) $$Y_{1i} = X_{1i}\beta_1 + U_{1i} \qquad i \in I'$$

(1b) $$Y_{2i} = X_{2i}\beta_2 + U_{2i} \qquad i \in I$$

where I' is the subset of participants with non-zero bids. The first equation can be viewed as the continuous inverse demand equation for the glass of "normal" milk where Y_{1i} represents the bid of participant i. Y_{2i} is a qualitative variable taking on the value of one when participant i has a nonzero bid, zero otherwise. Instead of postulating an indicator variable, we assume that all positive realizations of Y_{2i} are assigned the value one and all negative realizations are assigned the value zero. X_{2i} and X_{1i} are the sets of explanatory variables which influence the decision to bid and the level of bid. We assume for now that the errors are normally distributed with mean zero. The relevant properties of their joint distribution are discussed below.

Following Heckman (1979), if we let I'=I (i.e. assume that all participants submit a positive bid) the *population* regression function for equation (1a) can be written as

$$E(Y_{1i}|X_{1i}) = X_{1i}\beta_i$$

The question arises as to whether the observations available for estimating equation (1a) represent a random drawing from the population. In our case observations on Y_{1i} occur as a result of a selection rule. A positive bid occurs only when the decision has been made to submit a non-zero bid, i.e. when Y_{2i} takes on the value one. The regression function for the subsample of positive bidders can thus be represented as

$$E(Y_{1i}|X_{1i}, Y_{2i}{=}1) = X_{1i}\beta_i + E(U_{1i}|X_{1i}, Y_{2i}{=}1)$$

which, given the definition of Y_{2i} can be written

$$(2) \qquad E(Y_{1i}|X_{1i}, U_{2i}{\geq}-X_{2i}\beta_2) = X_{1i}\beta_i + E(U_{1i}|X_{1i}, U_{2i}{\geq}-X_{2i}\beta_2)$$

If U_{1i} and U_{2i} are independent, the conditional expectation of U_{1i} is zero and least squares can be used to estimate β_1 on the subsample of non-zero bidders. In general we do not expect the errors to be independent. This illustrates that the nature of the bias resulting from an estimation on the selected sample is due to the omission of the final term in equation (2). Heckman points out that the Tobit model arises as a special case of this model when $U_{1i} \equiv U_{2i}$, $X_{1i} = X_{2i}$, and $\beta_1 \equiv \beta_2$.

Assuming that the joint distribution of U_{1i} and U_{2i} is bivariate normal, and using a result for the conditional mean of U_{1i} (see Heckman), equation (2) can be written as

$$(3) \qquad E(Y_{1i}|X_{1i}, U_{2i} \geq -X_{2i}\beta_2) = X_{1i}\beta_i + (\lambda_i)\frac{\sigma_{12}}{(\sigma_{22})^{1/2}}$$

where σ_{12} and σ_{22} represent the covariance between U_{1i} and U_{2i} and the variance of U_{2i}. λ_i is the inverse Mills ratio (IMR) and is given by

$$\lambda_i = \frac{f(Z_i)}{1-F(Z_i)}$$

where f and F represent the standard normal density and distribution functions, and

$$Z_i = -\frac{X_{2i}\beta_2}{(\sigma_{22})^{1/2}}$$

The IMR is a decreasing function of the probability that an observation is selected into the sample, that probability being given by $[1-F(Z_i)]$.

The two-stage estimation procedure is as follows. First, probit analysis on the full sample is used to estimate parameters of the probability that a participant will bid a positive amount to upgrade to the "normal" milk. The estimated parameters of the probit equation allow for the estimation of Z_i and hence for the estimation of the IMR for each observation. The estimated IMR is then used as a regressor in the OLS equation (3) which is estimated only over participants who bid a positive amount. Inclusion of the IMR allows for the consistent estimation of β_1 using least squares.

Results

First Bid for "normal" Milk

The first analysis deals with the initial bid to avoid "bST milk". Table 2 presents the results from the probit and 2nd stage OLS estimations. The probit results indicate that attitude towards genetic engineering/biotechnology (Tech) has the most statistically significant influence on the probability of bidding for "normal" milk. The coefficient has the expected positive sign and is significant at the 5 percent level. Of the other coefficients, the relatively large negative effect associated with increased concern for food safety (Sfty) goes against a priori expectations.

The 2nd stage OLS estimates indicate a significant positive effect associated with concern for animal welfare (Welf). The coefficient on λ is not significant leading us to conclude that deleting zero bids and running OLS on the remaining observations would not seriously bias the estimates. None of the remaining coefficients in the second stage are statistically significant. It is notable that an indication of prior knowledge of bST (Know) had no effect at either stage. Likelihood ratio tests at both the first and second stages failed to reject the hypothesis of no regional effects. This is not surprising given the clustering of average bids evident in Figure 1.

Effects of Information

The effect of providing information about bST following the tenth trial is shown in Figure 1. The large decrease in the average bid of the urban California participants is the most striking. To quantify the effect of information we combine our pre- and post-information stabilized bids in a single regression using a dummy variable to distinguish between them. Tables 3 and 4 present the results.

The first probit equation in Table 3 shows the outcome of constrained estimation where coefficients are restricted to be equivalent in the pre- and post-information stages. The second equation shows the results from the unconstrained estimation. The only significant dummy coefficient in the 2nd equation is that on DSex. The signs and relative magnitudes of the coefficients on Sex and DSex in the 2 equations indicate that information has a significant effect on the probability for females to bid to avoid the "bST milk". Before receiving the description of bST, males and females were equally likely to bid, whereas with the new information females were less likely to bid than males. The first equation also indicates that attitude to biotechnology again has a significant influence on the probability of bidding.

To illustrate the effects of sample selection, the second stage OLS equation was estimated with and without the IMR calculated from probit equation 1. Table 4 shows the results. The coefficient on λ in the first OLS equation is significant at the 10 percent level. This suggests that exclusion of the IMR would bias the remaining coefficients and this is evident in comparing the two equations. For example, when the IMR is excluded the coefficient on Welf (concern for animal welfare) is double its unbiased value and appears significant. Also note the sign reversal in coefficients on Sex and Tech.

In the first OLS equation, the coefficient on sex is positive indicating a tendency for females to bid more than males. The coefficients on Sfty, Know (prior knowledge of bST), and the dummy variable for the Iowa group are significant at the 10 percent level. Prior knowledge of bST has a negative effect on the bid.

The analysis of stabilized bids indicates stronger regional differences in bidding behavior than were observed with initial bids. This is not surprising given the bidding patterns shown in Figure 1. Likelihood ratio tests indicate that regional differences are significant at the 5 percent level for both the first and second stages.

Nonparametric tests

In another test of the effects of information and repeated market experience the distributions of bids were compared using the Wilcoxon signed-rank test (Freund and Walpole,p529). Comparison of initial bids (median = \$0.05) to stabilized pre-information bids (median = \$0.30) indicated that the difference was significant at the 5 percent level ($z=4.39$) and we conclude that repeated market experience raised the level of bids. A similar comparison of pre- and post-information bids leads us to conclude that the information we supplied about bST resulted in lower bids (z=1.76), though this result is primarily due to the reduction in bidding by the urban California group. Region specific comparisons of the changes in bidding between trial 10 and trial 11 indicated significant decreases in both urban California and Arkansas.

Discussion

The overall level of acceptability of bST found in these experiments appears similar to that found in surveys. In trial 1, 33 of 75 uninformed participants (44 percent), having received $18, would not pay anything to upgrade from a glass of "bST milk" to a glass of "normal" milk. After receiving information about bST, a total of 40 participants (53 percent) submitted zero bids in at least 5 of the final 10 trials. Smith and Warland's (1992) review of surveys on the issue found that 60 percent of those surveyed said that they would not change their milk purchases if bST were introduced.

The fact that 11 of 75 participants (15 percent) were willing to pay $1.50 or more to avoid a glass of bST milk points to the possibility of a profitable niche market for milk products from untreated animals. This 15 percent appears to correspond to Smith and Warland's figure of 10 percent of survey respondents who indicated that they would stop purchasing milk if bST were introduced. A more likely scenario is that many of those people will seek out milk and milk products labelled as coming from untreated animals and that they will be prepared to pay a premium for those products.

Conclusions

Nonhypothetical auction experiments have recently emerged as a viable alternative to consumer surveys. The advantage of these experiments is that they can closely replicate the consumers' point of purchase decision. This approach was used to examine the acceptability of "bST milk" to students in Arkansas, California (urban and rural), Iowa and Massachusetts.

Heckman's two-step procedure was used to model participants' bids to upgrade from a glass of "bST milk" to a glass of "normal" milk. Results indicate that attitude to genetic engineering, as revealed on a questionnaire, is an important factor in explaining the bid to avoid bST. This conclusion, while appearing to state the obvious, indicates a degree of consistency between what people say they will do and what they actually do. The apparent lack of such consistency is currently a point of debate in the contingent valuation literature. In the context of bST it suggests that efforts to foster more favorable attitudes towards biotechnology may be worthwhile in the attempt to boost consumer acceptability.

The importance of providing consumers with accurate, scientifically balanced information about biotechnological products was borne out in these experiments. In particular, the description of bST given to the urban Californian subjects served to almost completely eliminate their concerns about the product. The description of bST also resulted in a significant difference in bidding behavior between males and females, which was not evident before information was provided. Following information, females were less likely to bid to avoid bST than males. This suggests that females were more readily reassured that "bST milk" is the same as "normal" milk. The implication of this finding, if accurate, is that efforts aimed at reassuring consumers of the safety and wholesomeness of these products might more profitably be directed to a female audience.

Finally, the fact that some participants consistently bid in excess of $1.00 to avoid the bST milk, with or without information, suggests that a profitable niche market may exist for products labelled as coming from untreated animals.

Footnotes

1. See Davis and Holt (pp.25,449) for a discussion on financial incentives.
2. Experimental instructions are available on request.
3. See Davis and Holt (pp.451) for a discussion of wealth effects in experimental markets.
4. The use of the word "normal" to describe milk from a cow that was not treated with bST is not meant to imply that milk from animals treated with bST is "abnormal". The word is used only to avoid tiresome repetition of the longer but more correct description. The same applies to the term "bST milk".
5. This section draws heavily on Heckman's work.

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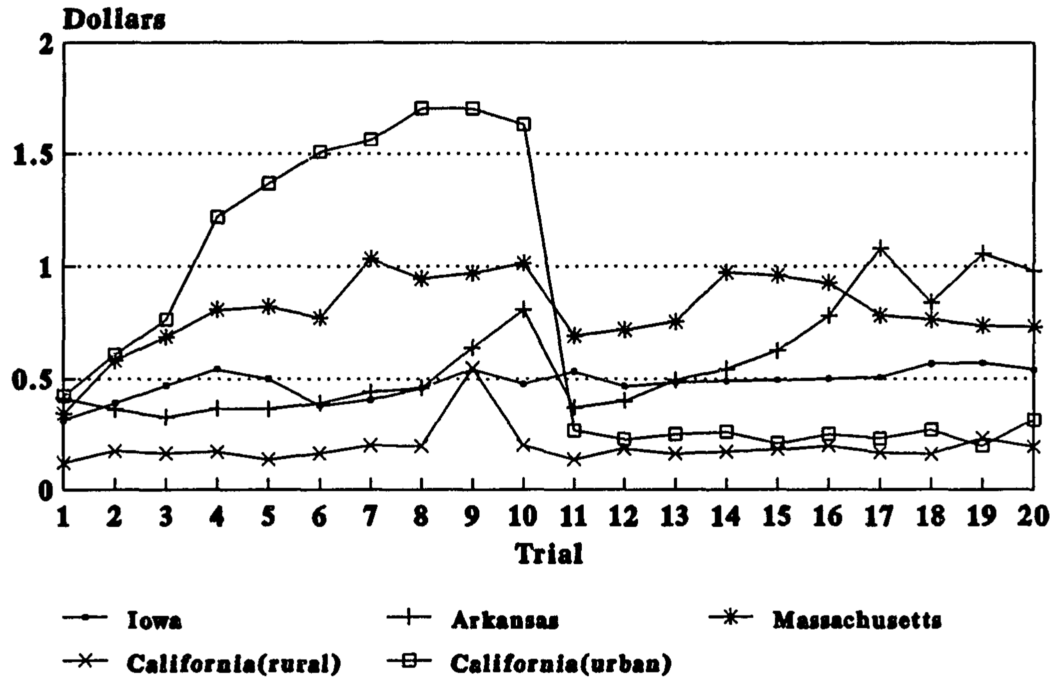

Figure 1. Average willingness to pay for "non-bST" (normal) milk. From Fox *et al.* (1994).

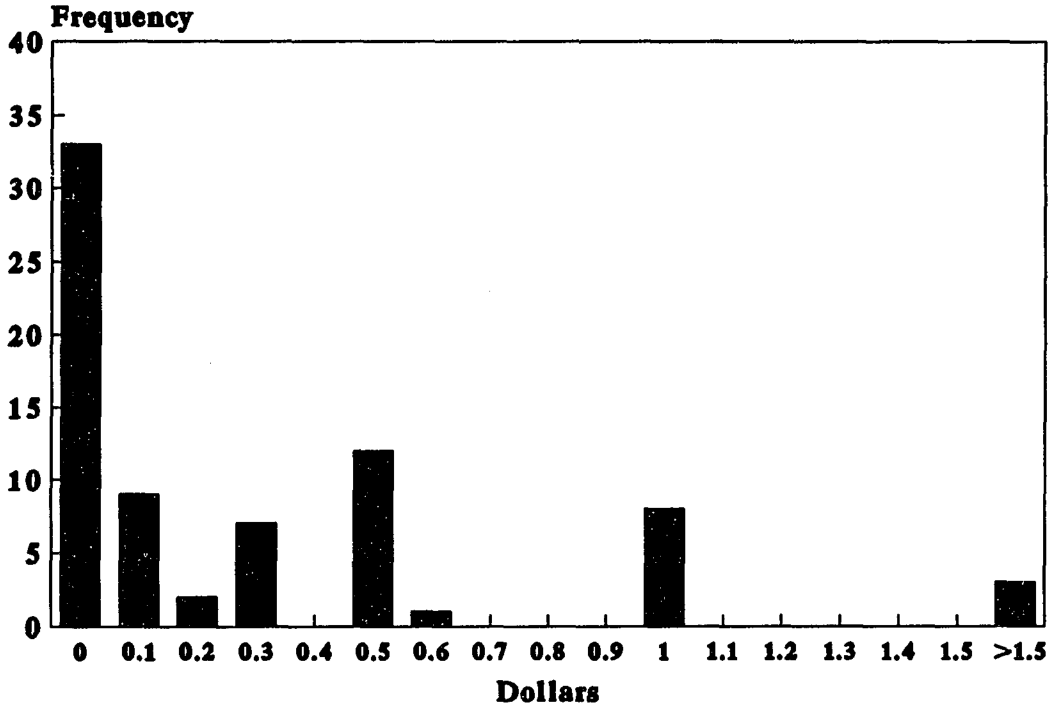

Figure 2. Trial 1 bids for "non-bST" milk. (N=75)
Mean Bid - $0.32; Median Bid - $0.05.

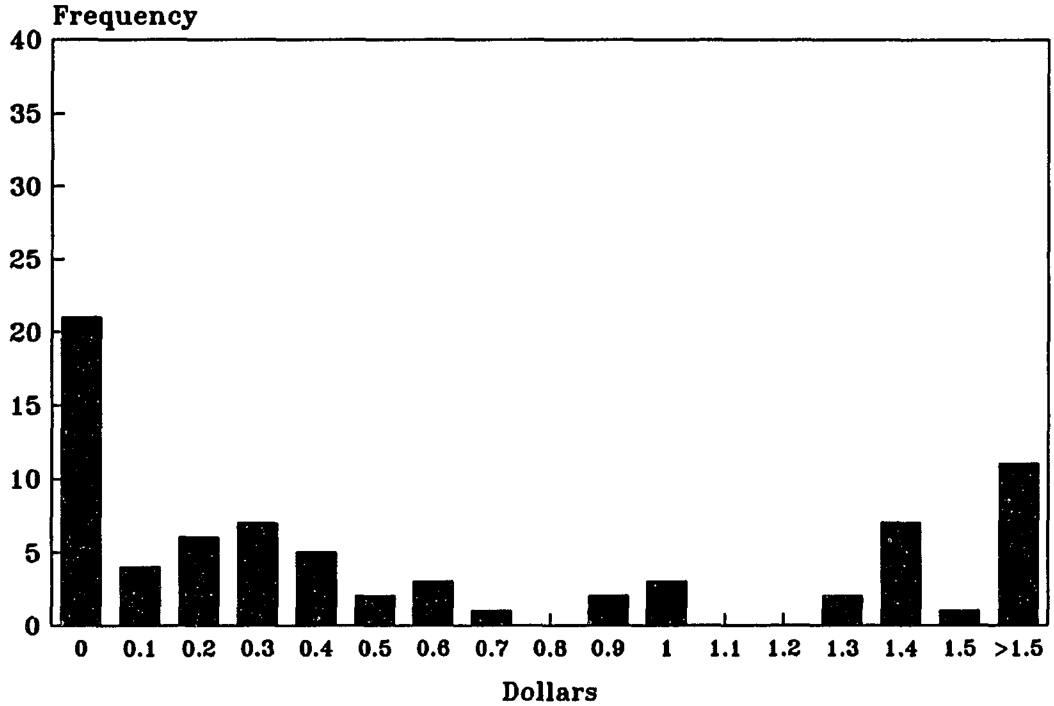

Figure 3. Stabilized Pre-Information bids for "non-bST" milk. (N=75)
Mean Bid - $0.74; Median Bid - $0.30.

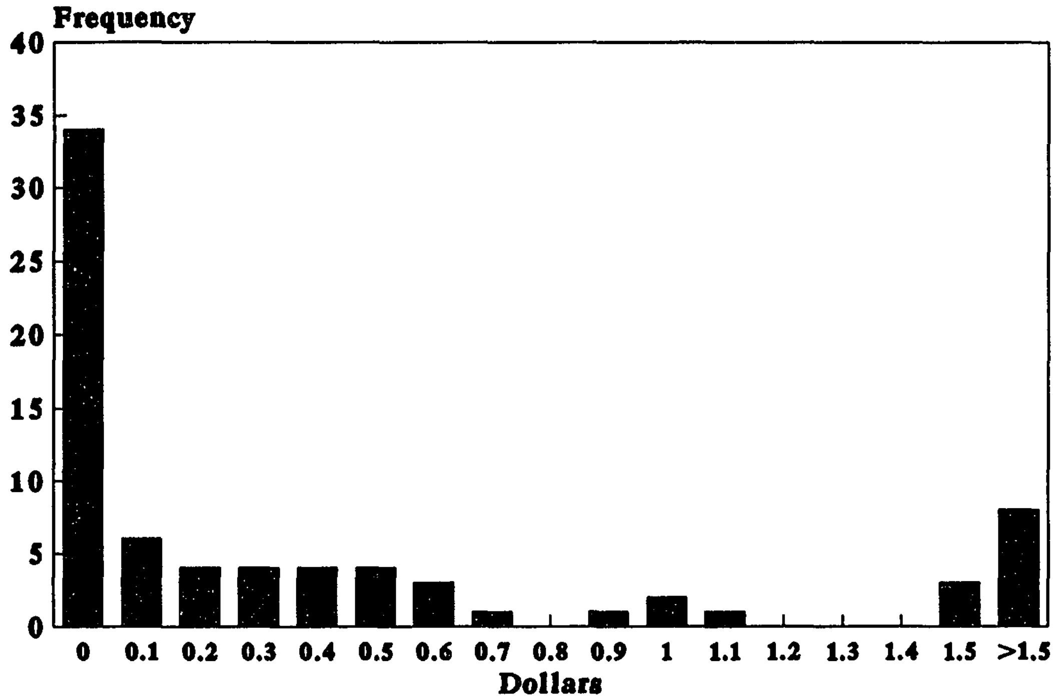

Figure 4. Stabilized Post-Information bids for "non-bST" milk. (N=75)
Mean Bid - $0.46; Median Bid - $0.07.

Table 1. Variable Definitions and Values

Variable	Definition	Mean (s.d)
Sex	1 if female	0.55 (0.50)
Know	1 if subject expressed prior knowledge of bST.	0.12 (0.32)

The variables Sfty, Tech, and Welf take values between:

0 if not concerned
4 if very concerned

Variable	Definition	Mean (s.d)
Sfty	Index of the subject's concern for food safety.	3.13 (0.50)
Tech	Subject's attitude towards Genetic Engineering/Biotechnology	2.17 (1.23)
Welf	Subject's level of concern for animal welfare	2.55 (1.16)

Regional Dummy Variables		Number
Calurb	1 if urban California	15
Calrur	1 if rural California	15
Iowa	1 if Iowa	15
Mass.	1 if Massachusetts	15

Total number of observations = 75

Table 2. Two-stage Analysis of First Bids

Variable	Probit (n=75)		OLS (n=42)	
Intercept	1.35	(1.22)	0.12	(0.18)
Sex	-0.26	(-0.76)	0.48	(0.62)
Sfty	-0.57	(-1.45)	0.57	(0.34)
Tech	0.35	(2.17)	-0.26	(-0.25)
Know	-0.11	(-0.22)	-0.05	(-0.10)
Welf	-0.01	(-0.01)	0.21	(2.32)
Calurb	0.34	(0.69)	-0.65	(-0.64)
Calrur	-0.19	(-0.40)	-0.11	(-0.15)
Iowa	-0.30	(-0.61)	0.19	(0.19)
Mass.	0.07	(0.15)	-0.24	(-0.73)
λ			-1.97	(-0.38)
R^2 =	0.09		0.35	
Log Likelihood	-47.95		-28.63	
% Correct	65.33			

Note: Numbers in parentheses are t-statistics.

Table 3. Effect of Information - First-stage Probit Analysis of Stabilized Bids

Variable	Eqn.1 (n=150)		Eqn.2 (n=150)	
Intercept	1.78	(2.21)	2.56	(2.09)
Sex	-0.51	(-2.04)	0.01	(0.02)
Sfty	-0.53	(-1.90)	-0.74	(-1.74)
Tech	0.29	(2.58)	0.24	(1.43)
Know	0.12	(0.34)	0.28	(0.51)
Welf	0.04	(0.37)	-0.01	(-0.08)
Calurb	0.09	(0.26)	0.21	(0.39)
Calrur	-0.29	(-0.78)	-0.08	(-0.14)
Iowa	-0.97	(-2.67)	-0.94	(-1.81)
Mass.	0.05	(0.14)	0.08	(0.16)
Dummy			-1.37	(-0.82)
DSex			-1.06	(-2.02)
DSfty			0.34	(0.59)
DTech			0.14	(0.58)
DKnow			-0.27	(-0.36)
DWelf			0.10	(0.46)
DCalurb			-0.17	(-0.22)
DCalrur			-0.38	(-0.51)
DIowa			-0.19	(-0.25)
DMass.			-0.05	(-0.07)
R^2 =	0.14		0.21	
Log Likelihood	-88.06		-82.39	

Note: Numbers in parentheses are t-statistics.

Table 4. Effect of Information - Second-stage OLS Analysis of Stabilized Bids

Variable	Eqn.1 (n=95)		Eqn.2 (n=95)	
Intercept	-0.74	(-0.95)	-0.16	(-0.23)
Sex	1.56	(1.64)	-0.05	(-0.24)
Sfty	1.70	(1.68)	0.01	(0.03)
Tech	-0.86	(-1.52)	0.10	(0.96)
Know	-0.73	(-1.86)	-0.27	(-0.93)
Welf	0.14	(1.09)	0.29	(3.22)
Calurb	0.20	(0.61)	0.48	(1.69)
Calrur	0.51	(0.81)	-0.48	(-1.79)
Iowa	4.11	(1.95)	0.52	(1.62)
Mass.	0.31	(1.14)	0.40	(1.52)
λ	-6.47	(-1.73)		
R^2 =	0.33		0.31	
Log Likelihood	-111.98		-113.64	

Note: Numbers in parentheses are t-statistics.

CHAPTER 5. GENERAL SUMMARY

In this thesis we used laboratory experimental auctions to investigate factors related to consumer acceptability of two new food products. The experimental auction used real food, real money, and included an explicit obligation to consume a food product. Because the experiment closely replicates consumer purchase behavior, results are more reliable than those from hypothetical surveys.

In the first paper we investigated acceptability of irradiated pork by conducting a survey followed by an experiment. Participants in both survey and experiment were asked how much they would be willing to pay to upgrade from non-irradiated pork to irradiated pork (and vice versa). The relationship between bids in the hypothetical survey and those in the experimental auction facilitated the formulation of a simple calibration function which we applied to the hypothetical bids of subjects who did not participate in the experiment. The results showed: (1) a high level of acceptability for irradiated pork (preferred by 75 percent of respondents), (2) that hypothetical bids in general overestimated true willingness-to-pay, and (3) that overestimation of hypothetical bids was more pronounced among participants bidding to avoid irradiated pork.

Paper 2 investigated how different descriptions (favorable and unfavorable) of the food irradiation process influenced willingness-to-pay for irradiated pork. The results showed, as expected, that the favorable description caused bids to increase, and the unfavorable description caused bids to decrease. We discovered that when participants were given both the favorable and unfavorable descriptions, the unfavorable description dominated. This result demonstrates the effectiveness of the anti-irradiation campaign. Negative information, because it succeeds in placing doubts in consumers minds about irradiation, convinces them to stick with the (non-irradiated) status quo. This shows that, given the current situation, major food processors are justified in their decision to avoid food irradiation.

The third paper examined acceptability of milk from cows treated with bovine somatotropin (bST). The objectives were to determine (a) the overall level of acceptability of the product, (b) regional differences in acceptability, (c) the effect on acceptability of providing a detailed description of the product, and (d) the relationship between acceptability and socioeconomic and anthropomorphic factors. The results showed significant differences in acceptability among the five groups of participants. Initially, bids to avoid "bST milk" were highest in urban California but additional information about bST resulted in a significant drop in those bids. The bidding patterns we observed over repeated trials demonstrated the importance of the information context in which bids are elicited and the likely inadequacies of "one-shot" survey methods.

These papers demonstrate the suitability of experimental auctions as a tool for investigating consumer acceptability of new products. The auction is realistic because it closely replicates consumer point-of-purchase behavior. It is also flexible because it permits alternative informational structures, and facilitates a quantification of the effects of additional or alternative information. By providing a well defined measure of acceptability (willingness-to -pay) it also allows estimation of the effects of socioeconomic or other characteristics. In combination with surveys and appropriate calibration methods, experimental auctions have a potentially wider application in the valuation of public goods.

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