Valuing Food Safety and Nutrition

EDITED BY
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Book Originally Published by
Westview Press, Boulder, Colorado, 1995

PART TWO: A Comparison of Valuation Methodologies

6. Experimental Auctions to Measure Willingness to Pay for Food Safety

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Keywords: Food safety, experimental economics, auctions, willingness to pay

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Effective food safety policy requires information on the costs and benefits of reducing the risk of illness from foodborne pathogens (Roberts 1989). Tragedies such as the recent outbreak of *E. coli* infection in the Pacific Northwest emphasize the need to understand the demand for safer food. This chapter describes how experimental auction markets can measure the demand for food safety. By using real food, real incentives, and repeated market participation, experimental auction markets replicate a consumer's point of purchase decision. As such, lab experiments provide a viable complement or alternative to standard elicitation methods such as contingent valuation surveys and hedonic pricing.

The chapter begins by discussing nonmarket valuation in experimental auction markets and its advantages for valuing safer food. We then describe the experimental design to value the reduced risk of illness from *Salmonella*, and discuss the results of a regional comparison. We also explore other applications of lab experiments before offering our concluding remarks.

Experimental Auction Markets and Valuation

Experimental auctions have been generally promoted as a tool to help improve the contingent valuation (CV) of nonmarket goods.[2] Coursey and Schulze (1986) stress that lab experiments can be used ex ante to improve the design of contingent valuation surveys. The idea is to go into the lab prior to the CV survey to pretest incentive design. Prior to field application, the lab allows the researcher to design, test, and replicate the preference revealing incentives of the elicitation method. The ex ante research should improve the accuracy of

the CV survey by observing how bidding behavior is affected by alternative incentive compatible auctions and repeated market experience.

Experiments can also be used ex post, either as a hybrid procedure or as an independent measurement method. Shogren (1993) defines this hybrid procedure as CVM-X. There are four steps to CVM-X. First, after pretesting and focus groups, run a CV method survey and elicit hypothetical bids for the good in question. Second, bring subsamples of the CVM respondents into the lab to determine how their initial hypothetical CV bids are impacted by a lab environment with real goods, real money, repeated market experience, and alternative demand revealing auctions. Third, apply appropriate statistical analysis to predict the final experienced bids (X) based on the initial hypothetical bids and other socioeconomic characteristics. Finally, adjust the bids of the CVM respondents who did not participate in the lab experiments for the learning and market experience revealed by the subsample. The CVM-X procedure could prove a cost-effective tool to combine the strengths of CVM and the lab— increasing the accuracy of surveys while broadening the scope of nonmarket valuation in the lab.

Experimental auctions also can be used independently as a valuation process in their own right—an alternative to traditional nonmarket valuation techniques such as CV surveys (Bohm 1972, Coursey et al. 1987). Traditional methods are problematic if respondents have vague or undefined incentives to seriously evaluate the safety of food. In contrast, laboratory experimental auctions provide participants with a well-defined incentive structure that enables the researcher to more accurately elicit the value of a nonmarket good, product, or process. Experiments can test and control for noise and strategic behavior with replication and incentives (Coursey 1987, Shogren and Nowell 1992). Experimental auction markets provide four main advantages for independent valuation. We illustrate by using the food safety experimental design of Shin et al. (1992) as a motivating example.

Firstly, experiments use an auction design to truthfully reveal preferences—Shin et al. use the Vickrey second-price, sealed-bid auction mechanism (Vickrey 1961). In several induced valuation experiments, the Vickrey auction has been shown to induce a participant to submit a bid equal to his or her actual valuation of the item being auctioned, independent of other bidders' behavior. Given that the product is sold at the second highest rather than the highest bid means that for the highest bidder there is a built-in gain equal to the difference between his or her valuation of the product, i.e., his or her bid, and the amount of the second highest bid. Bidding less than one's full value serves only to reduce the chances of winning at what would have been a profitable price. Bidding more than one's full value increases the chances of winning but at a price that may be higher than value.

Since in the experiment only one product is offered for sale to a group of fifteen subjects, the question arises as to whether bids might be boosted due to

an artificial scarcity. Vickrey's theory suggests that one could offer three or four units of the product to be sold at the fourth or fifth highest price (see Menkhaus et al. 1992) and it would still be optimal for subjects to bid their true value. Thus, if we assume that the product does not have intrinsic scarcity value (as would a painting by Van Gogh), we would expect similar bids irrespective of the number of products offered. It must be remembered that the objective is not to find an equilibrium between supply and demand, but rather to elicit the value of the good. But note that the Vickrey auction is not without critics—other mechanisms that have been considered include Becker et al.'s (1964) random number method and Smith's (1980) collective auction (Brookshire and Coursey 1987).

Secondly, the experiments use real food, real money, and repeated market participation. Participants receive full information on the product, such as the objective probability and severity of illness from a specific pathogen. Subjects are given repeated opportunities to participate in the auction market, a feature that allows for learning and that has been shown to be particularly useful in generating demand revealing behavior (Coursey 1987). Furthermore, participants realize the actual monetary consequences of their bidding, thereby providing opportunity for them to learn that revealing their true preferences is the dominant strategy (Cox et al. 1982).

Thirdly, Shin et al. (1992) use a "requirement-to-eat" factor to reinforce the truth revealing properties of the auction. Although subjects are paid $18 to participate in an experiment, they are also informed that the product must be consumed before they can leave with their take-home income. This proviso led to the withdrawal of vegetarian subjects in some experiments.

A fourth advantage of the experimental method is the absence of non-response bias, a common problem with survey techniques (Cummings et al. 1986). Because participants are not given any indication as to the nature of the experiment at the time they are recruited, their willingness to participate or lack thereof is completely unrelated to their attitude to the product being studied.

Application to Food Safety-Experimental Procedures

Following Shin et al. (1992), the experimental design can be described as consisting of three stages. In Stage 1 (the pre-auction stage), each subject is given an identification number and asked to sign a consent form. Subjects are then asked to complete a short questionnaire dealing with dietary habits and experiences, attitudes and beliefs about food safety, and some demographic information.

The objective of Stage 2 is to familiarize the participants with the Vickrey auction. Each subject is endowed with a candy bar (brand X) and $3. A different candy bar (brand Y) is then auctioned over five trials, only one of which is

binding. The random trial procedure controls for wealth effects, but does not alter truthful preference revelation if the subject's expected utility is linear in probabilities (Davis and Holt 1993). Following each trial, subjects are provided with the identification number of the highest bidder and the amount of the second highest bid. At the end of Stage 2, one of the five trials is randomly drawn to determine the binding trial. The highest bidder in the binding trial then exchanges his or her brand X candy bar for the brand Y candy bar and pays the posted price—the highest losing bid in that trial. This transaction makes participants aware that there are monetary consequences to their bidding behavior.

Stage 3 then introduces the food safety auction. The objective is to find out how much subjects are willing to pay to upgrade from a "typical" chicken sandwich to a sandwich that has been screened for *Salmonella*. The auction consists of twenty bidding trials, the first ten of which are based on the participants' subjective assessments of the risk of contamination of the "typical" sandwich. Following the tenth trial, the subjects are provided information about the objective odds of contracting salmonellosis from the "typical" sandwich. Changes in bidding between the uninformed and the informed trials are expected to be correlated to the degree to which a subject over- or underestimates the actual odds of contracting salmonellosis from the typical sandwich.

After providing the winner of the candy bar auction with a new identification number, subjects are asked to record their subjective assessment of the annual probability of becoming ill from *Salmonella*. Then each participant is endowed with a Type I (typical) chicken sandwich and $15. A Type II (stringently screened) chicken sandwich is offered for auction. Participants were provided with the following descriptions of the sandwiches:

Type I

This food has a typical chance of being contaminated with the foodborne pathogen *Salmonella*; i.e., it has been purchased from a local source.

Type II

This food has been subject to stringent screening for *Salmonella*. There is a *1 in 100,000,000* chance of getting salmonellosis from consuming this food.

For the first ten trials, the participants' bids are based on these descriptions and their subjective perception of the typical chance of contamination of the Type I sandwich. As in the candy bar auction, subjects are provided with the identification number of the highest bidder and the amount of the second highest bid following each trial. After the tenth trial, the following description (Acha and Szyfres 1980) of salmonellosis is provided:

> Symptoms are those of a mild "flu-like" intestinal disease of short duration with abdominal pains, nausea, vomiting, and diarrhea. The actual individual chance

> of infection of salmonellosis is 1 in 125 annually. Of those individuals who get sick, 1 individual out of 1,000 will die annually. The average cost for medical expenses and productivity losses from a mild case of salmonellosis is $220.

At this point the participants are also told that the objective risk of salmonellosis from the "typical" product that they own is *1 in 137,000* (calculated from Bennett et al. 1987). After all twenty trials are completed, one trial is randomly drawn to be binding to determine who purchases the Type II sandwich. Because participants did not know that they would get more information following the tenth trial, no distinction is made between informed and uninformed bids in selecting the binding trial. Participants were required to consume their sandwich in order to leave with their take-home pay and were aware of this requirement at the beginning of the auction.

Experiments were conducted to explore whether there exists evidence of regional differences in the demand for food safety. These experiments were conducted at four universities in Iowa, Arkansas, Massachusetts, and California. Fifteen undergraduate students from a range of degree programs participated in each experiment. Care was taken to replicate the experiments as closely as possible. A similar lab environment was used at all four locations and the auctions were conducted by the same investigator.

Bidding Behavior in Food Safety Auctions

Figure 6.1 shows the distribution of the participants' subjective assessments of the annual risk of contracting salmonellosis. It is based on 58 observations from all 4 experiments (2 subjects did not record a value). The distributions for individual experiments (not shown) were virtually identical, with 10 participants at each location giving an estimate of 100 cases or less per million population. Since the actual number of cases is approximately 8,000 per million (Bennett et al. 1987), most participants underestimated the risk of salmonellosis.

Figure 6.2 shows the mean bid of each trial in all four locations. The figure reveals that participants in Arkansas and Massachusetts would pay more for a reduction in *Salmonella* risk than would participants in Iowa[3] and California. The mean bid over all trials was $0.93 in Arkansas, $0.88 in Massachusetts, $0.52 in Iowa, and $0.45 in California.[4]

The first round of bidding in each experiment reflects the respondents' initial preferences given the "requirement-to-eat" factor. In trial 1, the mean bid in Iowa ($0.55) was greater than the mean bid in Massachusetts ($0.45) (see Table 6.1 for comparisons). If these initial bids had been used as indicators of the demand for food safety, our conclusions would have been different. With repeated market experience, however, these same participants revealed a significant change in bidding behavior. The patterns of bidding that emerged

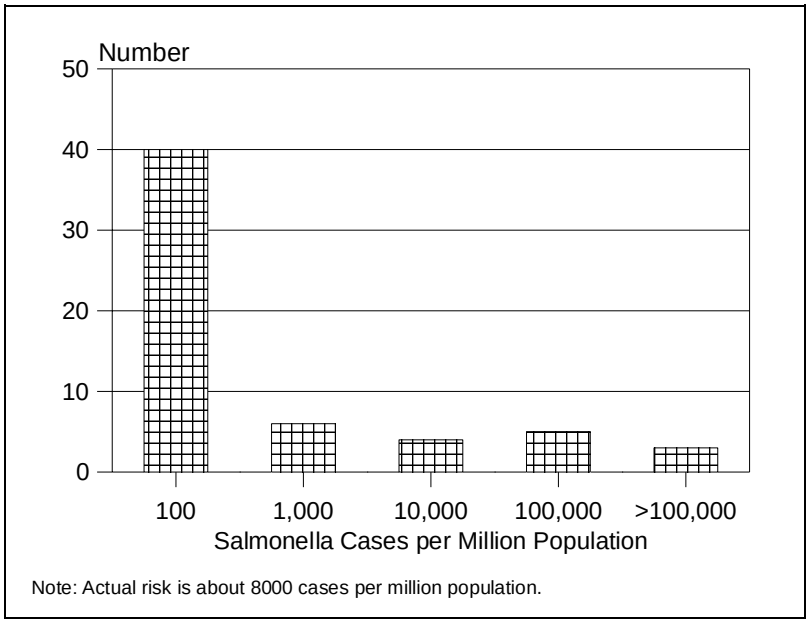

FIGURE 6.1 Subjective Assessments of the Annual Risk of Contracting Salmonellosis

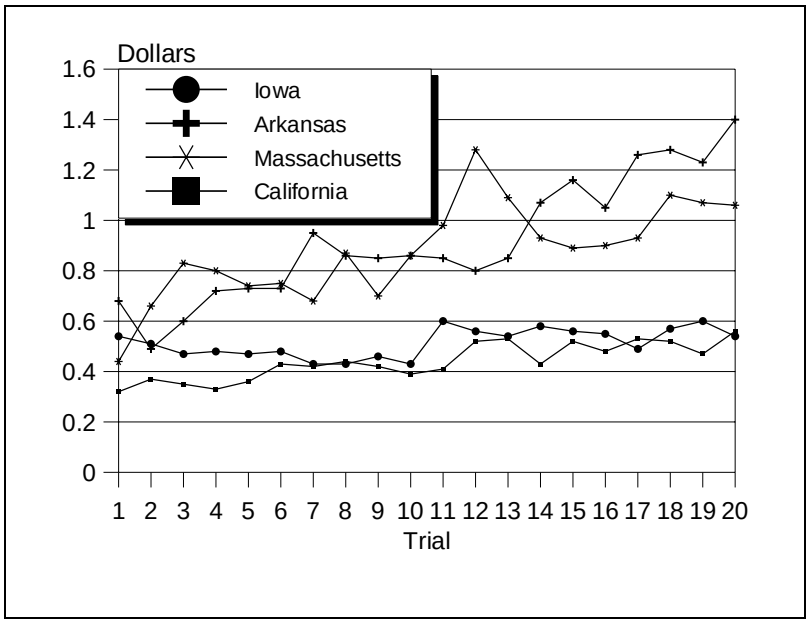

FIGURE 6.2 Average Willingness to Pay for Reduced *Salmonella* Risk

TABLE 6.1 Differences in Mean Bids[a] at Trial 1 and Trial 20

1st \ 20th	Arkansas	Massachusetts	Iowa	California
Arkansas		\$0.33 (.94)[b]	\$0.85 (3.03)**	\$0.84 (2.97)**
Massachusetts	\$0.24 (1.19)		\$0.52 (2.17)***	\$0.50 (2.10)***
Iowa	\$0.14 (0.83)	\$0.10 (0.54)		\$0.02 (0.15)
California	\$0.37 (2.17)***	\$0.12 (0.69)	\$0.22 (1.55)	

Note: Numbers in parentheses are t-statistics. The superscripts *, **, and *** correspond to levels of statistical significance of 1 percent, 5 percent, and 10 percent, respectively.

[a]Figures below the main diagonal are differences in mean bids at Trial 1. Figures above the main diagonal are differences in mean bids at Trial 20.

[b]T-statistics for the difference in 2 means were calculated assuming independent samples from populations with unknown and *unequal* variances (see Wonnacott and Wonnacott 1977: 214).

with experience at the different locations emphasizes the value of repeated trials as an important feature in value elicitation where preferences and beliefs remain ambiguous and malleable for unfamiliar risks.

Through trials 1-10, the average bid increased considerably in Massachusetts and Arkansas suggesting that these participants were actively competing for the right to consume the safer food. At trial 10 the average bid at both locations was \$0.86. In contrast, there was relatively little movement in the mean bid during the first 10 trials in Iowa and California, with a slight increase for California and a slight decrease for Iowa. Notice how the average bid in Iowa and California stabilizes after 6 trials, Arkansas after 8 trials, while after 7 trials the Massachusetts bid begins to fluctuate around \$0.80. It has been observed that individuals participating in a Vickrey auction do not initially reveal their true value, but that a number of iterations are required for them to learn that honest revelation is their best strategy (Coppinger et al. 1980, Cox et al. 1982). The results reported here appear consistent with these earlier findings.

In three of the four locations the mean bid increased when the objective odds of contracting salmonellosis and the description of symptoms were provided. In Arkansas the average bid actually decreased slightly at this stage. When we compared changes in individual bids between trials 10 and 11 against participants' subjective odds of becoming ill from *Salmonella* we found a positive, but very low, correlation (0.13) between under/overestimation of risk from the typical sandwich and an increase/decrease in bidding.

There was a marked difference between regions in the behavior of the average bid following trial 11. In both Arkansas and Massachusetts the average bids continued their upward trend, finishing at $1.40 and $1.07. In California and Iowa, however, following the increase in bidding at trial 11, the average bid appeared to stabilize at a slightly higher level than had prevailed for the first 10 trials. The average bid in Iowa increased to $0.56 over trials 11-20 from $0.47 over trials 1-10, while bids in California increased to $0.50 from $0.39.

Table 6.2 shows the frequency distribution of bids at the 1st, 10th, 11th, and 20th trials for all four experiments. Note the total number of bids exceeding $1 received at each location for the four trials examined: 1 for California, 3 for Iowa, 16 for Massachusetts, and 21 for Arkansas. Bids of this magnitude represent a large premium relative to the value of one meal and therefore imply a high estimate of the value of safer food. But because participants in the experiment are subject to a number of constraints (e.g., one-time purchase, no substitutes, no control over food preparation), the Le Chatelier principle dictates that these bids represent an upper bound on true willingness to pay.

Consumers typically have a greater degree of control over their level of exposure to foodborne pathogens outside the experimental lab. For example, to reduce exposure to *Salmonella* they may choose to completely avoid poultry or choose to cook the meat themselves. The experiment is also a novel, unfamiliar situation and it is possible that in repeated experiments with the same subjects the average bid would decrease.

In order to refine the estimates one therefore needs to relax the constraints of the experimental auction. This could be achieved by repeating the experiments, then perhaps allowing subjects some control over cooking, then eliminating the initial endowment of sandwiches and the "requirement-to-consume," and simply seeking bids for both sandwiches from the experienced subjects. By relaxing the constraints in a systematic manner, we can explore the sensitivity of the revealed value of safer food as the subject's opportunity set expands.

As we saw in Table 6.1, there are some significant differences in the mean bids between regions. As with any sample based survey it cannot be positively concluded that these differences reflect genuine regional differences or simply the effects of different groups of participants. Nevertheless, the variation between regions was not explainable by reference to the subjects' prior subjective assessments of the probability of contracting a foodborne illness since these were similar in all 4 experiments.

TABLE 6.2 Frequency Distribution of Bids

		Trial			
	Bid Range	1	10	11	20
Arkansas	$0-$0.25	5[a]	5	4	4
	$0.26-$0.50	1	0	0	0
	$0.51-$0.75	1	1	3	1
	$0.76-$1.00	6	3	4	1
	> $1.00	2	6	4	9
Massachusetts	$0-$0.25	8	4	3	4
	$0.26-$0.50	4	3	2	2
	$0.51-$0.75	0	2	2	2
	$0.76-$1.00	1	2	4	1
	> $1.00	2	4	4	6
Iowa	$0-$0.25	5	6	2	5
	$0.26-$0.50	5	4	5	3
	$0.51-$0.75	2	4	4	2
	$0.76-$1.00	1	1	3	5
	> $1.00	2	0	1	0
California	$0-$0.25	8	4	6	3
	$0.26-$0.50	4	7	4	4
	$0.51-$0.75	0	4	1	1
	$0.76-$1.00	3	0	3	7
	> $1.00	0	0	1	0

[a]Table entry represents the number of bids falling in each bid range.

One factor that may account for the regional disparity in bids is public awareness of food safety problems. In recent years both Arkansas and Massachusetts have experienced well publicized outbreaks of pathogenic contamination of food products. Consumers in both Iowa and California may have perceived that the typical sandwich was safe, in part because they have had no recent exposure to problems in the food supply. To the extent that this argument is true, it is suggestive of the ability of information to influence perceptions and willingness to accept new products and methods.

Usefulness of the Experimental Auction

This experimental auction procedure was initially developed as an alternative to surveys as a means of estimating willingness to pay for food safety. Like surveys, the method is flexible and can be applied to a number of different issues. To further illustrate the advantages of the procedure we now briefly outline some recent applications.

Shogren et al. (1994) used experimental auctions to examine the disparity between willingness to pay (WTP) and willingness to accept (WTA). They found that for market goods with close substitutes (candy bars, coffee mugs), the divergence of WTP and WTA disappeared with repeated trials. However, for a nonmarket good with no close substitutes—reduction in health risk from foodborne pathogens—the divergence between WTP and WTA persisted. These results support Hanemann's (1991) conjecture that the divergence of WTP and WTA is related to ease of substitutability for the good.

Buhr et al. (1993) used the experimental method to investigate consumer reaction to leaner pork from animals treated with the growth hormone porcine somatotropin (pST). They concluded that the average participant was more concerned with reducing the fat content of the meat than with avoiding the hormone-treated product. However, 10-20 percent of the participants were prepared to bid large amounts to avoid the hormone treated product.

In a similar vein, Fox et al. (1994) used experimental auctions to investigate consumer acceptability of milk from cows treated with bovine somatotropin (bST). The bST experiments highlighted one feature of the experimental method—the ability to observe the effect of information on the bidding behavior of individual subjects or groups of subjects. Subjects were endowed with a glass of "bST" milk and asked to bid on a glass of "normal" milk. As in the food safety experiments, subjects were initially asked to reveal uninformed bids and, following the tenth bidding trial, were provided with a scientifically balanced description of bST. They were also informed that the amount of bST in milk from treated cows was no different from that in milk from untreated cows. Figure 6.3 shows the magnitude of the effect of this information on the average bid from a group of participants in urban California. The urban California participants had the least prior information on bST of any group of participants, and their behavior demonstrates the importance of providing consumers with accurate information. Overall, the results of the bST experiments showed that more than 50 percent of participants would not require any price discount to purchase bST milk. A relatively small group would pay a large premium to avoid drinking milk from cows treated with bST.

Results reported in Fox et al. (1993) showed a high level of acceptability for pork products treated by irradiation to control *Trichinella*. The structure of these experiments was similar to that of the *Salmonella* experiments described

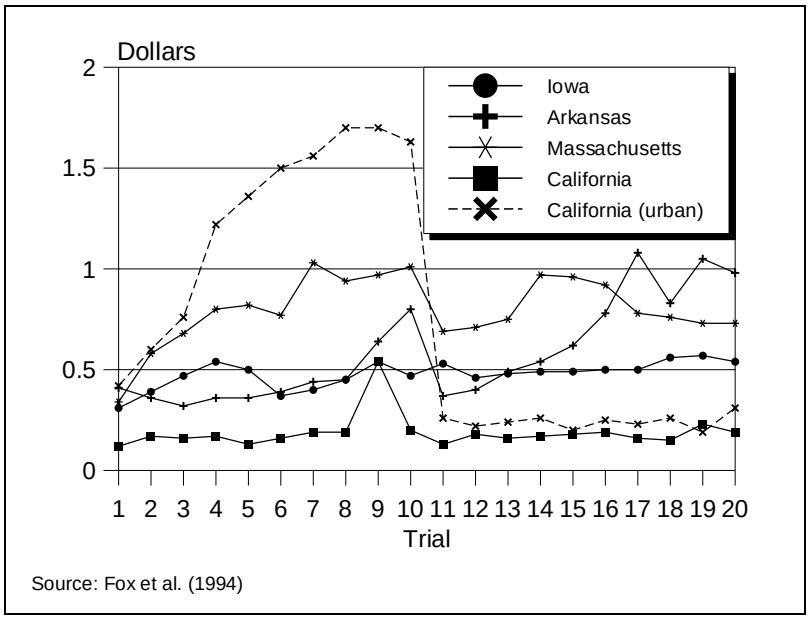

FIGURE 6.3 Average Willingness to Pay to Avoid bST Milk

above with participants receiving a detailed description of the irradiation process and a guided tour of the Iowa State University linear accelerator facility following the tenth bidding trial. Two groups of 14 and 15 undergraduate students were given "normal" pork sandwiches and were asked to bid to upgrade to a sandwich made from irradiated pork. Another two groups of undergraduates were given an irradiated pork sandwich and were asked to bid to upgrade to a "normal" sandwich. Twenty-six of twenty-nine subjects were prepared to pay a premium to upgrade to irradiated pork in order to reduce the risk of contracting trichinosis. Only one of twenty-nine subjects would pay to upgrade to the "normal" pork sandwich based on an aversion to the irradiation process.

Conclusions

An experimental auction with repeated market experience can provide a well-defined incentive structure to allow participants to learn that honest revelation of their preferences is their best strategy. Given the use of truth revealing auctions such as the Vickrey auction over nonhypothetical goods, we believe experimental auctions both complement and offer a viable alternative to standard nonmarket valuation methods.

We used the experimental auction method to obtain estimates of consumer willingness to pay for food safety. Participants were provided the opportunity to eat an ordinary meat product (possibly contaminated with *Salmonella*) free of charge or to bid instead for a product guaranteed to be free of *Salmonella*. The experiment was conducted at 4 locations—Iowa, Arkansas, Massachusetts, and California. Using bids from the Iowa experiment, Shin et al. (1992) suggested that the aggregate willingness to pay for safer food would be several times larger than previous estimates of $4.8 billion (Roberts 1989) to $23 billion (Garthright et al. 1988), if it could be translated to national levels. When replicated at different locations, we observed that subjects in Arkansas and Massachusetts were willing to pay approximately twice as much as subjects in Iowa and California for the same reduction in exposure to *Salmonella*, suggesting an even higher value. However, given the strictly defined opportunity set for participants in our experiments, we believe that these estimates represent an upper bound on the true value of safer food.

The future of valuation with experimental auction markets is more than just promising—it is wide open. The next step in this research agenda is to systematically relax the constraints in the experimental auction markets we have developed. By allowing for repeated participation, substitution opportunities, and home preparation, we can explore the sensitivity of value estimates given controlled changes in the auction environment. The opportunity to specify these changes and alter the auction environment is open to all interested in estimating the value of safer food.

Notes

1. This work was funded by the Food Safety Consortium.

2. See Plott (1987, 1989) for a general discussion on experimental economics.

3. The bids from Iowa are those reported in Shin et al. (1992).

4. Due to erratic bidding by some participants in the Arkansas experiment, the highest and lowest bid in each trial was eliminated (see also Shogren et al. 1994). Since the objective was to compare results across regions, data from the other three locations were treated in the same way. In the raw data, the differences between Iowa/California and Massachusetts/Arkansas are even more pronounced.

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