Policy Implications for U.S. Agriculture of Changes in Demand for Food

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An Experimental Approach to Measuring the Value of Safer Food

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There is an optimal level of societal expenditures for safe food. In the absence of a public goods problem, this level would equal the sum of individual consumer optimal expenditures. Presently, little is known about these expenditure levels. One measure of optimal expenditure level is the consumer's willingness to pay (WTP) for safer food. Alternatively, the individual's need to be compensated (called willingness to accept or WTA) for consuming unsafe food could be measured. These estimates provide guidance to those determining the level of expenditures on programs enhancing the safety of the food supply. Currently, food-safety expenditures in the United States are determined in part by the government's interpretation of signals sent by consumers via direct contact, interest groups, and the media. Many of the participants in this process lack information on existing food-safety expenditures and the incidence rate or probability of becoming ill from a particular pathogen or chemical contaminant. Recently, this estimation process has been supplemented by research and testimony on food safety, related hospitalization costs, and the opportunity cost of time away from work (Roberts 1985, 1989).

Previous estimates of food-borne illness costs have been broad and ranged from $4.8 billion (Roberts 1989) to $8.4 billion (Todd 1989) to a high of $23 billion (Garthright, Archer, and Kuenberg 1988). Even with the wide-ranging estimates, it is well known that the human-capital method used in these studies (see Linnerooth 1979) underestimates the true cost of food-borne illness because individuals presumably would pay more to prevent the illness than the actual costs incurred. Moreover, costs have only included direct costs.

Further decreases in the incidence rate of pathogens in the United States will likely be attained at increasing cost. Further improvements in food safety will become increasingly costly. Therefore, an interesting question arises. At what point do food safety costs exceed benefits? To answer this question, van Ravenswaay (1988) reviewed the limited literature about consumer demand for food safety. Her survey summarized what is known about consumer concerns and suggested that research was needed on methodological approaches offering promise for information on consumer demand for food safety. Van Ravenswaay emphasized that a key question in food safety research is the individuals' WTP for risk or exposure reductions and concluded that "we know nothing about the demand for food safety . . ." and that more research is needed to develop methods for evaluating WTP values.

To the authors' knowledge, no scientific method has yet been implemented to measure the full level of sickness costs, despite the need for this estimate by those involved in lawsuits where illness has occurred and by those responsible for allocating food-safety expenditures. The absence of estimated illness (or morbidity) costs is understandable since it is difficult for individuals to place a monetary value on sickness, where there is no readily available market price. Thus, it is not surprising that aggregating across available sickness cost estimates has been difficult.

One method to measure the costs and benefits of reducing food-safety related illness would be to survey consumers directly. Mitchell and Carson (1989) provide a good overview of the contingent valuation methods used to estimate values for items that do not have readily available prices. Regardless of how well these surveys are designed, however, respondents are responding to a hypothetical situation. Penner, Kramer, and Frantz (1985) conducted a food-safety survey that asked broad questions about consumer WTP for a safety label on meat products. Seventy-one percent of the respondents would pay slightly more or considerably more for the safety information. Slightly more than one-fourth (28 percent) were willing to pay more than 3 cents per pound of meat products.

Recently, an experimental approach has been developed as an alternative to the survey-based methodology. This experimental technique attempts to force participants to concentrate on the food-safety question by simulating real-world decisions in a laboratory environment (Smith 1982). This approach appears to offer promise for valuing increased food safety or reduced food-borne risk. Laboratory experiments are often used to test the principles of economic theory (Kahneman, Knetsch, and Thaler 1990) or to induce the valuation in environmental economics and public good provision (Brookshire and Coursey 1987). To date, most valuation experiments for nonmarket goods, such as visibility (Rowe, d'Arge, and Brookshire 1980), have been implemented in hypothetical settings. One exception was the work by Coursey, Hovis, and Schulze (1987). They conducted a survey and series of experiments in nonhypothetical settings to examine the disparity of the WTP measure to avoid and WTA measure to endure an unpleasant taste experience caused by sucrose octa-acetate (SOA), a bitter but harmless chemical. This study was nonhypothetical in the sense that those whose bids were not accepted were required to swallow a small amount of SOA to receive the compensation that was agreed upon.

In this paper, we use an experimental approach to measure an individual's WTP to remove existing levels of food-borne pathogens from a particular meal. The experimental design focused on convincing participants that one sandwich had a greater probability of being contaminated with a food-borne pathogen than did an alternative. The hope was that by using real risks and real money the participants would be forced to concentrate on the trade-off between risks and returns and would provide a more accurate consumer value of food safety. By isolating the food-safety decision within an experimental setting, we hoped to infer WTP and WTA values more precisely than would be the case with a survey. [See Hoffman and Spitzer (1985) for a discussion of the benefits of experimental over survey techniques.]

One additional benefit of this experimental approach is that we can directly measure the monetary value of increasing the safety of the U.S. food supply without first estimating risk aversion and the monetary value of an illness. In the methodology used, participants are implicitly performing their own combination of probability and payoff to arrive at their individual WTP and WTA values.

The experimental methodology used has some drawbacks. In particular, it is unclear to what extent the results can be generalized. Also, it is unclear how group composition and group dynamics influence the experimental results. A secondary purpose of this paper is to examine the sensitivity of the experimental results to changes in reported probabilities and group composition. The literature on nonhypothetical experiments is still in its infancy. The results presented in this paper contribute by providing heretofore unreported measures of errors induced by group dynamics and the extent to which participants in nonhypothetical group auctions behave in a rational manner.

The first section of the paper describes ten experiments, each with approximately 15 participants, that were performed to measure WTP and WTA for five common food-borne pathogens in the United States. The second section describes a follow-up experiment for which we changed (a) only the people in each group (trials 1 through 10), and (b) the reported risks associated with the less safe food (trials 11 through 20). The last section draws conclusions from the experimental analysis and those results that are useful for policy analysts and others who may wish to conduct nonhypothetical experiments.

Experimental Design and Procedure

In each of the ten experiments described in this section, approximately 15 individuals were paid to participate in a Vickrey's second-price, sealed-bid auction (Vickrey 1961). The first five experiments attempted to estimate individual WTP for a safer food, and the second five attempted to measure how much an individual had to be paid (WTA) to eat food with a potentially lower level of food safety.

Participants were selected by announcing to several nonintersecting classes of undergraduate students that an experiment providing a stipend of $18 was scheduled and that volunteers were requested for the experiment. Fifteen participants and two alternatives were chosen from each class and asked to appear at a specified time in an on-campus taste-testing room. This taste-testing room is regularly used to measure reactions to experimental products developed at a nearby facility.

The benefits of using Vickrey's second-price, sealed-bid auction are that each participant submits a bid equal to his/her actual value for the item in question, independent of the other bidders' behaviors, and that truth is the dominant strategy (Cox, Roberson, and Smith 1982). Furthermore, the auction iteration process allows the learning effects to be incorporated by the participants with their true preference (value) for auctioned items revealed (Coursey 1987).

In each experiment, fifteen participants were first familiarized with the experimental procedure with a candy bar auction. Participants were given a small candy bar and told to bid for a larger candy bar. It was made clear that the student whose bid was successful would pay the monetary bid and receive the larger candy bar. We explained that we wished to measure how much they were willing to pay to upgrade their candy bar.

The candy bar experiment had five trials and participants were provided $3. In each trial, participants wrote down their bids and these bids were collected by one of three monitors who then made public the first-highest and second-highest bids. At the end of the fifth bidding trial, one of the trials was randomly selected to be binding. In this binding trial, the second-highest bid was used. The individual who bid the highest price paid the second-highest bid amount and upgraded his or her candy bar.

Next, participants were shown two meat sandwiches. We explained that one had been stringently screened for pathogens. The other sandwiches were described as having a typical chance of contamination with one of five common food-borne pathogens in the United States: *Camplyobacter, Salmonella, Staphylococcus aureus, Trichinella spiralis,* and *Clostridium perfringens.*

Participants were then asked to bid to upgrade to the safer sandwich. It was made clear that, with the exception of the individual whose bid was ultimately selected, all other bidders would be required to eat one of the experimental sandwiches or forfeit the $15 provided for the sandwich experiment. After ten trials of bidding, participants were provided information on the actual odds of being contaminated from consuming the experimental food along with a description of the food-borne illness (Bennett, et al.) The probabilities provided were those for a typical U.S. consumer becoming ill from that particular pathogen for one meat-based meal. Ten more bidding trials followed the introduction of this information. After all 20 trials had been completed, one binding trial was randomly selected, as before.

The five WTA experiments were identical except that 14 stringently screened sandwiches and one typical product were used. In this case we measured how much the participants had to be paid to eat the typical product.

Experimental Results

Willingness to Accept

The average WTA values of all five pathogen experiments significantly exceed the average of WTP values in all inexperienced one-shot bids (trial 1), naive bids (trials 7 through 10), and informed bids (trials 17 through 20). Figure 1 provides the results for *Campylobacter* and *Trichinella spiralis*. Even with repeated exposure to the auction market in naive bids and with detailed information of the food-borne illness in informed bids, the divergence between WTP and WTA values remained significant. We include these WTA values for comparison (Figure 2); however, it is likely that these values are overestimates for the following reasons.

• From Prospect theory, we know that the shape of value function is generally concave for gains (safer food) and convex for losses (less safe food) and that from any reference point the slope for losses is steeper than that for the gains (Kahneman and Tversky 1979). Subjects asked (bid) an extremely high WTA value (compensation) to give up the screened food they had already acquired because health risk is not easily substitutable for money (see Hanemann 1991 and Shogren et al. 1991).

• The WTP measure is more appropriate and accurate than the WTA measure for public goods in valuation settings because the degree of loss aversion is sensitive to the existence of nonmarket or market-like environments (Brookshire and Coursey 1987).

• For our purposes, these WTA values can be regarded as the cost to society of reintroducing pathogens into a previously safe world, whereas the WTP values are the benefits of eliminating pathogens from the existing U.S. food supply.

• In these WTA experiments, all but one of the participants ate the stringently screened food, whereas in the WTP experiments, only one participant ate the "safer" food. One would hypothesize that, as the more risk-averse individuals bid against each other for the one safe sandwich, the WTP bids would be higher than the WTA bids; yet the opposite was the case. In all cases, the WTA bids were significantly higher (see Figure 1). This phenomenon has been observed by others (Knetsch and Sinden 1982; Coursey, Horis, and Schulze 1987).

• For policy purposes, the WTP bids are more useful because the WTA bids were likely inflated because participants asked for large monetary values in hopes of making more than the promised $18, whereas in the WTP case participants had to provide the cost and were more careful with their bids. Also, the WTP bids measured the benefits of reducing pathogens from today's levels, whereas the WTA measure implicitly assumes a world where food-borne pathogens have all but been eliminated and then measures the welfare loss of reintroducing pathogens. The WTP and WTA results are very different. For these reasons, we will focus on the WTP results.

Willingness to Pay

Figure 3 shows the average bid for trials 1 through 20 for each of the pathogens for each of the WTP experiments. The first bid is felt to be similar to those which would be obtained from a one-shot survey that was answered truthfully and without information. Bids in trials 2 through 10 allow for the gaming and informational flow of the auction process. The average WTP for *Staphylococcus aureus* in trials 1 through 10 was greater than that for the other pathogens, possibly because of a lack of familiarity with this name. The results for trials 7 through 10 are most useful for policy analysis and for measuring the perception of an uninformed public.

Information on the probability and nature of food-borne illness was introduced in trial 11. In trials 1 through 10, individuals were told that the test product had a typical chance of being contaminated, whereas in trials 11 through 20, individuals knew the actual probability. When information about the true probability and nature of the food-borne illness was introduced, average bids increased in all cases. The

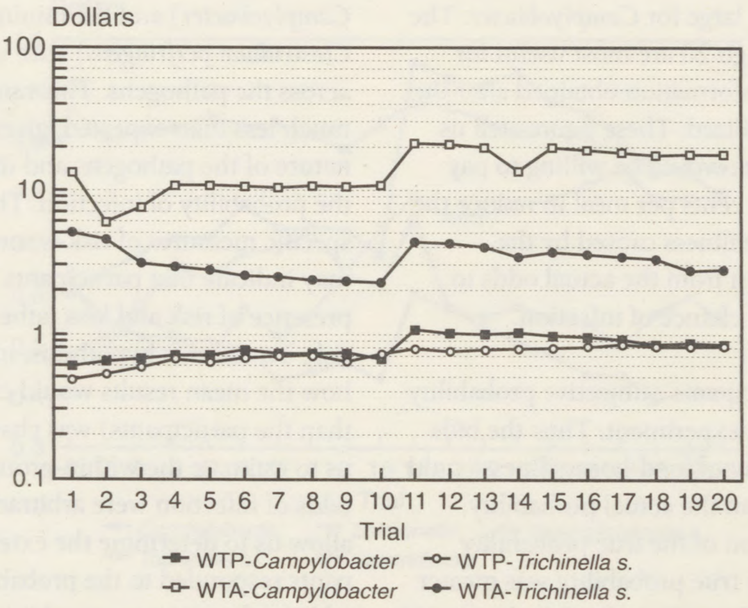

Figure 1. Comparison of WTP and WTA

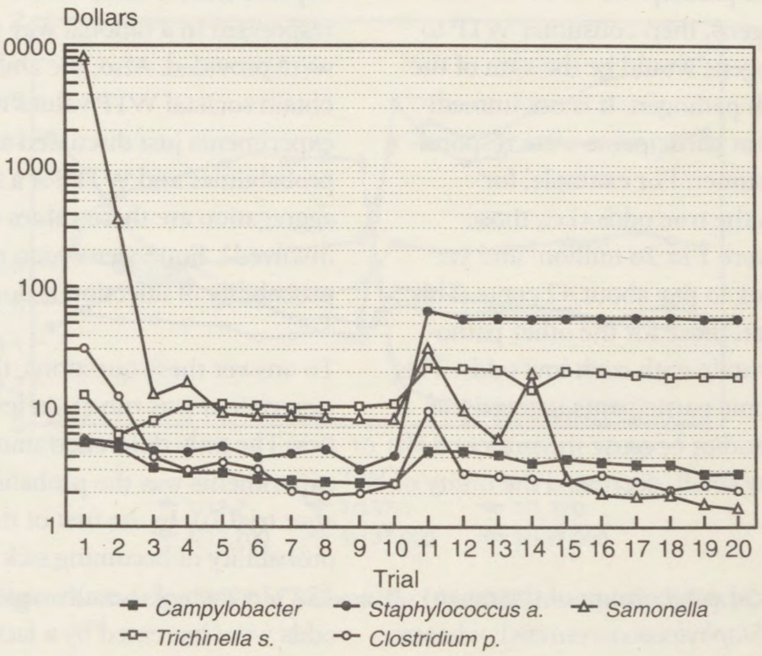

Figure 2. Comparison of average WTA (five foodborne pathogens)

increase was particularly large for *Camplyobacter*. The results for trials 17 through 20 are most useful for policy. The bids reflect information obtained after the bidding process had stabilized. These figures tell us that the typical participant would be willing to pay between 42 cents and 86 cents per meal to reduce the probability of food-borne illness caused by the presence of each pathogen from the actual odds to that of a 1 in 100 million chance of infection.

Information on the participants' subjective probability was obtained prior to the experiment. Thus the bids from perceived probability of food-borne illness could be compared to those from the actual probability. Interestingly, the provision of the true probability increased WTP when the true probability was greater than the subjective probability (i.e., *Camplyobacter, Salmonella,* and *Trichinella spiralis* experiments) and decreased WTP when the opposite was the case (i.e., *Clostridium perfringens*).

If it was assumed that the results for trials 17 through 20 accurately reflect the participants' WTP to eliminate each of the pathogens, then consumer WTP to eliminate all five pathogens would be the sum of the individual bids for each pathogen. It is not immediately clear, however, that participants were responding in such a logical manner. For example, for *Clostridium perfringens* the true odds (i.e., those reported for trial 11) were 1 in 26 million[1] and yet participants were willing to pay about 42 cents. This WTP value is lower than those for the other pathogens but not commensurate with such low odds. This may be true because some participants ignored the information provided and/or because the presence of any risk, no matter how small, decreased the utility of the product.

For trials 7 through 10, the maximum of the mean bids was 92 cents (for *Staphylococcus aureus*), whereas the minimum was 44 cents (for *Salmonella*). For trials 17 through 20, the maximum was 86 cents (for *Camplyobacter*) and the minimum was 42 cents (for *Clostridium perfringens*) with an average of 70 cents across the pathogens. This range in mean values is much less than expected, given the differences in the nature of the pathogens and the large differences in the probability of infection. This lack of response to specific measures of risk is somewhat troubling and may indicate that participants were responding to the presence of risk and loss rather than to the level of risk. To test this hypothesis, information is needed on how the mean results would change if nothing (other than the participants) was changed (this would allow us to estimate the within-group variability) and if the odds of infection were arbitrarily changed (this would allow us to determine the extent to which the participants responded to the probabilities we provided). To address these issues, an additional five experiments were conducted. These results are discussed in the next section.

The Generality of the Experimental Results

To derive meaningful policy implications from these experiments, it must be first assumed that people responded in a rational way to the probabilities that were provided. Also, the ability to aggregate values to obtain societal WTP values needs to be evaluated. The experiments just discussed accurately portrayed the probabilities and WTP for a single meal. Through aggregation are these values doubled if two meals are involved? Equivalently, do the values double if the probability of infection is doubled?

To answer these questions, the *Salmonella* WTP experiment was run at six levels of infection probabilities. The only difference among these *Salmonella* experiments was the probability information provided after trial 10. In the first of these experiments, the probability of becoming sick was provided as one in 13.7. In each of the subsequent experiments, these odds were increased by a factor of 10; that is, the second was 1 in 137, the third was 1 in 1370, and so on. Results are summarized in Figure 4. Notice the relatively wide range in WTP values before trial 11. All six of these experiments were identical in every way before trial 11. Any differences that exist prior to trial 11 can therefore be attributed to differences

[1]The odds reported for the stringently screened product were 1 in 100 million.

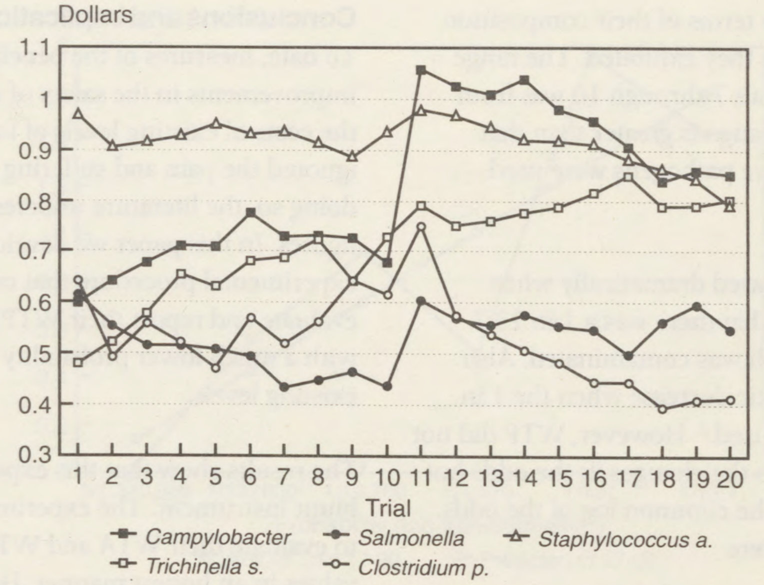

Figure 3. Comparison of average WTP (five foodborne pathogens)

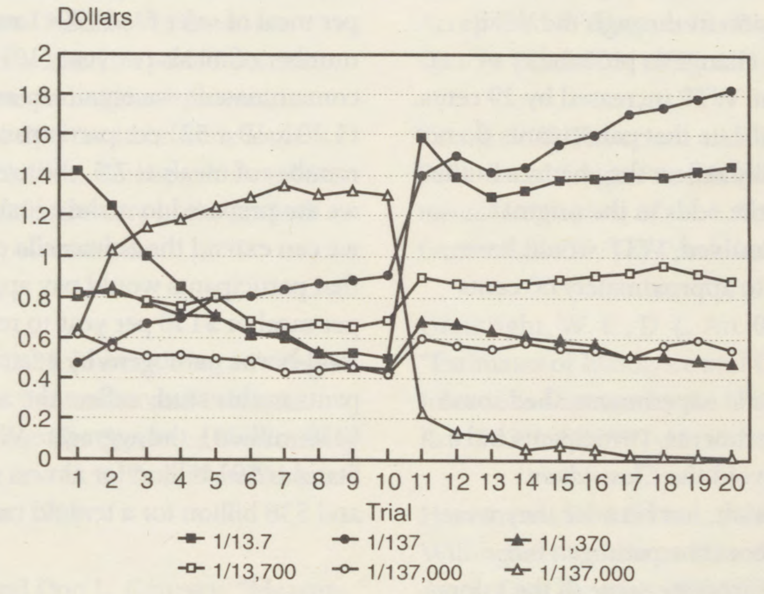

Figure 4. Average WTP of *Salmonella* (with different probability of illness)

among the six groups in terms of their composition and the group dynamics they exhibited. The range of the mean values at trials 7 through 10 was from 44 cents to $1.32. This range is greater than that obtained when alternative pathogens were used (see Figure 3).

As expected, WTP increased dramatically when participants discovered that there was a 1 in 13.7 chance that the sandwich was contaminated. Also expected was the dramatic decrease when the 1 in 1.37 million odds were used.[2] However, WTP did not increase in proportion to the changes in the odds but rather in proportion to the common log of the odds. The regression results were

$$\begin{aligned} WTP = \; & 1.920 + 0.2910\, LOG_{10}\,(\text{Probability}). \\ & (0.365) \quad (0.091) \end{aligned}$$

$R^2 = 0.72$

This regression is demonstrated in Figure 5, which shows a semi-log regression fit through the WTP results. For each tenfold change in probability of infection with *Salmonella,* WTP increased by 29 cents. These results seem to indicate that participants do not increase their WTP to fully reflect the changes in the odds. For example, had the odds in the original *Salmonella* experiment doubled, WTP would have increased from 55 cents to approximately 60 cents and not doubled to $1.10.

These additional *Salmonella* experiments shed some light on the original experiments. Participants bid a relatively high value to avoid the *Clostridium perfringens*-tainted sandwich, not because they were particularly concerned about the pathogen but because they failed to incorporate some of the information provided on incidence rates.

[2]In this case, the reported odds for the test product were greater than those for the stringently screened product, a feature that was not fully reflected in the bids until trial 17.

Conclusions and Implications for Policy

To date, measures of the benefits to society of further improvements in the safety of the food supply or of the costs of existing levels of food-borne illness have ignored the pain and suffering involved in being ill. In doing so, the literature underestimates the true figures. In this paper we develop and implement an experimental procedure that causes the participants to evaluate and report their WTP to purchase a meal with a much lower probability of contamination than existing levels.

The results show that this experimental method is a blunt instrument. The experiment forced participants to evaluate their WTA and WTP and to report these values in an honest manner. However, because the participant did not incorporate all the pathogen-specific information, one cannot interpret these results on a pathogen-by-pathogen basis.

If we take the **average**, across the five pathogens, WTP from trials 17 through 20 as a measure of the benefit per meal of safer food (70¢) and multiply this by the number of meals per year (10) that might possibly be contaminated[3], we obtain an average WTP of $364 ($.70 x 10 x 52) per participant per year. If the number of meals is 7.5, the average WTP is $273. If we are prepared to make equally heroic assumptions, we can extend the *Salmonella* experiments to indicate that participants would pay approximately 29 cents per meal or $150 per year to reduce existing levels of food-borne pathogens by a factor of 10. If the participants in this study reflect the average U.S. consumer (250 million), the aggregate WTP for the United States is $91 billion for almost complete elimination and $38 billion for a tenfold reduction.

[3]Not all meals are unsafe. Some meals are prepared at home in a foolproof fashion; others are not complex enough to contain pathogens (e.g., coffee). In the pretrial survey, we asked participants how many meat-based meals they ate per week. The average response was 7.5; therefore, for convenience we assume that only 10 meals per week might possibly be contaminated.

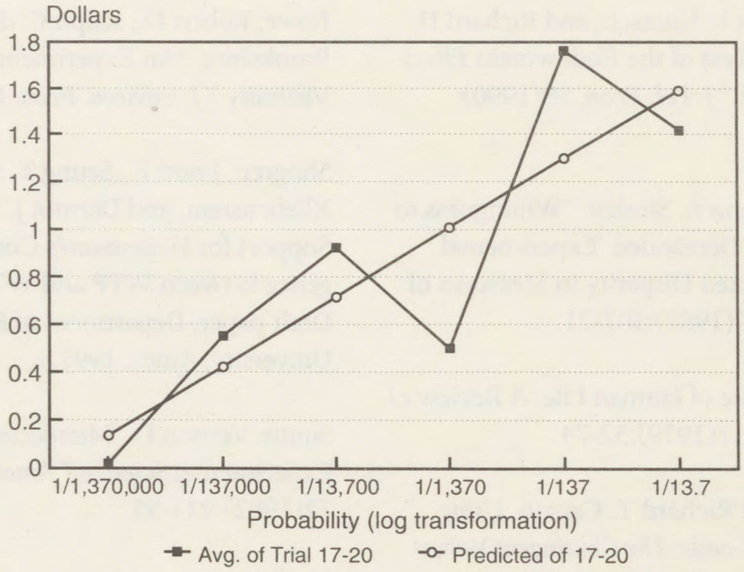

Figure 5. Average WTP of Salmonella (actual and regressed WTP values)

These figures are considerably greater than previous estimates and yet are based on a conservative interpretation of our experimental results. We have not attempted to measure how much it would cost to reduce or eliminate these pathogens; however, it seems likely that a great deal could be done for less than $38 billion to $91 billion. Perhaps this explains the current emphasis on food safety in the United States and other developed countries.

References

Bennett, John V., Scott D. Holmberg, Marta F. Rogers, and Steven L. Solomon. "Infectious and Parasitic Diseases." *Closing the Gap: The Burden of Unnecessary Illness,* ed. R. W. Amler and H. B. Dull. New York: Oxford University Press, 1987.

Brookshire, David S., and Don L. Coursey. "Measuring the Value of a Public Good: An Empirical Comparison of Elicitation Procedures." *Amer. Econ. Rev.* 77(1987):554-66.

Coursey, Don L. "Markets and the Measurement of Value." *Public Choice* 55(1987):291-7.

Coursey, Don L., John J. Hovis, and William D. Schulze. "The Disparity between Willingness to Accept and Willingness to Pay Measures of Value." *Quar. J. Econ.* 102(1987):679-90.

Cox, J. L., B. Roberson, and V. L. Smith. "Theory and Behavior of Single Price Auction." *Research in Experimental Economics,* ed. V. L. Smith, pp. 1-43, vol 2. Greenwich CT: JAI Press, Inc., 1982.

Garthright, W. E., D. L. Archer, and J. E. Kvenberg. "Estimates of Incidence and Costs of Intestinal Infectious Diseases in the United States." *Public Health Rep.* 103(1988):107-15.

Hanemann, W. Michael. "Willingness to Pay and Willingness to Accept: How Much Can They Differ?" *Amer. Econ. Rev.* 81(1991):635-47.

Hoffman, Elizabeth, and Matthew L. Spitzer. "Experimental Law and Economics: An Introduction." *Columbia Law Rev.* 85(1985):991-1025.

Kahneman, Daniel, and Amos Tversky. "Prospect Theory: An Analysis of Decision under Risk." *Econometrica* 47(1979):263-91.

Kahneman, Daniel, Jack L. Knetsch, and Richard H. Thaler. "Experimental Test of the Endowment Effect and the Coase Theorem." *J. Pol. Econ.* 98(1990): 1325-48.

Knetsch, Jack L., and John A. Sinden. "Willingness to Pay and Compensation Demanded: Experimental Evidence of an Unexpected Disparity in Measures of Value." *Quar. J. Econ.* 99(1982):507-21.

Linnerooth, J. "The Value of Human Life: A Review of the Models." *Econ. Inq.* 17(1979):52-74.

Mitchell, Robert C., and Richard T. Carson. *Using Surveys to Value Public Goods: The Contingent Valuation Method.* Washington DC: Resources for the Future, 1989.

Penner, Karen P., Carol S. Kramer, and Gary Lee Frantz. *Consumer Food Safety Perceptions.* Manhattan KS: Cooperative Extension Service, Kansas State University, 1985.

Roberts, Tanya. "Microbial Pathogens in Raw Pork, Chicken, and Beef: Benefit Estimates for Control Using Irradiation." *Amer. J. Agri. Econ.* 67(1985): 957-65.

____________. "Human Illness Costs of Food-borne Bacteria." *Amer. J. Agri. Econ.* 71(1989):468-74.

Rowe, Robert D., Ralph C. d'Arge, and David S. Brookshire. "An Experiment of the Economic Value of Visibility." *J. Environ. Econ. Manage.* 7(1980):1-19.

Shogren, Jason F., Seung Y. Shin, James B. Kliebenstein, and Dermot J. Hayes. "Experimental Support for Hanemann's Conjecture on the Divergence between WTP and WTA Measures of Value." Draft paper, Department of Economics, Iowa State University, Ames, 1991.

Smith, Vernon L. "Microeconomic Systems as an Experimental Science." *Amer. Econ. Rev.* 72(1982):923-55.

Todd, Ewen C. D. "Preliminary Estimates of Costs of Food-borne Disease in United States." *J. Food Prot.* 52(1989):595-601.

Van Ravenswaay, Eileen O. "How Much Food Safety Do Consumers Want? An Analysis of Current Studies and Strategies for Future Research." *Demands in the Marketplace: Public Policy in Relation to Food Safety, Quality and Human Health,* ed. Katherine L. Clancy, Washington DC: Resources for the Future, 1988.

Vickrey, William. "Counterspeculation, Auctions and Competitive Sealed Tenders." *J. Finance* 16(1961): 8-37.

Food Away from Home