Alternative Calibration and Auction Institutions for Predicting Consumer Willingness-to-Pay for Non-Genetically Modified Corn Chips

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Abstract

This study explores two important issues in experimental economics: calibration and auction institution. Consumer willingness-to-pay bids for corn chips made with non-genetically modified ingredients are elicited from a 1st price and 2nd price auction. Results suggest that responses to scale differential questions, in a survey, accurately predict consumer willingness-to-pay bids. The 2nd price auction induces a greater percentage of marginal bidders to offer a positive bid than a 1st price auction. However, average bid levels in the 1st and 2nd price auctions were not statistically different from one other. In a small and unrepresentative sample, 70 percent of student participants were unwilling to pay to exchange a bag of genetically modified corn chips for a bag of non-genetically modified corn chips. However, 20 percent of respondents were willing to pay at least $0.25/oz for the exchange.

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Experimental economics are increasingly being used to estimate consumer demand for newly developed food products (Buzby et al.; Fox et al.; Fox; Hayes et al.; Lusk et al.; Melton et al.; Roosen et al.; Shogren et al., 2000). Researchers are increasingly choosing experimental methods to gain perceived benefits relative to previously used contingent valuation methods. Because real products and real money are exchanged in an experimental setting, participants have a greater incentive to reveal their true value for a good than in a hypothetical survey setting (Fox et al.). Although experimental methods are increasingly used in applied research with general acceptance, several aspects of experimental methods merit further discussion.

The representativeness of experimental results is of non-trivial concern. Because experiments are often conducted in a laboratory setting with relatively few participants, results may not reflect the views of the entire population. In addition, only a particular type of consumer segment may be attracted to participate in a laboratory setting, resulting in potentially large sample selection bias. For these reasons, recent work by Fox et al. and List and Shogren have attempted to combine the advantages of survey methods (large samples, relatively small sample selection bias, and cost effectiveness) and experimental methods (choice accountability) by calibrating hypothetical willingness-to-pay values from a survey and actual willingness-to-pay values elicited in an experimental setting. By observing the extent that participants over-bid in hypothetical surveys relative to experimental auctions, actual willingness-to-pay values can be estimated for a larger sample of participants who did not participate in an experimental auction.

Of further interest to experimental economists is the auction mechanism used to elicit willingness-to-pay bids. Previous experimental auction research in agricultural economics has utilized a variant of the Vickrey 2nd price auction (Vickrey). In a Vickrey 2nd price auction, participants submit sealed bids for a product and the highest bidder wins the auction and pays the 2nd highest bid amount. This auction mechanism is frequently used because of its theoretical demand revealing properties (see Shogren et al. 1994b or Vickrey for a formal discussion of these properties). Although the 2nd price auction has several theoretical advantages over other auction mechanisms, these benefits may disappear in practice.

One problem with the 2nd price auction may be that participants do not necessarily realize, even when told, that their incentive is to bid their true maximum willingness-to-pay. Coppinger, Smith, and Titus (pg. 18) state, "Although the Second-Price auction provides an 'obvious' incentive for full value bidding based on a simple dominance criterion, real people may not perceive this property except through learning, reflection, or perhaps even training or conditioning." In addition, it has been shown that bid prices in 2nd price auctions may take considerable time to converge to their theoretically predicted value (Coppinger, Smith, and Titus) or do not converge to this "true" value at all (Kagel, Harstad, and Levin).[1] Thus, researchers interested in procedures where only one trial is conducted may find the 2nd price auction to be ineffective at revealing true willingness-to-pay. Other auctions, such as 1st price auctions, where the highest bidder pays their own bid price, may provide a good approximation for true maximum willingness-to-pay values because inexperienced participants may better understand the experimental procedure. Exploring alternative experimental auction methods is important when experiments are moved from laboratory environments to more familiar settings for the consumer, such as a grocery stores, where repeated trials are logistically more difficult

(e.g., Lusk et al. 1999a). Further, combining results from repeated-trial 1st and 2nd price auctions may yield more robust estimates of willingness-to-pay than 2nd price auctions alone.

This paper explores alternative calibration and auction mechanisms in an experiment with application to a timely topic: consumer willingness-to-pay for non-genetically modified corn chips. The paper proceeds as follows: a) issues surrounding production and consumption of genetically modified foods are introduced, b) literature regarding survey and experimental calibration is reviewed and an alternative calibration mechanism is discussed, c) theoretical and empirical properties of 1st and 2nd price auctions are reviewed, d) methods and procedures for the experimental design are outlined, e) results of the experiments are discussed, and f) implications and conclusions are presented.

Genetically Modified Foods

Genetically modified (GM) foods are made with crops that have been supplemented by foreign genes (Feldmann, Morris, and Hoisington). Although various degrees of plant and animal modification have occurred for years, new genetic engineering technologies are creating feed grains and oilseeds tolerant to pesticides, diseases, etc. These characteristics have promoted increased crop yields and production flexibility and consequently have resulted in high levels of acceptance among agricultural producers. When introduced in 1996, GM corn and soybeans comprised less than 2 and 8 percent, respectively, of total planted crop acres but accounted for 25 and 52 percent, respectively, of planted acreage by 2000 (USDA/NASS).

Despite the growth in production of GM grains and oilseeds, demand for foods produced from GM grains is uncertain (Miranowski et al.). Although it is thought that most U.S. consumers generally accept foods with GM ingredients, resistance is growing among some

consumer segments both domestically and internationally, particularly in the European Union. For example, in the fall of 1999, French activists and farmers protested a U.S. fast food chain not only because it sells food products made with GM ingredients, but also because it represents American's general acceptance of GM foods (Kluger). Foreign reluctance to accept GM foods threatens U.S. grain exports. If the EU continues its ban on GM grains, the U.S. grain industry may be compelled to segregate GM and non-GM grain. Further, some U.S. consumers are demanding labeling of products that are made with GM ingredients. Such identity preservation would increase costs for U.S. producers, processors, and grain merchants. In 1999, premiums from 8 to 15 cents/bu. for non-GM corn and 5 to 35 cents/bu. for non-GM soybeans were identified at the farm level in selected areas (Muirhead).

Demand for information concerning consumer premiums for non-GM foods has grown as the safety and nutritional characteristics of GM foods are increasingly being debated. Although scientific research indicates no safety differences between GM and non-GM foods, some consumers perceive dissimilarities, resulting in some food companies (e.g., Gerber and Heinz) purchasing only non-GM crops for their ingredients. Due to the relative infancy of this growing market, little economic research has quantified consumer willingness-to-pay for non-GM food products. This study offers an initial step in the valuation of non-GM foods by examining consumer willingness-to-pay for non-GM corn chips.

Experimental Calibration

Comparing willingness-to-pay values from hypothetical surveys with experimentally elicited willingness-to-pay bids allows for the calculation of a calibration factor. For example, Fox et al. (1998) found calibration factors in the range of 0.68 and 0.69 for consumer

willingness-to-pay for irradiated pork. This indicates that an individual, who indicated a willingness-to-pay value of $1.00 in a hypothetical survey, would actually pay about $0.68 in an experimental auction setting. However, Fox et al. also found asymmetries in the calibration factors (a calibration factor of 0.55 to 0.59 was calculated for consumer willingness-to-pay for non-irradiated pork), indicating that calibration factors may be good specific. List and Shogren found calibration factors in the range of 0.3 to 0.4 for baseball cards, further supporting the product specific nature of the calibration factors.[2]

Previous calibration research has compared respondents' willingness-to-pay values from experimental auctions with values obtained from an open ended hypothetical question. One drawback to this approach is that the relationship between willingness-to-pay values elicited via survey and consumers' "true" willingness-to-pay may be random and unpredictable. In other words, some participants may indicate values near their true willingness-to-pay value while others may provide willingness-to-pay values quite different from their true valuation. Of course, there may be more accurate ways of eliciting hypothetical willingness-to-pay values than an open-ended question format, such as the double bounded dichotomous choice framework (Hanneman, Loomis, and Kanninen) or a choice experiment (Adamowitz). However, all these elicitation procedures require participants to respond to hypothetical situations regarding their true willingness-to-pay for a product. Thus, respondents always have an incentive to under- or over-report their true valuation to gain some perceived economic surplus.

We propose using an indirect method of eliciting consumers' attitudes that may reflect their true valuation for a good more accurately than hypothetical willingness-to-pay questions. Scale differential questions provide a method of indirectly obtaining consumer preferences that may be calibrated with willingness-to-pay values.[3] These questions typically require respondents

to rank personal preferences or opinions over a pre-specified scale. For example, Lusk, Fox, and McIlvain compared concerns for food safety issues by asking consumers to rank their degree of concern for bacterial contamination, spoilage, food irradiation, additives, etc. on a scale between one and five, where one was "not concerned at all" and five was "very concerned." As with other survey methods, responses to such scale differential questions may be acquired relatively inexpensively and may be subject to relatively less sample selection bias than experiments.

Calibration using scale differential questions may provide advantages over hypothetical willingness-to-pay questions. First, consumers may find scale differential questions easier to answer than an open ended willingness-to-pay question. Further, because economic valuations are not directly tied to scale questions, respondents have less incentive to misrepresent their true preferences for a good. Therefore, responses to hypothetical scale differential questions may more closely approximate consumers' true willingness-to-pay than hypothetical willingness-to-pay questions. As a result, we formulate the following maintain hypothesis:

$$\sum_{i=1}^{N}\left(P_i - P_i^*\right)^2 \geq \sum_{i=1}^{N}\left(S_i - S_i^*\right)^2 \qquad (1)$$

where P_i is the i^{th} consumer's response to a hypothetical willingness-to-pay question, P_i^* is the consumer's true willingness-to-pay (elicited via experimentation), S_i is the consumer's response to a hypothetical scale differential question, and S_i^* is the consumer's true attitude, as represented on a scale. If we fail to reject the hypothesis, then scale differential questions may predict actual willingness-to-pay values more accurately than hypothetical willingness-to-pay questions. However, the hypothesis in equation 1 is not directly tested (there is no feasible way to estimate S^*), rather, we only estimate the ability of scale differential questions to predict actual willingness-to-pay values.

Auction Mechanism

Several methods are available to conduct experimental auctions. As previously mentioned, Vickrey's 2nd price auction has received much attention in the agricultural economics literature. Notable alternatives to this auction are the English, Dutch, and 1st price sealed bid auctions.[4] Vickrey discusses, in some detail, the theoretical strategic equivalence between English and 2nd price auctions and between the Dutch and 1st price auctions. Theoretically, the advantage of using an English or 2nd price auction is that a participant's dominant strategy is to bid their true maximum willingness-to-pay. However, in a 1st price or Dutch auction, participants are essentially involved in a game where they must choose a balance between 1) winning the auction and 2) gaining economic surplus when they submit a bid. Vickrey shows that if bidders are homogenous, risk neutral, and draw their values from a known rectangular distribution, then the Nash equilibrium bid, b_i, offered in a Dutch or 1st price auction is:

$$b_i = \left(\frac{N-1}{N} \right) v_i \qquad (2)$$

where N is the number of bidders and v_i is the bidder's true value for the good. Obviously, as the number of bidders increases, the bid value approaches the true value.

Several studies have attempted to compare respondent behavior in alternative auction settings to test Vickrey's equivalency hypotheses, but conflicting results have been found. Using induced values, Coppinger. Smith, and Titus found that bids in English and 2nd price auctions were similar, however, Dutch and 1st price bids diverged. They also found that 1st price bids tended to be greater than Dutch, 2nd price, and English bids. Cox, Smith, and Walker also found 1st price bids to be greater than the predicted Nash equilibrium bidding behavior suggested by Vickrey. They attributed much of the divergence from theory to risk averse bidding behavior and generalized Vickrey's results to allow for risk aversion. In contrast, Harrison attributed the

divergence of empirical 1st price bids from theoretical values to heavily debated "pay-off dominance" problems. He argued that the participant's pay-off function is flat in the area of the optimal bid and they consequently have poor incentives to bid optimally. In contrast, Lucking-Reiley found, in Internet auctions, that revenues generated via Dutch auctions were significantly higher than 1st price auctions.

Vickrey 2nd price auctions also appear to violate theoretical predictions. Although the 2nd price and English auctions have been found to be isomorphic in some studies, Kagel, Harstad, and Levin and Kagel and Levin found a tendency for both experienced and inexperienced participants to "over bid" in 2nd price auctions. They determined that a 2nd price auction yielded higher bids than a 1st price auction. While Coppinger, Smith, and Titus, and Cox, Smith, and Walker observed 2nd price values below predicted theoretical values, Kagel, Harstad, and Levin and Kagel and Levin found 2nd price values above predicted theoretical values. In all four studies, 2nd price auctions either required several repeated trials to converge to the predicted theoretical value, or never converged at all.

No doubt much of the debate regarding the divergence of 1st and 2nd price auctions from theoretically predicted values depends upon the assumed behavior of auction participants, as well as the particular experimental design. In the case of independent private values and risk neutrality, revenues from 1st and 2nd price auctions should be theoretically equivalent. In practice, there are a wide variety of results from various auction mechanisms. When selecting an appropriate auction mechanism to elicit participants' true willingness-to-pay, all auction mechanisms involve the exchange of real money and real products and thus more accurately reveal a consumer's true preferences than a hypothetical survey. Although the 2nd price auction theoretically elicits participants' maximum willingness-to-pay, 1st price auctions may aid in

predicting future premiums in the marketplace. Because research indicates that participants may overbid in a 2nd price auction and that bid values are less than true values in a 1st price auction (although somewhat higher than the predicted Nash equilibrium), perhaps results from 1st and 2nd price auctions may generate lower and upper bounds for true willingness-to-pay values. First-price auctions still reflect a premium that consumers' paid in an experiment and thus may reflect a lower or upper bound, depending upon participant's risk preference and perception of other participant values, on what they will pay for the good in the marketplace. Therefore, we compared two sealed bid auctions, a 1st and 2nd price auction, to value non-GM corn chips. This study: a) contributes to the sparse literature comparing 1st and 2nd price auctions where private values are not known (i.e. participants are not assigned induced values), b) calculates lower and upper bounds for consumer willingness-to-pay for non-GM corn chips, and c) compares bids from the two auction formats across trials to determine which auction may perform best with inexperienced bidders when repetitious trials are infeasible.

Methods and Procedures

Consumer valuation for non-GM corn chips was measured using two sealed bid auctions, a 1st and 2nd price auction. Students enrolled in two sections of a junior/senior level agricultural economics class at a large midwestern university comprised the participants for both treatments. Initially, participants were requested to complete a short survey in which they provided demographic information and answer several scale differential questions regarding their preference and concern for GM foods. Following completion of the survey, a candy bar auction was conducted to familiarize participants with the experimental procedure.

In both the 1st and 2nd price auctions, participants were endowed with one dollar and a one-ounce bag of corn chips identified as manufactured with GM corn. Participants were informed that consumption of the bag of chips was mandatory upon completion of the auction. In each auction, five trials were conducted and participants were asked to indicate their maximum willingness-to-pay to exchange their bag of GM corn chips for a bag of corn chips not made with GM corn. Following each trial, the winning bidder number and market price were announced. At the end of the session, one of the five trials was randomly selected as the binding trial and the highest bidder in that trial paid the appropriate bid amount to receive the bag of corn chips identified as free of GM corn. In the 2nd price auction, the highest bidder paid the second highest bid price. However, the highest bidder in the 1st price auction paid the highest bid (i.e. his or her own bid price).

A number of methods may be used to econometrically examine the impacts of scale differential questions and auction mechanisms on willingness-to-pay bids from an experiment. Some participants may bid nothing to exchange a GM food for a non-GM food, resulting in zero willingness-to-pay. In this case, bids are represented by a positive distribution truncated at zero. The double hurdle model was used to estimate willingness-to-pay because it allows for different determinants of zero bids and positive bids (Cragg). The first hurdle, represented by a probit model, is the respondents' decision to pay a positive amount for the exchange. If P_i is the i^{th} consumer's bid for the exchange, the probability of the respondent choosing not to bid a positive amount, ($P_i = 0$), is given by:

$$\text{Prob}\,(P_i = 0) = \Phi(-b_1^{'} x_i) \qquad (3)$$

where Φ is the standard normal distribution function, x_i is a vector of consumer i's economic and demographic characteristics, and b_1 is a vector of coefficients. The second hurdle determines the

effect of independent variables on P_i given that $P_i > 0$. The distribution of P_i conditional on being positive is truncated at zero with mean $b_2' x_i$ and variance σ^2. The second hurdle is formulated as:

$$f\left(P_i \mid P_i > 0\right) = \frac{\left(1/s\right)\ f\left[\left(P_i - b_2' x_i\right)/s\right]}{\Phi\left(b_2' x_i / s\right)} \tag{4}$$

where f is the standard normal density function and b_2 is a vector of coefficients. This specification of the double hurdle model assumes that error terms in equations 3 and 4 are independent and normally distributed.

To examine the relationship between scale differential questions and willingness-to-pay bids, several variables were incorporated into x_i in equations 3 and 4. Parameter estimates corresponding to particular scale differential questions are useful for assessing the ability of the scale to predict actual purchases. Further, dummy variables were included to estimate the impact of the alternative auction mechanisms on the probability a participant would have a positive bid, as well as the bid level, given a positive bid.

Results

There were thirty-two participants in the 2nd price auction and 18 participants in the 1st price auction.[5] Table 1 reports descriptive statistics for both treatments. Participant characteristics were fairly homogeneous across both treatments although there were a greater percentage of female participants in the 1st price auction.

Scale Differential Questions

Survey responses for several scale differential questions are also reported in table 1. The first scale differential question polled respondents regarding their feelings for GM foods on a

scale between one and ten, where one was "good" and ten was "bad." The mean response for both treatments was near eight, indicating little objection to GM foods. In the second scale differential question, participants indicated their willingness to purchase GM foods. The scale ranged between one (not at all willing) and ten (very willing to purchase GM foods). Both groups expressed a strong willingness to purchase GM foods.

The remainder of the scale differential questions focused on individuals' concern for food safety issues such as use of genetic engineering/biotechnology, fat, cholesterol, bacteria, and use of growth hormones in livestock. Participants characterized their concern on a scale of one to ten where one was "not at all concerned" and ten was "very concerned." 1st price auction participants tended to indicate slightly more concern for food safety issues than participants in the 2nd price auction, however the differences are not statistically different. Participants in both treatments indicated that genetic engineering/biotechnology was of only slight concern among the food safety issues. The seemingly high level of acceptance of GM products, as indicated in the scale questions, reflects the selected survey sample. All students were from midwestern towns, enrolled in an agricultural major, and many students were from a farm background. Given the nature of the sample, it is likely that the participants would be more accepting of GM foods than the general population.

The value of scale questions rests with its ability to predict consumer willingness-to-pay values. Multiple criteria were considered to evaluate which scale questions to include in the econometric model. Ideally, all three GM related scale questions could be used to predict willingness-to-pay bids. However, because the scale questions were highly correlated, only one was included in the model. Initially, the correlation between each of the scale questions (GM feel, GM willing, and GM concern) and WTP and PAY was calculated. GM concern was most

highly correlated with both WTP and PAY. The models specified in equations 3 and 4 were estimated with WTP and PAY as dependent variables and included each of the three scale questions as independent variables. T-tests and F-tests for joint significance revealed that, among the three GM scale questions, the GM concern variable was the most economically and statistically significant determinant for WTP and PAY. The remaining discussion is limited to results pertaining to the GM concern variable; however, similar results were found for the GM feel and GM willing variables.[6]

Results from the estimation of equations 3 and 4 are presented in table 2. The dependent variables, WTP and PAY, were constructed by averaging bids from trials 4 and 5. The scale variable, GM concern, was highly significant in explaining both the probability a participant would pay a positive amount and the amount they would pay for non-GM corn chips. A one-unit increase in the level of concern for GM food is associated with an 8.6 percent increase in the probability that an individual offers a positive bid, *ceteris paribus*. Thus, an individual who indicated a high level of concern for GM food (scale value = 8) would be over 50% more likely to pay to avoid GM corn chips as an individual with little concern for GM foods (scale value = 2). Given that an individual offered a positive bid, a one-unit increase in the level of concern for GM foods was associated with a $0.058 increase in the bid level. The sign and statistical significance of the GM concern variable indicates that that survey responses can be used to predict actual willingness-to-pay values (i.e. survey results can be calibrated to experimental results). For example, if a respondent indicated a GM concern level of 8, our calibration results suggest that there is over a 70 percent chance they would submit a positive bid. This same individual, assuming that a positive bid was given, would bid $0.34.[6]

Auction Format

Figure 1 illustrates participants' willingness-to-pay for non-GM corn chips by treatment group. In the 2nd price auction, more participants were willing to pay a positive amount relative to the 1st price auction. Only three participants in the 1st price auction indicated a positive willingness-to-pay in the 4th and 5th trials. However, 2nd price auction participants demonstrated willingness-to-pay at several increasing price premiums. The 2nd price auction appears to motivate a larger percentage of marginal bidders to bid some small amount as compared to the 1st price auction.

Figure 2 presents the average bid levels for both auctions across each of the 5 trials. Average bid levels differed between by over $0.03/oz. in trials 1 and 2 but appeared to converge in trials 4 and 5. However, the difference between bid levels in the two auction formats is not statistically different at any of the five trials. Average bids were fairly consistent across all trials for the 1st price auction but were relatively variable over the trials for the 2nd price auction. This suggests that a "learning curve" was associated with the 2nd price auction while participants in the 1st price auction did not require repeated trials to understand the process. Thus, "one-shot" auctions may produce more valid results when a 1st price auction format is used. In fact, the average bids in trials 1 and 5 were identical in the 1st price auction.

Results of the double hurdle model lend additional insight into the impact of auction mechanism on participant bids (table 2). The auction format was significant in determining the probability of paying for non-GM corn chips. Participants in the 2nd price auction were 50 percent more likely to pay for the exchange than participants of the 1st price auction. This may imply that the 2nd price auction is more proficient than the 1st price auction in motivating marginal bidders (those that may not win the auction) to bid their true willingness-to-pay values.

The auction format, however, did not significantly impact the average level of the bids. Estimates of the 2nd hurdle indicate that the 1st price auction may have produced lower bids relative to the 2nd price auction, but this difference was not statistically significant. Thus, from a statistical standpoint, there is no advantage in using the demand revealing Vickrey 2nd price auction as opposed to the 1st price auction, if the average bid is the only statistic of concern. In this particular application, both auctions produced equivalent average bids although the distributions of bids were not identical.

Willingness-to-Pay for Non-Genetically Modified Corn Chips

Figure 3 illustrates willingness-to-pay bids for non-GM corn chips among all participants in both treatments, measured as the average of trials 4 and 5. Seventy percent of participants were not willing-to-pay for non-GM corn chips. The average bid to exchange a bag of GM corn chips for non-GM corn chips was $0.07/oz. Although the majority of participants did not wish to pay for non-GM corn chips, a number of individuals indicated a relatively large willingness-to-pay to exchange the corn chips made with GM corn. Twenty percent of participants were willing-to-pay at least $0.25/oz. for the exchange and two percent of participants offered bids as high as $0.50/oz. This indicates a potentially viable niche market for non-GM chips. Based on these results, a standard bag of corn chips made with non-GM corn could capture a sizeable premium among particular consumer groups.

Results from the double hurdle model indicate that participant demographics have an impact on willingness-to-pay values. Gender and hometown population, as well as the health variables (Fat Concern and Exercise), had little influence on the probability that an individual would pay to avoid chips made from GM corn. However, the frequency of chip consumption significantly affected the probability of paying for non-GM chips. Results indicate that for a

one-unit increase in chip consumption, consumers are 20 percent less likely to pay for chips made with non-GM corn. Results of the truncated regression (i.e. the second hurdle) suggest that chip consumption and exercise are significant determinants of the amount consumers are willing to pay to avoid chips made with GM corn. The most significant determinant of willingness-to-pay values was participants' level of exercise. Although exercise does not affect a consumer's decision to pay for non-GM chips, it is significant in determining the amount consumers will pay for non-GM chips. An increase in the amount of exercise increases bids for non-GM chips by $0.34/oz. Consumers with higher levels of chip consumption are significantly less likely to pay for non-GM corn chips. This may imply that individuals who frequently consume chips made from GM corn are less averse to the perceived risks associated with GM foods.

Conclusions and Implications

This study addressed two relevant issues concerning experiments conducted in agricultural economic research: improving the representativeness of experimental results and the practical validity of auction mechanisms. We use a small and unrepresentative sample of students to estimate the demand for non-genetically modified (GM) foods. We found that scale differential questions, where participants ranked their level of concern for GM foods on a scale of 1 to 10, provided accurate predictions of participant willingness-to-pay bids. Scale questions were statistically significant in explaining both the probability that an individual will offer a bid as well as the bid level to exchange a bag of chips made with GM corn for a bag of chips made without GM corn. Thus, hypothetical surveys with scale differential questions administered to a large sample may potentially be used to estimate consumer willingness-to-pay using calibration factors found in laboratory settings. Future research should be directed at comparing the relative

ability of scale questions, hypothetical open-ended questions, and other contingent valuation methods to predict willingness-to-pay values in experimental auctions.

Choice of auction format may have important implications for experimental studies. Due to its theoretical demand revealing properties, the Vickrey 2nd price auction has been the auction mechanism of choice for agricultural economists. However, other auction formats may perform relatively well in practice. Previous research has indicated that 2nd price auctions may produce results inconsistent with theoretical predictions. In this study, a 1st price auction was conducted and results were compared across auction format. We found that a larger percentage of participants offered positive bids in the 2nd price auction, indicating that marginal bidders, who have little chance of winning, may be more inclined to state their true willingness-to-pay in a 2nd price auction as opposed to a 1st price auction. However, bid levels across auction formats were not statistically different. Thus, from a practical standpoint, the 1st and 2nd price auctions produced virtually identical average bids after several trials. Participants seemed to have better *a priori* understanding of the 1st price auction mechanism, as bid levels remained relatively constant across all 5 trials. However, 2nd price auction bids varied and appeared to converge to 1st price bid levels after 3 trials. Since our sample is small and results may be product specific, we cannot conclude, with a large degree of confidence that 1st and 2nd price auctions will always produce identical average bid levels. In the future, the relative comparisons between the 1st and 2nd price auctions should be compared in a larger number of experiments to evaluate the robustness of the results presented here. Useful extensions of this research should focus on comparing the relative performance of the English and Dutch auctions, in addition to the 1st and 2nd price auctions. The English and 2nd price auctions should theoretically produce identical results because the dominant strategy in both auctions is to bid full value regardless of risk

orientation. It is curious that the English auction, which is potentially more understandable than the 2nd price auction, is demand revealing, and has performed extremely well in previous studies, has not been used in applied experimental studies to value non-market food items.

The continuing development and controversy surrounding GM foods necessitates the need for information regarding consumer willingness-to-pay for segregation between GM and non-GM food products. In a small and unrepresentative sample, we found that the majority of experiment participants were unwilling to pay a premium for non-GM corn chips. However, twenty percent of consumers bid $0.25/oz. or more in order to exchange their GM chips for non-GM chips. Although our sample was limited, inferences about the general population can be made. It is reasonable to believe that relative to the general public, participants in our sample may have more favorable opinions towards GM foods given their educational background and geographic location. If experiments were conducted with a larger and potentially more representative sample, we would expect a larger percentage of participants to bid and bid at higher levels. The extent to which our results represent a lower bound on consumer willingness-to-pay for non-GM chips is uncertain. A safe assumption however is that a viable, albeit somewhat small, niche market may be willing-to-pay a large premium for non-GM corn chips.

Footnotes

[1]Shogren et al. (1994b) used a Vickrey n^{th} price auction to encourage marginal bidders to bid their true value. In addition Shogren et al. (2000), have shown that the willingness-to-pay/willingness-to-accept disparity converges more quickly with a random n^{th} price auction than in a 2^{nd} price auction. However, in their settings, not only are the true willingness-to-pay values of the items unknown, but it is also unknown how long it takes the values to converge to their true value, if at all.

[2]Blackburn, Harrison, and Rutstrom and Harrison et al. have also studied calibration of hypothetical and real valuations. Their studies are somewhat more complex in that they estimate bias functions to correct for cross commodity comparisons and free-rider problems.

[3]The term calibration, as it is used here, simply implies that scale differential questions may serve as a predictor of actual willingness-to-pay values.

[4]In an English auction, participants offer ascending bids until only one participant, the one with the highest bid, is left in the auction. This participant then pays the high bid. In a Dutch auction, a "clock" begins by reporting bids at an arbitrarily high value. Over time, the and bids descend incrementally. The first participant to "signal" an acceptance of a bid, wins the auction and pays the bid amount.

[5]Results of the Vickrey auction should be invariant to sample size because the dominant strategy should be to bid full value regardless of other participant values. Fox et al. found that 2^{nd} price auction bids were invariant to sample size. In our experimental design, the sample size may influence results in the 1^{st} price auction. A larger number of participants in the 1^{st} auction (i.e. 30 or 40) would likely produce bids that more closely resemble true values than an auction with a small number (i.e. 15 or 20) of individuals (see equation 2). We chose to conduct the 1^{st} price

auction with the smaller sized class to determine whether strategic bidding behavior in the 1st price auction produced results different from the 2nd price auction where the true willingness-to-pay should theoretically be revealed. Although our total sample is small, other research has produced useful results from a group of 50 to 100 students (Busby et al.; Fox).

[6]Estimates using GM willing and GM feel are available from the authors.

[7]Estimates are calculated using the mean values of the independent variables.

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Table 1. Survey Summary Statistics

Variable	Definition	2nd Price Auction	1st Price Auction
Gender	1 = female; 0 otherwise	0.212[a] (0.415)[b]	0.444 (0.511)
Age	Age in years	21.297 (1.944)	20.611 (0.698)
Population	Hometown population (thousands)	17.314 (86.672)	36.933 (91.170)
Eat Chips	Number of times chips consumed per week	1.500 (1.329)	0.653 (0.959)
Exercise	1 = exercise on regular basis; 0 otherwise	0.545 (0.501)	0.888 (0.428)
GM feel[c]	1 = bad; 10 = good	7.939 (1.694)	7.778 (1.665)
GM willing[d]	1 = not at all willing; 10 = very willing	8.667 (1.291)	8.000 (1.782)
GM concern[e]	1 = not at all concerned; 10 = very concerned	3.182 (1.776)	3.833 (2.203)
Fat concern[e]	1 = not at all concerned; 10 = very concerned	5.636 (2.434)	6.389 (2.330)
Cholesterol concern[e]	1 = not at all concerned; 10 = very concerned	5.121 (2.342)	5.278 (2.321)
Bacteria concern[e]	1 = not at all concerned; 10 = very concerned	8.818 (1.261)	8.833 (1.383)
Hormone concern[e]	1 = not at all concerned; 10 = very concerned	3.091 (1.627)	3.889 (2.398)
WTP	Willingness-to-pay ($/oz) – trial 4 and 5 average	0.071 (0.122)	0.068 (0.164)
PAY	1 = positive bid; 0 = zero	0.375 (0.492)	0.167 (0.383)

Note: there were 32 participants in the 2nd price auction and 18 participants in the 1st price auction
[a]Mean value of variable
[b]Numbers in parentheses are standard deviations
[c]Survey question asked, "How do you feel about genetically modified foods?"
[d]Survey question asked, "How willing are you to purchase genetically modified foods?"
[e]Survey question stated, "Indicate your level of concern for the following food safety issues."

Table 2. Double Hurdle Model – Determinants of Consumer Willingness to Pay for Non-Genetically Modified Corn Chips

Variable	1st Hurdle Probability of Paying[a]	2nd Hurdle Amount Paid
Constant	-0.290*[b]	-0.090
	(0.168)[c]	(0.133)
Gender	-0.193	-0.020
	(0.147)	(0.069)
Population	0.001	0.000
	(0.000)	(0.000)
Fat Concern	0.032	0.010
	(0.033)	(0.022)
Eat Chip[d]	-0.195**	-0.215**
	(0.082)	(0.060)
Exercise	0.059	0.342**
	(0.143)	(0.095)
GM concern	0.086**	0.058**
	(0.039)	(0.026)
1st price auction[e]	-0.512**	-0.142
	(0.168)	(0.110)
Sigma[f]		0.079**
		(0.015)

Dependent variables were calculated by averaging trial 4 and 5 bids
Number of observations = 50
Log likelihood of 1st hurdle = -20.7; Log likelihood of 2nd hurdle = -20.08
Percentage of correct predictions in 1st hurdle = 76%

[a]Estimates are marginal effects

[b]One and two asterisks indicate statistical significance at the 0.10 and 0.05 levels, respectively.

[c]Numbers in parenthesis are standard errors

[d]Eat Chip= number of times corn chips consumed per weeek.

[e]1st price auction = 1 if participant was in 1st price auction, 0 if in 2nd price auction

[f]Sigma is the disturbance standard deviation

Figure 1 - Distribution of Consumer Willingness-to-Pay Bids for Non-Genetically Modified Corn Chips, by Treatment

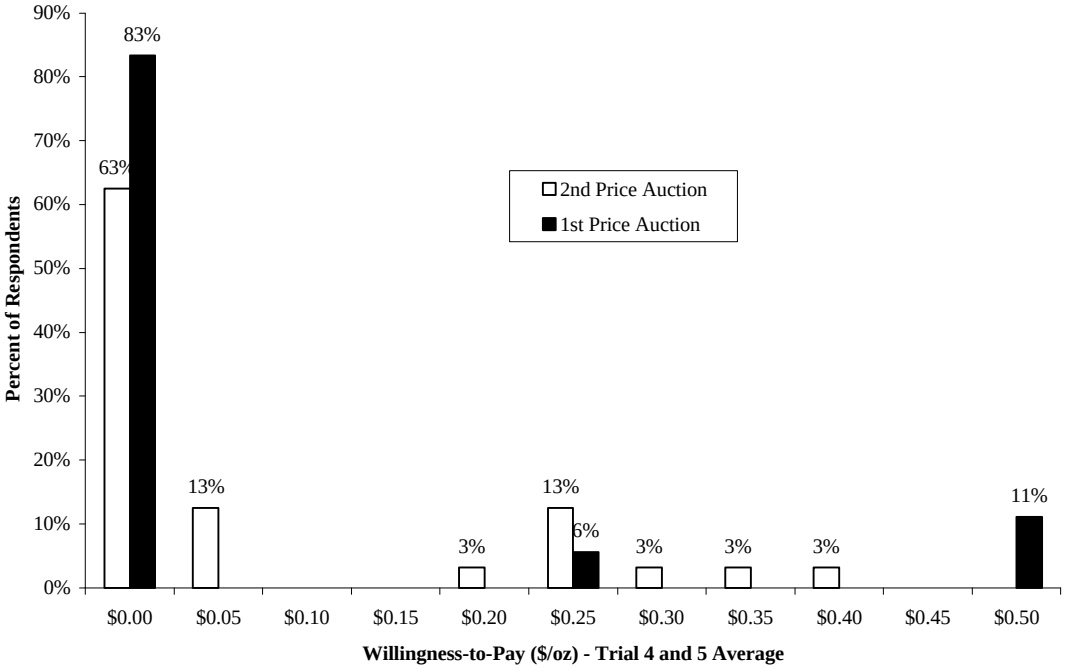

Figure 2 - Average Consumer Willingness-to-Pay for Non-Genetically Modified Corn Chips by Experimental Trial

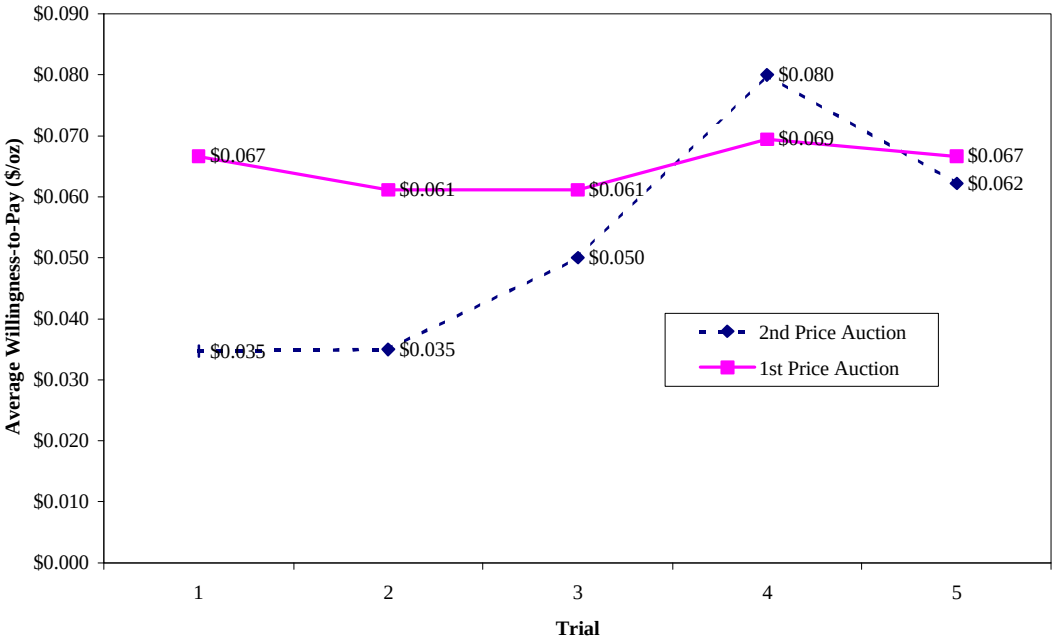

Figure 3 - Distribution of Consumer Willingness-to-Pay Bids for Non-Genetically Modified Corn Chips