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Alternative Calibration and Auction Institutions for Predicting Consumer Willingness to Pay for Nongenetically Modified Corn Chips

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

Key words: calibration, consumer demand, experimental auctions, genetically modified foods, GMO, willingness to pay

Introduction

Economic analyses are increasingly using experimental economics 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, List, and Hayes). Researchers are more frequently 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 widely used in applied research with general acceptance, several issues merit further discussion.

The representativeness of experimental results is of nontrivial concern. Because experiments are often conducted in a laboratory setting with relatively few participants, results may not reflect views of the entire population. In addition, only a particular type of consumer segment may be attracted to participate in a laboratory setting, resulting

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in potentially large sample selection bias. For these reasons, recent works by Fox et al., List and Shogren (1998), and others 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 to actual willingness-to-pay values elicited in an experimental auction setting. By observing the extent to which participants overbid 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.

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

One significant problem is observed with the second-price auction: Participants may not necessarily realize, even when told, that their incentive is to bid their true maximum willingness to pay. As noted by Coppinger, Smith, and Titus, "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" (p. 18). In addition, bid prices in second-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 second-price auction to be ineffective at revealing true willingness to pay.

Other auctions, such as a first-price auction, where the highest bidder pays his/her 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 (e.g., grocery stores), where repeated trials are logistically difficult (Lusk et al.). Further, combining results from repeated trial first- and second-price auctions may yield more robust estimates of willingness to pay than second-price auctions alone.

This study explores alternative calibration and auction mechanisms in an experiment with application to a timely topic: consumer willingness to pay for nongenetically modified corn chips. The remaining sections of the article proceed as follows: (*a*) introduction of issues surrounding production and consumption of genetically modified foods, (*b*) discussion of literature regarding survey and experimental calibration and introduction of an alternative calibration mechanism, (*c*) review of theoretical and empirical properties

[1] Shogren et al. (1994) used a Vickrey *n*th-price auction to encourage marginal bidders to bid their true value. In addition, Shogren et al. (2000) have shown the willingness-to-pay/willingness-to-accept disparity converges more quickly with a random *n*th-price auction than in a second-price auction. However, in these 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 they converge at all.

of first- and second-price auctions, (*d*) outline of methods and procedures for the experimental design, (*e*) presentation of results of the experiments, and (*f*) implications and conclusions.

Genetically Modified Foods

Genetically modified (GM) foods are produced with crops that have been supplemented with 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 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%, respectively, of total planted crop acres, but grew correspondingly to 25% and 52% of planted acreage in 2000 (U.S. Department of Agriculture/National Agricultural Statistics Service).

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 believed 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 (EU). 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 Americans' 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 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¢/bushel for non-GM corn and 5¢ to 35¢/bushel for non-GM soybeans were identified at the farm level in selected areas (Muirhead).

Demand for information concerning consumer premiums for non-GM foods is growing as the safety and nutritional characteristics of GM foods are being debated with increased frequency. Although scientific research to date indicates no safety differences between GM and non-GM foods, some consumers perceive dissimilarities, prompting some food companies (e.g., Gerber and Heinz) to purchase 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

Calibration is fast becoming a topic of interest because of the growing evidence that people respond differently in hypothetical and real settings (i.e., hypothetical bias) (Cummings, Harrison, and Rutström; Loomis et al.; Neill et al.). Several years ago, the National Oceanic and Atmospheric Administration (NOAA) suggested simply reducing hypothetical bids by one-half to estimate actual willingness to pay for damage assessment (U.S. Department of Commerce/NOAA). Since that time, literature regarding calibration

has increased steadily.[2] Blackburn, Harrison, and Rutström estimated a statistical bias function to examine how well consumer demographics predicted actual responses to dichotomous-choice questions. With limited success, they used the statistical bias functions to correct for hypothetical bias across commodities. Champ et al. and Blumenschein et al. also compared hypothetical and real responses in a dichotomous-choice framework. In a hypothetical setting, they asked participants how sure they were about their YES/NO contingent valuation answer (a certainty scale). They found that YES responses accompanied with a reply of "very certain" on a certainty scale could be used to accurately predict actual responses. In a similar dichotomous-choice study, Johannesson et al. estimated a statistical bias function using participant demographics and responses to a certainty scale to predict actual responses. After calibration using the estimated statistical bias function, they could not reject hypothetical and real response equivalence.

In a more direct fashion, Fox et al.; List, Margolis, and Shogren; and List and Shogren (1998) calibrated bids from hypothetical open-ended willingness-to-pay questions and hypothetical auctions to bids in nonhypothetical auctions. Fox et al. reported calibration factors in the range of 0.68 to 0.69 for consumer willingness to pay for irradiated pork. Based on this finding, an individual who indicated a willingness-to-pay value of $1 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 nonirradiated pork), suggesting calibration factors may be good specific. List and Shogren (1998) reported calibration factors in the range of 0.3 to 0.4 for baseball cards using hypothetical and real second-price auctions. List, Margolis, and Shogren also found calibration factors to be product specific because hypothetical bias varied significantly across commodities. Recent research has also begun to focus on calibration of willingness-to-accept values (List and Shogren 2001).[3]

Previous calibration research has compared respondents' willingness-to-pay values from experimental auctions with values obtained from (*a*) open-ended hypothetical willingness-to-pay questions, (*b*) hypothetical dichotomous-choice questions, or (*c*) hypothetical auctions.[4] One drawback to these approaches is that the relationship between willingness-to-pay values elicited via survey or hypothetical experiment 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, whereas others may provide willingness-to-pay values quite different from their true valuation. These

[2] Much of the calibration literature implicitly assumes that results from nonhypothetical experiments accurately predict behavior in retail or policy settings. Shogren et al. (1999) found nonhypothetical experiments may not accurately predict behavior in a retail grocery store. Horowitz and McConnell also express such concerns. However, the nonhypothetical experiment we report here differs substantially from those reported in Shogren et al. (1999) and Horowitz and McConnell; we estimate maximum willingness-to-pay values rather than have consumers respond to dichotomous-choice questions. Without further study, we cannot be certain the experiment reported here is subject to the same criticism.

[3] There is a growing literature regarding the use of "cheap talk" to alleviate hypothetical bias (Cummings and Taylor; List). In such studies, the problem of hypothetical bias is discussed at great length with participants (thus the terminology "cheap talk") before a hypothetical bid is elicited. There is evidence to suggest extensive amounts of "cheap talk" can alleviate hypothetical bias for some, but not all goods (Cummings and Taylor; List). However, "cheap talk" may fail to eliminate hypothetical bias if (*a*) subjects are very familiar with the good in question (List), or (*b*) only small amounts of "cheap talk" are administered (Cummings, Harrison, and Taylor; Poe, Clark, and Schulze).

[4] The relative ability of hypothetical willingness-to-pay values elicited via an open-ended question format (Fox et al.), the double-bounded dichotomous-choice framework (Hanneman, Loomis, and Kanninen), a choice experiment (Adamowitz et al.), or hypothetical auctions (List and Shogren 1998) to predict actual values in a nonhypothetical setting is an issue open for debate.

elicitation procedures require participants to respond to hypothetical situations regarding their true willingness to pay for a product. Thus, respondents 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 which 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.[5] These questions typically require respondents to rank personal preferences or opinions over a prespecified 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 five-point scale, where 1 = "not concerned at all" and 5 = "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 laboratory 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 open-ended willingness-to-pay questions or hypothetical auctions. 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 other hypothetical elicitation procedures. Based on this assumption, we formulate the following maintained hypothesis:

$$(1) \qquad \frac{\sqrt{(P_i - P_i^*)^2}}{P_i^*} \geq \frac{\sqrt{(S_i - S_i^*)^2}}{S_i^*},$$

where P_i is the ith consumer's response to a hypothetical willingness-to-pay question, P_i^* is the consumer's true willingness to pay (elicited via experimental auction), 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. The two measures are similar to the coefficient of variation because they compare the relative variability of a subject's stated versus true preference.

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 or hypothetical auctions. However, the hypothesis in equation (1) is not directly tested (there is no feasible way to estimate S_i^*); rather, we estimate only the ability of scale-differential questions to predict actual willingness-to-pay values.

Auction Mechanism

Several auction institutions are available to elicit consumers' "homegrown" values.[6] As previously mentioned, Vickrey's second-price auction has received much attention in agricultural economics literature. Notable alternatives to this auction are the English,

[5] 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.

[6] Homegrown values refer to the values subjects bring into an experiment, which are not induced by the experimenter.

Dutch, and first-price sealed bid auctions.[7] Under conditions of risk neutrality and independent private values, Vickrey discusses in some detail the theoretical strategic equivalence between English and second-price auctions and the strategic equivalence between Dutch and first-price auctions. Theoretically, the advantage of utilizing an English or second-price auction to estimate neoteric product values is that the participants' dominant strategy is to bid their true maximum willingness to pay. In contrast, in a first-price or Dutch auction, participants are essentially involved in a game where they must choose a balance between (*a*) winning the auction, and (*b*) gaining economic surplus when they submit a bid. Vickrey showed that if bidders are independent, homogeneous, risk neutral, and draw their values from a known uniform distribution, then the Nash equilibrium bid, b_i, offered in a Dutch or first-price auction is:

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

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

Several studies have compared respondent behavior in alternative auction settings to test Vickrey's equivalency hypotheses, and conflicting results have been reported. Using induced values, Coppinger, Smith, and Titus found that bids in English and second-price auctions were similar, whereas Dutch and first-price bids diverged. They also observed a tendency for first-price bids to be greater than Dutch, second-price, and English bids. Likewise, Cox, Smith, and Walker reported first-price bids to be greater than predicted Nash equilibrium bidding behavior suggested by Vickrey. They attributed much of the divergence from theoretical predictions to risk-averse bidding behavior and generalized Vickrey's results to allow for risk aversion. In contrast, Harrison attributed the divergence of empirical first-price bids from theoretical values to heavily debated "pay-off dominance" problems. Because consumers' pay-off function is flat in the area of the optimal bid, Harrison argued participants consequently have poor incentives to bid optimally. Conversely, in Internet auctions, Lucking-Reiley found revenues generated via Dutch auctions were significantly higher than those of first-price auctions.

Vickrey second-price auctions also appear to violate theoretical predictions. Although second-price and English auctions have been found to be isomorphic in some studies, Kagel, Harstad, and Levin, and Kagel and Levin, noted a tendency for both experienced and inexperienced participants to "overbid" in second-price auctions. They determined second-price auctions yielded higher bids than first-price auctions. While Coppinger, Smith, and Titus, and Cox, Roberson, and Smith, observed second-price values below predicted theoretical values, Kagel, Harstad, and Levin, and Kagel and Levin, in less restrictive studies, found second-price values above predicted theoretical values. In all four studies, second-price auction bids either required several repeated trials to converge to predicted theoretical values or never converged at all.

When a good is unfamiliar or novel to subjects, such as the case with non-GM foods, the potential for bidder affiliation exists in experiments with repeated trials and market information (List and Shogren 1999). Affiliation exists when high values for one

[7] 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 bids descend incrementally. The first participant to "signal" an acceptance of a bid wins the auction and pays the bid amount.

individual imply that other individuals also have high values (Milgrom and Weber). In this case, bidders' values are private, but not independent. When bids are affiliated, the theoretical predictions provided by Vickrey fail to hold. Milgrom and Weber illustrated that under risk neutrality, English and second-price auctions should theoretically yield higher revenues than Dutch or first-price auctions. However, in the presence of risk aversion, no clear prediction can be made regarding the relative rankings of bids in first- and second-price auctions (Milgrom and Weber). Milgrom and Weber also showed that when information is introduced to bidders, expected auction revenue should increase.

In a study conducted by Kagel, Harstad, and Levin, some of the theoretical predictions suggested by Milgrom and Weber failed to hold in practice (notably the divergence of the second-price and English auction bids). List and Shogren (1999) report that posted prices in repeated experimental trials can cause bidders' values to become affiliated. They found affiliation existed in second-price auctions for novel, but not familiar goods. However, the influence of affiliation on median bids was small; posted prices increased median willingness-to-pay bids by 1%.

Much of the debate regarding the divergence of first- and second-price auctions from theoretically predicted values likely 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 first- and second-price auctions should be theoretically equivalent. In practice, there is a wide variety of results from various auction mechanisms. In an experimental setting, all auction mechanisms involve the exchange of real money and real products, and thus more accurately reveal a consumer's true preferences relative to a hypothetical survey. Although the second-price auction theoretically elicits participants' maximum willingness to pay, first-price auctions may aid in predicting future premiums in the marketplace.

Because research indicates participants may overbid in a second-price auction, and bid values are less than true values in a first-price auction (although somewhat higher than the predicted Nash equilibrium), results from first- and second-price auctions may generate lower and upper bounds for true willingness-to-pay values. First-price auctions still reflect a premium paid by consumers in an experiment, and thus may reflect a lower or upper bound (which is dependent on the participant's risk preference and perception of other participants' values) on true willingness-to-pay bids.

Given the auction mechanisms and properties considered above, we utilize first- and second-price auctions to value non-GM corn chips. This study contributes to the sparse literature comparing first- and second-price auctions where private values are not known (i.e., participants are not assigned induced values). In the discussion that follows, we calculate lower and upper bounds on consumer willingness to pay for non-GM corn chips, and investigate the relative stability of first- and second-price auction bids across five repeated trials.

Methods and Procedures

Consumer valuation for non-GM corn chips was measured using first- and second-price sealed bid auctions. Students enrolled in two sections of a junior/senior-level agricultural economics class at Kansas State University comprised the participants for both treatments. Initially, participants were asked to complete a short survey in which they provided demographic information and answered 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 first- and second-price auctions, participants were endowed with $1 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 produced 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 second-price auction, the highest bidder paid the second-highest bid price. However, the highest bidder in the first-price auction paid the highest bid (i.e., his or her own bid price).

Because the first- and second-price auctions were conducted with two different samples, it is important to control for participant-specific characteristics across treatments to accurately determine the effect of auction institution on willingness-to-pay bids. Regression analysis is an appropriate tool to accomplish this task. In this case, we are interested in estimating the impact of participant characteristics, auction institution, and GM scale questions on willingness-to-pay bids. We expect some participants might not be willing to bid to exchange GM chips for non-GM chips, resulting in zero willingness to pay, whereas others bid some positive amount. In this instance, bids are represented by a positive distribution truncated at zero.

The double-hurdle model is used to estimate the impact of the aforementioned factors on willingness-to-pay bids because it allows for different determinants of zero and positive bids. Thus, it is more general than the frequently used tobit model (Cragg). The first hurdle is the respondents' decision to pay a positive amount for the exchange. If P_i is the ith consumer's bid for the exchange, the probability of the respondent choosing not to bid a positive amount ($P_i = 0$) is given by:

$$\text{Prob}(P_i = 0) = \Phi(-\beta_1'\mathbf{x}_i), \tag{3}$$

where Φ is the cumulative standard normal distribution function, $\mathbf{x}_i$ is a vector of consumer i's economic and demographic characteristics, and β_1 is a vector of coefficients.

The second hurdle determines the effect of independent variables on P_i, given $P_i > 0$. The distribution of P_i conditional on being positive is truncated at zero with mean $\beta_2'\mathbf{x}_i$ and variance σ^2. The second hurdle is formulated as:

$$f(P_i|P_i > 0) = \frac{(1/\sigma)\phi\left[(P_i - \beta_2'\mathbf{x}_i)/\sigma\right]}{\Phi(\beta_2'\mathbf{x}_i/\sigma)}, \tag{4}$$

where ϕ is the standard normal density function, and β_2 is a vector of coefficients. This specification of the double-hurdle model assumes error terms in equations (3) and (4) are independent and normally distributed.[8]

[8] A statistical test, proposed by Lin and Schmidt, indicates preference of the double-hurdle model over the tobit model for our particular data. Further, independence of the errors in equations (3) and (4) is supported by (*a*) calculation of simple correlation (−0.05), and (*b*) statistical insignificance of the inverse Mills ratio in the truncated regression when the model is estimated in a Heckman sample selection framework in which the two errors are correlated (see Greene for further detail).

It is common practice to incorporate participant demographics into models to predict consumer willingness-to-pay values. For example, Blackburn, Harrison, and Rutström; Cummings and Taylor; Fox; Fox et al.; Roosen et al.; Rutström; and Shogren et al. (1999), among others, include some combination of the following demographic factors as explanatory variables: age, gender, education, income, marriage status, race, household size, and/or presence of children in the household.

In this study, the respondent population was comprised of a fairly homogeneous group of students. Thus, many of the typical demographic variables, such as age, education, income, and marriage status, were excluded from the analysis since they would contribute little explanatory power to the model due to the lack of variability across participants and across treatments. This practice is common in other studies using student participants (e.g., Fox).

Because we were unable to examine differences across traditional demographics, other variables were incorporated into the model. Following Fox; Roosen et al.; and Shogren et al. (1999), we include information about participant consumption habits (amount of chips consumed each week), attitudes about the product (concern for fat and GM products), and health-related information (amount of exercise per week). These variables are likely to vary across participants and have the potential to influence willingness to pay for non-GM corn chips. Further, hometown population, a quasi-demographic variable, was added to the model because residents of rural areas (who potentially have more interaction with production of GM crops) likely have different preferences for GM foods than residents of more urban areas. Last, scale-differential questions about GM foods and an auction dummy variable were incorporated into $\mathbf{x}_i$ in equations (3) and (4) to test hypotheses regarding calibration and auction institutions.

Results

There were 32 participants in the second-price auction and 18 participants in the first-price auction.[9] Table 1 reports descriptive statistics for both treatments. Participant characteristics were fairly homogeneous across both treatments, although there was a greater percentage of female participants in the first-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 about GM foods (*GM_FEEL*) on a scale between 1 and 10, where 1 = "bad" and 10 = "good." The mean response for both treatments was near 8, indicating little objection to GM foods. In the second scale-differential question, participants indicated their willingness to purchase GM foods (*GM_WILLING*). The scale ranged from 1 (not at all willing) to 10

[9] Theoretically (as shown by Vickrey) and empirically (as shown by Fox et al.), second-price auction bids are invariant to sample size because the dominant strategy is to bid full value regardless of other participant values. In our experimental design, the sample size may influence results in the first-price auction. A larger number of participants in the first-price auction would likely produce bids more closely resembling true values than an auction with a small number of individuals [see equation (2)]. We chose to conduct the first-price auction with the smaller sized class to determine whether strategic bidding behavior in the first-price auction produced results different from the second-price auction where the true willingness to pay should theoretically be revealed.

Table 1. Survey Summary Statistics

Variable	Definition	Mean Value of Variable: Second-Price Auction (N = 32)	Mean Value of Variable: First-Price Auction (N = 18)
GENDER	1 = female; 0 otherwise	0.212 (0.415)	0.444 (0.511)
AGE	Age in years	21.297 (1.944)	20.611 (0.698)
POPULATION	Hometown population (000s)	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	Respondent's feeling about genetically modified foods: 1 = bad; 10 = good	7.939 (1.694)	7.778 (1.665)
GM_WILLING	Willingness to purchase genetically modified foods: 1 = not at all willing; 10 = very willing	8.667 (1.291)	8.000 (1.782)
GM_CONCERN	Concern about genetically modified foods: 1 = not at all concerned; 10 = very concerned	3.182 (1.776)	3.833 (2.203)
FAT_CONCERN	Concern about fat: 1 = not at all concerned; 10 = very concerned	5.636 (2.434)	6.389 (2.330)
CHOLES_CONCERN	Concern about cholesterol: 1 = not at all concerned; 10 = very concerned	5.121 (2.342)	5.278 (2.321)
BACTERIA_CONCERN	Concern about bacteria: 1 = not at all concerned; 10 = very concerned	8.818 (1.261)	8.833 (1.383)
HORMONE_CONCERN	Concern about hormones: 1 = not at all concerned; 10 = very concerned	3.091 (1.627)	3.889 (2.398)
WTP	Willingness to pay ($/oz.), average of trials 4 and 5	0.071 (0.122)	0.068 (0.164)
PAY	1 = positive bid; 0 = no bid	0.375 (0.492)	0.167 (0.383)

Note: Numbers in parentheses are standard deviations.

(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 1 to 10, where 1 = "not at all concerned" and 10 = "very concerned." First-price auction participants tended to indicate slightly more concern for food safety issues than their counterparts in the second-price auction; however, the differences are not statistically significant. Participants in both treatments indicated genetic engineering/biotechnology was of only slight concern. The seemingly high level of acceptance of GM products, as identified in responses to the scale questions, reflects the selected survey sample. All students were from midwestern towns, enrolled in an agricultural major, and many students had a farm background. Given the nature of the sample, it is likely these participants would be more accepting of GM foods than the general population.

The value of a scale question is a function of its ability to predict consumer willingness-to-pay values. Multiple criteria were considered when evaluating 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. As revealed by *t*-tests and *F*-tests for joint significance, the *GM_CONCERN* variable was the most economically and statistically significant determinant for *WTP* and *PAY* among the three GM scale questions. The remaining discussion is limited to results using the *GM_CONCERN* variable; however, similar (albeit less significant) results were found for the *GM_FEEL* and *GM_WILLING* variables.[10]

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 he/she 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% increase in the probability 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 than an individual with little concern for GM foods (scale value = 2). Given 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. Based on the sign and statistical significance of the *GM_CONCERN* variable, survey responses may 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 there is over a 70% chance a positive bid would be submitted. This same individual, assuming a positive bid was given, would bid $0.34.[11]

Auction Format

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

Figure 2 presents the average bid levels for both auctions across each of the five trials. Average bid levels differed by over $0.03/oz. in trials 1 and 2, but appeared to converge in trials 4 and 5. However, the difference between average bid levels in the two auction formats is not statistically different at any of the five trials. Average bids were

[10] Estimates using *GM_WILLING* and *GM_FEEL* are available from the authors on request.

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

Table 2. Estimation Results of Double-Hurdle Model: Determinants of Consumer Willingness to Pay for Nongenetically Modified Corn Chips

Variable[a]	First Hurdle Probability of Paying[b]	Second Hurdle Amount Paid ($)
Constant	-0.290*	-0.090
	(0.168)	(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_CHIPS[c]	-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)
FIRST-PRICE AUCTION[d]	-0.512**	-0.142
	(0.168)	(0.110)
σ (disturbance standard deviation)		0.079**
		(0.015)
Log Likelihood	-20.7	-20.08
Correct Predictions (first hurdle) = 76%		
Number of Observations = 50		

Notes: Single and double asterisks (*) denote statistical significance at the 0.10 and 0.05 levels, respectively. Numbers in parentheses are standard errors.

[a] Dependent variables were calculated by averaging trial 4 and trial 5 bids.

[b] Estimates are marginal effects.

[c] *EAT_CHIPS* = number of times corn chips are consumed per week.

[d] *FIRST-PRICE AUCTION* = 1 if participant was in first-price auction, 0 if in second-price auction.

fairly consistent across all trials for the first-price auction, but were relatively variable over the trials for the second-price auction. This implies a "learning curve" was associated with the second-price auction, whereas participants in the first-price auction did not require repeated trials to understand the process. Thus, "one-shot" auctions with only one trial may produce more stable results when a first-price auction format is used. In fact, the average bids in trials 1 and 5 were identical in the first-price auction.

The relative stability of the bids can also be examined in the context of bidder affiliation. List and Shogren (1999) reported that announcement of market prices at the conclusion of each trial can cause bidder values to become affiliated. When bidder values are affiliated, announcement of prices should increase bid levels (Milgrom and Weber). Because first-price bids in our study are relatively stable across all five auction periods, either (*a*) bidders' values were not affiliated, or (*b*) bidders followed some risk-averse Nash equilibrium or ad hoc bidding strategy. However, the hypothesis that the average bids in trials 1 and 5 are equal is rejected ($p = 0.09$) for the second-price auction. Thus, we cannot rule out affiliation as a possible explanation for the increase in bids over the five second-price auctions. Perhaps some auction institutions may be more susceptible to bidder affiliation than others.

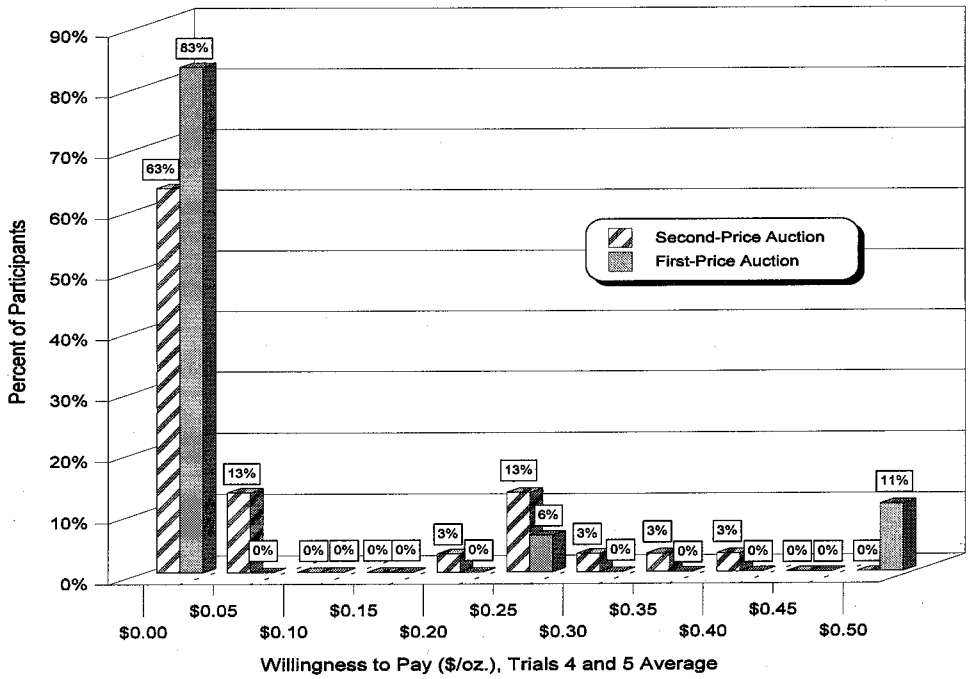

Figure 1. Distribution of consumer willingness-to-pay bids for nongenetically modified corn chips, by treatment

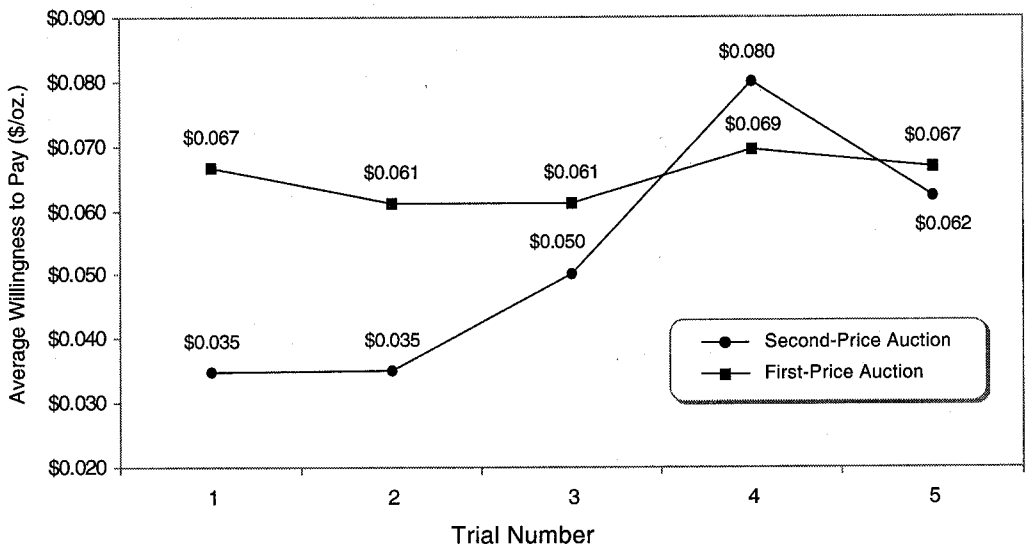

Figure 2. Average consumer willingness to pay for nongenetically modified corn chips, by experimental trial

Results of the double-hurdle model lend additional insight into the impact of the 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 second-price auction were 50% more likely to pay for the exchange than participants in the first-price auction. This may indicate the second-price auction is more proficient than the first-price auction in motivating marginal bidders (those who 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 from the second hurdle show the first-price auction may have produced lower bids relative to the second-price auction, but this difference was not statistically significant. With a larger sample size, average willingness-to-pay bids across the two auctions may differ due to the larger number of small positive bids in the second-price auction. In this particular application, both auctions produced equivalent average bids, although the distributions of bids were not identical.

Willingness to Pay for Nongenetically 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 unwilling 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 2% offered bids as high as \$0.50/oz. This finding reveals a potentially viable niche market for non-GM chips.[12]

As observed from the double-hurdle model results, 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 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. For a one-unit increase in chip consumption, participants are 20% less likely to pay for chips made with non-GM corn. Results of the truncated regression (the second hurdle) identify chip consumption and exercise as significant determinants of the amount consumers are willing to pay to avoid chips made with GM corn. While 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. Students who exercised on a regular basis were willing to pay \$0.34/oz. more than those who did not regularly exercise. Participants reporting higher levels of chip consumption are significantly less likely to pay for non-GM corn chips. This finding may imply that individuals who frequently consume chips made from GM corn are less averse to the perceived risks associated with GM foods.

[12] A portion of the estimated premium for non-GM corn chips could be related to preference learning. Preference learning occurs when subjects bid for an item because they want to learn about an unfamiliar good they have not previously consumed. Shogren, List, and Hayes found preference learning was the main source for high premium in novel goods (such as irradiated pork), but not for familiar goods (such as candy bars and mangos). Given the nature of our sample (students from midwestern and mostly rural agricultural backgrounds), GM corn chips may not be as unfamiliar or novel as it may first appear. Thus, a premium due to preference learning potentially exists, but may be relatively small. Even if preference learning had a large impact on our results, the estimated values can be viewed as the premium for an initial purchase of non-GM chips, but may not be interpreted as the value achievable with repeated purchases.

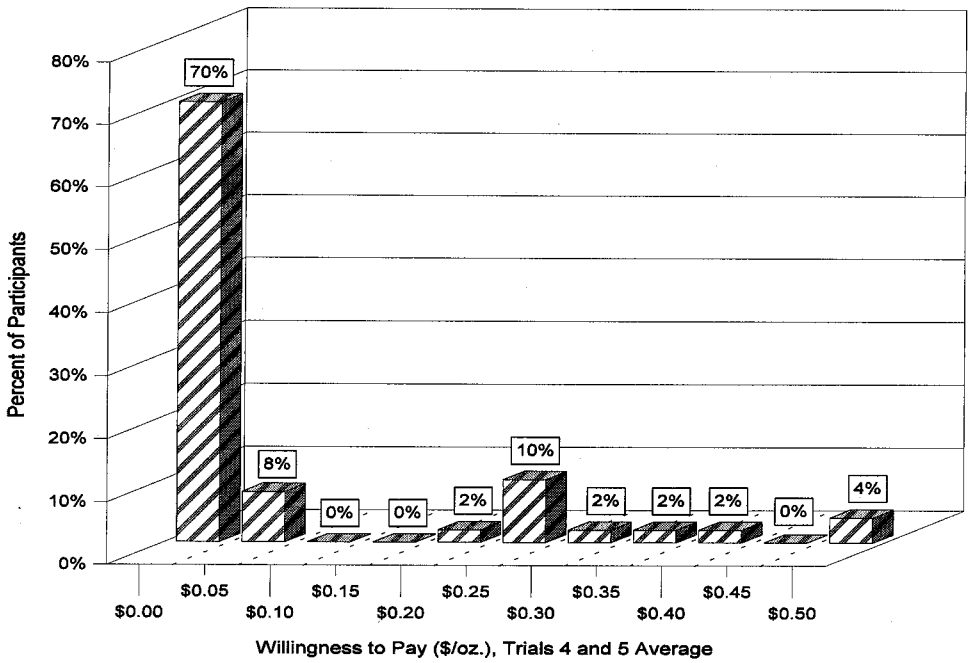

Figure 3. Distribution of consumer willingness-to-pay bids for nongenetically modified corn chips

Conclusions and Implications

This study has addressed two relevant issues concerning experiments conducted in agricultural economics research: improving the representativeness of experimental results and the practical validity of auction mechanisms. We used a small and unrepresentative sample of students to estimate the demand for a nongenetically modified food. Based on our findings, 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 offered 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 of individuals potentially may be used to estimate consumer willingness-to-pay values 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 second-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 shown second-price auctions may produce results inconsistent with theoretical predictions. In this study, both a first- and second-price auction were conducted, and results were compared

across auction format. We found a larger percentage of participants offered positive bids in the second-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 second-price auction as opposed to a first-price auction. However, average bid levels across auction formats were not statistically different.

Participants seemed to have better a priori understanding of the first-price auction, as bid levels remained relatively constant across all five trials. Conversely, second-price auction bids varied across trials. The increase in second-price bids over the five trials is likely due either to increased market experience (learning) or to affiliation among bidder values. After three trials, average bids across the two auction formats were similar. Because our sample was small and results may be product specific, we cannot conclude with a great deal of confidence that first- and second-price auctions will always produce identical average bid levels. In future analyses, the relative comparisons between first- and second-price auctions should be examined using 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 English and Dutch auctions, in addition to first- and second-price auctions in a field setting. The English and second-price auctions should theoretically produce identical results because the dominant strategy in both auctions is to bid full value regardless of risk orientation. Interestingly, the English auction—which is potentially more understandable than the second-price auction, is demand revealing, and has performed extremely well in previous studies—has not been used in applied experimental studies to value nonmarket food items. Another useful extension of this research would be to examine the impact of bidder affiliation, potentially caused by announcement of market prices in repeated trials, across alternative auctions.

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 our small and unrepresentative study sample, the majority of experiment participants were unwilling to pay a premium for non-GM corn chips. However, 20% of consumers bid \$0.25/oz. or more in order to exchange their GM chips for non-GM chips. Because non-GM chips are a novel good, the estimated willingness-to-pay values may only reflect the premium consumers will pay for an initial purchase (Shogren, List, and Hayes). Premiums for repeat purchases may be somewhat less.

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 toward 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 to 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.

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