Modeling Unobserved Consumer Heterogeneity in Experimental Auctions: A Censored Random Parameters Approach

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Selected poster prepared for presentation at the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting Washington, DC, August 4-6, 2013

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INTRODUCTION

- Data collected using experimental auctions often contain multiple bids from the same respondent for multiple products or treatments. Previous experimental auction studies have used different approaches to model the bids to account for the panel structure of the data, including pooled linear regression, and linear and nonlinear fixed effects and random effects models. However, a key limitation in these panel data models is the assumption that the regression coefficients are constant.

- Random Parameters models have been used more recently in the literature to fully account for unobserved individual heterogeneity given that they allow flexible modeling of within-cluster correlation. McAdams et al. (2013) and Yue et al. (2010) estimate Random Parameters Linear models. They found individual heterogeneity, indicating a correlation between the multiple bids submitted by the same participant. Yet, both studies failed to account for the censoring structure of the data. While many of the applications of random parameters have used the linear regression framework, there exists a growing literature on nonlinear models with random parameters (Greene 2004).

- This article examines the importance of accommodating unobserved individual heterogeneity in the coefficients and the censoring nature of the data collected in experimental auctions with multiple bids per respondent. We show the usefulness of the Random Parameters Tobit model by applying it to a non-hypothetical sealed-bid second price auction conducted to elicit consumers' valuation of specialty melons, tasting treatments, and food safety certification programs.

OBJECTIVES

- To suggest the use of a Random Parameters Tobit Model in the analysis of experimental auction data to account for bid censoring and extend the measurement of individual heterogeneity to other parameters in the bid equation, while maximizing the sample size when a within-subjects experimental design is chosen.
- To use and compare different estimation methods including Constant Parameters Tobit, Random Effects Tobit, Random Parameters Linear, and Random Parameters Tobit models.
- To value consumer preferences for government-sponsored or industry-sponsored food safety certification programs in specialty melons.

REFERENCES

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METHODS

A non-hypothetical Vickrey sealed-bid second price auction was used. The participants were representative consumers (nonstudents) recruited from Central Texas. Eight sessions were conducted during three days, with a total of 172 participants.

Experiment Design

1. Learn how bids are submitted
2. Learn how prices and buyers of the auction are determined
3. First practice round
4. Short knowledge quiz
5. Second practice round
6. Non-hypothetical auction rounds for fruit products
   - Tasting (between)
   - Industry-based Food Safety Certification Label – Global GAP (within)
   - Government-based Food Safety Certification Label – FSMA (within)
7. Determine auction buyers
8. Receive payment

Econometric models

The experimental auction consisted of bids with the maximum willingness-to-pay (WTP) for multiple goods $j = 1, \dots, J$ and multiple rounds $s = 1, \dots, S$, by each participant $i = 1, \dots, N$. For a given individual i, the Random Parameters Tobit specification is:

$$WTP_i = \max\{0, WTP_i^*\}$$
$$WTP_i^* = a\eta_i + x_{1,i}\beta_i + x_{2,i}\theta + e_i$$

$$\eta_i = \bar{\eta} + u_i \text{ and } \beta_i = \bar{\beta} + \alpha_i$$

$$E(\alpha_i) = 0, E(\alpha_i\alpha_j') = \Delta = \begin{bmatrix} \sigma_{1,1}^2 & \cdots & \sigma_{1,k} \\ \vdots & \ddots & \vdots \\ \sigma_{k,1} & \cdots & \sigma_{k,k}^2 \end{bmatrix} \text{ if } i = j \text{ or } E(\alpha_i\alpha_j') = 0 \text{ if } i \neq j$$

where WTP_i^* is a $(S \times J) \times 1$ vector of latent values of the dependent variable
u_i represents the deviation of the mean intercept for the group of observations submitted by individual i (η_i) from the grand mean or the mean of the intercepts for the observations submitted by all individuals $(\bar{\eta})$
α_i is a vector that indicates individual-specific deviations of the mean coefficients vector (β_i) from the set of grand mean coefficient values $(\bar{\beta})$
θ is a vector of coefficients that are constant for all bidders
Δ is the variance-covariance matrix associated with the K random covariates

The term of the likelihood function corresponding to the censored observations is a cdf that can include up to $(S \times J)$ integrals, i.e. if all bids reported by i are censored at zero. Because it does not have a closed form solution, the model is estimated using Simulated Maximum Likelihood Estimation (SMLE). The Simulated log-likelihood for all participants is:

$$\ln(\tilde{L}) = \sum_{i=1}^{N} [\ln(l_i^{uc}) + \ln(\tilde{l}_i^{c})]$$

RESULTS

- A likelihood ratio test rejected the hypothesis of a nested Constant Parameters Tobit in favor of a Random Parameters Tobit (Table 1). This model also provided better fit than a Random Effects Tobit.

- The Random Parameter Linear provided better fit than the Constant Parameters linear model. Yet, this model fails to account for bid censoring.

- Except for certain tasting coefficients, the standard deviations of all the random parameters were significant, implying that the valuations are heterogeneous across individuals.

Table 1. Estimation Results: Random Parameters Tobit

	Parameter	Standard Error	Marginal Effect
Means of Random Parameters			
Intercept	1.3717***	0.0457	
Honeydew	-0.0709**	0.0354	-0.0709
Tuscan	0.0621*	0.0345	0.0621
Canary	-0.0721**	0.0318	-0.0720
Galia	-0.0146	0.0329	-0.0146
Personal watermelon	0.5345***	0.0369	0.5344
Tasting × Cantaloupe	-0.1525*	0.0895	-0.1525
Tasting × Honeydew	-0.1680*	0.0970	-0.1680
Tasting × Tuscan	0.0132	0.0956	0.0132
Tasting × Canary	-0.1129	0.0922	-0.1129
Tasting × Galia	-0.1307	0.0922	-0.1307
Tasting × Personal watermelon	-0.1489	0.0982	-0.1489
Global GAP food safety label	0.1251***	0.0222	0.1251
USDA food safety label	0.1831***	0.0244	0.1831
Standard Deviations of Random Parameters			
Intercept	0.7985***	0.0096	
Honeydew	0.4299***	0.0222	
Tuscan	0.5496***	0.0228	
Canary	0.6208***	0.0261	
Galia	0.3727***	0.0225	
Personal watermelon	0.8336***	0.0279	
Tasting × Cantaloupe	0.1114	0.0828	
Tasting × Honeydew	0.0004	0.0850	
Tasting × Tuscan	0.0928	0.0722	
Tasting × Canary	0.1559*	0.0846	
Tasting × Galia	0.1919***	0.0740	
Tasting × Personal watermelon	0.1045	0.0752	
Global GAP food safety label	0.3977***	0.0126	
USDA food safety label	0.1592***	0.0153	
Demographics/Behaviors			
AGE2 (30 to 49)	0.3456***	0.0324	0.3455
AGE3 (50 or more)	-0.1564***	0.0324	-0.1564
EDU2 (College)	0.1669***	0.0229	0.1669
EDU3 (Graduate school)	-0.0063	0.0382	-0.0063
HHSIZE (Household size)	0.1212***	0.0097	0.1212
FEMALE	-0.1364***	0.0230	-0.1364
MARRIED	-0.3696***	0.0322	-0.3696
INC2 ($50,000 to less than $100,000)	-0.0298	0.0273	-0.0298
INC3 ($100,000 or more)	-0.1345***	0.0379	-0.1345
ASPENDFV (Expenditures on produce)	0.0090***	0.0007	0.0090
FVOH (Percentage of produce on hand)	0.0021***	0.0003	0.0021
σ(ε)	0.5559***	0.0032	
No. of usable observations		2968	
Log-Likelihood		-3212.84	
Likelihood ratio test		2,601.94***	

Note: Based on 500 Halton draws.
*** Likelihood ratio test of Random Parameters Tobit vs. Constant Parameters Tobit regression.

- Consumers are willing to pay a price premium of around $0.13 for a product that carries an industry-issued (Global GAP) certification label for food safety and a price premium of around $0.18 for a fruit product baring a government-issued certification label (FSMA), compared with a non-certified product.

CONCLUSIONS

- The Random Parameters Tobit model provided the best fit, while accounting for bid censoring and effectively capturing heterogeneity in preferences.
- Experimental economists could employ a within-subjects design, which results in a larger number of observations under treatment and control, and account for within-cluster correlation in the modeling stage.
- Consumers are willing to pay price premiums for food safety in specialty melons, and these valuations are heterogeneous. A government-based program is valued higher than an industry-based program, suggesting a greater degree of consumer trust in government food safety oversight and enforcement.

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