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Nonparametric Estimation of Court Auction in South Korea

한국 법원 경매에서의 비모수적 추정

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Abstract

South Korean court auction has a distinctive feature which separates it from other court auctions. The court repeatedly auctions a property with a lower reser- vation price if it fails to sell. According to the conventional auction theory, the role of reservation price is to encourage competition while risking the possibility of miscarriage. From this perspective, the same property being repeatedly auctioned with lower reservation price might not stimulate competition as reservation price is supposed to do. Thus, it is important to assess if this failed commitment actually undermines the court's revenue from auction and consequently prevents from reim- bursing creditors fully enough. In this regard, this paper tries to nonparametrically estimate bidders' value from South Korean court auction results.

keyword: court auction, repeated auction, reservation price, first-price auction, nonparametric estimation, CIPV model

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Contents

1 Introduction

Court auction refers to a type of public auction where auctioned properties are sold to liquidate a mortgage foreclosure. In this regard, the revenue maximization of court auction is important; if transaction price is too low, creditors will not be given their fair share. However, the auction mechanism which South Korean court employs has some elements against revenue maximization.

In South Korea, district courts auction a mortgaged property in first-price auction with reservation price when its owner is unable to pay the mortgage and the associated creditor(s) requests. The starting reservation price in South Korean court auction is appraised value of the property, which often is too

high given that public auction distresses prices. The role of appraising the value of auctioned property is not undertaken by the district courts. Third party certified appraisers are employed by the district courts and appraise the properties.

The fact that the starting reservation price is appraised value implies that South Korean court auction has a high rate of failure to sell in the first round. That being said, high reservation price by itself does not necessarily lead to lower revenue earned. It increases the possibility that the auction fails to sell the auctioned item but also increases competition when there are multiple bidders willing to bid more than the reservation price. Thus when a proper level of reservation price is set, an auctioneer can maximize his ex-ante revenue.

However, South Korean court auction has one more element which makes the high reservation price questionable; repetition. When no valid bid equal to or higher than the reservation price is made, the court auctions the same property again, with a discounted reservation price; usually 20 percent off from the original reservation price. This repetition is known to every bidder in the market since they can observe previous auction history which is disclosed by the courts.

Therefore, there exists an incentive for a bidder to wait until the reservation price is lowered if he is patient enough. Auction theory suggests that if each bidder's value for an auctioned property follows an independent and private value

model (IPV) - i.e., how much a bidder values an auctioned property is perfectly known to oneself and independent of each other bidder's valuation - and it is common knowledge that the auctioned property will be auctioned again with a lowered reservation price until it is lower than the smallest valuation, non time-discounting bidders will act as if there is no reservation price at all.

McAfee and Vincent (1997) discussed an auction environment where commitment is not credible and auctioneer can resell unsold auctioned items, which is applicable to South Korean court auction. In the paper, it is shown that when time discount factor approaches to one, which means no time discount, the auctioneer's expected revenue is equal to the expected revenue of a static first price auction without any reservation price.

To sum up, the auction mechanism with high first-round reservation price and repetition, which South Korean court employs, has some distinctive characteristics which are against revenue maximization; repetition makes the auctioneer's commitment to reservation price futile and history of previous miscarriage implies that bidders' valuations for the auctioned property are generally low. Thus, it is of great importance to see how much revenue the court can earn and redistribute to debtors if a different auction mechanism is applied.

For that purpose, a prerequisite needs to be completed;

value distribution of bidders in South Korean court auction market needs to be estimated. After the value distribution is successfully estimated, it is possible to anticipate how bidders will react to different types of auctions. Also, by imposing some restricting assumptions, we can test if the reserve price does encourage competition among bidders. Fortunately, with a help of advances in econometrics, there exist some methods of nonparametric estimation of value from first-price auction data. Laffont et al (1995) deals with nonparametric estimation of private value first-price sealed-bid auction. Guerre et al (2000) builds on that and considers the case with reservation price. Athey and Haile (2002) and Athey and Haile (2006) cover more restrictive cases where not all bids are observed, or common value is assumed.

This paper aims to nonparametrically estimate bidders' value from first and second round results of the South Korean court auction with a simple model of conditionally independent and private value model. Using different sets of values nonparametrically estimated from different rounds of the court auction, we test if bidders employ the same bidding strategy in different rounds of the auction, as auction theory suggests under no time discount and perfect information. Then, using the estimated valuation, we aim to compute the optimal reservation price in case there is no repetition rule and reservation price is credible.

2 Data

The data in use covers all auction results from Seoul district court in 2015. Since the auctioned properties are heterogeneous to a huge degree, only apartments are included to control heterogeneity. Also, for lack of enough data cumulated, only auction results of first and second round auctions are used. In addition, we suspect that auctions with a huge number of valid bids might have been wrongly appraised. Thus, we excluded observations more than 0.85 quantile number of valid bids, which is seven in the first round and 15 in the second round.

The data is accumulated from a private company named *Korea Court Auction Information*, which provides and sells information regarding court auction[1].

For each auction, followings are observed: winning bid, second-highest bid, the number of valid bids, appraised value of the auctioned property, reservation price, previous auction history, characteristics of the auctioned property and etc.

The table 1 gives descriptive statistics about the auction results. Note that the number of auctions with more than one valid bids is much higher in the second round. This is because of the lower reservation prices in the second round. As one can easily see, the auctioned items are highly heterogeneous,

[1] www.courtauction.co.kr. Collection of the data was examined by institutional review board at Seoul National University and was exempted from a full review. IRB No. E1705/003-008

Table 1: South Korean court auction, Seoul district court, 2015

apartments						
first round						
	Q1	Q2	Q3	max	mean	number of obs.
appraised value (KRW)	0.290 bn.	0.410 bn.	0.615 bn.	6.520 bn.	0.530 bn.	1409
appraised vlaue (KRW, successful auctions only)	0.257 bn.	0.350 bn.	0.550 bn.	3.500 bn.	0.468 bn.	326
winning bid (KRW)	0.261 bn.	0.359 bn.	0.566 bn.	3.500 bn.	0.485 bn.	326
area (m^2)	98.5	125.1	162.8	398.8	135.356	1401
area (m^2, successful auctions only)	74.55	97.1	129.3	487.8	111.817	324
number of valid bids (not counting 0)	1	1	3	6	2.141	326
second round						
	Q1	Q2	Q3	max	mean	number of obs.
appraised value (KRW)	0.300 bn.	0.450 bn.	0.706 bn.	6.520 bn.	0.594 bn.	932
appraised value (KRW, successful auctions only)	0.310 bn.	0.450 bn.	0.670 bn.	3.600 bn.	0.572 bn.	771
winning bid (KRW)	0.292 bn.	0.411 bn.	0.612 bn.	3.002 bn.	0.522 bn.	771
area (m^2)	110.4	131.6	178.6	398.8	147.881	925
area (m^2, successful auctions only)	76	104	144.5	899.8	119.423	759
number of valid bids (not counting 0)	3	6	10	14	6.437	771

even after some restrictions. The first quartile of the appraised value is 0.290 billion Korean won in the first round and the third quartile is 0.615 billion Korean won, which is bigger than double of the first quartile. Moreover, the maximum appraised value is 6.52 billion Korean won in both rounds, which is ten times bigger than the third quartile. Similar patterns are observed in reservation prices, winning bids, and the second highest bids. The heterogeneity is more drastic with the number of valid bids. While the number of the valid bids is one in most of the cases where the auctioned item is sold, the maximum number of valid bids observed is bigger than 10.

Also, not only the auctioneers' valuation of the auctioned items or bidder's behaviours but also the physical characteristics of the auctioned items are heterogeneous. In both rounds, the third quartiles of the area of the auctioned properties is as one and a half big as the first quartiles. In short, the distributions of properties of the auction results are skewed to the right. Thus in the following process of estimation, a portion of observations are dropped in order to eradicate the thick right tail.

3 Model - CIPV

3.1 Conditionally Independent Private Value model

To estimate value distribution, several simplifying assumptions are adopted. First of all, all bidders are assumed to be identical. The following estimation is under assumption that bidders who win at least once are homogeneous enough and they are the ones of significance in analysing court auctions and models them to be identical.

Secondly, value distribution is assumed to be not only identical across bidders, but also identical across auctioned properties, if normalized with appraised value and conditioned on covariate containing characteristics of auctioned property. This simplification assumption is borrowed from Li et al (2000).

Lastly, each auction is assumed to be independent of each other. In other words, when bidding, bidders are not concerned about other auctions which might be going on simultaneously. Though there are some literature covering dynamic auctions such as Bergemann and Said (2010), developing an estimation method based on a dynamic auction environment is a extremely sophisticated work. Thus, we assume each auction to be independent of each other.

$$V_{ij} = a_j + \varepsilon_{ij} \cdot a_j \tag{1}$$

$$\text{for } i = 1, 2, \cdots, I \text{ and } j = 1, 2, \cdots, J$$

$$\varepsilon_{ij}|\mathbf{X}_j \sim^{iid} F(\cdot|\mathbf{X}_j) \text{ and } \text{supp}F(\cdot|\cdot) = [-1, \infty)$$

V_{ij} : bidder i's valuation of auctioned property j

A_j : appraised value of auctioned property j

ε_{ij} : idiosyncratic shock to bidder i's valuation of auctioned property j

$\mathbf{X}_j$: covariate denoting characteristics of auctioned property j

$F(\cdot|\cdot)$: conditional distribution function of ε given $\mathbf{X}$

Since valuation of each bidder is identical and independently distributed after normalized with appraised value of auctioned property, this model is referred to as conditionally independent and private value model (CIPV). Under conditionally independent and private value model, bids can also be normalised with appraised value. The normalisation does not compromise findings about differentiable symmetric Bayesian Nash equilibrium strategy in first-price auction since independence and identicalness of value distribution uniquely characterizes the equilibrium strategy in first-price auction to be a bidder's private value plus a function of distribution function of value; the

normalisation does not change the basic characteristics of the distribution function.

Thus, by normalising bids and reservation prices, ε_{ij} instead of V_{ij} can be estimated. In fact, estimation of ε_{ij} is equivalent with estimating V_{ij} if conditional private value model holds true. In this sense, instead of discussing in terms of bids, we use the term 'deviation' to indicate the proportional difference between bid and appraised value.

Also, we only consider the static first-price auction without reservation price case. We focus on this benchmark case since we suspect the optimal bidding strategy in this repeated auction to be identical to the optimal bidding strategy of a static first-price auction. If every bidder fully understands the nature of the repeating auction and does not discount future, their optimal bidding strategy will be equal to that in the static first-price auction without reservation price.

Definition 1. *If a bidder submits a bid of b and the appraised value of the corresponding auctioned property is a, the deviation d is defined as*

$$d = \frac{b - a}{a}$$

Proposition 1. *In the conditionally independent and private value model as defined in (1), the unique differentiable symmetric Bayesian Nash equilibrium of a static first-price auction*

without reservation price can be equivalently characterized with a deviating strategy γ, which is a function of idiosyncratic shock ε, instead of a bidding strategy β, which is a function of value v.

$$\beta(v) = \beta(a + a * \varepsilon) = a + a * \gamma(\varepsilon)$$

Proof. The first-order differential equation for the unique differentiable Bayesian Nash equilibrium strategy without reserve price can be derived as follows

$$\gamma(\varepsilon) = \arg\max_{d}(a + \varepsilon * a - a - d * a)F(\gamma^{-1}(d))^{I-1}$$

$$\varepsilon = \arg\max_{e} a(e - \gamma(e))F(e)^{I-1}$$

$$\text{by F.O.C.,} \ -\gamma'(\varepsilon)F(\varepsilon)^{I-1} + (\varepsilon - \gamma(\varepsilon))(F(\varepsilon)^{I-1})' = 0$$

$$\gamma'(\varepsilon)F(\varepsilon)^{I-1} = (I-1)(\varepsilon - \gamma(\varepsilon))F(\varepsilon)^{I-2}f(\varepsilon)$$

$$1 = (\varepsilon - \gamma(\varepsilon))\frac{f(\varepsilon)}{F(\varepsilon)}\frac{I-1}{\gamma'(\varepsilon)}$$

Note that the first-order differential equations is equivalent to that derived from bidding strategy. The equivalence of the first-order differential equations makes many theoretical application based on bidding strategy readily available to our analysis in terms of deviating strategy. □

3.2 Identification of value with deviation distribution

By modifying findings from Guerre et al (2000), the idiosyncratic shock can be identified with deviation and distribution function of deviation.

$$\varepsilon_{ij} = D_{ij} + \frac{1}{I-1}\frac{G(D_{ij}|\mathbf{X}_j)}{g(D_{ij}|\mathbf{X}_j)} \tag{2}$$

I : the number of bidders in auction market

D_{ij} : bidder i's deviation for auctioned property j

$G(\cdot|\cdot)$: distribution function of D given $\mathbf{X}$

$g(\cdot|\cdot)$: probability density function D given $\mathbf{X}$

Equation (2) refers to the identification of the symmetric BNE without reservation price. Since we can only observe winning bids when it is bigger than reservation price and the number of bidders in the auction market is not observed, we cannot directly apply the result of Guerre et al (2000). However, since distribution function of an order statistics is a transformation of the distribution function of original random variable, we can substitute G and g with $G_{\max}$ and $g_{\max}$, the

distribution function and the probability density function of $\max_i \varepsilon_{ij} =: \varepsilon_{\max,j}$ as in Athey and Haile (2002).

Proposition 2. *Under the regularity assumptions A1-A4 employed in Guerre et al (2000), the maximal value in the static first-price auctions without reservation price under the conditionally independent and private value model can be identified as follows.*

$$\varepsilon_{\max,j} = D_{\max,j} + \frac{I}{I-1}\left(\frac{G_{\max}(D_{\max,j};\mathbf{X}_j|D_{\max,j}\geq r)}{g_{\max}(D_{\max,j},\mathbf{X}_j|D_{\max,j}\geq r)} + \frac{G_{\max}(r;\mathbf{X}_j)}{P(D_{\max,j}\geq r)}\frac{1}{g_{\max}(D_{\max,j},\mathbf{X}_j|D_{\max,j}\geq r)}\right) \tag{3}$$

I : the number of bidders in auction market

$\varepsilon_{\max,j}$: maximum idiosyncratic error for auctioned property j

$D_{\max,j}$: maximum deviation for auctioned property j

r : normalised reservation price

$G_{\max}(\cdot;\cdot)$: distribution function of $D_{\max}$ when $\mathbf{X}$ is fixed.

$g_{\max}(\cdot,\cdot)$: joint density function of $D_{\max}$ and $\mathbf{X}$

$$G_{\max}(d;\mathbf{x}) = \int I_{\{D_{\max}\leq d\}} dP_{D_{\max},\mathbf{x}}$$
$$g_{\max}(d,\mathbf{x}) = \frac{\partial}{\partial t}G_{\max}(t,\mathbf{x})\Big|_{t=d}$$

Proof.

step 1

$$G(D_{\max}|\mathbf{X}) = G_{\max}(D_{\max}|\mathbf{X})^{1/I}$$

$$g(D_{\max}|\mathbf{X}) = \frac{1}{I}\left(\frac{1}{G_{\max}(D_{\max}|\mathbf{X})}\right)^{(I-1)/I} g_{\max}(D_{\max}|\mathbf{X})$$

leads to

$$\varepsilon_{\max,j} = D_{\max,j} + \frac{I}{I-1}\frac{G_{\max}(D_{\max,j}|\mathbf{x}_j)}{g_{\max}(D_{\max,j}|\mathbf{x}_j)}$$

step 2

$$G_{\max}(D_{\max}|D_{\max} \geq r, \mathbf{X}) = \frac{G_{\max}(D_{\max}|\mathbf{X}) - G_{\max}(r|\mathbf{X})}{1 - G_{\max}(r|\mathbf{X})}$$

$$g_{\max}(D_{\max}|D_{\max} \geq r, \mathbf{X}) = \frac{1}{1 - G_{\max}(r|\mathbf{X})} g_{\max}(D_{\max}|\mathbf{X})$$

leads to

$$G_{\max}(D_{\max}|\mathbf{x}) = G_{\max}(r|\mathbf{x}) + (1 - G_{\max}(r|\mathbf{x})) \cdot G_{\max}(D_{\max}|D_{\max} \geq r, \mathbf{x})$$

$$g_{\max}(D_{\max}|\mathbf{x}) = (1 - G_{\max}(r|\mathbf{x})) \cdot g_{\max}(D_{\max}|D_{\max} \geq r, \mathbf{x})$$

thus,

$$\varepsilon_{\max,j} = D_{\max,j} + \frac{I}{I-1}\left(\frac{G_{\max}(D_{\max,j}|D_{\max,j} \geq r, \mathbf{x}_j)}{g_{\max}(D_{\max,j}|D_{\max,j} \geq r, \mathbf{x}_j)}\right.$$
$$\left. + \frac{G_{\max}(r|\mathbf{x}_j)}{1 - G_{\max}(r|\mathbf{x}_j)}\frac{1}{g_{\max}(D_{\max,j}|D_{\max,j} \geq r, \mathbf{x}_j)}\right)$$

step 3

let $f(\cdot)$ denote density function of $\mathbf{X}$

then,

$$G_{\max}(D_{\max}|D_{\max} \geq r, \mathbf{X}) = \frac{G_{\max}(D_{\max}; \mathbf{X}) - G_{\max}(r; \mathbf{X})}{f(\mathbf{X}) - G_{\max}(r; \mathbf{X})}$$

$$g_{\max}(D_{\max}|D_{\max} \geq r, \mathbf{X}) = \frac{g_{\max}(D_{\max}, \mathbf{X})}{f(\mathbf{X}) - G_{\max}(r; \mathbf{X})},$$

and

$$G_{\max}(D_{\max}; \mathbf{X}|D_{\max,j} \geq r) = \frac{G_{\max}(D_{\max}; \mathbf{X}) - G_{\max}(r; \mathbf{X})}{P(D_{\max} \geq r)}$$

$$g_{\max}(D_{\max}, \mathbf{X}|D_{\max,j} \geq r) = \frac{g_{\max}(D_{\max}, \mathbf{X})}{P(D_{\max} \geq r)},$$

and

$$G_{\max}(r|\mathbf{X}) = \frac{G_{\max}(r; \mathbf{X})}{f(\mathbf{X})}$$

lead to equation(3)

□

Equation (3) refers to the identification of the symmetric BNE without reservation price. Even when bidders fully understand the rule of the court auction, disregard reservation price, and act as if there is no reservation price, we can only observe $D_{\max,j}$ when $D_{\max,j} \geq r$. Thus, distribution of $D_{\max,j}$ can estimated only after conditioning that $D_{\max,j} \geq r$ and reservation price is still included in equation (3).

The rule of the repetition in the South Korean court auction forces that r_j be 0 in the first round $\forall j$ and r_j be -0.2

in the second round $\forall j$. Since we estimate maximum values from the first round results and from the second round results independently, r_j is substituted with r altogether.

From Proposition 2, we can establish an estimator of $\varepsilon_{\max,j}$ as in Guerre et al (2000).

$$\hat{\varepsilon}_{\max,j} = d_{\max,j} + \frac{\hat{I}}{\hat{I}-1}\left(\frac{\widehat{G_{\max}}(d_{\max,j}, \mathbf{x}_j | D_{\max,j} \geq r)}{\widehat{g_{\max}}(d_{\max,j}, \mathbf{x}_j | D_{\max,j} \geq r)} + \frac{\widehat{G_{\max}(r; \mathbf{x}_j)}}{P(\widehat{D_{\max,j}} \geq r)} \frac{1}{\widehat{g_{\max}}(d_{\max,j}, \mathbf{x}_j | D_{\max,j} \geq r)}\right) \tag{4}$$

if $(d_{\max,j}, \mathbf{x}_j) + S(2h_G) \subset \hat{S}(G), (d_{\max,j}, \mathbf{x}_j) + S(2h_g) \subset \hat{S}(G)$

where $S(G) = \{(d, \mathbf{x}) : d \in [\underline{\hat{d}}(\mathbf{x}), \hat{\bar{d}}(\mathbf{x})], \mathbf{x} \in [\underline{\mathbf{x}}, \bar{\mathbf{x}}]\}$,

$\underline{\hat{t}}(\mathbf{x}) = \min\{d_j : \mathbf{x}_j \in$ hypercube of side h which contains $\mathbf{x}\}$,

$\hat{\bar{t}}(\mathbf{x}) = \max\{d_j : \mathbf{x}_j \in$ hypercube of side h which contains $\mathbf{x}\}$,

h_G denotes the support of the kernel used in estimating $\widehat{G_{\max}}$,

and h_g denotes the support of the kernel used in estimating $\widehat{g_{\max}}$.

$$\hat{I} = \max_j I_j^*,$$

where I_j^* denotes the number of valid bids for auction property j.

$$\hat{f}(\mathbf{x}) = \frac{1}{J}\frac{1}{h_x}\sum_{j=1}^{J} K_x\left(\frac{\mathbf{x}-\mathbf{x}_j}{h_x}\right),$$

$$\widehat{G_{\max}(r;\mathbf{x})} = \hat{f}(\mathbf{x}) - \frac{1}{J}\frac{1}{h_x}\sum_{j=1}^{J} 1_{\{I_j^*\geq 1\}} K_x\left(\frac{\mathbf{x}-\mathbf{x}_j}{h_x}\right),$$

$$\widehat{G_{\max}}(d;\mathbf{x}|D_{\max}\geq r) = \frac{1}{J^*}\frac{1}{h\cdot h_x}\sum_{j^*=1}^{J^*} K\left(\frac{d-d_{\max,j^*}}{h}\right) K_x\left(\frac{\mathbf{x}-\mathbf{x}_{j^*}}{h_x}\right),$$

$$\widehat{g_{\max}}(d,\mathbf{x}|D_{\max}\geq r) = \frac{1}{J^*}\frac{1}{h_x}\sum_{j^*=1}^{J^*} 1_{\{d\geq d_{\max,j^*}\}} K_x\left(\frac{\mathbf{x}-\mathbf{x}_{j^*}}{h_x}\right),$$

where j^* refers to identifier for auction with more than one valid bids

The estimation is not possible for every $(d_{\max,j}, \mathbf{x}_j)$ since the estimation of $g_{\max}$ is not accurate around the boundaries of the support. Thus, the estimator given in (4) has conditions as mentioned above.

4 Estimation Results

Using the court auction results from Seoul district court in 2015, maximum values, which can only be observed when more than one valid bid is submitted, can be nonparametrically estimated.

We used three different specification. The first setting is

where bidders bid as if there is no reservation price and distribution and density functions are estimated as marginal. The second and third settings are where bidders bid as if there is no reservation price and distribution and density functions are estimated as joint distribution and density functions where total area of the auctioned property and logged appraised value area are used as $\mathbf{X}$. The key difference between the first and the other two settings is that by allowing the distribution of the idiosyncratic error to vary across other variables, we can further integrate heterogeneity among auctioned properties into our model.

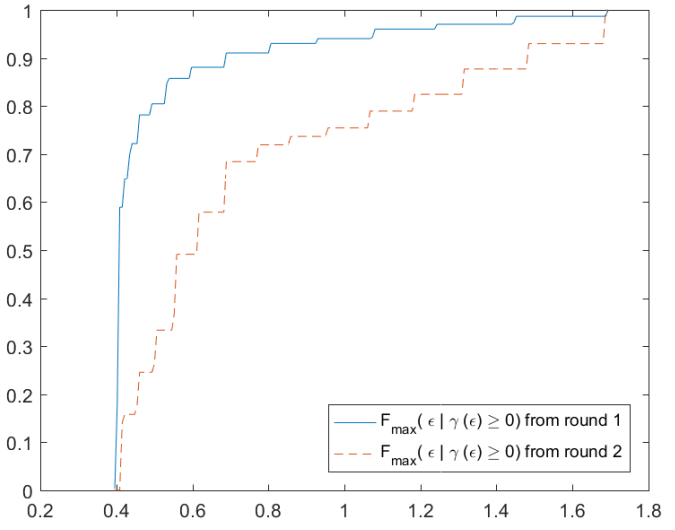
Table 2 gives descriptive statistics of estimated maximum value. From Table 2, one can see that distributions of maximum value and maximum idiosyncratic error to value are also skewed to the right. Even when the distribution of the idiosyncratic error is allowed to vary as $\mathbf{x}$ changes, some extreme estimates are observed. Also, three different specifications yield relatively stable results, which weakly supports the estimation method.

Based on the estimated maximum idiosyncratic errors from different settings, we have estimated distribution function and density function, using empirical distribution function and kernel estimation. Figure 1 and 2 show estimated distribution

Table 2: Estimated Maximum Values (KRW) and Maximum Errors to Values

				first round			
	conditioning on $\mathbf{x}_j$	Q1	Q2	Q3	max	mean	number of obs.
$V_{\max,j}$	NO	0.394 bn.	0.568 bn.	0.805 bn.	8.906 bn.	0.810 bn.	318
	area	0.339 bn.	0.493 bn.	0.764 bn.	12.751 bn.	0.712 bn.	291
	ln(app value)	0.343 bn.	0.498 bn.	0.801 bn.	9.775 bn.	0.763 bn.	271
	conditioning on $\mathbf{x}_j$	Q1	Q2	Q3	max	mean	number of obs.
$\varepsilon_{\max,j}$	NO	0.404	0.407	0.489	8.675	0.682	318
	area	0.298	0.372	0.496	14.090	0.603	291
	ln(app value)	0.336	0.406	0.525	9.563	0.570	271
				second round			
	conditioning on $\mathbf{x}_j$	Q1	Q2	Q3	max	mean	number of obs.
$V_{\max,j}$	NO	0.354 bn.	0.492 bn.	0.737 bn.	4.890 bn.	0.640 bn.	769
	area	0.335 bn.	0.460 bn.	0.699 bn.	3.763 bn.	0.589 bn.	701
	ln(app value)	0.332 bn.	0.461 bn.	0.706 bn.	3.334 bn.	0.601 bn.	717
	conditioning on $\mathbf{x}_j$	Q1	Q2	Q3	max	mean	number of obs.
$\varepsilon_{\max,j}$	NO	-0.019	0.046	0.147	6.191	0.128	769
	area	-0.030	0.029	0.103	1.476	0.067	701
	ln(app value)	-0.031	0.034	0.114	2.547	0.066	717

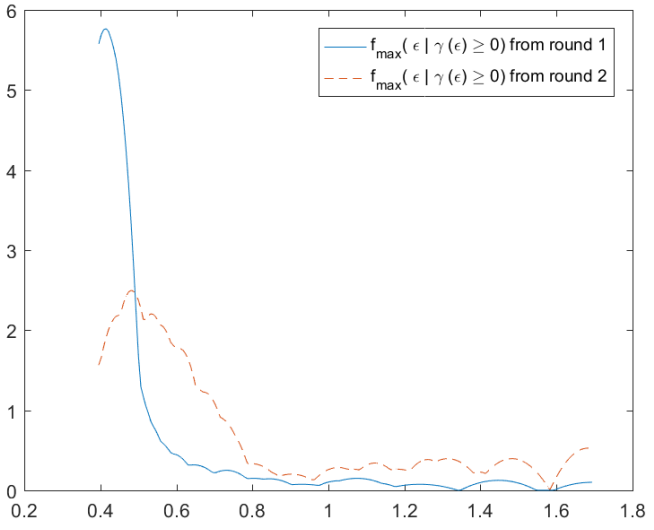
Figure 1: Estimated distribution functions of $\varepsilon_{\max}$ given $\varepsilon_{\max} \geq 0$, no conditioning variable



functions and density functions using estimates from the first setting, where no conditional covariate is used. The two graphs suggest that the two distributions derived from estimates from the first round and estimates from the second round differ from each other to a certain extent.

In a sense, this result runs against our assertion that bidders will bid as if there is no reservation price. If bidder do disregard reservation price, their bidding strategies in the first round and in the second round should not differ from each other. Then, distribution of the maximal bid in the first round should be identical to distribution of the maximal bid in the second

Figure 2: Estimated density functions of $\varepsilon_{\max}$ given $\varepsilon_{\max} \geq 0$, no conditioning variable



round. It should be the only difference between the two rounds that the maximal bid is truncated differently; in the first round, the maximal deviation bigger than zero are observed while the maximal deviation bigger than -0.2 are observed in the second round. Thus, estimated valuation which is based on the distribution of the maximal deviation in the first round should be identical to that in the second round.

However, this result does not either strongly support that the estimated valuations are indeed different, thus undermining assumption that bidders act as if there is no reservation price since heterogeneity in auctioned properties are not controlled.

Figure 3: Estimated distribution and density functions of $\varepsilon_{\max}$ given $\varepsilon_{\max} \geq 0$ in round 1, conditioning on ln(app value)

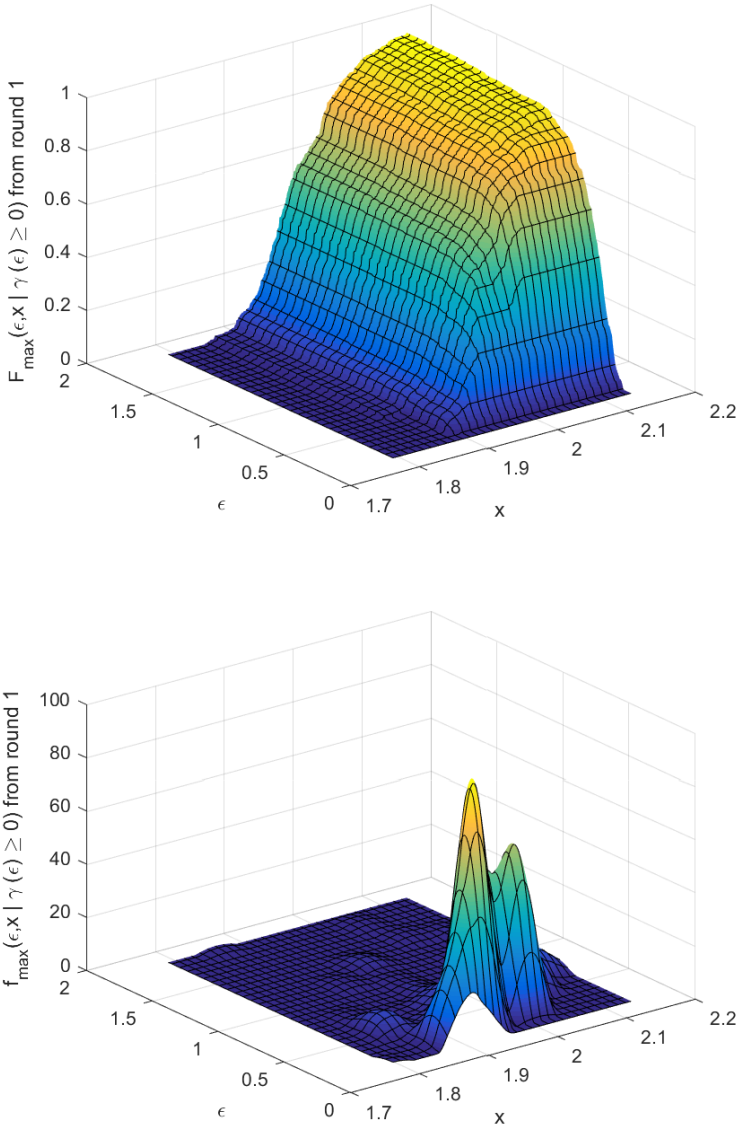


Figure 4: Estimated distribution and density functions of $\varepsilon_{\max}$ given $\varepsilon_{\max} \geq 0$ in round 2, conditioning on ln(app value)

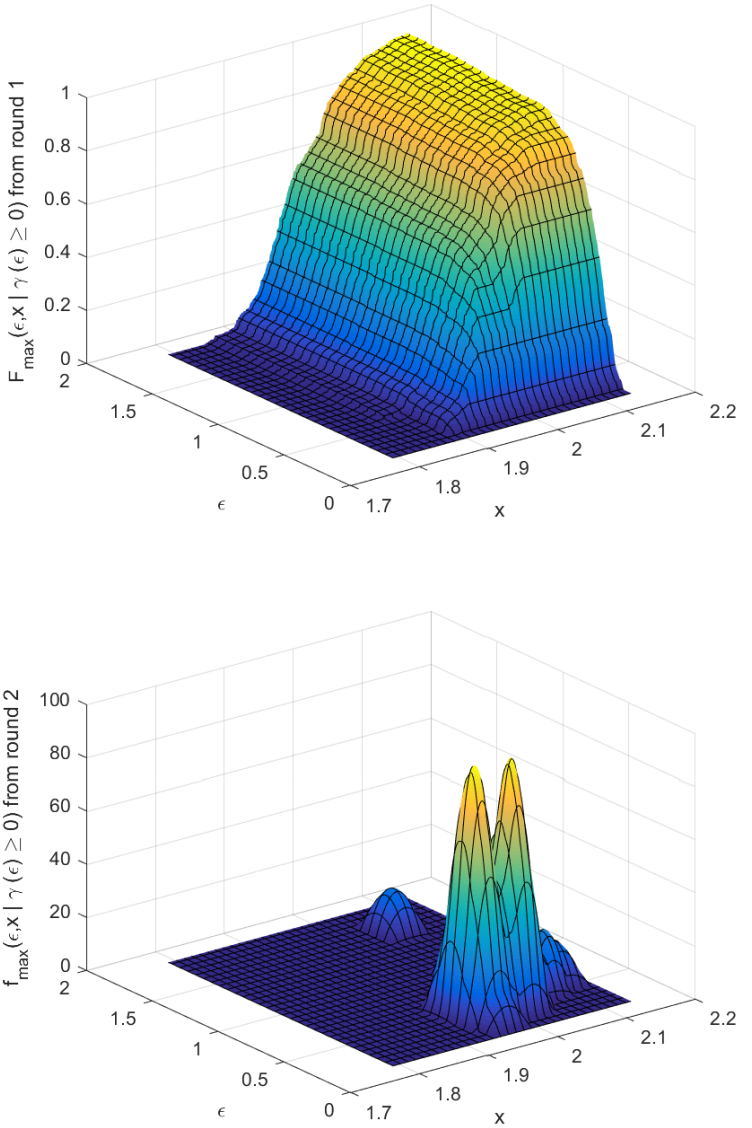


Figure 3 and 4 show estimates for joint distribution function and density function of maximum idiosyncratic error and logged appraised value, when the error is estimated using logged appraised value as a conditioning variable. In this case, by looking at joint distributino functions, more heterogeneity is incorporated. Since the relationship between the estimates from the first round and those from the second round is not visually evident like in Figure 1 and 2, a nonparametric testing method like conditional stochastic dominance test can be used here.

However, if we plan to control heterogeneity using non-parametric methods such as conditional stochastic dominance and to use multiple control variables, there is an issue of high dimensionality. Consequently, we decided to use conventional ordinary least square regression to control heterogeneity and to see if idiosyncratic errors are distributed differently even after heterogeneity is controlled by OLS.

Table 3 and 4 contain the OLS results with estimated value as a dependent variable. In order to limit the range of estimated idiosyncratic errors to where $D_{\max,j} \geq 0$ as constrained in the first round results, observations with $D_{\max,j} < 0$ in the second round are dropped. Appraised value, floor area, plot area, district dummies, and number of valid bids dummies are used as control variables. Among these control variables,

Table 3: OLS results from estimated values

	$V_{\max}$		
appraised value	1.86***	2.99***	2.23***
floor area	2.10e+05	8.06e+05	-5.34e+05
plot area	4.15e+50	-9.69e+05	9.72e+05
district dummy	YES	YES	YES
# of valid bids dummy	YES	YES	YES
second round dummy	1.32e+08	-3.08e+08	2.67e+08
constant	-1.66e+07	-6.94e+08***	-2.20e+08
$\mathbf{x}_j$	-	Area	ln(app value)
N	595	501	482
R^2	0.1023	0.1590	0.2156

Table 4: Robustness check with $\ln V_{\max}$ and quantile regression

	$\ln V_{\max}$, $\mathbf{x}_j$ = area			
Regression type	OLS	quantile regression		
	-	p25	p50	p75
ln(app value)	1.162***	1.094***	1.140***	1.142***
dummies	YES	YES	YES	YES
2nd round dummy	-0.128	0.064*	-0.038	-0.066
constant	-2.855	-1.628	-2.497	-2.435**
N	324	324	324	324
(pseudo) R^2	0.8610	0.8266	0.7752	0.7084

	$\ln V_{\max}$, $\mathbf{x}_j$ = ln(appraised value)			
Regression type	OLS	quantile regression		
	-	p25	p50	p75
ln(app value)	1.103***	1.122***	1.137***	1.109***
dummies	YES	YES	YES	YES
2nd round dummy	0.098	-0.054*	0.223***	0.091
constant	-1.636**	-2.101***	-2.375***	-1.767***
N	295	295	295	295
(pseudo) R^2	0.9073	0.8720	0.8426	0.8008

appraised value and district dummies are estimated to be statistically significant. Other than appraised value, which is self-evidently connected to valuation as in Equation (1), district dummies are important since there are 25 districts in Seoul and their distinctive characteristics affect rent and housing prices considerably. For example, Gangnam district is famous for its expensive housing prices.

As shown in Table 3, when controlled with district dummies, area, and other control variables, the dummy variable indicating if an observation is from the first round or from the second round is estimated to be statistically insignificant. This suggests that the estimated valuation from the first round do not differ from the estimated valuation from the second round supporting that bidders act as if there is no reservation price.

In Table 4, we have some robustness check results. Instead of $V_{\max}$ and appraised values, we used logged estimated valuation and logged appraised values. As expected, the estimated coefficient for logged appraised value is near one. In addition, we conducted quantile regression to see how estimated valuations are distributed. Overall, the second round dummy was estimated to be statistically insignificant.

Lastly, we aim to compute the optimal reservation price. From Myserson (1981), we know that the optimal reservation

price r^* for a static first-price auction satisfies Equation (5).

$$r^* - \frac{1 - F(r^*|\mathbf{X})}{f(r^*|\mathbf{X})} = 0 \tag{5}$$

Using estimates when area is used as a control variable, we have approximated r^* satisfying (4) as nearly as possible. Table 5 contains the result.

Table 5: Estimated optimal reservation price

area	23.371	43.131	62.890	82.650	102.409	122.168
optimal r	0.149	0.149	0.149	0.149	0.149	0.224
area	141.928	161.687	181.447	201.206	220.965	240.725
optimal r	0.224	0.448	0.523	0.598	0.971	0.971

Though some estimates for r^* where area is huge seem implausible, we can find that the optimal reservation price should be higher than zero in general.

5 Conclusion

We aim to estimate valuation of bidders in South Korean court auction based on nonparametric, structural estimation method. The main purpose of the estimation is to see if the conditionally

independent and private value model and the optimal bidding strategy without reservation price yield estimation results which are not contradictory to each other. According to the regression results discussed in section 4, the values estimated from the first round results and the second round results are not significantly different from each other. In this sense, we have not found evidence against the assumption that conditionally independent and private value model holds true and thus bidders act as if there is no reservation price. Also, the optimal reservation price are estimated to be higher than current reservation price in the first round. Thus, if the court consider abolishing the rule of of repetition in court auction, the reservation price should be higher than current reservation price.

In order to derive more concrete findings about the court auction, we hope to improve the estimation method by exploring the asymptotic theory behind the estimation in depth. Surely, we had already employed some refining procedures in the estimation process, like the restrictions discussed in equation (4) in order to drop extreme cases. However, to construct a test statistics based on the nonparametric estimation about the hypothesis that bidders act as if there is no reservation price, asymptotic properties of the estimators we used should be studied and more restrictions on estimator for $G_{\max}$ and

$g_{\max}$ are necessary.

In this sense, our next work would be to construct more theoretically rigorous estimation method, in order to retrieve values from observed bids, in a more reliable manner. After that, using estimated value, we can test various conjectures, most of which are inspired by the distinct nature of South Korean court auction being repeated.

Appendix

Figure 5: Estimated distribution and density functions of $\varepsilon_{\max}$ given $\varepsilon_{\max} \geq 0$ in round 1, conditioning on area

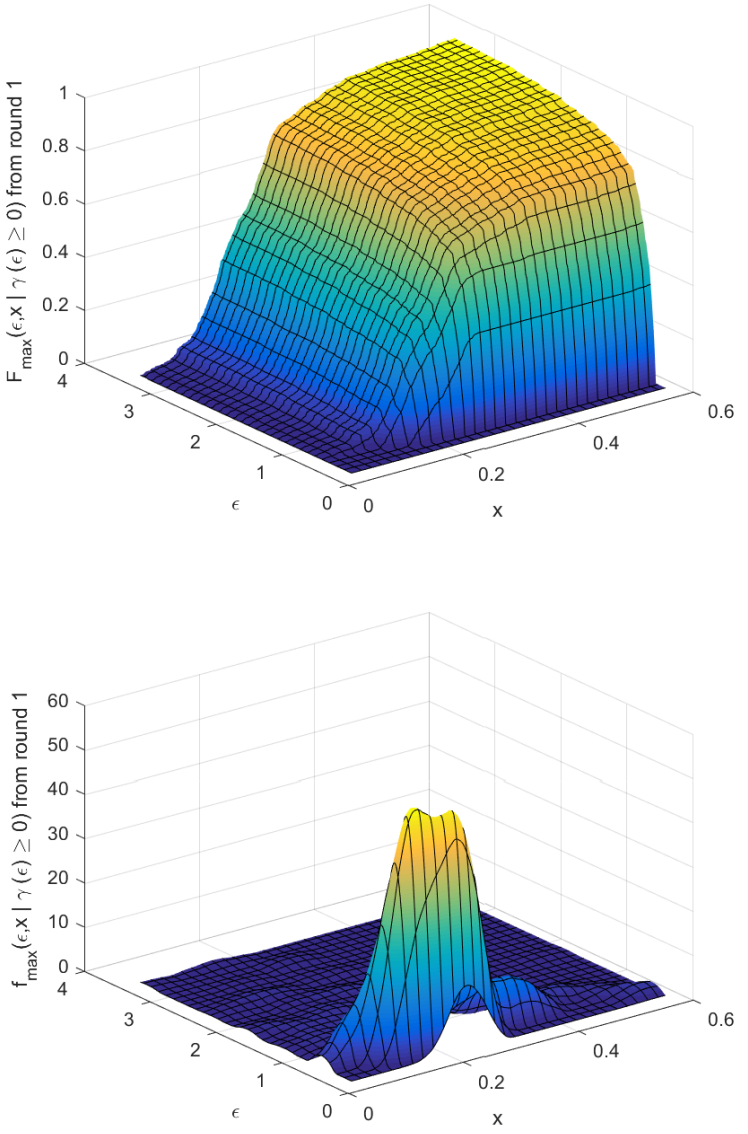
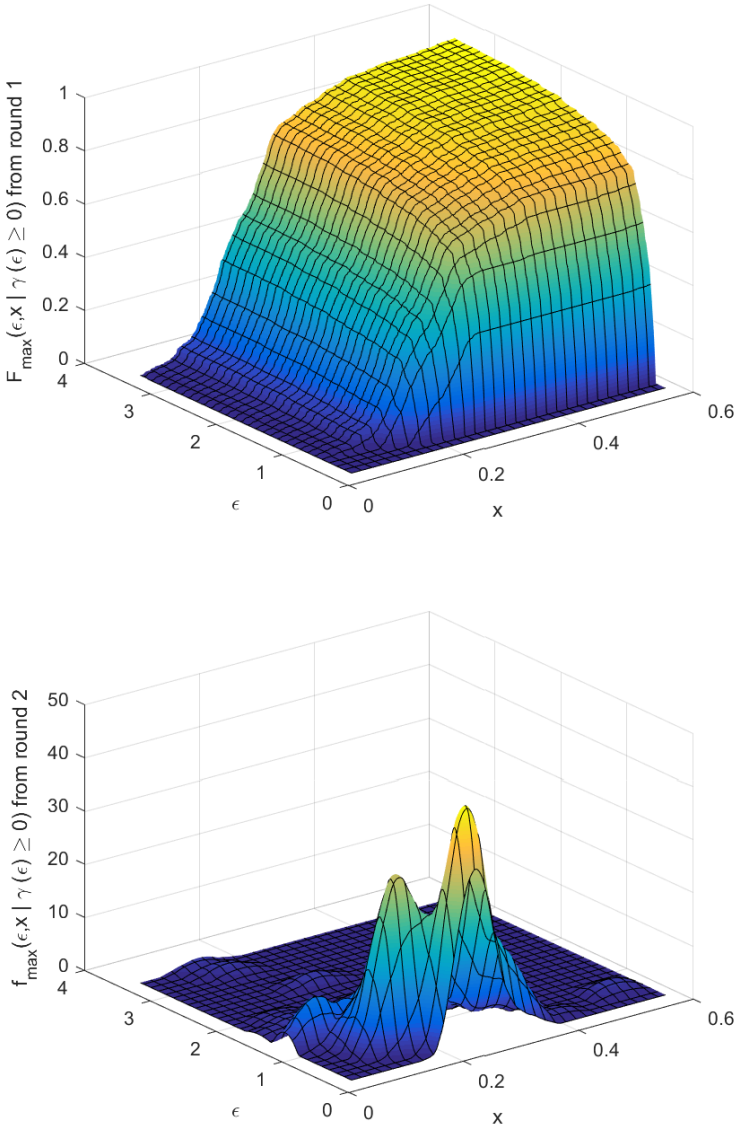


Figure 6: Estimated distribution and density functions of $\varepsilon_{\max}$ given $\varepsilon_{\max} \geq 0$ in round 2, conditioning on area



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국문 초록

법원 경매란 채무자가 채무를 제때 청산하지 못하고 채권자의 요청에 의해 소송이 제기된 경우, 채무를 변제하기 위해 채무자의 담보물을 경매하는 과정을 말한다. 법원 경매는 최저가격이 존재하는 1차가격 경매의 방식으로 진행되며 채권자의 재산권을 보호하고 금융 시장에서 활발한 금융 거래가 일어날 수 있도록 돕는다는 점에서 중요하다. 그런데, 우리나라의 법원 경매의 진행 과정에는 한 가지 특별한 특징이 있다. 만약 최저가격보다 더 높은 가격으로 입찰하는 입찰자가 없는 경우 최저가격을 낮추어 다시 경매를 진행한다는 점이다. 때문에 시간 할인의 폭이 크지 않은 입찰자들로 시장이 구성된 경우, 최저가격의 본래 목적인 입찰자 사이의 경쟁 심화가 일어나지 않을 수 있다. 현재 진행 중인 경매가 유찰될 가능성이 크다고 생각하는 입찰자들은 비록 현재의 최저가격이 자신이 부여하는 가치보다 더 작아도 이번 기에 유찰되고 다음 기로 넘어가 더 낮은 최저가격으로 재경매가 진행되길 기다릴 유인이 있기 때문이다.

본 논문은 이러한 점에 착안해 2015년 서울지방법원의 실제 법원 경매 결과를 이용해 최저가격의 역할을 살펴보려 한다. 만약 예상대로 입찰자들의 시간 할인의 폭이 크지 않아 최저가격이 아무런 역할을 하지 않는다면, 입찰자들은 첫 번째 경매에서와 두 번째 경매에서 같은 전략을 사용할 것이다. 또한, 이러한 가정으로부터 출발해 관측 가능한 자료를 토대로 입찰자들의 가치를

추정한다면, 입찰자들의 가치 역시 첫 번째 경매에서와 두 번째 경매에서의 분포가 같아야 한다. 본 논문은 실제 자료를 사용한 추정의 결과 첫 번째 경매에서와 두 번째 경매에서의 추정치들이 유의하게 다르지 않다는 결과를 확인할 수 있었다. 추정을 위해서는 조건부 독립 개인 가치 모형을 사용하였으며 커널 추정법 등 비모수적 추정방법을 사용하였다.

주요어: 법원경매, 반복경매, 최저가격, 1차가격경매, 비모수적 추정, 조건부 독립 개인 가치 모형

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