An Empirical Study of an Auction with Asymmetric Information

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1988

Drainage and Wildcat Tracts

- Drainage tracts: oil tracts adjacent to tracts on which deposits have been discovered. Firms that own the adjacent tracts have private information on the profitability of the tract. Firms that do not rely on the results of the seismic tests which is known to every firm.
- Wildcat tracts: tracts which do not have any adjacent tracts that were drilled. All firms rely on seismic tests.

Difference: Distribution of Information

- Drainage tracts: Asymmetric Information: owners of neighboring tracts have more information. Nonneighbor firms have less information and would bid more cautiously to avoid winner's curse. They may only win the auction when the assessment of the neighboring firm are low.
- Wildcat tracts: Symmetric Information: all firms only rely on the results of the seismic tests.
- For drainage tracts: nonneighbor firms choose to participate with positive probability. If not, then neighbor firms will bid the lowest price that government allows. Then, non-neighbor firm can bid slightly higher, and win the auction.

Data and Estimation Methods

- Federal lands off the coast of Louisiana and Texas. 1959-1969.
- Government revenue: sales price at the auction plus fixed rental fee plus a portion of the revenue.
- Government reservation price: 25$ per acre. Has the right to reject the winning bids if it is too low.

Sample Statistics

Variables	Mean	Std. Dev
B_I: Maximum bid by neighbor	3.78	11.52
B_U: Maximum bid by nonneighbor	3.60	9.57
N_I: Number of neighbor bids	1.00	0.67
N_U: Number of nonneighbor bids	1.69	2.09
N: Number of neighbor tracts	3.01	1.98
N_F: Number of neighbor firms	2.06	1.08
π: Ex post gross tract profit (million doll)	8.75	20.83
V: Ex post gross profit of adjacent tract	14.51	20.16
A: Tract acreage	2.679	1.533

Number of neighboring tracts is larger than number of neighboring bidders: neighboring firms are allowed to bid together, or coordinate in their bids.

Wildcat and Drainage Tracts

Variables	Wildcat	Drainage
Number of Tracts	1056	144
Number of Tracts Drilled	748	124
Number of Productive Tracts	385	86
Average Winning Bid	2.67	5.76
Average Net Profits	1.22	4.63
Average Tract Value	5.27	13.51
Average No. of Bidders	3.46	2.73

Value: ex post estimated present value of revenues minus drilling cost.

- Informational advantage of the drainage tracts: fraction of tracts drilled, fraction of productive tracts, average net profits, average tract value is higher.
- Hence, average winning bid is higher.
- However, average number of bidders lower: because of asymmetric information.

Tracts Won: Drainage Tracts

	nb win		nnb win		
	A	Total	B	C	Total
No. of Tracts	35	59	19	36	55
No. of Tracts Drilled	23	47	18	33	51
No. of Productive Tracts	16	36	12	19	31
Average Winning Bid	3.28	6.04	2.15	6.30	4.87
Average Gross Profits	10.05	12.75	-0.54	7.08	4.45
Average Net Profits	6.76	6.71	-2.69	0.78	-0.42

A No nonneighbor bids

B No neighbor bids

C Both bids but nonneighbor wins

- 83 % At least one neighbor firm participated in auction.
- 68 % At least one nonneighbor firm participated in auction.
- 62 % Neighbor firm wins in participated bids (59 to 36)
- Average net profit: zero for nonneighbor firms. Negative when neighbor firms do not bid. For neighbor firm wins, average net profit does not depend on whether nonneighbor firm bid or not.

Theoretical Predictions of the Auction Model with Asymmetric Information. For Drainage Tracts

- It is more likely that at least some neighbor firm bids than that at least some nonneighbor firm bids.
- The neighbor firm wins at least half of the drainage tracts.
- Expected profits of non-neighbor firms are zero. Negative if neighbor firms bid and positive if not.
- Positive expected profits for the neighbor firm: reflects informational advantage over non-neighbor firms.

- If the benefit to the neighbor firm is purely informational, then the ex ante predicted gross profit (before realization of the private information) should be the same for neighbor and nonneighbor firms.
- The bidding strategy of the neighbor firm is independent of the number of nonneighbor firms.
- The bidding strategy of the neighbor firm is a positive function of the public signal (results of the seismic tests). Positive seismic tests increase the nonneighbor bids

Evidence on neighbor firms' coordination

	Single nb	Multiple nb. Tracts		
	Tracts	1	≥ 2	Total
No. of Tracts	40	48	15	74
No. of Tracts, no nb bid	8			11
No. of Wins	19	29	11	40
Average Winning Bid of nb firm	4.795 (1.444)	2.615 (0.697)	17.193 (9.953)	6.624 (2.885)
Average Gross Profits of nb firm	13.601 (5.608)	4.670 (2.148)	32.597 (11.506)	12.350 (3.965)
Average Net Profits of nb firm	8.806 (4.762)	2.055 (1.690)	15.404 (10.963)	5.725 (3.297)

- There is no difference in profitability between single neighbor tracts and multiple neighbor tracts.
- Multiple firm bids in multiple neighbor tracts have higher net profits than single firm bids in multiple neighbor tracts. Evidence of shadow bidding.

Evidence on Private information of nonneighbor firms

Does nonneighbor firm bidding dummy have additional predictive power given variables on neighbor firm's bids?
Firm's profit equation: Does informed neighbor firms predict profits?

$$\pi_{jt} = X_{jt}\beta + \epsilon_{jt}$$

X_{jt}:
D_I, D_U neighbor, nonneighbor firms bid or not
N_I, N_U: number of neigbor or nonneighbor bidders
A: acreage, V: adjacent tract value, N: number of nb tracts.
B_I, B_U: neighbor and nonneighbor bids.

TABLE 5—PREDICTION OF TRACT PROFITABILITY[a]

Variable	Equation (1)	Equation (2)	Equation (3)
Constant	−3.60	0.11	3.16
	(−0.75)	(0.02)	(0.81)
D_I	5.03	−3.12	
	(1.42)	(−0.60)	
D_U		−0.09	4.89
		(−0.03)	(1.03)
N_I	3.98	−2.01	
	(1.01)	(−0.46)	
N_U		1.64	0.93
		(1.68)	(0.87)
N	−0.26	0.003	−1.03
	(−0.48)	(0.007)	(−1.41)
A	−.46	−0.18	0.80
	(−0.62)	(−0.23)	(0.67)
B_I	3.55	3.09	
	(3.90)	(3.35)	
B_I^2	−0.023	0.061	
	(−2.57)	(1.76)	
B_U		−0.229	0.181
		(−0.31)	(0.26)
B_U^2		0.014	0.021
		(0.65)	(1.36)
V	0.013	0.116	0.259
	(0.11)	(1.30)	(1.80)
V^2	$-0.9E-4$	$-0.41E-3$	−0.0013
	(−0.12)	(−0.37)	(−0.72)
$B_I \cdot B_U$		−0.093	
		(−1.99)	
$B_I \cdot V$	−0.0067	−0.026	
	(−0.24)	(−1.04)	
$B_U \cdot V$		−0.034	−0.034
		(−1.41)	(−0.85)
SSE	17673	14766	41483
R^2	.640	.699	.154
d.o.f.	104	98	104

[a] The dependent variable in each equation is π. Heteroskedasticity-consistent t-statistics are displayed in brackets.

neighbor firms as informed. The evidence summarized in Table 5 does not contradict this nomenclature.

Note that the significant coefficients in Table 5 also support the view that the informed firms do indeed possess payoff-relevant information. True tract profitability is positively correlated with their bids, over the entire observed range of bids. The final column indicates that the incremental predictive power of the informed firm bid and participation decisions is very significant, even after conditioning on public information and non-neighbor bid and participation information.

B. *Bid Distributions*

One implication of the theoretical model is that, conditioning solely on publicly available information, the distribution of the informed bid and that of the maximum uninformed bid should be approximately the same if tract valuations are symmetric (i.e., c is equal to zero). Accordingly, we computed the maximum likelihood estimates of the parameters of the joint distribution of these two variables. We explicitly accounted for the truncation of the bid variables at the reservation price, for the sample selection rule that the only observed tracts are those in which at least one bid was positive, and for the possibility of correlation between the error terms of the two bid equations. The explanatory variables are the publicly available information in our sample: tract acre-

- Only neighbor bid (B_I) is significant (positive effect) for profit.
- Value of adjacent tract (private information) is insignificant after the neigbhor bid is controled for. Relevant private information is contained in the neighbor bid.

Likelihood Function

Firm's valuation equation:

$$Y_{it} = W_{it}'\theta_i + \epsilon_{it}; i = I, U; t = 1, ..., T$$

Firm's bid equation:

$$\begin{aligned} log\left(\frac{B_{it}}{R_t}\right) &= Y_{it} \text{ if } Y_{it} \geq 0 \\ &= 0 \text{ otherwise} \end{aligned}$$

Y_{it}: (maximum) valuation of firm i (informed or uninformed) at tract t. I: Informed: Neighbor firms
U: Uninformed: Nonneighbor firms.
R_t: Government reservation price.
W_{it}: RHS variables: tract acreage (A), number of neighbor tracts (N), the value of adjacent tract (V), and V^2

$$\begin{bmatrix} \epsilon_{It} \\ \epsilon_{Ut} \end{bmatrix} \sim N\left(0, \begin{bmatrix} \sigma_I^2 & \sigma_{IU} \\ \sigma_{IU} & \sigma_U^2 \end{bmatrix}\right)$$

TABLE 8—BID EQUATIONS[a]

Independent Variable	Equation (1)		Equation (2)		Equation (3)	
	Dependent Variable		Dependent Variable		Dependent Variable	
	$\log(B_I/R)$	$\log(B_U/R)$	$\log(B_I/R)$	$\log(B_U/R)$	$\log(B_I/R)$	$\log(B_U/R)$
Constant	1.86973	2.13073	1.64933	2.15018	1.67785	0.064395
	(−4.19)	(2.90)	(3.52)	(2.96)	(3.66)	(1.14)
π	0.08967		0.08505		0.08501	
	(4.26)		(4.09)		(4.08)	
π^2	−0.00051		−0.00047		−0.00047	
	(−2.04)		(−1.88)		(−1.88)	
V	0.04452	0.00257	0.04814	0.00120	0.04757	0.02083
	(2.58)	(0.10)	(2.82)	(0.04)	(2.79)	(1.08)
V^2	−0.00045	−0.00006	−0.00047	−0.00005	−0.00046	−0.00011
	(−2.25)	(−0.21)	(−2.47)	(−0.18)	(−2.42)	(−0.58)
A	−0.20738	0.12154	−0.25435	0.12908	−0.25713	−0.22645
	(−1.95)	(0.68)	(−2.32)	(0.74)	(−2.38)	(−1.71)
N	−0.01001	−0.27341	0.03228	−0.27116	0.03506	0.03029
	(−0.12)	(−1.92)	(0.36)	(−1.93)	(0.41)	(0.28)
N_U			0.13505		0.11312	0.83705
			(1.26)		(1.42)	(8.48)
$\begin{bmatrix} \sigma_I & \\ \rho_{UI} & \sigma_U \end{bmatrix}$	$\begin{bmatrix} 1.5956 & \\ (11.5) & \\ 0.0453 & 2.6238 \\ (0.43) & (13.0) \end{bmatrix}$		$\begin{bmatrix} 1.5664 & \\ (11.3) & \\ -0.0782 & 2.6101 \\ (-0.62) & (13.0) \end{bmatrix}$		$\begin{bmatrix} 1.5663 & \\ (11.5) & \\ -0.0576 & 1.8769 \\ (-0.56) & (13.0) \end{bmatrix}$	
	Log $L = -409.3745$		Log $L = -408.6295$		Log $L = -378.5628$	

[a]Asymptotic t-statistics are displayed in brackets. They are computed from the analytic second derivatives.

namely, the value of the adjacent tract and that value squared, are the same in the informed and maximum uninformed bid equations. They are significant only in the bid equation of the informed firm. This is consistent with the prediction of the theoretical model that the bids of the non-neighbor firms are much "noisier" than the bids of the

tive is to determine whether estimation under this behavioral hypothesis leads to implications which are not consistent with the theory of competitive bidding.

In the competitive bidding model, each neighbor firm observes a private signal on the value of the drainage tract, which, conditional on the value of the tract, is inde-

Evidence on the symmetry of ex ante profits given publicly available information.

- Weak evidence that they are similar. But some publicly observable variables (V, V^2 are significant for informed bids and insignificant for uninformed, and the opposite for N)
- Informed bid contains private information, which helps predict profitability, whereas (maximum) uninformed bids does not contain it. π, π^2 significant for informed bids but insignificant for uninformed bids.
- Informed bid is independent with number of neighbor tracts and number of uninformed bids.
- (maximum) uninformed bids are correlated with the number of uninformed bids.