

Detection of Bid Rigging in Procurement Auctions

Porter & Zona (JPE 1993)

Motivation

- Research Question: Was there any bid rigging in procurement auctions for highway construction contracts in New York?
- Approach: model bids and bid ranks as a function of cost shifters for different groups of firms (“cartel” vs. competitive”), assuming competitive equilibrium (i.e. $b_i = B(c_i; \theta)$)
- Key idea: differences in estimated parameters = cannot reject collusion
- Contribution: show that collusion among firms is plausible even in the presence of variable market shares

Background

- Procurement auctions by New York State Department of Transportation (DOT)
 - 04/1979 to 03/1985: ~\$120m in highway contracts in Nassau and Suffolk counties (Long Island)
 - Only 22 firms competed for large contracts > \$1m; 45% of such bids from 4 firms
- Market characteristics could have facilitated collusion:
 - Homogenous product → cartel only has to coordinate price behavior
 - Significant barriers to entry, esp. for large contracts → no outside competition
 - Public info. on no. of bidders and winner → deviation is detectable
 - Auctions are held regularly → cartel members know continuation value and can be disciplined

Background

- Firms in the market were known to exhibit collusive behavior:

“In 1984, one of the five biggest firms in the Nassau and Suffolk counties was convicted in federal court of rigging bids...four other firms were listed as unindicted coconspirators

All five firms have been named as participants in bid-rigging schemes in separate antitrust or racketeering suits”

- Informs the ex-ante grouping of firms (“cartel” vs. “competitive”)

Unusual bidding patterns

Example of February 1983 letting for resurfacing 0.8 miles of road:

- 1st auction: 8 bids, lowest bid \$4m > DOT estimate of cost
- 2nd auction: 4 bids (3 firms returned), lowest bid 20% higher
- 3rd auction: 3 bids (all firms returned twice since 1st auction), lowest bid ~10% higher than 2nd auction and ~30% higher than 1st
- “...notable that the same firm submitted the low bid in each of the auctions”
- Contract not awarded until 1987

Look for phantom bidding in DOT auctions

TABLE 3

PROBABILITY OF MULTIPLE CARTEL BIDS GIVEN A BID BY A CARTEL FIRM

Firm	Paving (%) (1)	Nonpaving (%) (2)
Firm 1	88	75
Firm 2	79	55
Firm 3	89	80
Firm 4	67	
Firm 5	100	

- Cartel firms tend to bid for the same projects
- Cartel firms: 54% of bids on large contracts; awarded 37% of all contracts
- Hypothesis: cartel members submit phantom bids to make the market appear competitive

Model: bid levels

- In a competitive equilibrium, firm i 's bid in auction t satisfies the FOC:

$$\phi_{it}(b_{it}) + (b_{it} - c_{it}) \frac{\partial \phi_{it}(b_{it})}{\partial b} = 0$$

- If so, then equilibrium behavior can be fitted with a bidding rule:

$$\log(b_{it}) = \alpha_t + \beta \mathbf{X}_{it} + \epsilon_{it}$$

Where α_t = auction-specific effect, \mathbf{X}_{it} = observable cost shifters and ϵ_{it} = unobserved private information with $\mathbb{E}[\epsilon_{it}] = 0$, $\mathbb{E}[\epsilon_{it}^2] = \sigma_t^2$

- Estimate β for (i) all firms; (ii) competitive firms; (iii) cartel firms

Independent variables

- Use the DOT data to construct \mathbf{X}_{it} that captures shifts in firms' cost:

$BACKLOG_{it}$ = sum of contracts won but not yet completed

CAP_i (capacity) = $\max_t \{ BACKLOG_{it} \}$

$UTIL_{it}$ (utilization rate) = $\frac{BACKLOG_{it}}{CAP_i}$ if $CAP_i > 0$ and 0 if o.w.

$NOBACK_i = 1$ if $CAP_i = 0$

$ISLAND_i = 1$ if HQ of bidder i is on Long Island

Include higher order terms $UTILSQ_{it}$ and $CAPSQ_i$ to address non-linearities

Results: bid levels

	Data from All Firms (1)	Data from Competitive Firms (2)	Data from Cartel Firms (3)
Observations	476	319	157
Degrees of freedom	395	238	81
Wald statistic	21.9	494.7	28.4
UTIL	-.0053 (.2)	-.0973 (2.8)	.1991 (1.2)
UTILSQ	.0358 (1.0)	.1720 (4.0)	-.1143 (.8)
NOBACK	-.0010 (.1)	-.0178 (1.6)	
CAP	.1666 (1.8)	-1.2691 (10.4)	1.8225 (4.6)
CAPSQ	-.4430 (2.1)	4.8519 (13.0)	-2.9029 (4.4)
ISLAND	-.0288 (.6)	-.0334 (1.2)	

- Competitive firms have a U-shaped log-bidding rule with the expected sign on coefficients, but cartel firms do not (opposite sign)
- Bids of cartel firms are statistically different from bids of competitive firms

Model: bid ranks

- Assume multinomial logit ($\epsilon \sim \text{i.i.d.}$), then the probability of any observed ranking for an auction t with n_t bids is

$$\Pr_{\beta}(b_{r_1 t} < b_{r_2 t} < \dots < b_{r_{n_t} t}) = \prod_{i=1}^{n_t} \frac{\exp(\beta Z_{r_i t})}{\sum_{j=i}^{n_t} \exp(\beta Z_{r_j t})}$$

MNL probability that
any given firm wins the
auction

Where the auction-specific constants cancel out and Z 's = re-scaled X 's

- Use MLE to estimate β from all auctions in sample:

$$L(\beta) = \prod_{t=1}^T \Pr_{\beta}(b_{r_1 t} < b_{r_2 t} < \dots < b_{r_{n_t} t})$$

- Estimate β for (i) competitive firms; (ii) cartel firms, both split by winning/losing bids and use Likelihood Ratio Test to test whether coefficients are identical

Likelihood Ratio Test

- If the multinomial logit model is correctly specified, then β can be estimated from any subset of the auction dataset
- H_0 : no phantom bidding $\rightarrow \beta$ estimated from winning bids (low ranked) should be the same as β estimated from losing bids (high ranked)
- LR test: statistically significant difference in the ratio of β 's \rightarrow reject H_0

Results: bid ranks, competitive firms

COMPETITIVE RANK BASED ESTIMATES			
	All Ranks (1)	Low Ranks (2)	Higher Ranks (3)
Observations	244	75	169
Log likelihood	− 291.4	− 89.85	− 199.4
UTIL	− .0070 (.1)	.0161 (.1)	− .0552 (.3)
UTILSQ	.0986 (.8)	.0534 (.3)	.1596 (1.0)
NOBACK	− .0283 (1.0)	.0089 (.2)	− .0454 (1.3)
CAP	− 1.888 (3.8)	− 1.641 (2.4)	− 2.100 (3.0)
CAPSQ	6.869 (3.9)	6.517 (2.6)	7.020 (2.9)
ISLAND	− .0182 (.3)	− .0759 (.9)	.1016 (.9)

- Estimates of bidding function are stable across ranks; LR test cannot reject null hypothesis
- Cannot conclude that competitive bids are generated by a different process depending on whether or not they are low or high ranked

Results: bid ranks, cartel firms

CARTEL RANK BASED ESTIMATES			
	All Ranks (1)	Low Ranks (2)	Higher Ranks (3)
Observations	85	50	35
Log likelihood	−73.97	−44.58	−24.92
UTIL	.0429 (.3)	.2107 (1.0)	.2310 (.6)
UTILSQ	−.0112 (.1)	−.1128 (.6)	−.4300 (.9)
CAP	.4306 (.9)	1.101 (1.3)	−2.537 (1.6)
CAPSQ	−.8473 (.9)	−1.904 (1.2)	3.861 (1.4)

- LR test: coefficients from (2) and (3) are different (statistically significant at 94%)
- Reject null hypothesis of no phantom bidding

Comments

This paper presents plausible econometric evidence of phantom bidding in a procurement market

- Estimated 2 different models (bid levels and bid ranks) and showed both times that cartel firms employed bidding rules that were statistically different from competitive firms
- Models are tractable and rely only on auction data
- Results are reliant on the ex-ante grouping of firms (authors acknowledge that some cartel firms could be classified as competitive: “...*it is perhaps best to view the contribution of this paper as methodological as well as descriptive*”); could have considered placebo tests to show robustness