Detection of Bid Rigging in Procurement Auctions

Porter and Zona (*JPE* 1993)

October 20, 2021

Overview

- Authors suspect construction firms of engaging in bid-rigging
- They want to test whether the observed bidding behavior can be explained by competitive behavior
- Split the firms into two groups (cartel firms and competitive firms) and see if their behavior is the same

How these bids work

1. Interested firms request plans and specifications (the list of interested firms is public info)

2. On the "auction day", each bidder's sealed bid is opened and announced to everyone present

3. The lowest bid is accepted, provided it is "responsible" (direct quote)

4. If the DOT determines that the bid is responsible, they accept it and publicize the bids and awarded contracts

Why do we expect collusion?

- One of the firms already got caught rigging bids
- Firms *only* compete on prize (no differentiated goods)
- Public DOT announcements allow for detection of and punishment for non-cooperative behavior
- Buyer lists ensure common knowledge prior to the auction
- Largely inelastic demand (bidders keep any increase in price)

Model/Bid Levels

- IPV Auction

$$\varphi_{it}(b_{it}) + (b_{it} - c_{it})\frac{\partial \varphi_{it}(b_{it})}{\partial b} = 0 \qquad \text{(FOC)}$$

- Assume equilibrium behavior satisfies log-linear bidding rule (restrictive assumption):

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

- Emphasizes between-firm instead of between-job differences
  - This part of the data is more informative

- Estimate this via OLS; compare the coefficients for cartel members and other firms

Bid Ranking

- Competitive firms need to balance their expected profits against their probability of winning
- Cartel firms *know* that their probability of winning is 0 if they aren't the designated low-bidder
- The (approximate) probability of submitting the lowest bid is

$$\ln P[b_{it} < b_{jt}, \forall j \neq i] = \theta_t + \beta \frac{\mathbf{X}_{it}}{\sigma_t} \sqrt{\frac{\pi}{6}} \qquad \text{(MNL)}$$

- Estimate the standard deviations for each auction, then

$$\ln P[b_{it} < b_{jt}, \forall j \neq i] = \alpha_t + \beta Z_{it}$$

$$\implies P[b_{it} < b_{jt}, \forall j \neq i] = \frac{e^{\beta Z_{it}}}{\sum_j e^{\beta Z_{jt}}}$$

Bid Ranking

- We can combine all these probability to get the probability of seeing a specific bid ranking in a given auction,

$$P[b_{r1t} < b_{r2t} < \ldots < b_{rnt}] = \prod_{i=1}^{n_t} \frac{e^{\beta Z_{r_i} t}}{\sum_{j=i}^{n_t} e^{\beta Z r_j t}}$$

- And now combine all these guys to get the probability of seeing the actual rankings in the data across all auctions,

$$L(\beta) = \prod_{t=1}^{T} \prod_{i=1}^{n_t} \frac{e^{\beta Z_{r_i} t}}{\sum_{j=i}^{n_t} e^{\beta Z r_j t}}$$

MLE Estimation and Hypothesis Testing

- If the model is correctly specified, we can use any subset of the data to estimate the parameters.
- Split the data into cartel firms and competitive firms.
- Hausman test that the parameters are the same.
- If they're not the same, then we have suggestive evidence of "phantom bidding" or other weird behavior by the cartel firms.

Are Competitive and Cartel Firms the Same? Levels

TABLE 4

GLS Estimates

	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	−.0973	.1991
	(.2)	(2.8)	(1.2)
UTILSQ	.0358	.1720	−.1143
	(1.0)	(4.0)	(.8)
NOBACK	−.0010	−.0178	
	(.1)	(1.6)	
CAP	.1666	−1.2691	1.8225
	(1.8)	(10.4)	(4.6)
CAPSQ	−.4430	4.8519	−2.9029
	(2.1)	(13.0)	(4.4)
ISLAND	−.0288	−.0334	
	(.6)	(1.2)	

Note.—Absolute values of t-statistics are displayed in parentheses. Auction-specific constants were included but are not reported to save space. The Wald statistics pertain to a test of the joint significance of the reported coefficients. The coefficients of CAP and CAPSQ are scaled up by 10^4 and 10^8, respectively.

- The model fits the competitive data pretty well
- Bids from cartel firms are statistically different from competitive firms' bids

Competitive Rank Based Estimates

TABLE 5

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	.0161	−.0552
	(.1)	(.1)	(.3)
UTILSQ	.0986	.0534	.1596
	(.8)	(.3)	(1.0)
NOBACK	−.0283	.0089	−.0454
	(1.0)	(.2)	(1.3)
CAP	−1.888	−1.641	−2.100
	(3.8)	(2.4)	(3.0)
CAPSQ	6.869	6.517	7.020
	(3.9)	(2.6)	(2.9)
ISLAND	−.0182	−.0759	.1016
	(.3)	(.9)	(.9)

NOTE.—Absolute values of t-statistics are displayed in parentheses. The coefficients of CAP and CAPSQ are scaled up by 10^4 and 10^8, respectively.

- Cannot reject the null that low bids and non-low bids are generated by the same DGP.

Cartel Rank Based Estimates

TABLE 6

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	.2107	.2310
	(.3)	(1.0)	(.6)
UTILSQ	−.0112	−.1128	−.4300
	(.1)	(.6)	(.9)
CAP	.4306	1.101	−2.537
	(.9)	(1.3)	(1.6)
CAPSQ	−.8473	−1.904	3.861
	(.9)	(1.2)	(1.4)

NOTE.—Absolute values of t-statistics are displayed in parentheses. The coefficients of CAP and CAPSQ are scaled up by 10^4 and 10^8, respectively.

- Reject the null of no phantom bidding
- Conclude that cartel bids are generated by a different process depending on whether they are low or not

Wrapping Up

- Features in the DOT auction market make it susceptible to bid rigging
- There is a group of candidate cartel firms, and a group of non-cartel firms
- The authors estimate the firms' parameters and impose some restrictions on the bidding functions they can be using.
- Non-cartel firms behave the same whether they win or lose; they're trying to maximize their expected profits as a function of surplus and probability of winning.
- Cartel firms do something different; they aren't trying to maximize profits when they submit non-winning bids, since they know another cartel member will win anyway.