# Detection of Bid Rigging in Procurement Auctions

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(JPE, 1993 )

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# Motivation

**Question:** Was there collusion in bidding auctions for state highway construction contracts in Long Island in the 1980s?

**What this paper do:**

1. Proposes a test procedure designed to detect the presence of bid rigging in procurement auctions.
2. How? By identifying differences between the observable implications of collusive and competitive behavior.

**Why is this important:** Sustained (high) price collusions on public procurements damage tax payers.

# NY state highway construction auctions (1)

- Firms compete only in price (only need to collude in price), regardless of cost estimations.
- Bids and bidder identity were public.
- High entry costs.
- Public procurement agency (DOT) high paying procurements followed predictable rules.

$\Longrightarrow$ Suitable framework to collude.

# NY state highway construction auctions (2)

- 186 contracts in the period, 161 awarded for $< \$1M$.
- 66 firms bid on at least one of the 161 vs only 22 firms for $> \$1M$ ones, and 45% bids submitted by four firms.
- 5 firms ("The cartel") were convicted in federal court for collusion in 1984 in the only case that was analized.
- The cartel firms regularly bid "against" each other.

**Attempted to create the appearance of competition:**

- Market shares were relatively stable during the period for the cartel firms.
- The distribution of cartel bids on individual contracts is more tightly concentrated than the corresponding distribution of competitive bids

# Model (1)

- Set of risk neutral bidders on any particular job is common knowledge.
- Costs for firm i on job t are random with a known distribution, costs are independently distributed across firms.
- Firm i knows its own costs but only the distribution of the costs of its competitors.

Firms maximize:

$$\underset{\{b\}}{\mathbb{E}}\,\pi(\underbrace{b}_{\text{bid}}) = (b - \underbrace{c_{it}}_{\text{cost}})\ \underbrace{\varphi_{it}(b)}_{\text{prob. b winning}}$$

$\varphi_{it}$ depends on the distribution of costs of other firms and on others bidding strategies.

# Model (2)

In equilibrium, the FOC is:

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

Assuming that equilibrium behavior satisfies the log-linear bidding rule:

$$\log(b_{it}) = \underbrace{\alpha_t}_{\text{auction-specific effect}} + \beta \underbrace{X_{it}}_{\text{observable cost}} + \underbrace{\epsilon_{it}}_{\text{private info}}$$

Comparing estimations for cartel vs competitive firms might shed light on different behaviors.

# Test: framework

The designated low cartel bidder must compete for real. Differences may arise between the ordering of competitive and cartel bids conditional on the observed data.

The probability of submitting the lowest bid with can be expressed as a multinomial logit:

$$\text{ln } P(b_{it} < b_{jt}) = \theta_t + \beta \frac{X_{it}}{\sigma_t} \sqrt{\frac{\pi}{6}}$$

$\theta_i$: Auction-specific constant.
$\beta$: Coefficient from equilibrium estimation.
$\sigma_t$: Auction-specific standard deviation.

# Test: estimation

1. Variance estimation to get prob(firm i win) (Z= deflated data):

$$\ln P(b_{it} < b_{jt}) = \alpha_t + \beta Z_{it}$$

$$P(b_{it} < b_{jt}) = \frac{e^{\beta Z_{it}}}{\sum_j e^{\beta Z_{it}}}$$

2. Combine the latter to get the probability of observing some bid ranking ($r_m$) for one auction ($t$):

$$P(b_{r1t} < b_{r2t} < ... < b_{rnt}) = \prod_{i=1}^{n_t} \frac{e^{\beta Z_{rit}}}{\sum_j e^{\beta Z_{rjt}}}$$

3. So that the likelihood of observing the rankings across all auctions ($T$) is:

$$\mathbb{L}(\beta) = \prod_{t=1}^{T} \prod_{i=1}^{n_t} \frac{e^{\beta Z_{rit}}}{\sum_j e^{\beta Z_{rjt}}}$$

# Test: how to understand it

Under the $H_0$ of no phantom bidding, parameters estimated using only the lowest cartel ranks and those estimated from higher cartel ranks should be the same. 2 key things to observe:

1. If the test was applied to competitive data and did not lead to a rejection, the test might be valid.
2. If rejected when using cartel data, the rejection source can be an effect that is common to nonwinning cartel bids but not nonwinning competitive bids.

$\Longrightarrow$ **The rejection is likely to be the result of phantom bidding.**

# Results (1)

| | 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) | |

BACKLOG: Value of DOT contracts won but not yet completed.
CAP: Maximum BACKLOG carried by each firm.
UTIL: BACKLOG/CAP

# Results (2)

**First order**

1. The model fits the competitive data reasonably well (ie. bids increase with costs).
2. Bids from cartel firms statistically differ from those of competitive firms.

**Second order**

1. Cannot conclude that competitive bids are generated by a different process depending on whether they are low or not.
2. $H_0$ is rejected of no phantom bidding.
3. Ranking of cartel bids does not coincide with rankings of costs.
4. Cartel bids are generated by a different process depending on whether or not they are low.

# Personal comments

**Amazing paper to learn how biding strategies works with suitable rules to collude**

- Smart rank-based test designed to detect differences in the ordering of higher bids, for cartel and competitive firms.
- Very illustrative on how collusion works in auctions (ideal for second year IO PhD students).

**Just one point**

- Very good strategy to predict past collusion in auctions in a specific framework, but will it work for current and future ones? Maybe using a small innovation a really useful tool for antitrust agencies may be developed.