Selective Entry in Highway Procurement Auctions

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October 17, 2020

Overview

- Introduction
- Data
- Evidence of Selection
- Model
- Estimation
- Results and Conclusion

Background

- Public procurement auctions (low-bid)
  - The government has a contract to be awarded through an auction. Firms bid. The winning firm gets paid to do this project

- Bid discount policy (or bid preference program)
  - Commonly used to promote certain firms

  e.g. domestic & local firms, small business, firms owned by minority groups

  - Example: 5% bid discount to Small Business

- Endogenous, selective entry
  - If participating in an auction is costly, the firm (a potential bidder) has to decide whether to "**enter**" (participate) the auction or not

  - Before making the entry decision, if the firms have private information about their costs, low-cost firms are more likely to enter (entry is **selective**)

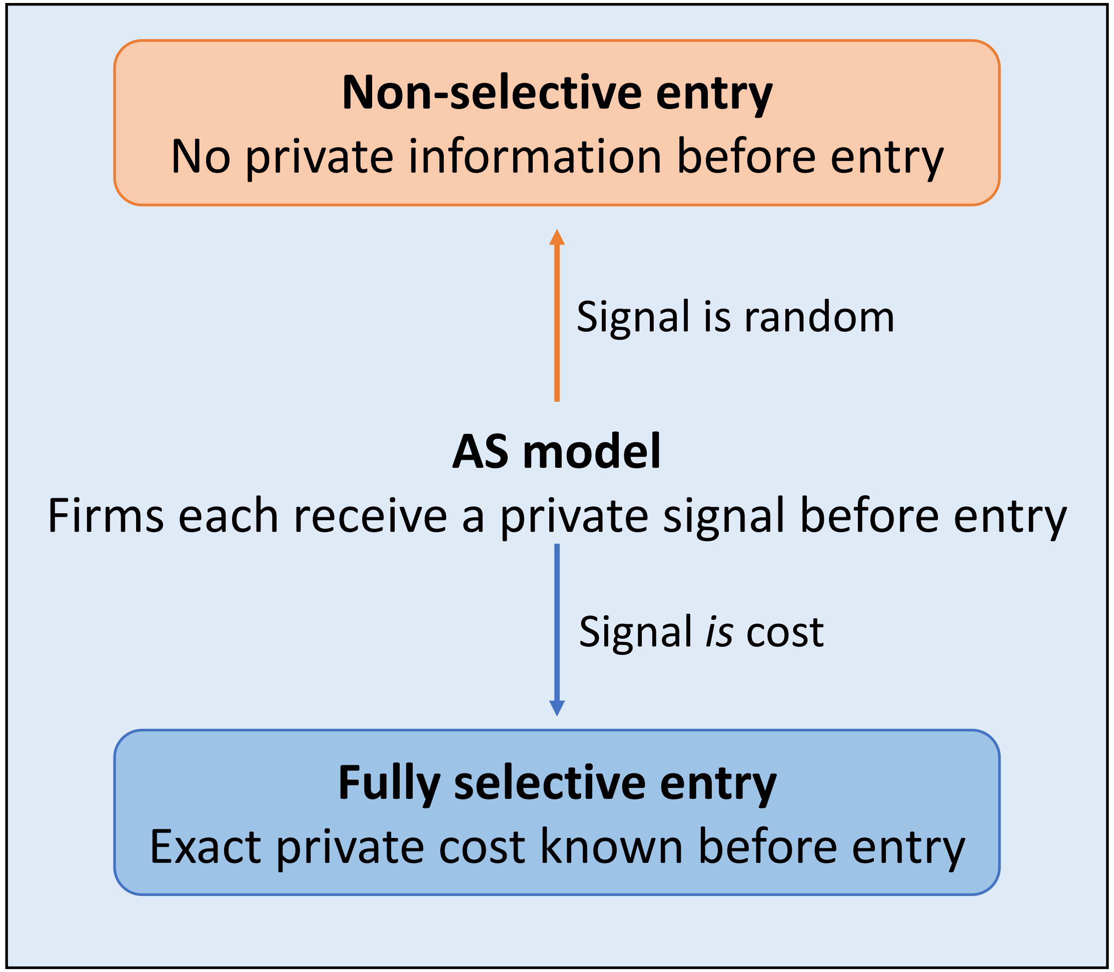
Motivation

- Selective entry affects the optimal bid discount
  - A seller's revenue-maximizing bid discount level can vary from 2.5% to 12.5% depending on the degree of selection (Sweeting & Bhattacharya 2015)
  - A **weak** bidder's probability of winning **increases** with the degree of selection
- Bid preference programs have been empirically studied under
  - Exogenous entry (Marion 2007)
  - Endogenous but ***non-selective*** entry (Krasnokutskaya & Seim 2011)
- Incorrectly assuming non-selection may lead to
  - Incorrect estimates of model primitives (Roberts and Sweeting 2010)
  - → in turn bias the policy recommendation

Does the non-selective entry assumption hold?

- Setting: California's highway procurement auctions
  - CA DOT (Caltrans) uses auctions to award highway construction and repair contracts
  - Bidders: construction companies
  - 5% bid discount to Small Business (SB) in state-funded contracts
  - Allocative goal: use SB in 25% the State's contract dollars
- Flexible entry model: the Affiliated-Signal (AS) model (Gentry & Li 2014)

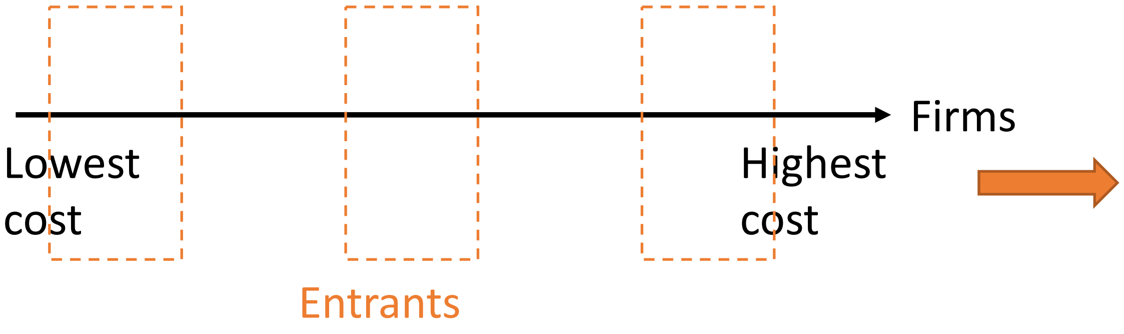
The Affiliated-Signal (AS) model



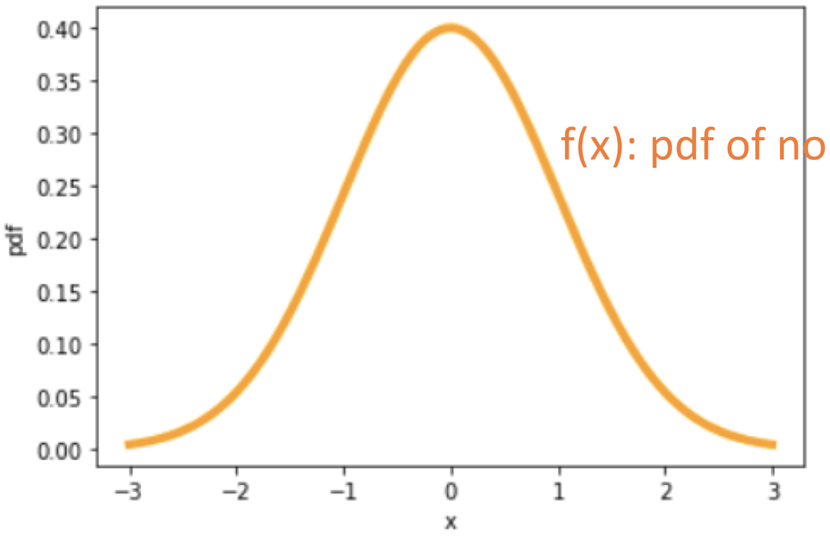
Signal:
Gives a firm a "vague" idea of its cost

Method on a High Level

Non-selective (random) Entry



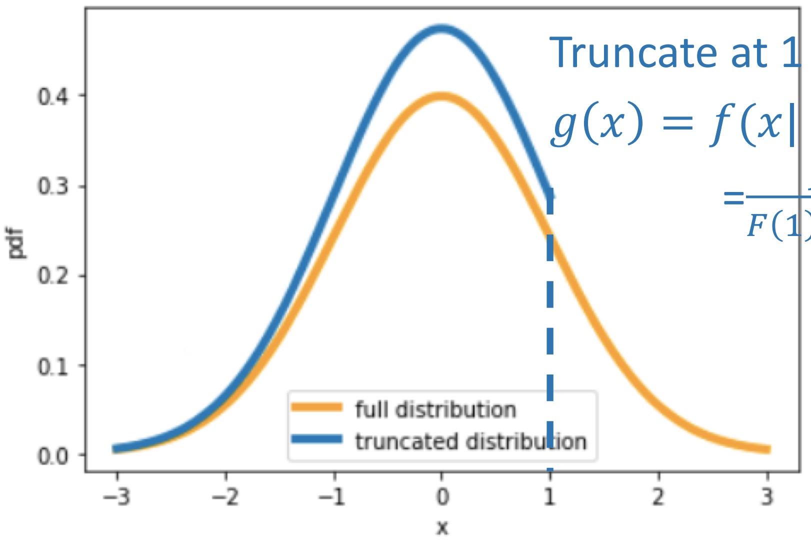
Distribution of project cost among the entrants *is* that of all firms



Selective Entry

Entry is selective → bid discount Caltrans needs is lower than what is previously found under non-selective entry

The former is a **truncated** distribution



Truncate at 1 and -4:

$$g(x) = f(x \mid -4 < X \leq 1) = \frac{f(x)}{F(1) - F(-4)}$$

Contribution to the Literature

- Evidence of selection I find contributes to the literature on empirical testing of different entry models

- Ties the theory on selective entry and auction design to empirical evaluations of bid preference

- Apply a nonparametric estimation method to the Caltrans setting: first attempt to empirically estimate auction models with endogenous, potentially selective entry nonparametrically

Data

- 819 contracts 1999-2005, with $2.2 billion contract value in total
  - 348 contractors submitted 3,666 bids
  - Contracts range from small-scale highway resurfacing to four-lane freeway construction

- Each contract has a list of items to be completed
  - To bid, the contractor needs to prepare bid document detailing:
    - Unit price for each item
    - List of subcontractors and the work item(s) subcontracted to each
  - Median number of items is 21. **Bidding is costly** and involves negotiation with subcontractors

Project cost: a firm's cost of completing the contract

- Project cost is private information
  - Depends on firm's prior experiences, current workload relative to production capacity

- Exact project cost not known before negotiating with subcontractors
  - Affiliated-Signal models this imperfect knowledge

- Two types of firms differ in size and experience
  - Top 20 firms capture 73% of the market share →*regular (non-fringe) bidders*
  - Remaining 328 firms each has less than 1% → *fringe bidders*
  - 47% of the 819 contracts were awarded to fringe firms
  - Regular and fringe firms may have different distributions of project cost

Evidence of Selection

1. Data do not align with theoretical prediction of non-selective entry

   Theory assumes type-symmetric entry equilibrium under non-selective entry (Athey et al. 2011)

Scenario	Theory predicts	Data align with prediction?
Weak type enters with probability > 0	All strong type enters	Only 34% instances do
Strong type enters with probability < 1	No weak type enters	Only 8% instances do

2. If entry is non-selective, the entrants should be a random sample of the potential entrants → Use a Heckman selection model to test this

Regression Results with and without Accounting for Selection

- Heckman:
- Regression equation $y_j = X_j\beta + u_{1j}$

  y_j: Bids; X_j: Project characteristics excluding the number of potential bidders

- Selection equation $Z_j\gamma + u_{2j} > 0$

  Z_j: X_j plus the number of potential bidders of each type

- Exclusion restriction: the number of potential bidders affects entry without affecting bids directly

Dependent Variable: ln (Bids)	OLS	Heckman
Constant	0.733*** (0.119)	0.728*** (0.118)
Fringe	0.038*** (0.006)	0.045*** (0.010)
ln (Engineer's Estimate)	0.947*** (0.008)	0.948*** (0.008)
Working Days	0.0001** (0.00006)	0.0001** (0.00006)
Number of Fringe Bidders	-0.016*** (0.003)	-0.015*** (0.003)
Number of Non-fringe Bidders	-0.014* (0.008)	-0.012 (0.008)
Number of Items	0.001*** (0.0003)	0.0009*** (0.0003)
λ (Estimated Inverse Mills Ratio)		-0.024 (0.028)

Model

Framework: Independent Private Values (IPV)

fringe non-fringe

The firms' project costs are IPV drawn from type-specific distributions F_f, F_n

Firms who decide to enter pay entry cost

Stage 1: Entry | Stage 2: Bidding | Two Stages

time

	Stage 1: Entry	Stage 2: Bidding
Firm i knows	# of potential bidders $N = (N_f, N_n)$ $F = (F_f, F_n)$ Its private signal s_i	# of entrants $n = (n_f, n_n)$ Its project cost c_i
Firms decide on	Whether to enter	How much to bid b_i

Next, I assume firms use the same monotone equilibrium strategy

Equilibrium

- Stage 1 Equilibrium Entry Strategy: entry threshold $\overline{s_\tau}$
  - Potential bidder i of type τ enters if and only if $s_i \leq \overline{s_\tau}$

    $\rightarrow$ cost low enough to expect a net profit from entry
  - The distribution of project costs among entrants, F_τ^* is F_τ truncated at $\overline{s_\tau}$

- Stage 2 Equilibrium Bidding Strategy
  - Expected Stage 2 profit of entrant:

$$\Pi_\tau^{II} = (b_i - c_i) \cdot \Pr(winning)$$

$(price - cost)$ Depends on F^* and n

Payoff from winning

  - Bidders maximize $\Pi_\tau^{II} \rightarrow$ first order condition w.r.t. b_i gives equilibrium bidding strategy

Estimate F_τ^* with a nonparametric method

1. Bids data $\xrightarrow[\text{(standard kernel used)}]{\text{Nonparametrically estimate}}$ Distribution of bids G_τ and density g_τ

2. Equilibrium bidding strategy: $b = f_1(c; n, F^*, f^*)$
   Bids increase with project costs → $c = f_2(b; n, G, g)$

3. Recovered c from above $\xrightarrow[\text{(standard kernel used)}]{\text{Nonparametrically estimate}}$ F^*

F_τ^* is F_τ truncated at $\bar{s}_\tau$

- $\bar{s}_\tau$ is exogenous: variation of $\bar{s}_\tau$ results in different truncation levels

- Scenario 1: all potential entrants enter

There is no truncation: F_τ^* *is* F_τ

- Scenario 2: not all potential entrants enter

F_τ^* is

  - A truncated distribution of F_τ if entry is selective
  - The same as F_τ if entry is random (non-selective)

1. Subset data into these two scenarios
2. Estimate F_τ^* for each
3. Compare the two estimated distributions

Results

Comparing density estimates of the full and selected distributions

(conditional on median engineer's estimate)

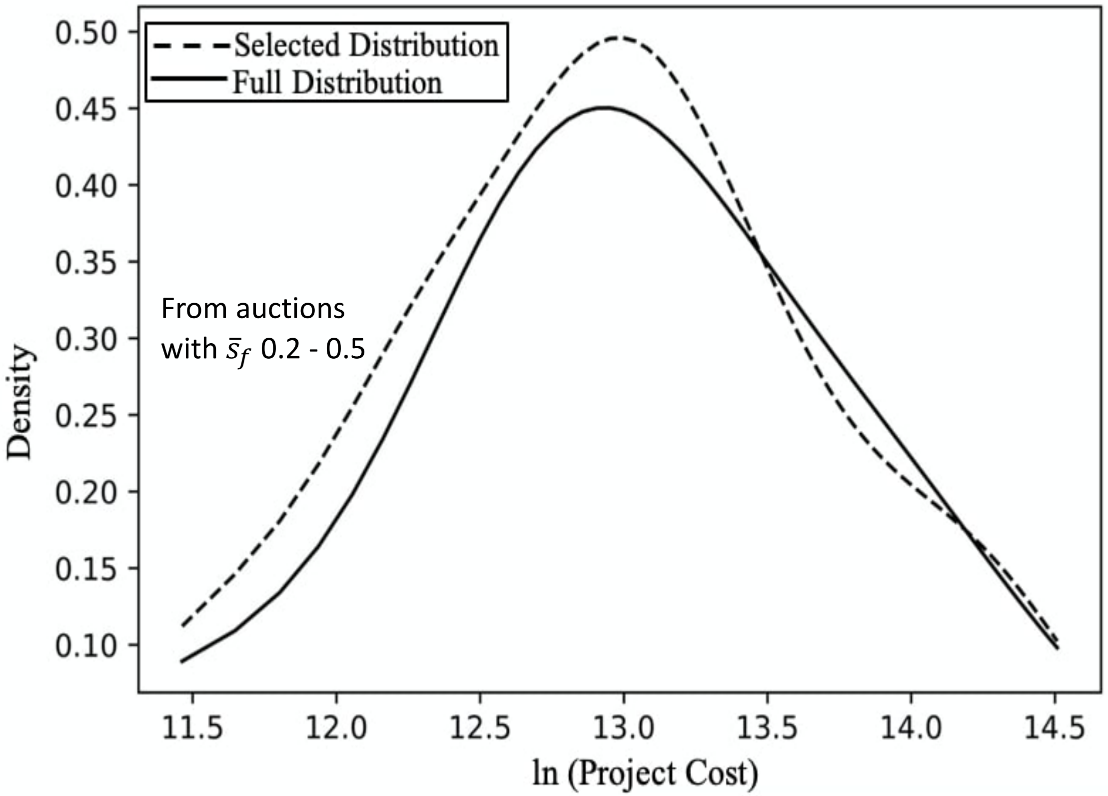


Fig. 1 Fringe Firms Project Cost Density Comparison

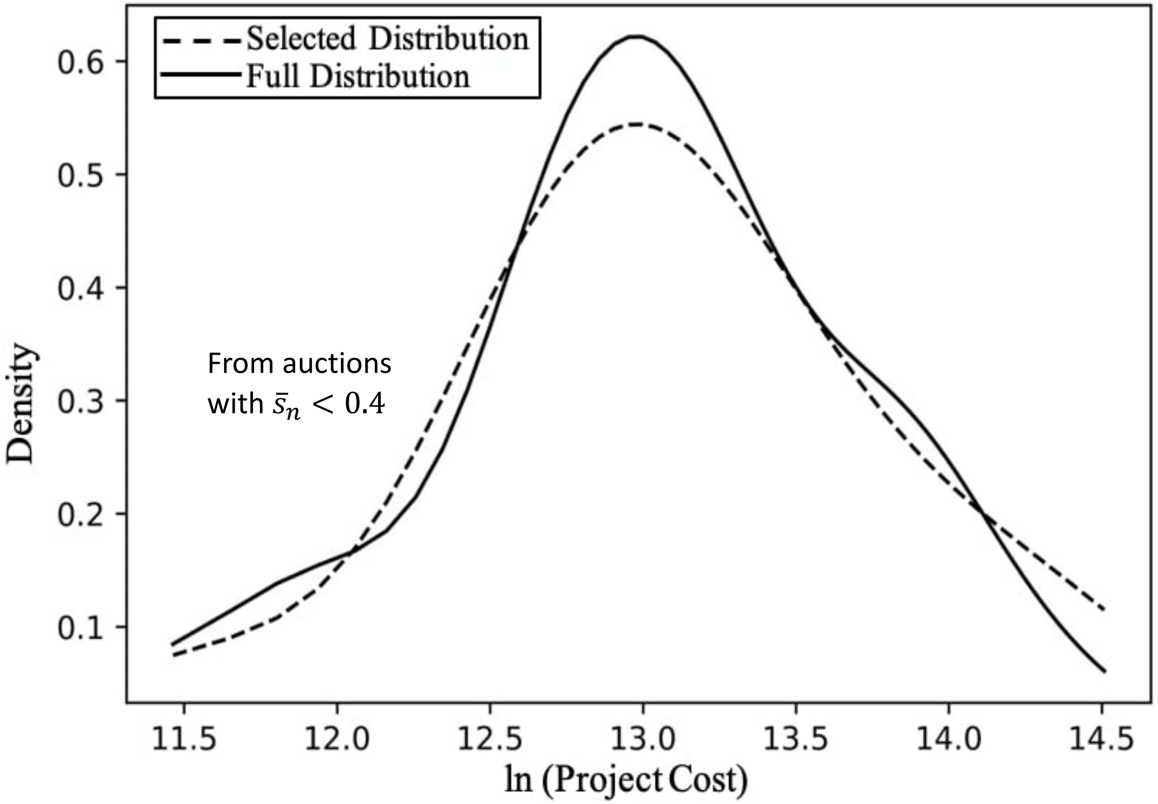


Fig. 2 Non-fringe Firms Project Cost Density Comparison

Resembles a truncated distribution skewed to the left

Conclusion

- My results favor **selective** entry among the fringe firms
- Implication: bid discount needed to achieve the 25% allocative goal is lower than what is previously found under non-selective entry
- Future research:
  - How does selective entry alter the empirical evaluation of bid preference programs? (effects on procurement costs, contract allocation)
  - What is the government’s cost-minimizing bid discount level that also satisfies the allocative goal? (numerical analysis in Sweeting and Bhattacharya 2015)

Thank you International Atlantic Economic Society!