Supplier rationing and efficient procurement: Renewable energy auctions in India
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Introduction

Motivation:
• At 10GW, India is one of the top 5 countries for installed solar and wind energy capacity.
• Most of it is contracted via auctions.
• Novel feature for theory: Quantity asymmetry, open descending-price auction, and residual award to the lowest price loser (Asymmetric case of Holmberg and Wolak, 2018).
• Awarding residual (or rationing) is a simple rule to clear market and foster competition.

Questions:
Theory: Key feature of equilibrium bids?
Response: Highest quantity bidder is less aggressive, bunches at the reserve. Inefficient selection.
Empirical and Policy: Tweaks to improve social welfare or auctioneer payments?
Response: Discriminatory price auction improves social welfare, without affecting auctioneer payment.

Institutional Background

• Auctioneer: Government agencies.
  • Object auctioned: Power purchase agreement for a utility-scale solar/wind project at fixed price for 25 years.
  • Pre-auction: Procurement target M, reserve bid announced.
  • Stages:
      – Capacity and price bids in qualifier round,
      – Price bids in final round, capacity revealed.

<table>
<thead>
<tr>
<th>Bidder</th>
<th>Qualifier</th>
<th>Final Award</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>B2</td>
<td>30</td>
<td>2.5</td>
</tr>
<tr>
<td>B3</td>
<td>200</td>
<td>2.8</td>
</tr>
<tr>
<td>B4</td>
<td>100</td>
<td>3.2</td>
</tr>
<tr>
<td>B5</td>
<td>200</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Table 1: Allocation rule, with M = 500

B1 is rationed to clear the market,
B1 could concede at 2.5 and get 150.

Data and Stylized facts

• Data: Public documents inviting the bidders, published auction results from Solar Energy Corporation of India (SECI); contracts 54GW capacity.
• Observables: firms, final bids, awards.
• 54 auctions with 374 bids.
• 45 auctions with positive residual; 27 have no competition by residual winner.

![Fig. 1: Decision to concede immediately](image)

Theory

Simple model with 2 bidders:
• Target M = 1 revealed, 1 > q1 > q2, q1 + q2 > 1.
• Quantities and other information from qualifier round assumed exogenous for final round.
• Final round modelled as descending clock auction.
  • Assume same reserve, bR, for each bidder.
• Private information: B1’s constant marginal cost c1 ∈ [0, c].
  • Common knowledge: Quantities q1, q2, and c1, i.e., F (c) (IPV), σ(c) = f(c)/F(c), ∀c, σ′(c) < 0, f(c) > 0, very small atom at c = 0.
• First bidder to exit gets residual award, sets the tariff.
B1’s bid b1 is the price at which she exits if opponent hasn’t exited (cutoff strategy).

Ex-post payoffs:

\[ p_b^1(b_1, q, b, b_i) = q(p - c) \]

\[ p_b^2(b_2, q, b, b_i) = (1 - q) + p(c) \]

where \( p = \max(b_1, b_2) \).

Semi-separating Bayes Nash Equilibrium:

![Fig. 2: Equilibrium bidding functions](image)

Intuition: B1 has high residual (q1 > q2) \( \implies 1 - q2 > 1 - q1 \). At any given bid:
• B1 gains lower in quantity if she wins, and
• B1 loses more in amount if she loses.
So, she is less aggressive, and bunches at the reserve.

Formal results:

Lemma 1. (Characterisation) For each B1, \( \beta(c) \) constitutes a semi-separating Bayes Nash Equilibrium of the 2 player clock auction with rationing if and only if it satisfies following properties:
1. \( \beta(c) \) is non-decreasing in c.
2. \( \beta(c) \) is continuous and atomless for \( b < b^R \) for both i.
3. \( \beta(0) = 0 \).
4. For each player B1, \( \beta(c) \) solves:
\[ \sigma(\beta(c)(\beta(c))\beta(c)(\beta(c) - c) = 1 - q_i \]
for \( c > 0 \).
5. \( \beta(c) = b^R, \exists \epsilon > 0 \) such that \( \beta(c) = b^R, \forall c \in [\epsilon, c] \).

Theorem 1. The equilibrium described in Lemma 1, exists and is unique.

Extensions:
• 3 bidders with \( 1 > q1 > q2 > q3, q1 + q2 + q3 > 1 \).
• Asymmetric cost distribution if \( \sigma(c_1) > \sigma(c_2) \), i.e., B1 is more likely to have higher costs.
  – B1 is less aggressive if \( \sigma(c_2) > \sigma(c_1) \).

Identification and Estimation

Identification:
• Observe the bids and identities of losers.
  • In open auction, such bids reveal bidder cost.
  • Bidder identity and costs can then identify the cost distribution as in Dutch auction (Athey and Haile, 2007).

Endogeneity problem:
• Costs observed are conditional on qualification.
  • Self-selection in SECI auctions: bidders with low qualification bids qualify.
  • Endogenous selection threshold: Qualification bid depends on distribution of costs.

Resolving endogeneity:
• Suppose that each bidder is either strong or weak (just 2 possible distributions), i.e., c1, c2 ∈ F (c), \( \epsilon \), where \( \epsilon \in \{0, \epsilon, \epsilon\} \) are parameters to be estimated.
  • The probability density of observing an order statistic, \( c_1 \), conditional on observing a higher order statistic, \( c_2 \), is given as:
\[ f_{\epsilon}(c_1|c_2) = \frac{c_2}{\epsilon^{2}}, \epsilon \in (0,1) \]

It’s independent of selection threshold.

Estimation of parameters:
• Estimate the following using MLE, where likelihood function is based on (1):
\[ c_\epsilon \sim N(\mu_\epsilon, \sigma_\epsilon^2) \]

where \( \mu_\epsilon = \alpha_1 + \alpha_2X_i + \alpha_3X_k \).
• Auction features: Solar or wind, Pre- or post-2018, and their interaction.
• Bidder features: Large producer or not.

Counterfactuals

Bidders assumed to respond to a mixture of distribution of large and small bidders, as they don’t observe identities.

![Fig. 3: Inefficiency - Uniform vs Discriminatory pricing, M = 120GW](image)

Conclusion

• Key Takeaway: Selection inefficient in current format, significant welfare improvement on switching to discriminatory pricing.
  • Future tasks: Find more counterfactuals, analyse incentives in qualifier round, analyse auctioneer’s incentives.

References