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Structural Estimation of an Asymmetric Model on Drainage Oil Auctions

Seda Bülbül Toklu, Kerem Yener Toklu

Motivation

- The department of the Interior leases the offshore lands for oil and gas extraction since 1954.
- One important policy question is the optimal reserve price (optimal in the sense that maximizes the government's auction revenue)
- Very few empirical studies were attempted to asses the optimal reserve price using OCS auctions field data.
- This is because implementing it requires the use of unobservables such as the latent distribution of private signals of bidders.

Contributions

- First study to do structural estimation for the asymmetric common value auction model for OCS drainage leases (developed by Wilson, 1967; Engelbrecht-Wiggens et al. 1983; Hendricks and Porter, 1988 (HP hereafter))
- We find the optimal reservation price via counterfactual simulations for these auctions.

OCS Auctions

- Department of the Interior auctions the production rights on the Outer Continental Shelf (OCS) off Texas and Louisiana since 1954.
- Each lease is sold via a first price sealed bid auction.
- The highest bidder earns the right to extract oil and gas on that particular tract.
- If no exploration is done in 5 years, ownership reverts to the government.
- A fixed fraction of the revenues from extraction is paid to the government as *royalty payment.*
- A reservation price (per acre) is announced by the government for each sale ($15 for wildcat, $25 for drainage)

Drainage Tracts vs. Wildcat Tracts

- **Wildcat Tracts**: tracts in areas that have not been drilled before
  - Firms are allowed to acquire seismic information only.
  - Information is symmetrically distributed.
- **Drainage Tracts**: Tracts that are adjacent to tracts on which deposits have been discovered
  - Firms which have drilled an adjacent tract have private (and much more precise) information about the deposits in and around the area.
  - Informational asymmetry: high informational rents for neighbor firms.
  - Value is two times higher than wildcat tracts.
  - Less competition in drainage tracts.
  - Profit is 4 times higher in drainage tracts.
  - Government captures only 66% of the value of these tracts while capturing 77% for the wildcat tracts.

Theoretical Model

- Bidding model is a simplified version of the first price, sealed bid model with asymmetric information.
- Focus is on the individual tract ***t***.
- ***V*** is the unknown common value of the tract.
- **Asymmetric Information:**
  - nonneighbor firms have only seismic survey information ***Z*** (public).
  - firms that already own a neighbor tract to tract ***t*** have more informative signals (on site drilling information-private) ***X***.
  - ***X*** is a more informative signal than (sufficient for) ***Z***.
- **Noncompetitive behavior** among neighbor firms (strong evidence in the data, HP)
  - no law prohibiting firms from forming a bidding consortium;74 tracts with multiple neighbor firms but only 17 tracts have multiple neighbor bids; bids of neighbor firms are strictly decreasing in the number of neighbor firms.
  - hence highest neighbor bid is taken as "the neighbor bid".
  - An arbitrary number of nonneighbor firms.
- $H = E[V \mid X, z]$ summarizes the information of the neighbor firm about the value of the tract.
- $H \sim F(\cdot \mid z),\ E[H \mid z] = \bar{H} < \infty$
- $\sigma(h)$: strategy of the neighbor firm, differentiable, strictly increasing function on the range (R, ∞).
- *R:* reservation price, $\sigma^{-1}(b) = \tau(b)$: inverse of the bid function.
- $G_i(\cdot)$: strategy of the nonneighbor firm *i* (a distribution function). $G(b) = G_1(b) \cdots G_n(b)$ is the distribution of the highest nonneighbor bid.
- Expected payoff of bidding to neighbor firm when its estimate of *V* is *h*: $G(\sigma(h)) \cdot (h - \sigma(h))$
- Expected payoff to nonneighbor firm *i* of bidding *b*:

$$E[H - b \mid \tau(b) > h; z] \cdot F(\tau(b) \mid z) \cdot \prod_{j \neq i} G_j(b)$$

Equilibrium

- The (n+1) tuple $(\sigma^*, G_1^* \cdots G_n^*)$ is a Bayesian-Nash Equilibrium if and only if

$$G^*(b) = \begin{cases} 1, & b > \bar{H} \\ F(\tau(b); z), & R < b < \bar{H} \\ F(\tau(R); z), & 0 \le b < R \end{cases}$$

$$\sigma^*(h) = \begin{cases} E[H \mid H \le h; z], & h > \hat{h} \\ R, & \hat{h} \ge h \ge R \\ 0, & h < R \end{cases}$$

where $\hat{h}$ solves $E[H \mid H \le \hat{h}; z] = R$.

OCS Drainage Auctions Data

- 137 tracts which were adjacent to previously auctioned tracts, were auctioned between 1954-1969.
- Tract numbers, auction dates, tract locations, tract acreages, bids and bidder firms are the available data
- Ex-post tract values as calculated by HP:
  - Future production paths were converted into revenues by using the real wellhead prices at the date of sale and discounted to the auction date at 5% per annum rate.
  - Cost data is from the American Petroleum Institute
  - Ex-post tract value=discounted revenues – discounted costs.
- Reservation price is $25 on most leases
  - Government has the right to reject the highest bid, and rejected at 15 % of the auctions in the data set.
- We do not have the neighborhood information that HP has, so we produced a proxy dummy for the neighborhood information using the distance between the tracts.

Econometric Model

- We assume the following distribution for the private value of the neighbor firm: $H_t \sim \log Normal(\mu_t, \sigma_t^2) = F(H_t \mid V_t)$

where $\mu_t = a_1 + a_2 V_t \qquad \sigma_t^2 = a_3 + a_4 V_t$

- After applying Jacobian Transformation we get:

$$F_{b_n}(b_n \mid V_t) = F(\tau(b_n) \mid V_t) \text{ and } f_{b_n}(b_n \mid V_t) = \frac{F(\tau(b_n))}{|\tau(b_n) - b_n|}$$

with a support on $\{0\} \bigcup [R, \mu_t]$

➢ Parameter dependent support!
  - Common problem in structural estimation of auction models, renders MLE inappropriate since the standard asymptotics do not apply.

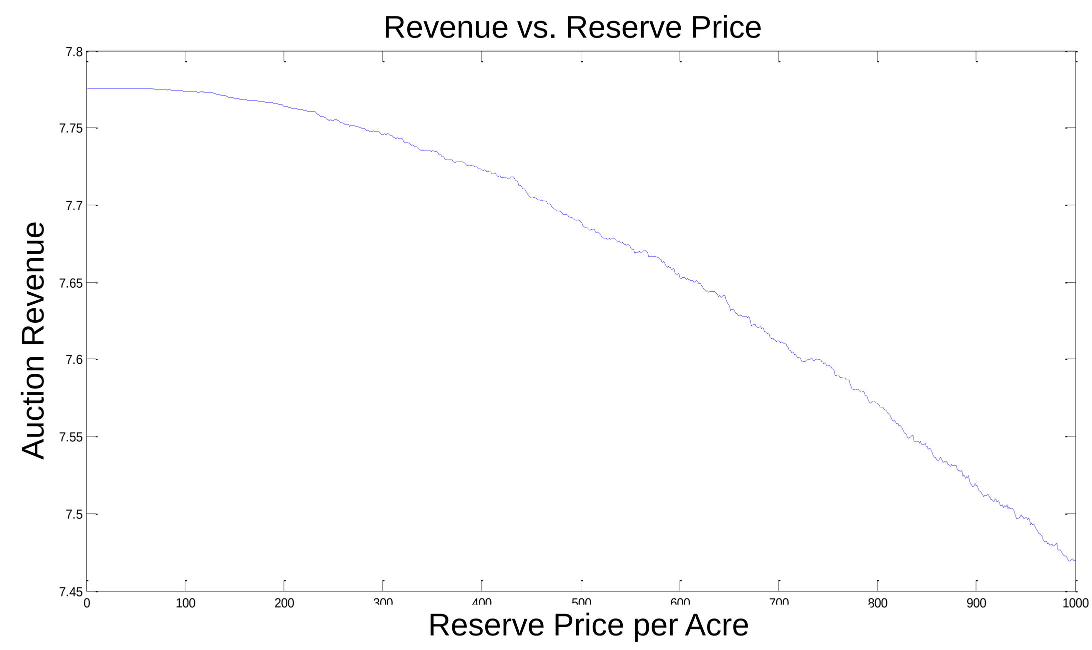
✓ We do Bayesian Estimation (Bajari and Hortacsu, 2003) with flat priors on bounded intervals.

✓ Simulate from the posterior distribution using Metropolis- Hasting Algorithm, find the estimates of (a_1, a_2, a_3, a_4)

✓ Run counterfactual simulations to find the optimal reserve price.

Preliminary Results

- The effect of decreased possibility of selling dominates the effect of increased selling price.



- Government's 25$ reserve price policy is in the optimal range.