Price Regulations in a Multi-unit Uniform Price Auction

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- ... but also in treasury auctions, emission permit auctions, placements of IPOs on financial markets.
- They are used by auctioneers to either sell or buy multi-units of an item.
- Sellers bid supply functions.
- Buyers bid demand functions.
- In a uniform price auction the market clearing price is paid to all sellers/by all buyers independent of their bids.
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Schwenen (2012) shows that the pre-2008 data for the NYICAP market is consistent with the predictions made by multi-unit uniform price models in the spirit of von der Fehr and Harbord (1993).

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The model is a linearized version of Moreno and Ubeda (2006).
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If **general bid caps** affect the bidding behaviour of some generators

⇒ they do not only reduce the maximum price that can be sustained as an equilibrium,
⇒ but they can also reduce the minimum price by allowing smaller capacity firms to be price setting.

If **selective bid caps** affect the bidding behaviour of some generators

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Results - Price Floors

- All price floors either do not affect the possible pure strategy equilibria or
  - they destroy pure strategy equilibria with relatively low equilibrium prices
  - and might for extremely high price floors even destroy all pure strategy equilibria.

- Low price equilibria are more likely destroyed by selective than by general price floors.
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Consider a market with a set of $N = 1, 2, \ldots, n$ active firms with $n > 2$.

Each firm $i \in N$ owns a certain amount of capacity $K_i$ that it potentially can supply without costs on the market.

The firms are indexed such that $K_i \geq K_{i+1}$.

Define $\bar{K} = \sum_{i=1}^{n} K_i$ as the total capacity available and $\bar{K}_{-i} = \bar{K} - K_i$ as the total capacity available if firm $i$ is not supplying its capacity $K_i$. 
Supply of Capacity

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The market demand $D(p)$ is assumed to be linear in the market price $p$ with

$$D(p) = \alpha - \beta p \text{ and } \alpha, \beta > 0.$$  \hspace{1cm} (1)

Each firm can submit a price bid $b_i \geq 0$ at or above which it is willing to supply its total capacity $K_i$ to the market.

The auctioneer sorts all bids according to the demanded price in an ascending order and forms an aggregate supply function.
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All firms that bid their capacity at a price below the equilibrium price sell their total capacity.

Those which bid above sell nothing.

Marginal firm(s) that bids(bid) the equilibrium price might be rationed in order to balance supply and demand.

The vector of all bids \((b_1, \ldots, b_n)\) needs to be a Nash equilibrium in order to determine an equilibrium price in the auction.
Rules of the Auction (2)

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Characterization of Equilibria

It depends on the total capacity in the market as well as on the distribution of capacities among the participating firms whether there are

⇒ multiple equilibria with all firms $i$ bidding $b_i \leq \bar{p}$ and the uniform price in equilibrium being the price $\bar{p}$ that equalizes total capacities with the demand,

⇒ or potentially multiple equilibria where one of the firms $j$ with a larger capacity bids its monopoly price on its residual demand $b_j = p_j$ and all other firms $i$ bid below a certain threshold $b_i \leq b_j$ and the uniform price would be $p_j$,

⇒ or a unique equilibrium where all firms $i$ bid $b_i = 0$ and the uniform price will be $p = 0$. 
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Potential Price Equilibria and Potentially Price setting Firms with a Small Total Capacity

\[ 0 < \bar{K} < \frac{\alpha}{2} \]

\[ \frac{\alpha}{2} < \bar{K} < \alpha \]
Potential Price Equilibria and Potentially Price setting
Firms with a Large Total Capacity

\[ \alpha < \bar{K} < 2\alpha \]

\[ \bar{K} - \alpha \]

\[ p = 0 \]

\[ p = p_1 \]

\[ p = p_j \]

\[ 2\alpha < \bar{K} \]

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General Bid Caps

The bid cap can only have an effect on the uniform price if \( \bar{p} < \hat{b} < p_1 \).

In this case the bid cap does not only wipe out all the bidding equilibria where \( p = p_j > \hat{b} \).

It also creates new equilibria where firms with smaller capacities than before can be price setting with a \( p_j \) smaller than what could be sustained without the bid cap.

The latter is due to the less profitable overbidding strategy that firms with larger capacities, thus, find less attractive.
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Illustration of General Bid Caps

\[ p_j = \beta \left( \alpha - \beta + K_1 - \bar{K} \right) - K_1 (\alpha - \bar{K}) \]

\[ \frac{(\alpha - K)^2 + K^2}{2K_1} \]

\[ K_1 \]
Illustration of General Bid Caps
Selective Bid Caps

- Selective price caps make a difference if some but not all of the potentially price setting firms can set \( p_j > \hat{b} \) because they have a capacity that is below the threshold \( K_j < \hat{K} \).
- If there are price setting firms \( j \) with \( K_j < \hat{K} \) and \( p_j > \hat{b} \) some of the equilibria with \( p = p_j > \hat{b} \) are sustained.
- Price equilibria where firms with \( K_j > \hat{K} \) set \( b_j = \hat{b} \) might not exist.
- Whether the lower bound of equilibrium prices differs from the one with general bid caps depends on the parameters of the model.
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Illustration of Selective Bid Caps

\[ 2\hat{b}(\alpha - \beta \hat{b} + K_1 - \bar{K}) \cdot K_1 \cdot (\alpha - \bar{K}) \cdot (\alpha - \bar{K})^2 + K_1^2 \]

\[ \hat{b} \]

\[ p_j \]

\[ K_j \]

Boom

Price Regulation in a Uniform Price Auction

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Illustration of Selective Bid Caps

\[ p_j = 2\hat{b}(\alpha - \beta \hat{b} + K_1 - \bar{K}) - K_1(\alpha - \bar{K}) \]

\[ = \frac{K_1}{2K_1} \left( \beta \hat{b} + K_1 - \bar{K} \right) \]

\[ = K_1 \]
The inframarginal bids that support potential equilibria with $p = p_j > \max\{\bar{p}, 0\}$ always need to be smaller than a threshold in order to make under-bidding unattractive.

If the capacity of the price setting firm is smaller (due to for example the bid cap) then this lower bound for the inframarginal bids is also lower.
Price Caps and Inframarginal Bids

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Price Effects of General Bid Floors

- General bid floors with $0 < \bar{p} < b_f$ can only destroy some equilibria with $p = p_j$ if $b_j < b_f < p_j$.

- If $b_j < b_f$ holds all bids $b_i < p_j$ must satisfy $b_i \geq b_f$ and firm $j$ would prefer $b_j = b_i - \epsilon$ to $p_j$ for all $b_i > b_f > b_j$.

- If all other firms would however bid $b_i = b_f$ instead, firm $j$ might still prefer bidding $p_j$ to matching $b_f$ and selling the relative share of one’s capacity in the total capacity of the demand at $p = b_f$.

- The latter is true if $b_f$ is not too high ($b_j < b_f \leq \bar{c}_j$).

- Otherwise ($b_f > \bar{c}_j$) all pure strategy bidding equilibria with $p = p_j$ would be destroyed.
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Selective versus General Bid Floors

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- These firms $j$ have always an incentive to underbid inframarginal bid restrained firms $i$ with $b_i \geq b_f$ if $b_f > b_j$.
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If the bid floor $b_i \geq b_f$ is only applied to firms with $K_i \leq \tilde{K}$, this makes only a difference to general bid floors if there are price setting firms $j$ with $K_j > \tilde{K}$.

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What Do We Learn from the Model for the NYICAP?

- The NYICAP market had a bid cap already before 2008.
- After the 2008 reform more stringent selective bid caps for high capacity firms were implemented as well as selective price floors.
- According to our model we should expect that the 2008 reform should have
  - reduced the highest observed prices and
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- In reality prices before 2008 were almost always at the general price cap and are now most of the time lower.
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