Mandatory vs. Voluntary a priori Investment in Information Acquisition in Procurement Auctions

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Background and motivation

- Procurement auctions are crucial for securing goods/services at competitive prices
- Key challenge: High uncertainty for bidders regarding future costs, particularly prominent in renewable energy auctions
- Common practice: certain prequalification prior to entering the auction (Kreiss et al. 2017) $\Rightarrow$ a priori investment in information acquisition
- Impact of the mandatory setting:
  - Reduce uncertainties regarding future costs
  - Reduce participation and competition (Samuelson 1985)
  - Exclude potential interested bidders, leading to inefficiency
- Alternative: voluntary setting, e.g., German photovoltaic auctions
- **Research question:** Mandatory vs. voluntary a priori investment in information acquisition

Related literature

- **Auctions with participation costs**
  - Pure strategy (cutoff strategy): Samuelson (1985), McAfee and McMillan (1987), Tan and Yilankaya (2006), Celik and Yilankaya (2009), and Gillen et al. (2017)
  - Mixed strategy (randomized participation): Levin and Smith (1994), Menezes and Monteiro (2000), and **Jehiel and Lamy (2015)**
- **Information acquisition before or during auctions**
  - General: Stegeman (1996), Persico (2000), **Bergemann and Välimäki (2002)**, and Schweizer and Szech (2017)
  - Static vs. dynamic auction: Compte and Jehiel (2007), Gretschko and Wambach (2014), and Gretschko and Simon (2024)

Our paper complements the existing literature on the voluntary setting, in which the auction winner must invest (either before or after the auction), and the comparison between mandatory and voluntary settings.

Model

- Single-unit second-price procurement auction
- The auctioneer has the maximum WTP $x_0, x_0 > \underline{x}$ and sets a reserve price $r \leq x_0$
- $N \geq 2$ risk-neutral firms (potential bidders)
- Each firm has private costs x_i, which are a priori unknown to the firm
- x_i is the realization of the random variable $X_i, i \in \{1, ..., N\}$, i.i.d. on $[\underline{x}, \bar{x}]$ with F and f
- The realization of X_i can only be known after an investment $c \geq 0$ in information acquisition

Settings

Mandatory setting:

- The auctioneer requires a priori investment in information acquisition
- For participants: c is sunk costs and x_i is known $\Rightarrow \beta(x_i) = x_i$ if $x_i \leq r$

Voluntary setting

- An investment in information acquisition is voluntary, except for the winner
- For investors: c is sunk costs and x_i is known $\Rightarrow \beta(x_i) = x_i$ if $x_i \leq r$
- For non-investors: only the distribution of X_i is known $\Rightarrow \beta = \mathbb{E}[X_i] + c$ if $\mathbb{E}[X_i] + c \leq r$ $\mathbb{E}[X_i] + c := \mathbb{E}[X] + c, \forall i \in \{1, ..., N\}$ (Ehrhart et al. 2015)

Equilibria in the mandatory setting

Proposition 1.

In the mandatory setting, the following applies:

- *For all $c \geq c_{max}(r)$, there exists an equilibrium without participation (the participation probability $q = 0$).*
- *For all $c \in [0, c^m_{min}(r)]$, there exists an equilibrium with full participation, where the participation probability $q = 1$ and the expected profit of each participant is positive.*
- *For all $c \in (c^m_{min}(r), c_{max}(r))$, there exists an unique equilibrium with randomized participation, where the participation probability $q \in (0, 1)$, determined by*

$$\sum_{n=0}^{N-1} P(n, q) \int_{\underline{x}}^{r} F(t)(1 - F(t))^n dt - c = 0,$$

and the expected profit of each participant is zero.

Equilibria in the voluntary setting

Proposition 2.

In the voluntary setting, the following applies:

- *If* $r < \mathbb{E}[X] + c$, *the equilibria and their conditions are the same as in the mandatory setting.*
- *If* $r = \mathbb{E}[X] + c$, *it holds that:*

  For all $0 \leq c \leq c^{v}_{min}(r) = c^{m}_{min}(r)$, *there exists an equilibrium with full participation and investment, where the participation probability* $q = 1$ *and the expected profit of each participant is positive.*

  For all $c \in (c^{m}_{min}(r), \bar{x} - \mathbb{E}[X])$, *there exists two equilibria: an equilibrium with randomized participation and investment, where the participation probability* $q \in (0, 1)$, *determined by*

$$\sum_{n=0}^{N-1} P(n, q) \int_{\underline{x}}^{r} F(t)(1 - F(t))^{n} dt - c = 0,$$

  and the expected profit of each participant is zero; and an mixed equilibrium, where all potential bidders participate with investment with probability $q_1 = q \in (0, 1)$ *as determined above and participate without investment with probability* $q_2 \in (0, 1 - q_1]$ *arbitrarily, and the expected profit of each participant is zero.*

Equilibria in the voluntary setting

Proposition 2 (continued).

For all $c \geq \bar{x} - \mathbb{E}[X]$, there exists an equilibrium with randomized participation without investment, where the participation probability $q' \in (0, 1]$ and the expected profit of each participant is zero.

- *If $r > \mathbb{E}[X] + c$, it holds that: For all $0 \leq c \leq c^v_{min}(r)$, there exists an equilibrium with full participation and investment, where the participation probability $q = 1$ and the expected profit of each participant is positive.*
  For all $c \in (c^m_{min}(r), \bar{x} - \mathbb{E}[X])$, there exists an mixed equilibrium, where all potential bidders participate with investment with probability q_1, determined by

$$\sum_{n_1=0}^{N-1} P(n_1, q_1) \int_{\underline{x}}^{\mathbb{E}[X]+c} F(t)(1 - F(t))^{n_1} dt - P(N-1, q_1) \int_{\mathbb{E}[X]+c}^{r} (1 - F(t))^N dt - c = 0,$$

  and participate without investment with probability $q_2 = 1 - q_1$. The expected profit of each participant is positive.
  For all $c \geq \bar{x} - \mathbb{E}[X]$, there exists an equilibrium with full participation without investment, where the expected profit of each bidder is zero and the participation probability $q' = 1$.

Possible symmetric equilibria

Our analysis identifies five types of symmetric equilibria depending on c and r

- E_0: No participation
- E_1^f: Full participation, all firms participate and invest c
- E_1^r: Randomized participation, all firms participate and invest c with probability $q \in (0, 1)$
- E_2: All firms participate without investment with probability $q' \in (0, 1]$
- E_{mix}: All firms participate and invest c with probability $q_1 \in (0, 1)$ and participate without investment with $q_2 \in (0, 1)$, $q_1 + q_2 \leq 1$.

Different equilibria depending on c and r

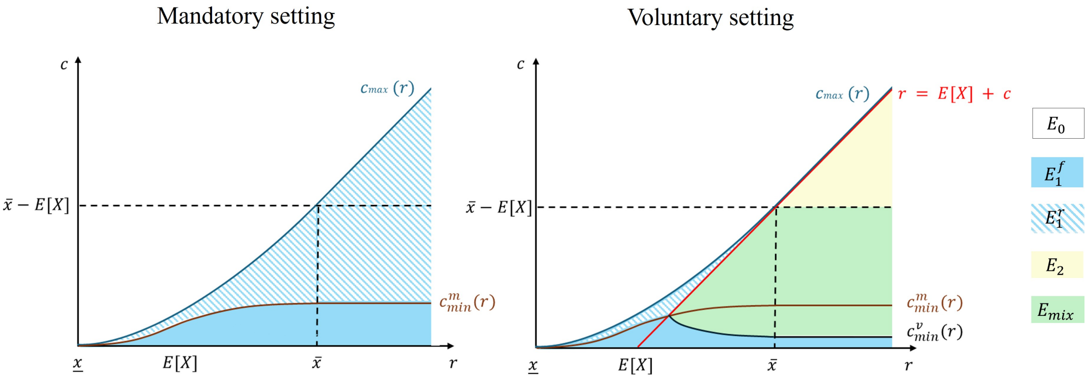

Figure: Different equilibria depending on c and r in mandatory and voluntary settings

Comparison between mandatory and voluntary settings

Under efficient reserve price $r = x_0$

- *Expected participation*: voluntary setting $\geq$ mandatory setting
- *Expected a priori investment*: voluntary setting $\leq$ mandatory setting
- *Expected welfare*: voluntary setting $\succeq$ mandatory setting

Under optimal reserve price r^*

- *Locally optimal reserve price*:
  - E_1^f: $r^* = x_0 - \frac{F(r_j^*)}{f(r_j^*)}$ (Myerson 1981)
  - E_1^e: $r^* = x_0$ (Jehiel and Lamy 2015)
  - E_2: $r^* \in [\bar{x}, x_0]$ arbitrary
  - E_{mix}: $r^* \leq x_0 - \frac{F(r_j^*)}{f(r_j^*)}$

  Globally optimal reserve price: continuous and increases in x_0 given c
- *The participants' expected profit*: voluntary setting $\succeq$ mandatory setting if $c \geq c_{min}^m(\bar{x})$
- *The auctioneer's expected profit*: Depending on c and x_0, either setting can be favored

Conclusion and discussion

- Our model shows advantages of the voluntary setting over the mandatory setting
- The results can be extended to incorporate risk aversion
- Ongoing work: centralized a priori investment in information acquisition by the auctioneer
- Open question: partial a priori investment in information acquisition

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Appendix: Equilibria in the mandatory model

Condition	Equilibrium	Characteristics
$0 \leq c \leq c^m_{min}(r)$	E^f_1	$q = 1, \pi^m \geq 0$
$c^m_{min}(r) < c < c_{max}(r)$	E^r_1	$q \in (0,1), \pi^m = 0$

$$c_{max}(r) := \int_{\underline{x}}^{r} (r-s) f(s) ds = \int_{\underline{x}}^{r} F(s) ds$$

$$c^m_{min}(r) := \int_{\underline{x}}^{r} F(t)(1 - F_{(1,N-1)}(t)) dt,$$

$$c^v_{min}(r) := \int_{\underline{x}}^{r} F(t)(1 - F_{(1,N-1)}(t)) dt - \int_{\mathbb{E}[X]+c}^{r} (1 - F_{(1,N-1)}(t)) dt$$

Appendix: Equilibria in the voluntary model

	Condition	Equilibrium	Characteristics
$r < \mathbb{E}[X] + c$	$0 \leq c \leq c^m_{min}(r)$	E^f_1	$q = 1, \pi^{vi} \geq 0$
	$c^m_{min}(r) < c < c_{max}(r)$	E^r_1	$q \in (0,1), \pi^{vi} = 0$
$r = \mathbb{E}[X] + c$	$0 \leq c \leq c^m_{min}(r)$	E^f_1	$q = 1, \pi^{vi} \geq 0$
	$c^m_{min}(r) < c < \bar{x} - \mathbb{E}[X]$	E^r_1 & E_{mix}	$q_1 \in (0,1), q_2 \in [0, 1 - q_1]$, $\pi^{vi} = \pi^{vn} = 0$
	$c \geq \bar{x} - \mathbb{E}[X]$	E_2	$\pi^{vn} = 0$
$r > \mathbb{E}[X] + c$	$0 \leq c \leq c^v_{min}(r)$	E^f_1	$q = 1, \pi^{vi} > 0$
	$c^v_{min}(r) < c < \bar{x} - \mathbb{E}[X]$	E_{mix}	$q_1, q_2 \in (0,1)$, $q_1 + q_2 = 1$, $\pi^{vi} = \pi^{vn} > 0$
	$\bar{x} - \mathbb{E}[X] \leq c < c_{max}(r)$	E_2	$q_2 = 1, \pi^{vn} = 0$

Appendix: An example of the optimal reserve price

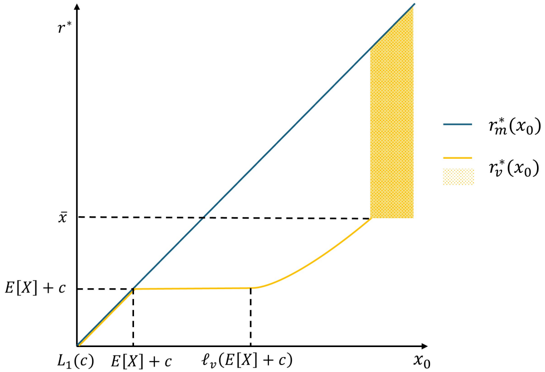

Figure: Exemplary optimal reserve price in case $c_{min}^m(\bar{x}) \leq c < \bar{x} - \mathbb{E}[X]$