Efficient Multi-Attribute Tendering Models for Project Procurement

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Background

Price-Only Tender

Multi-Attribute Tender
(multi-criteria selection)

AWARD CRITERIA

Price
+
Nonmonetary attributes

- completion time
- environmental characteristics
- running cost

etc..

Related research

Auction Theory
Vickrey(1961)

Public Procurement Auction

Multi-attribute procurement tendering model (scoring auction model)
Che(1993)
Branco(1997)
Asker(2004)

They focused on the pure properties of scoring auction, and not considered any other specific policies such as reserve price policy.

Motives for Our Research

In Japan, the government adopts reserve price policy **in multi-attribute tender** because of the regulation of Public Accounting Act

However,

- **Is it really efficient policy in multi-attribute tender?**
- **Isn't there any other policy that is more efficient ?**

→ **Still Not Clear**

Methodology and Results

Methodology

⇨ Game theoretic approach (**Auction Theory**)

- Analyze the mechanism of multi-attribute tender
- Clarify the effect of reserve price in multi-attribute tender

Results

- Reserve price policy is **not** efficient in multi-attribute tender
- **Reserve score** policy that sets the lower limit of score is more efficient policy in multi-attribute tender

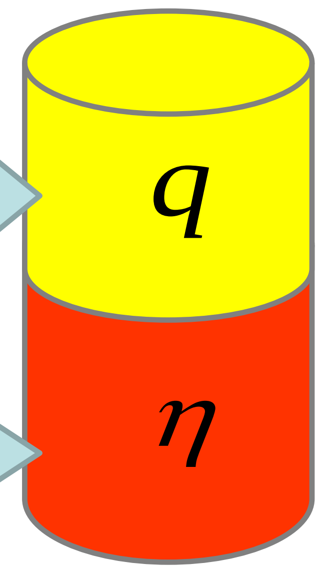
Assumption for modeling

All Non-Monetary Attributes

→ "**quality**"(two variables)

additional quality achieved as a result of each firm's technology (endogenous)

minimum required quality (exogenous)

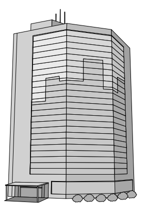


Scoring Auction

Multi-Attribute Procurement Auction
can be analyzed by scoring auction

Scoring Rule $S:(p,q)\rightarrow\Re$

Contract Price



Each participant proposes

p

q

Promised quality

Score

S

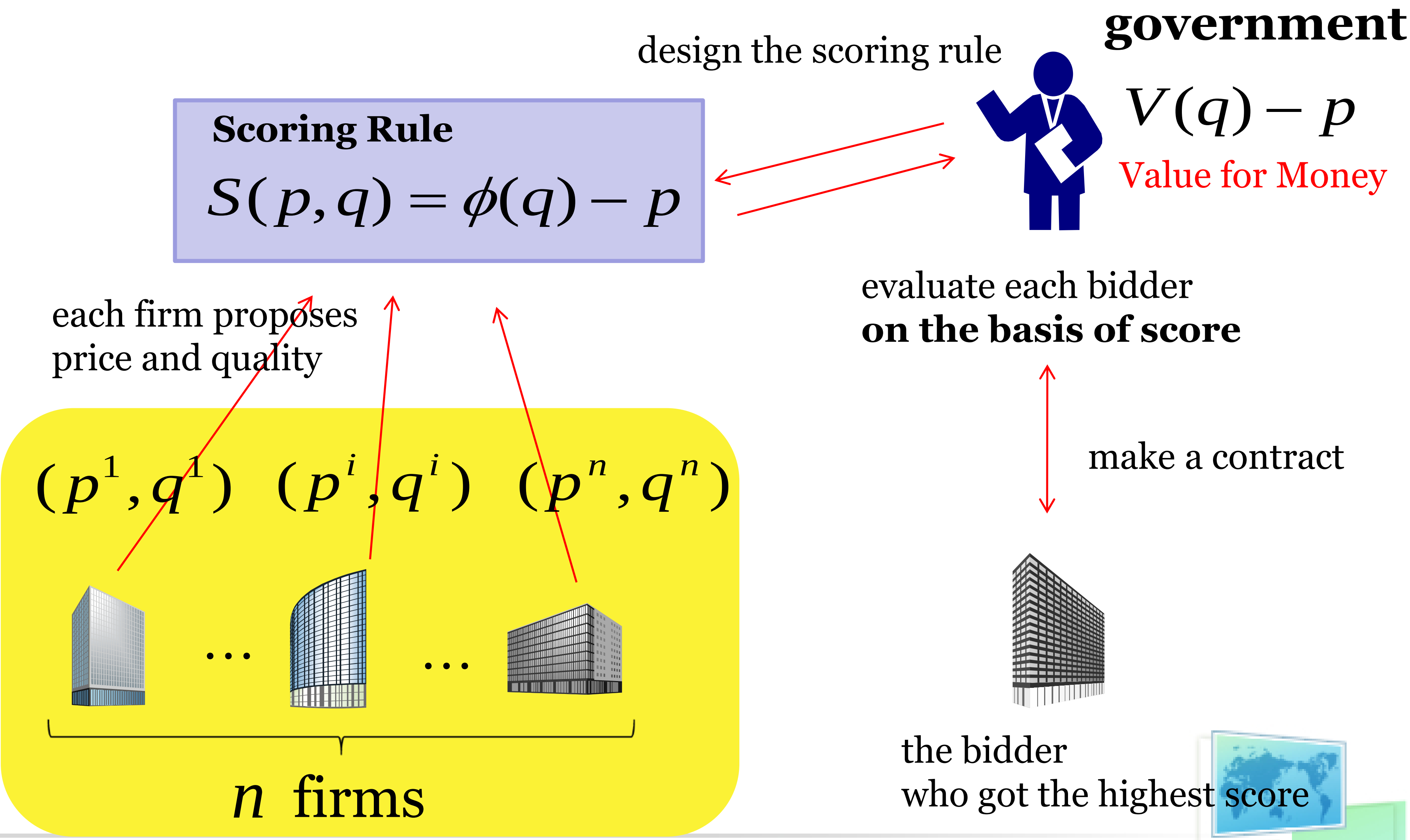
government

We restrict attention to
Quasi-Linear Scoring Rule

$$S(p,q)=\phi(q)-p$$

$$\phi'>0,\phi''<0$$

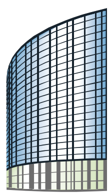
Model Structure



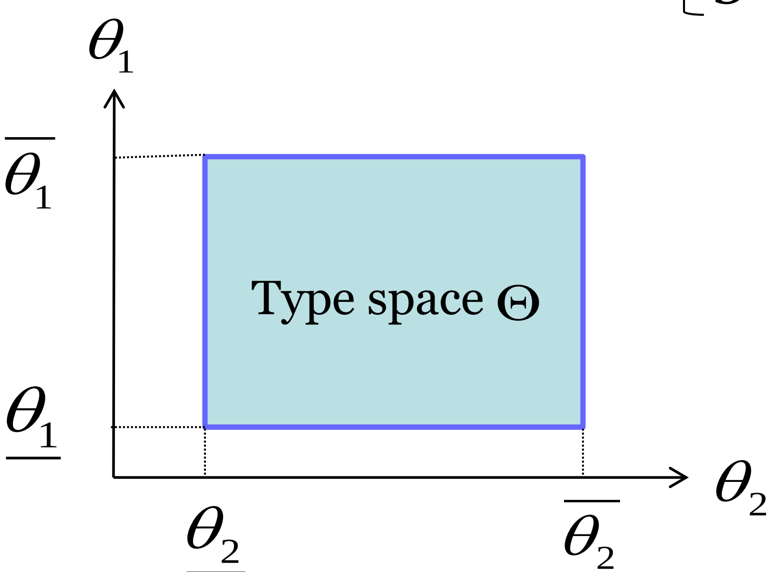
Marginal Costs are Private Information (Multi-dimensional scoring auction model)

Firm i's Expected Utility

$$(p^i - \theta_1^i q^i - \theta_2^i \eta)\, prob\{b^i > b^j,\, j \neq i\}$$



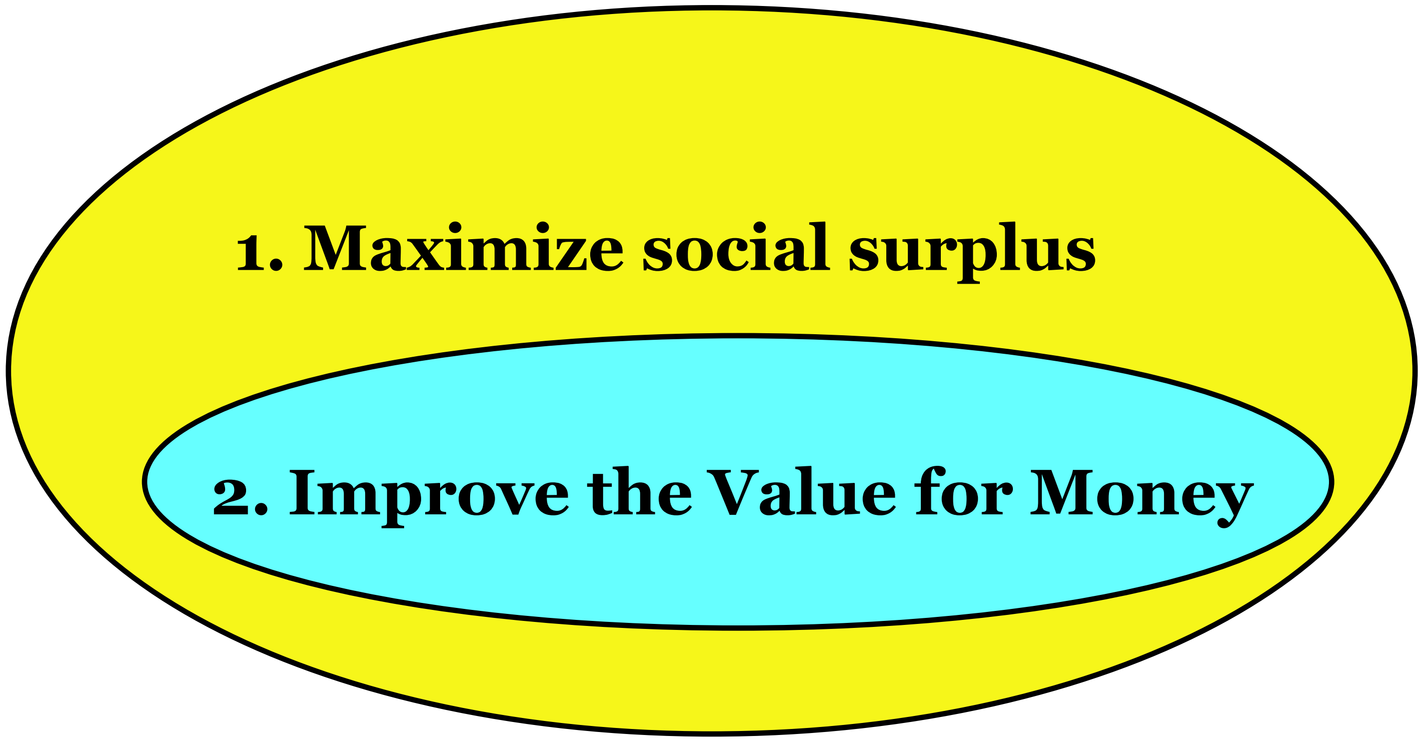
$$\begin{cases} \theta_1^i & \text{Marginal Cost over } q^i \\ \theta_2^i & \text{Marginal Cost over } \eta \\ b^i & \text{Bidding Score} \left(b^i = \phi(q^i) - p^i \right) \end{cases}$$



Common Knowledge

The (θ_1, θ_2) pairs (type) are *independently* and *identically* distributed across bidders with a density function $f(\theta_1, \theta_2)$

The Aim of Government in Public Procurement



Pseudo-Type

Pseudo-Type

$$
\begin{aligned}
v &= k(\theta_1, \theta_2) \\
&= \max_q \phi(q) - \theta_1 q - \theta_2 \eta \\
&= \phi(q^*) - \theta_1 q^* - \theta_2 \eta
\end{aligned}
$$

The maximum score
without getting negative profit

Asker(2004)

- Quasi-Linear Scoring rule
- Firm's types are independently and identically distributed

⇒

We can describe the equilibrium of
multi-dimensional scoring auction
by using one-dimensional firm's pseudo-type

Take advantage of the result of basic Independent Private Value (IPV) auction model

$$\max_{p,q}(p^i - \theta_1^i q^i - \theta_2^i \eta)\, prob\{b^i > b^j,\ j \neq i\}$$

s.t.

$$\phi(q) - p = b$$

$$q \geq 0$$

Price and Quality $\longrightarrow (p, q)$

Type $(\theta_1, \theta_2) \sim f(\theta_1, \theta_2)$

Pseudo-type model

$$\max_{b}(v - b)\, prob\{b^i > b^j,\ j \neq i\}$$

Score $\longrightarrow b$

Pseudo-Type $v \sim l(v)$

In the related **IPV auction model**, we can find the symmetric equilibrium of the multi-attribute tender

How should the government design the scoring rule?

$SW = V(q^*) + W(\eta) - \theta_1 q^* - \theta_2 \eta$ (equation of social surplus)

$v = \phi(q^*) - \theta_1 q^* - \theta_2 \eta$ (equation of pseudo-type)

If the government sets the scoring rule
$S(p,q) = V(q) - p$ $(\therefore \phi(q) = V(q))$

$SW = v + W(\eta)$

The winning firm should be the firm that maximizes the social surplus

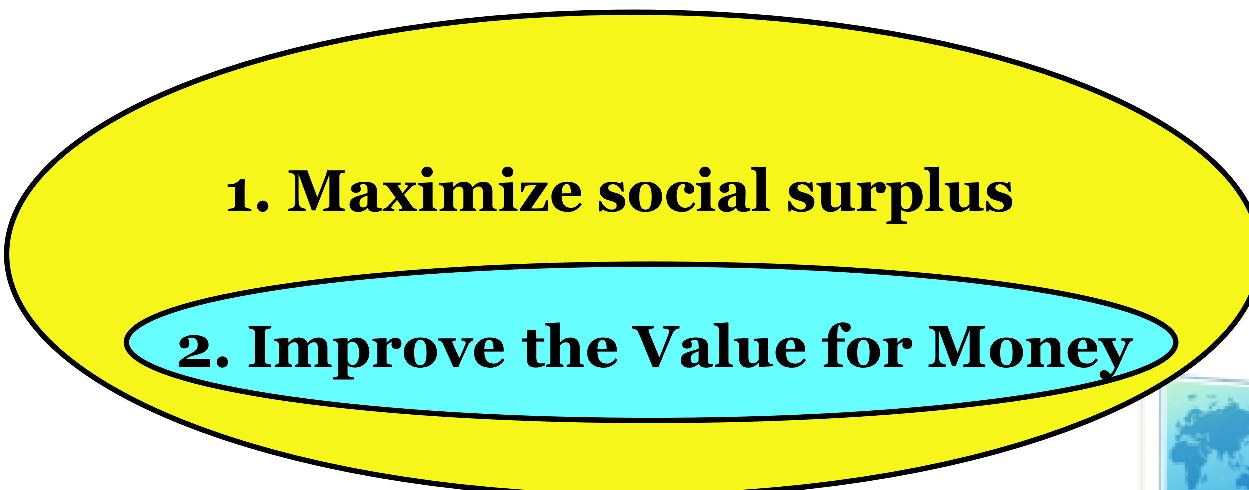
in the symmetric Nash Equilibrium of IPV auction, the bidder who has the most high type should be the winner of the auction

Social Efficient Scoring Rule

Proposition

In order to maximize social surplus (achieve social efficient quality), the buyer should set the scoring rule that reflects the true preference of her .

$$S(p,q)=V(q)-p$$



Reserve Price Policy vs. Reserve Score Policy

Both policy is intended to get more competition among bidders to improve the expected utility of government

$$\underline{S(p,q)} = V(q) - \overline{p}$$

Reserve score policy requires all bidders to meet the lower limit of the score ξ

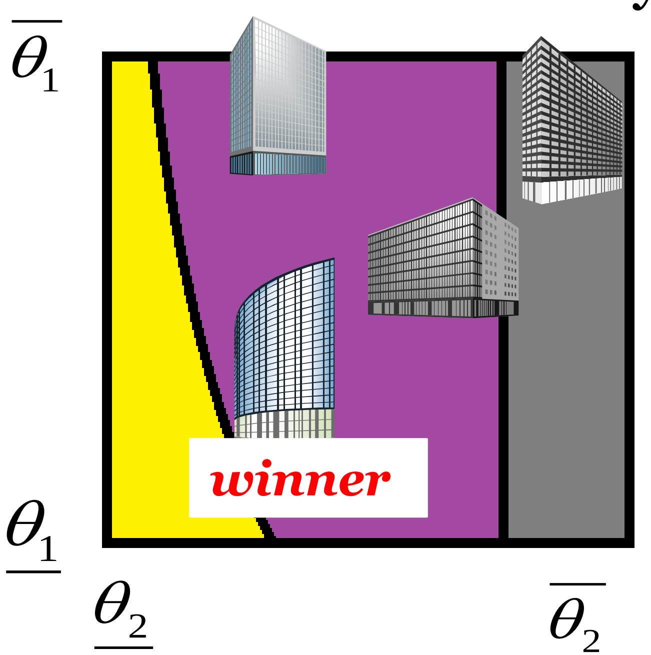
$$V(q) - p \geq \xi$$

Reserve price policy requires all bidders to bid the price that is smaller than the upper limit of price r

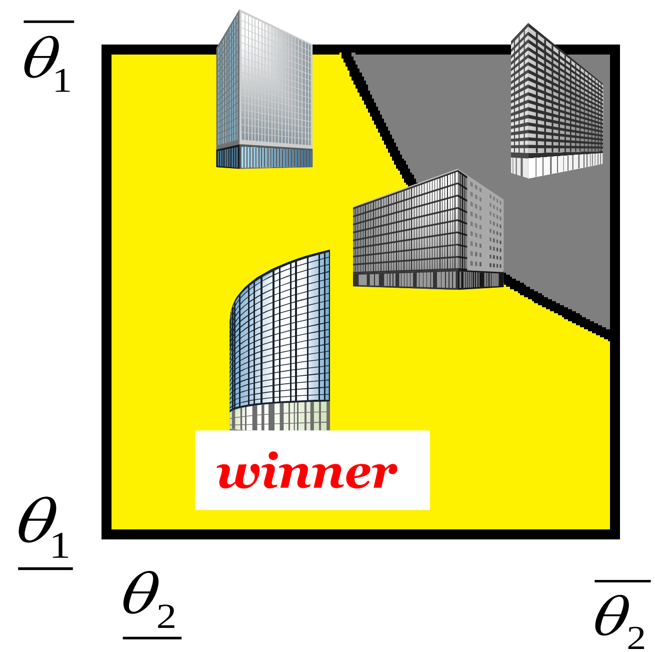
$$p \leq r$$

Comparison

Reserve Price Policy



Reserve Score Policy



Propose the social efficient quality that maximizes social surplus

Propose the quality which is ***smaller*** than the social efficient quality

Not participate the auction

Implication

Reserve price in multi-attribute has a possibility to influence bidders' decision of quality level to offer for negative direction.

$$S(p,q) = V(q) - p$$

Reserve score policy makes a condition not on each component, but on the total score.

Conclusion

1. **Maximizes Social Surplus**
2. **Improves the Expected Utility**

- Quasi-Linear Scoring rule

$$S(p,q) = V(q) - p$$

- Reserve Score Policy

Limitation and Future Study

Several important aspects are ignored in our analysis

- **Possibility of moral hazard after the contract**

- **transaction cost**

Thank you for your attention !